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Do exercise and fitness buffer against stress among Swiss police and emergency response service officers?☆

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ABSTRACT

Objectives: During the past three decades, researchers from many disciplines have been interested in whether exercise can help people to cope better with stress. Past research examining the stress buffering effects of exercise, however, is limited by small sample sizes, poorly validated measures of stress, exercise and health, and the exclusion of samples that are at-risk for chronic stress exposure. The purpose of the present study, therefore, was to address these limitations by exploring the stress buffering effects of exercise and fitness in a sample of police and emergency response service officers.
Design: The design of the current study is cross-sectional.
Method: The current study recruited 533 employees of the police force and emergency response service corps in an urban area of German-speaking, North-Western Switzerland (22.9% females). All respondents filled in a self-administered battery of validated questionnaires assessing stress, exercise, perceived fitness and health.
Results: The data showed that increased stress was associated with poorer health. There was no significant relationship between exercise and stress; however, increased fitness was associated with reduced stress. Exercise and fitness were associated with enhanced health. Hierarchical regression analyses revealed significant interactions, suggesting that exercise protects against stress-related health problems. Exercise was a more powerful stress buffer than perceived physical fitness. Moreover, moderate exercise was more suited to counteract stress than vigorous exercise activities.
Conclusions: The findings indicate that exercise and fitness can help foster a healthy and thriving workforce that takes less sick leaves and feels better prepared to cope with chronic stress.

During the past three decades, researchers from different fields within sport science, such as exercise physiology and sport and exercise psychology, have taken a great interest in exploring whether or not fitness and exercise can help people to cope more successfully with stress. Each discipline has used different methodological approaches to investigate the stress buffering effects of exercise. In particular, exercise physiologists have investigated whether exercise can be understood as a physical stressor that activates typical stress reactions (e.g., secretion of norepinephrine, cortisol) (e.g., Meeusen, 2006), acute bouts of exercise lead to reduced reactivity and increased recovery when individuals face experimentally induced stressors right after an exercise session (e.g., Boutcher & Hamer, 2006), and chronic exercise regimes or elevated fitness levels generally suppress individuals' stress reactions to, or boost recovery from experimentally induced stress (e.g., Jackson & Dishman, 2006). In sum, this line of research was concerned with exploring the plausibility of a cross-over effect from one particular stressor (exercise) to other stressors (e.g., cognitive, social threats) by attenuating (habituation) or precipitating (sensitization) the initial stress reactions (Sothmann, 2006). While physiological factors may present one explanatory mechanism for the influence of exercise on stress, stress buffer effects may also have psychological and behavioral foundations.

Researchers within health, sport and exercise psychology generally have been less concerned with establishing the underlying mechanisms for potential stress buffer effects (see Gerber, 2008a). Rather, they have made an effort to find out whether individuals who face taxing and stressful life circumstances are more capable of maintaining good health if they engage in regular physical exercise. From a public health point of view, this emphasis of such general aspects focusing on naturally occurring stress appears more pertinent than the previously described (physiological) approach,

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as investigating possible underlying mechanisms is of little consequence if there is no evidence to suggest that exercise has the potential to act as a stress buffer in real life.

Sport and exercise psychologists generally see exercise as an emotion-oriented coping strategy that provides stressed individuals with a time-out from daily stresses (Berger, 1996; Rostad & Long, 1996). Accordingly, research has shown that exercise has mood-enhancing effects, particularly if individuals initially felt low and irritated prior to exercise (Ekkekakis & Acevedo, 2006). Attempts to empirically examine the potential stress buffering effects of exercise began in the 1980s. In a study with 137 male business executives, Kobasa, Maddi, and Puccetti (1982) provided evidence that exercise interacts with stressful events to prevent illness. In line with this, Brown (1991) found that both exercise and objectively assessed aerobic fitness moderate the stress-illness relationship whereby active and fit individuals reported better health and fewer health center visits when exposed to stress. Furthermore, partial support for the stress buffer hypothesis was obtained in the U.S. National Health Interview Surveys (Zuzanek, Robinson, & Iwasaki, 1998). Similarly, Carmack, Boudreaux, Amaral-Melendez, Brantley, and De Moor (1999) reported that exercise inhibited the development of physical symptoms and anxiety associated with minor stressors in college students, although no moderation effects were found when major life events and aerobic fitness were used as predictor variables. Using a similar sample, Lochbaum, Lutz, Sells, Ready, and Carson (2004) found that strenuous exercise was associated with lower levels of psychosomatic complaints when respondents encountered increased stress. Likewise, Ensel and Lin (2004) indicated that exercise alleviated depressive and psychosomatic complaints when individuals were under stress in a representative sample of Upstate New York. Similarly, Kaluza, Keller, and Basler (2001) showed that exercise protected against back pain and psychological symptoms when employees of a university hospital were exposed to heightened occupational stress.

Prospective and longitudinal research mostly supported the stress buffer hypothesis as well. First, Howard, Cunningham, and Rechnitzer (1984) illustrated that exercise had a significant buffering effect on the relationship between life events and somatic complaints at entry, two and four years later. Second, Kobasa, Maddi, Puccetti, and Zola (1985) provided evidence that male business executives suffering from high stress levels reported fewer concurrent and prospective illnesses the more they originally had engaged in exercise activities. Equally, Fuchs and Appel (1994) found that exercise mitigated depression (20 months later) resulting from unemployment stress.

Past research, however, does not unanimously support the stress buffer hypothesis. Using a sample consisting of law enforcement officers, Young (1994) observed no moderating effect between cardiorespiratory fitness (assessed by maximal treadmill exercise testing) and both general and job-related stress on physiological health risk factors such as blood pressure and cholesterol level. Similarly, Roth, Wiebe, Fillingim, and Shay (1989) found no cross-sectional evidence for self-perceived fitness and exercise moderating the stress–illness relationship. This is in accordance with Manning and Fusilier (1999) who did not find reduced health care use among regular exercisers when exposed to stress. Likewise, Siu, Cooper, and Leung (2000) found that the association between occupational stress and health was largely independent of respondents' exercise levels in a study with male Hong Kong managers. Equally, no substantial significant interaction effect was observed in an investigation comparing college varsity athletes and non-athletes (Skirka, 2000).

In summary, although exercise physiologists have not been able to provide convincing evidence for the physiological mechanisms by which exercise buffers stress (Gerber, 2008b), there is increasing evidence from cross-sectional and longitudinal studies that exercise can alleviate the effects of real-life stress on health (Gerber & Pühse, 2009). In spite of past research providing mixed results whether exercise mitigates stress, exercise-based stress buffer effects were supported by a majority of the previous studies. Moreover, no evidence exists that increased exercise precipitates stress-related health problems. Given the large variability with regard to research designs, sample characteristics and assessments of key variables, these divergent results are not surprising. Moreover, when significant results were found, interaction effects were often weak and explained limited amounts of additional health variance. Thus, additional research is warranted to permit a more solid conclusion about the potential impact of exercise on the stress-health relationship.

Nevertheless, detecting statistically significant interaction effects is difficult, especially if sample sizes are small (McClelland & Judd, 1993). Accordingly, previous research might have underestimated the role of exercise by predominantly using small samples with less than 300 participants (Gerber & Pühse, 2009). The first aim of the present study, therefore, was to test the stress buffer hypothesis with a large sample. As prior research has with a few exceptions made little attempts to examine populations at-risk to be exposed to heightened stress levels, a second aim of the current study was to test the stress buffer hypothesis in two professional groups (police and emergency response service [ERS] officers) whose work is thought to be inherently stressful (e.g., Amaranto, Steinberg, Castellano, & Mitchell, 2003; Collins & Gibbs, 2003; Deschamps, Paganon-Badinier, Marchand, & Merle, 2003; Violanti et al., 2006). Furthermore, we compared the potential for exercise and perceived fitness, as well as moderate and vigorous exercise activities to buffer stress. Additionally, a special emphasis was placed on using validated measures of exercise and stress as previous studies have largely used poorly validated measures (see Gerber & Pühse, 2009). For example, exercise was often measured with general instruments consisting of one single item. Furthermore, stress measures varied from assessing single stressors, such as widowhood or unemployment after migration in some studies to using measures that disregarded the subjectivity of stress appraisals, had not been validated previously, or were too general in nature in other studies.

Based on the literature reviewed, the following five hypotheses were made. First, we hypothesized that stress would be negatively associated with health. Hypothesis 1 was based on prior literature reviews of police stress research which showed that stress affects almost every part of the human body (see Swanson, Territo, & Taylor, 1998). Second, we expected a negative relationship between exercise/fitness and stress. Hypothesis 2 was derived from previous studies that have shown associations between increased exercise levels and lowered stress perception (e.g., Aldana, Sutton, & Jacobson, 1996; Kouvonen et al., 2005). Third, based on conclusions drawn from epidemiological studies (see Biddle & Mutrie, 2006), Hypothesis 3 anticipated a positive relationship between exercise/fitness and health, which is in accordance with police studies, in which officers with elevated exercise participation reported lower levels of pain and absenteeism (e.g., Franke & Anderson, 1994; Nabeel, Baker, McGrail, & Flottemesch, 2007). Fourth, we expected that exercise would have a stronger potential to buffer against stress than perceived fitness. Hypothesis 4 is based on past research, which provided more support for exercise-based than fitness-based stress buffer effects (see Gerber & Pühse, 2009). Fifth, Norris, Carroll, and Cochrane (1992) found that high intensity exercise training was more efficient than moderate intensity exercise to mitigate stress; therefore, Hypothesis 5 assumed that vigorous activities would have a particularly strong impact to buffer stress.

Method

Participants

The participants were $N = 533$ employees of the police force ($n = 460$) and emergency response service (ERS) corps ($n = 73$) in an urban area of the German-speaking, North-Western part of Switzerland (age $M = 41.20$, $SD = 9.84$ years). The sample consisted of $n = 411$ men and $n = 122$ women, with the gender distribution (22.9% females) being representative of the police force and ERS corps (22.2% females). Participants reported on average $M = 14.10$ years of service ($SD = 10.01$). 15.0% of the sample had a high school or university diploma. 289 (54.2%) participants were working on shift schedules. The sample included personnel from all managerial levels.

Procedure

In the aftermath of several cases of cardiovascular health problems within the police management, the police commander made a request to initiate an educational preventive intervention. As a first step, the researchers sent a battery of validated questionnaires assessing stress, health, exercise and fitness to all police and ERS officers ($N = 1190$) in the region. Participants were informed about the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. The study has been performed in accordance with the ethical standards laid down in the Declaration of Helsinki. The questionnaire took approximately 20 to 25 min to complete. The return rate was 44.8%, with all participants giving informed consent.

Measures

Demographic and background characteristics

The following information was acquired: Age, gender, weight, height, highest level of education completed and length of service in the police force and the ERS corps. Moreover, respondents indicated whether they worked on shift schedules or normal office hours.

Stress

The Screening Scale for Chronic Stress (SSCS) of the TICS (Trier Inventory for the Assessment of Chronic Stress) was administered to measure stress (Schulz, Schlotz, & Becker, 2003). The SSCS includes 12 items, which are formulated in accordance with transactional concept of stress, which suggests an active interplay between the person and the environment in the onset and maintenance of stress. The SSCS had high internal consistency (Cronbach's $\alpha = .91$) and was moderately to highly correlated with other general stress measures such as the Life Experiences Survey, $r = .45$, $p < .001$, or the Perceived Stress Scale, $r = .76$, $p < .001$, in previous investigations (Schulz et al., 2003). Answers were scored on a 5-point Likert-type scale ranging from 1 (*never*) to 5 (*very often*), with higher scores indicating that officers experience more stress. As for all measures used in this study, the Cronbach's α coefficient of the SSCS is provided in Table 1.

Health

To measure individual's perceptions of their general health, respondents were asked how they would generally characterize their health. The ratings ranged from 1 (*poor*) to 5 (*excellent*) (Bullinger & Kirchberger, 1998). These items stem from the SF-12, which is one of the most frequently used measures within general population research (Rejeski, Brawley, & Schumaker, 1996). Psychosomatic symptoms were assessed with a validated symptom checklist that included 15 subjective health complaints (Hetland, Torsheim, & Aarø, 2002). Respondents were asked to report the frequency of nine somatic (e.g., headache, stomach-ache, backache) and six psychological complaints (e.g., feeling low, irritable, nervous) on a 5-point Likert-type scale ranging from 1 (*seldom/never*) to 5 (*daily*). Confirmatory factor analysis showed that all items had acceptable factor loadings and that both factors were highly correlated (Hetland et al., 2002). To measure job absenteeism, participants provided an estimate of how many days they stayed away from work due to illnesses during the preceding six months.

Exercise

To assess self-reported exercise, participants were asked to indicate a maximum of three activities that they practiced during their leisure time. For each activity, respondents reported the frequency (per month) and the duration (per episode) (Seelig & Fuchs, 2006). Non-exercise activities (i.e. household activities, gardening) and relaxation techniques (i.e. yoga) were not counted as exercise. A maximum duration of 240 min per episode was set to avoid an overestimation of exercise levels. Activities that are usually not practiced throughout the whole year were weighted with a seasonal factor (i.e. 4/12 for skiing). For every item, a weekly score was then calculated by multiplying the (weighted) frequency with the duration of each activity. A total exercise index was obtained by summing the scores for each activity. In addition, vigorous and moderate exercise indices were calculated by summing up activities with metabolic equivalents below (moderate exercise) or greater or equal (vigorous exercise) to 7 (Ainsworth et al., 2000). This measure proved to be a valid instrument to assess exercise activities in prior research (Fuchs, 2008).

Fitness

Self-perceived physical fitness was measured with a one item rating scale with semantic anchors from 1 (*very poor*) to 10 (*excellent*) (Plante, LeCaptain, & McLain, 2000). This measure has previously been demonstrated to be a valid indicator of actual fitness as it was highly correlated, $r = .71$, $p < .001$, with the 12-item Perceived Physical Fitness scale (Plante, Lantis, & Checa, 1998). Nevertheless, the fact that the Perceived Physical Fitness scale was only weakly associated with estimated VO_2max, $r = .24$, $p = ns$, indicates that perceived fitness and objectively assessed fitness are distinct constructs (Plante et al., 1998). Similarly, only a weak association, $r = .17$, $p = ns$, was found between the 1-item measure and physical activity (Plante et al., 2000).

Statistical analyses

Before testing the hypotheses stated above, we run univariate analyses of variance (ANOVAs) and Pearson product moment correlation analyses to examine how social and demographic factors were related to the predictor (stress), outcome (health indicators) and moderator variables (exercise and fitness) included in the hierarchical regression models. After that, all five hypotheses were tested consecutively.

Hypothesis 1–3

To test whether stress is negatively associated with health (Hypothesis 1), Pearson product moment correlation analyses were conducted. The same procedure was chosen to examine Hypothesis 2 (negative association between stress and exercise/fitness) and Hypothesis 3 (positive association between exercise/fitness and health).

Hypothesis 4–5

In Hypothesis 4 we tested whether exercise has a stronger potential to buffer stress than fitness. In Hypothesis 5 we examined

Table 1
Summary of intercorrelations, means, standard deviations and Cronbach's α coefficients for all predictor, outcome and moderator variables.

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Perceived fitness									
2. Total exercise	.44***								
3. Vigorous exercise	.37***	.60***							
4. Moderate exercise	.29***	.83***	.05						
5. Stress	−.12***	−.02	.01	−.03					
6. General health perception	.45***	.18***	.18***	.10**	−.35***				
7. Somatic complaints	−.22***	−.11**	−.12***	−.05	.31***	−.49***			
8. Psychological complaints	−.17***	−.06	−.06	−.04	.58***	−.37***	−.50***		
9. Absenteeism	−.10**	−.05	−.02	−.05	.10**	−.28***	.19***	.13**	
M	6.05	154	59	95	12.90	3.47	1.56	1.82	3.34
SD	1.79	160	89	129	7.15	0.80	0.58	0.69	5.93
N[a]	528	533	533	533	532	533	533	530	530
Range	1–10	0–720	0–665	0–720	0–42	1–5	1–4.67	1–5	0–60
Cronbach's α	–	–	–	–	.89	–	.79	.79	–

*$p < .05$. **$p < .01$. ***$p < .001$.
[a] Variations in number of cases depend on missing values in different subscales.

whether vigorous exercise is a more powerful stress buffer than moderate exercise. Both hypotheses were analyzed by means of hierarchical (three-stage) regression analyses determining if stress interacted with exercise and fitness in the prediction of health. In sum, sixteen separate regression equations (using listwise exclusion in the case of missing data) were computed in order to test the influence of stress together with the four distinct moderator variables (total, vigorous and moderate exercise and perceived fitness) on all health criteria (general health perception, somatic and psychological complaints, job absenteeism). To control for demographic and social background, occupation (police vs. ERS), sex, age, BMI, shift status (shift vs. office hours) and years of service were entered in the first step in each regression. Stress and exercise were then entered in the second step. In step three, the interaction term of Stress × Exercise was entered to test for the variance explained beyond that accounted for by the main effects (Cohen, Cohen, West, & Aiken, 2003). To prevent problems associated with multicollinearity, stress and exercise were centered before calculating the interaction term. Centering was achieved by computing z-standardized scores of the main predictors. In the result section, the following coefficients are displayed: (i) the multiple correlation coefficient squared R^2 for the whole model after the final step, (ii) stepwise changes in R^2 (ΔR^2), (iii) the standardized regression weights (β) for each predictor variable (for the final model), and (iv) unstandardized regression weights (B) as interaction terms were included in the regression equations (see Cohen, Cohen, West, & Aiken, 2003). All statistical analyses were carried out using SPSS 16 for Mac (SPSS Inc., Chicago, IL).

Results

Descriptive statistics and socio-demographic influences

Descriptive statistics for all study variables are displayed in Table 1. In addition, unifactorial ANOVAs showed that police women and female ERS officers reported lower fitness scores, $F(1,522) = 5.69$, $p < .05$, reduced amounts of vigorous exercise, $F(1,522) = 4.50$, $p < .05$, perceived more somatic complaints, $F(1,522) = 6.94$, $p < .01$, and self-reported more illness-related absences from work, $F(1,522) = 6.50$, $p < .05$, compared to their male colleagues. No differences were found for moderate exercise, stress, general health perception and psychological complaints.

Whereas no differences occurred regarding highest level of education, police officers reported a lower general health perception, $F(1,522) = 7.19$, $p < .01$, and higher absenteeism rates, $F(1,522) = 6.17$, $p < .05$, than ERS officers. No differences were found between police and ERS officers with regard to perceived fitness, all exercise indicators, stress and psychosomatic complaints.

Differences depending on shift vs. non-shift work were found in self-reported fitness, $F(1,522) = 13.13$, $p < .001$, total exercise, $F(1,522) = 21.60$, $p < .001$, vigorous exercise, $F(1,522) = 14.42$, $p < .001$, moderate exercise, $F(1,522) = 9.52$, $p < .01$, and general health perception, $F(1,522) = 10.03$, $p < .01$, with shift-workers being more physically active and rating their general health status more positively. In turn, shift status was not significantly associated with stress, psychosomatic complaints and job absenteeism.

To test whether stress, exercise and health depended on participants' age, BMI and years of service, Pearson product moment correlation coefficients were calculated. Age was significantly, but weakly correlated with perceived fitness, $r = -.17$, $p < .001$, total exercise, $r = -.17$, $p < .001$, vigorous exercise, $r = -.19$, $p < .001$, general health perception, $r = -.16$, $p < .001$, somatic complaints, $r = .14$, $p < .001$, and psychological complaints, $r = -.10$, $p < .05$. No significant associations emerged for moderate exercise, stress and absenteeism.

BMI was associated with fitness, $r = -.36$, $p < .001$, total exercise, $r = -.11$, $p < .05$, vigorous exercise, $r = -.10$, $p < .05$, and general health, $r = .16$, $p < .001$. No significant relationships were found with moderate exercise, stress, somatic and psychological complaints and job absenteeism.

Years of service were weakly associated with perceived fitness, $r = -.12$, $p < .001$, vigorous exercise, $r = -.09$, $p < .01$, general health perception, $r = -.15$, $p < .001$, and somatic complaints, $r = .10$, $p < .01$. In turn, years of service were unrelated with total and moderate exercise, stress, psychological complaints and absenteeism.

Hypothesis 1. Stress is negatively associated with health

To examine the associations between participants' stress levels and the different health outcomes, correlation analyses were conducted. The correlations matrix depicted in Table 1 shows that stress was significantly correlated with all health indicators. In particular, individuals with heightened stress exposure self-evaluated their general health status less favorably, suffered more from somatic and psychological complaints and were slightly more often absent from work. In summary, Hypothesis 1 was fully supported with the present data.

Hypothesis 2. Stress is negatively associated with exercise and fitness

Table 1 provides the correlations between exercise, fitness and stress. No significant relationships were found between moderate,

vigorous, total exercise and stress. In contrast, participants with high self-rated fitness reported slightly decreased amounts of stress. In summary, only weak support was found for Hypothesis 2 in the present sample. That is, the correlations between exercise/fitness and stress were predominantly insignificant or weak.

Hypothesis 3. Exercise and fitness are positively associated with health

Table 1 points to a weak negative association between fitness, psychosomatic complaints and job absenteeism. Furthermore, increased fitness was related to a more positive health perception. Similarly, higher amounts of exercise were associated with a slightly elevated health perception and fewer psychosomatic complaints. To summarize, Hypothesis 3 was consistently supported with the present data although the magnitude of the associations was low.

Hypothesis 4. Exercise has a stronger potential to buffer against stress than fitness

To find out whether total exercise and perceived fitness buffered the relationship between stress and health, a series of hierarchical regression analyses was performed. Tables 2 and 3 display the results of these analyses. As can be seen in Table 2, total exercise did not buffer against stress when general health perception was used as a criterion variable (after controlling for demographic and social background). Importantly, however, the interaction term between stress and total exercise was significant for all other health outcomes. With somatic complaints as a criterion, stress exerted a significant main effect, which was not the case for exercise. However, a significant interaction existed between exercise and stress. The algebraic sign shows that high stress in combination with high exercise scores was associated with reduced impairment from somatic and psychological complaints. Identical patterns of results were found for psychological complaints and job absenteeism.

With regard to fitness, a significant stress buffer effect emerged only for somatic complaints (see Table 3). In addition to significant main effects of stress and perceived fitness, the interaction between both predictors explained 2% of additional variance. Concerning the other criterion variables, no significant interaction effects occurred. However, a main effect for perceived fitness was found on general health, somatic complaints and psychological complaints, which indicates that perceived fitness is an important health resource even though its potential to mitigate naturally occurring stress is limited.

In summary, the results presented in Tables 2 and 3 supported the validity of Hypothesis 4. Thus, exercise seems to be a more powerful stress buffer than perceived fitness. In turn, perceived fitness contributes to increased health independent of whether individuals feel stressed. Furthermore, our findings show that when individuals encounter stress both exercise and fitness particularly protect against the development of somatic complaints, whereas the amount of explained variance through the Stress × Exercise interaction (1%) is more limited for psychological complaints and job absenteeism. Moreover, the total model fit depended strongly on the criterion used and ranged from explaining 5% of the variance in illness-related job absenteeism to 36% in psychological complaints.

Hypothesis 5. Vigorous exercise is a stronger stress buffer than moderate exercise

In Tables 4 and 5, the impact of vigorous and moderate exercise can be compared. As the findings of the hierarchical regression analyses demonstrate, moderate exercise buffered against stress for three of the four criterion variables (general health, somatic and psychological complaints) after controlling for social and demographic background (Table 4). A similar trend, $p < .10$, occurred when job absenteeism was entered as dependent variable. In contrast, vigorous exercise only buffered against somatic health complaints (Table 5). Nevertheless, a main effect was found for vigorous exercise on general health and psychological complaints, indicating that increased amounts of vigorous exercise activities are associated with higher general health satisfaction and enhanced psychological well-being.

In summary, counter to Hypothesis 5, the results indicated that moderate exercise activities were most beneficial to counteract stress and, therefore, should be recommended to realize the full potential of exercise as a stress buffer in adult populations. In contrast, vigorous exercise only mitigated stress regarding somatic complaints. The amount of variance explained exclusively by the interaction term ranged between 1% (general health, psychological complaints) and 2% (somatic complaints).

Discussion

Due to the nature of their duty, the work of police and ERS officers is generally portrayed as stressful (e.g., Amaranto et al., 2003; Collins & Gibbs, 2003). Most investigations focusing on police officers proposed two major categories of stress factors, that is, organizational and police inherent stress (Violanti & Aron, 1995). While police inherent stressors comprise potentially traumatic and harmful events such as danger, violence, crime and human

Table 2
Hierarchical multiple regression analyses predicting general health, somatic complaints, psychological complaints and job absenteeism with total exercise and stress.

Predictor	Health outcome											
	General health			Somatic complaints			Psychological complaints			Job absenteeism		
	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B
Step 1	.08***			.06***			.02			.03		
Control variables[a]												
Step 2	.13***			.10***			.33***			.02*		
Stress		−.34***	−.27***		.30***	.17***		.57***	.39***		.11*	.69*
Total exercise		.11**	.09**		−.02	−.01		−.07	−.05		−.03	−.15
Step 3	.00			.03***			.01*			.01*		
Exercise × Stress		.06	.05		−.18***	−.10***		−.09*	−.06*		−.10*	−.62*
Total R^2	.22***			.18***			.36***			.05**		

$^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$.
[a] Control variables: occupation (police vs. ERS), sex, educational level, age, BMI, shift status (shift vs. office hours) and years of service.

Table 3
Hierarchical multiple regression analyses predicting general health, somatic complaints, psychological complaints and job absenteeism with perceived fitness and stress.

Predictor	Health outcome											
	General health			Somatic complaints			Psychological complaints			Job absenteeism		
	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B
Step 1	.08***			.06***			.02			.03*		
Control variables[a]												
Step 2	.22***			.11***			.36***			.02*		
Stress		−.29***	−.23***		.25***	.14***		.54***	.37***		.09*	.57*
Perceived fitness		.37***	.30***		−.14**	−.08**		−.15***	−.11***		−.09	−.52
Step 3	.00			.02**			.00			.00		
Perceived Fitness × Stress		.04	.03		−.14**	−.07**		−.05	−.03		−.05	−.28
Total R^2	.31***			.19***			.36***			.05**		

$^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$
[a] Control variables: occupation (police vs. ERS), sex, educational level, age, BMI, shift status (shift vs. office hours) and years of service.

suffering, organizational practices embrace stressful experiences that derive from the administration and are perceived as bothersome (e.g., authoritarian structure, work impinging upon home life, perceived lack of consultation and communication). Violanti and Aron (1993) found that police organizational stressors increased psychological distress six times more than inherent police stressors. Accordingly, this study focused on organizational stressors.

The key findings of the present study can be summarized as follows: In support of Hypothesis 1, increased stress was associated with increased impairment on all health outcomes. The strongest relationship was found between stress and psychological complaints, followed by perceived general health and somatic complaints. A significant, but weak association existed between stress and illness-based absences from work. In sum, the significant relationship between increased stress and ill-health is in line with the vast body of literature showing that stress is connected with a variety of physical and mental health problems. For instance, Swanson et al. (1998) found a broad range of physiological and psychological disturbances among police officers with elevated stress levels. This underlines the need to reduce stress in the workplace, as recommended by the World Health Organization (Leka, Griffiths, & Cox, 2003), in order to support police and ERS officers in maintaining good health.

Counter to Hypothesis 2, no significant relationship was found between exercise and stress. Nevertheless, increased fitness was significantly (but weakly) associated with reduced stress. Consequently, our second hypothesis was only partially supported. The finding that participants with high fitness levels experienced less stress confirms previous research looking at bivariate associations between fitness and stress (e.g., King, Taylor, & Haskell, 1993). The zero-correlation between exercise and stress is in contrast with studies reporting that increased exercise involvement is related to lowered stress levels (e.g., Aldana et al., 1996; Kouvonen et al., 2005; Schnohr, Kristensen, Prescott, & Scharling, 2005). Interestingly, these findings support previous research, which points to a stronger relationship between stress and fitness than between stress and exercise (Roth et al., 1989).

Hypothesis 3 anticipated that increased exercise and fitness are associated with augmented health perceptions. An examination of the bivariate relationships between exercise, fitness and health mostly supported this assumption. Against our prediction and the patterns found in previous studies (e.g., Kaluza, Hanke, Keller, & Basler, 2002; Lochbaum et al., 2004), no significant correlations were found between exercise and psychological complaints. In summary, the results supported Roth and colleagues (1989) who concluded that the relationship between self-reported fitness and health is somewhat stronger than the one between exercise and health. The weak relationship between fitness, exercise and health may be due to a ceiling effect whereby the police and ERS officers reported relatively high exercise.

Finally and most importantly, eight of the 16 hierarchical regression equations produced significant interaction effects. Thus, the findings indicate that exercise protects against stress-related health hazards. Additionally, one interaction was approaching significance. Moreover, the findings supported our fourth hypothesis, and comply with some prior studies, that found stronger stress buffer effects for exercise compared to fitness (see Gerber & Pühse, 2009). Accordingly, while fitness and health are related, in the face of stress, exercise seems to be a stronger coping resource. In addition, the present findings suggest that moderate intensity exercise has particularly strong potential to mitigate stress, which is in contradiction with Hypothesis 5, but supports some leisure researchers who argue that low-intensity leisure activities (e.g., social, relaxing and cultural

Table 4
Hierarchical multiple regression analyses predicting general health, somatic complaints, psychological complaints and job absenteeism with moderate exercise and stress.

Predictor	Health outcome											
	General health			Somatic complaints			Psychological complaints			Job absenteeism		
	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B
Step 1	.08***			.06***			.02			.03		
Control variables[a]												
Step 2	.12***			.09***			.32***			.02*		
Stress		−.34***	−.27***		.31***	.17***		.57***	.39***		.11*	.70*
Moderate exercise		.06	.05		.02	.01		−.02	−.02		−.03	−.19
Step 3	.01*			.02**			.01**			.01^{+}		
Moderate Exercise × Stress		.08*	.07*		−.15**	−.08**		−.08**	−.11**		−.08	−.51
Total R^2	.21***			.17***			.36***			.05**		

$^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$.
[a] Control variables: occupation (police vs. ERS), sex, educational level, age, BMI, shift status (shift vs. office hours) and years of service.

Table 5
Hierarchical multiple regression analyses predicting general health, somatic complaints, psychological complaints and job absenteeism with vigorous exercise and stress.

Predictor	Health outcome											
	General health			Somatic complaints			Psychological complaints			Job absenteeism		
	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B	ΔR^2	β	B
Step 1	.08***			.06***			.02			.03		
Control variables[a]												
Step 2	.13***			.10***			.33***			.01*		
Stress		−.34***	−.27***		.30***	.17***		.57***	.39***		.11*	.70*
Vigorous exercise		.11*	.09*		−.08	−.04		−.08*	−.06*		.00	.01
Step 3	.00			.02**			.00			.00		
Vigorous Exercise × Stress		.00	.00		−.13**	−.07**		−.02	−.01		−.06	−.38
Total R^2	.21***			.17***			.35***			.05*		

$^{+}p < .10$. $^{*}p < .05$. $^{**}p < .01$.
[a] Control variables: occupation (police vs. ERS), sex, educational level, age, BMI, shift status (shift vs. office hours) and years of service.

leisure) might be (at least) equally important as activities involving strenuous physical activity in alleviating stress (Iwasaki, Mannell, Smale, & Butcher, 2005). Moreover, this finding is in line with Berger's (1996) contention that exercise must be pleasing, enjoyable and of moderate intensity to facilitate coping with stress. This finding also supports prior studies showing that moderate exercise is particularly suited to enhance mood (Ekkekakis & Acevedo, 2006) and corroborates previous reviews, in which moderate and vigorous activities had similar (direct) effects on psychological outcomes such as depression (Dunn, Trivedi, & O'Neal, 2001) or self-esteem (Fox, 2000).

While previous investigations have often provided insufficient information to gauge the magnitude of effects (Ensel & Lin, 2004; Fuchs & Appel, 1994; Kobasa et al., 1982; Kobasa et al., 1985; Lochbaum et al., 2004), our data support studies, in which the levels of additionally explained variance ranged between 1 and 3% (Brown, 1991; Howard et al., 1984; Zuzanek et al., 1998). Because the detection of interaction effects is difficult in field studies, which seem to have less than 20% of the efficiency of optimal experimental tests (Jaccard, Wan, & Turrisi, 1990; McClelland & Judd, 1993), we interpret the present findings positively although the interaction effects were small (Cohen, 1988).

In summary, sufficiently high leisure time exercise levels seem critical among police and ERS officers. First, policing and ERS work appear to be predominantly sedentary occupations, which do not provide sufficient opportunity to maintain high fitness. Bonneau and Brown (1995) stated that police work was physically demanding in the early part of the twentieth Century, that is to say, "policemen in cities walked their beat, in all kinds of weather, up and down hills and stairways, checking locks and peering into dark places. Physical confrontation happened regularly and the constable had to be able to defend himself and to apprehend the wrongdoer" (p. 157). From 1970 onwards, however, a change occurred compelling police departments to adopt community policing. As a consequence, police work has become less physically taxing, whereas psychological and social sources of distress have increased. Accordingly, Bonneau and Brown (1995) raised the question as to whether physical abilities are still required in modern policing. However, it is important to remember that despite physically demanding activities becoming infrequent, they remain critical to the occupation (cp. Sorensen, Smolander, Louhevaara, Korhonen, & Oja, 2000).

In addition, increased fitness and exercise are related to subjective well-being and help officers to cope with stress. As a consequence, making efforts to promote exercise participation and providing incentives for employees to maintain high fitness levels appear highly warranted. This is especially true as officers' fitness levels decrease substantially with increasing years of service, with the greatest decline between the age of 20 and 30 years (Burelle, Ricci, & Peronnet, 1987). Similarly, more effort is needed to provide police and ERS officers with coping skills to help them meet the challenges associated with their work (LeBlanc, Regehr, Jelley, & Barath, 2008) and to change organizational policies and practices that increase distress (Violanti & Aron, 1993). Collins and Gibbs (2003) suggest shifting the focus from the provision of welfare support and employee assistance programs towards more preventive measures to fundamentally eliminate or reduce organizational stressors. In support of this, the present study showed that exercise training can be recommended as a strategy to deal with stress in a constructive way.

The cross-sectional nature of this study is an important limitation and precludes causal interpretation of both main and interaction effects. Furthermore, all data were derived from subjective self-report measures. In a police and ERS sample, report bias may be a problem as reporting health symptoms may be socially undesirable due to the hegemonic masculine culture associated with these occupations. Particularly, there is disagreement whether or not self-report measures allow a valid assessment of exercise participation (see Livingstone, Robson, Wallace, & McKinley, 2003; Sallis & Owen, 1999). However, prior studies showed that self-report questionnaires provide acceptable estimates of exercise if they simultaneously assess frequency, duration, type and intensity (Mäder, Martin, Schutz, & Marti, 2006). It is also important that the results of this study are not over-generalized as the sample was (i) not nationally representative and (ii) composed of two specific occupational groups. In addition, perceived physical fitness was assessed with a relatively general self-report measure that might only partially correlate with police–specific physical ability tests (Rhodes & Farenholtz, 1992). Moreover, our analyses focused exclusively on leisure time exercise, when in reality people may pursue various types of leisure activities rather than strictly focus only on one type (Iwasaki et al., 2005). Furthermore, non-exercise activities (e.g., household, gardening) were not considered although they contribute to individual's overall physical activity levels (Caspersen, Powell, & Christenson, 1985). Additionally, the measure used in this study combined several activities to provide two indices for moderate and vigorous exercise. Thus, it cannot be concluded which particular activity had the highest potential to buffer stress. Finally, despite that previous research had portrayed the work of police and ERS officers as stressful (e.g., Amaranto et al., 2003; Berg, Hem, Lau, & Ekeberg, 2006; Collins & Gibbs, 2003; Deschamps et al., 2003), we found no significant difference in stress between our sample and population norms (cp. Schulz et al., 2003). Nevertheless, this finding corresponds with previous investigations, in which differences in perceived occupational stress between police officers and the population norm/other occupations were low (e.g., Deschamps et al., 2003).

In spite of the methodological limitations, the present study furthers the existing literature on the interrelationship between stress, exercise and health by (i) recruiting a relatively large sample, (ii) controlling for potentially confounding background variables (iii) using validated instruments to assess stress, exercise, fitness and health, (iv) distinguishing between the effects of exercise and perceived fitness, (v) examining the impact of moderate and vigorous exercise, (vi) embracing somatic vs. psychological health outcomes as well as specific vs. general health indicators and (vii) centering on two populations at-risk of exposure to stressful and traumatic events at work. As the present study showed, exercise and fitness can make a significant contribution to a healthy and thriving workforce that takes less sick leaves and feels better prepared to cope with chronic stress. Future studies should use more objective tools to assess exercise behavior (e.g., accelerometers) and find out how different motives (e.g., internally versus externally regulated motivation), outcome expectancies (e.g., belief in whether or not exercise is suited to reduce stress) and past experiences (e.g., exercise enjoyment, affiliation, competitiveness) impact the potential of exercise to alleviate stress.

References

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., et al. (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise, 32*, S498–S516.

Aldana, S. G., Sutton, L. D., & Jacobson, B. H. (1996). Relationship between leisure time physical activity and perceived stress. *Perceptual and Motor Skills, 82*, 315–321.

Amaranto, E., Steinberg, J., Castellano, C., & Mitchell, R. (2003). Police stress interventions. *Brief Treatment and Crisis Intervention, 3*, 47–53.

Berg, A. M., Hem, E., Lau, B., & Ekeberg, O. (2006). An exploration of job stress and health in the Norwegian police service: a cross sectional study. *Journal of Occupational Medicine and Toxicology, 26*, 1–9. doi:10.1186/1745-6673-1-26.

Berger, B. G. (1996). Psychological benefits of an active lifestyle: what we know and what we need to know. *Quest, 48*, 330–353.

Biddle, S. J., & Mutrie, N. (2006). *Psychology of physical activity: determinants, well-being and interventions*. London: Routledge.

Bonneau, J., & Brown, J. (1995). Physical ability, fitness and police work. *Journal of Clinical Forensic Medicine, 2*, 157–164.

Boutcher, S. H., & Hamer, M. (2006). Psychobiological reactivity, physical activity, and cardiovascular health. In E. O. Acevedo, & P. Ekkekakis (Eds.), *Psychobiology of physical activity* (pp. 161–176). Champaign: Human Kinetics.

Brown, J. D. (1991). Staying fit and staying well: physical fitness as a moderator of life stress. *Journal of Personality and Social Psychology, 60*, 555–561.

Bullinger, M., & Kirchberger, J. (1998). Der SF-12 [The SF-12 health questionnaire]. In M. Bullinger, & J. Kirchberger (Eds.), *Der SF-36-Fragebogen zum Gesundheitszustand* (pp. 65–72). Göttingen: Hogrefe.

Burelle, C., Ricci, J., & Peronnet, F. (1987). Condition physique des policiers de la communauté urbaine de Montréal. [Physical fitness of police officers in the city of Montreal]. *Médecine du Sport, 1*, 16–18.

Carmack, C. L., Boudreaux, E., Amaral-Melendez, M., Brantley, P. J., & De Moor, C. (1999). Aerobic fitness and leisure physical activity as moderators of the stress–illness relation. *Annals of Behavioral Medicine, 21*, 251–257.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports, 100*, 126–131.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Mahwah: Erlbaum.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences*. Mahwah: Lawrence Erlbaum Associates.

Collins, P. A., & Gibbs, A. C. (2003). Stress in police officers: a study of the origins, prevalence and severity of stress-related symptoms within a county police force. *Occupational Medicine, 53*, 256–264. doi:10.1093/occed/kqg061.

Deschamps, F., Paganon-Badinier, I., Marchand, A. C., & Merle, C. (2003). Sources and assessment of occupational stress in the police. *Journal of Occupational Health, 45*, 358–364.

Dunn, A. L., Trivedi, M. H., & O'Neal, H. A. (2001). Physical activity dose-response effect on outcomes of depression and anxiety. *Medicine and Science in Sports and Exercise, 33*, S587–S596.

Ekkekakis, P., & Acevedo, E. O. (2006). Affective responses to acute exercise: toward a psychobiological dose–response model. In E. O. Acevedo, & P. Ekkekakis (Eds.), *Psychobiology of physical activity* (pp. 91–110). Champaign: Human Kinetics.

Ensel, W. M., & Lin, N. (2004). Physical fitness and the stress process. *Journal of Community Psychology, 32*, 81–101. doi:10.1002/jcop.10079.

Fox, K. R. (2000). Self-esteem, self-perceptions and exercise. *International Journal of Sport Psychology, 31*, 228–240.

Franke, W. D., & Anderson, D. F. (1994). Relationship between physical activity and risk factors for cardiovascular disease among law enforcement officers. *Journal of Occupational Medicine, 36*, 1127–1132.

Fuchs, R. (2008). Aufbau eines körperlich-aktiven Lebensstils im Kontext der medizinischen Rehabilitation: Ein motivational-volitionales Interventionskonzept (MoVo-LISA Projekt). [Promoting a physically active life-style in the setting of clinical rehabilitation. A motivational and volitional intervention concept]. In *Unveröffentlichter Endbericht*. Freiburg: Universität Freiburg.

Fuchs, R., & Appel, E. (1994). Belastungsregulation durch sport. [Stress regulation through exercise participation]. In R. Schwarzer, & M. Jerusalem (Eds.), *Gesellschaftlicher Umbruch als kritisches Lebensereignis. Psychosoziale Krisenbewältigung von Übersiedlern und Ostdeutschen* (pp. 227–240). Weinheim: Juventa.

Gerber, M. (2008a). *Sport, Stress und Gesundheit bei Jugendlichen*. [*Exercise, stress and health among adolescents*]. Schorndorf: Hofmann.

Gerber, M. (2008b). Sportliche Aktivität und Stressreaktivität: Ein Review. [Exercise and stress reactivity: a review]. *Deutsche Zeitschrift für Sportmedizin, 59*, 4–10.

Gerber, M., & Pühse, U. (2009). Do exercise and fitness protect against stress-induced health complaints? A review of the literature. *Scandinavian Journal of Public Health, 37*, 801–819. doi:10.1177/1403494809350522.

Hetland, J., Torsheim, T., & Aarø, L. E. (2002). Subjective health complaints in adolescence: dimensional structure and variation across gender and age. *Scandinavian Journal of Public Health, 30*, 223–230. doi:10.1177/140349480203000309.

Howard, J. H., Cunningham, D. A., & Rechnitzer, P. A. (1984). Physical activity as a moderator of life events and somatic complaints: a longitudinal study. *Canadian Journal of Applied Sport Science, 9*, 194–200.

Iwasaki, Y., Mannell, R. C., Smale, B. J., & Butcher, J. (2005). Contributions of leisure participation in predicting stress coping and health among police and emergency response services workers. *Journal of Health Psychology, 10*, 79–99. doi:10.1177/1359105305048557.

Jaccard, J., Wan, C. K., & Turrisi, R. (1990). The detection and interpretation of interaction effects between continuous variables in multiple regression. *Multivariate Behavioral Research, 25*, 467–478. doi:10.1207/s15327906mbr2504_4.

Jackson, E. M., & Dishman, R. K. (2006). Cardiorespiratory fitness and laboratory stress: a meta-regression analysis. *Psychophysiology, 43*, 57–72. doi:10.1111/j.1469-8986.2006.00373.x.

Kaluza, G., Keller, S., & Basler, H.-D. (2001). Beanspruchungsregulation durch Sport?. [Exercise as a coping strategy with stress?] *Zeitschrift für Gesundheitspsychologie, 9*, 26–31.

Kaluza, G., Hanke, C., Keller, S., & Basler, H.-D. (2002). Salutogene Faktoren bei chronischen Rückenschmerzen: Moderieren sozialen Unterstützung, Arbeitszufriedenheit und sportliche Aktivität den Zusammenhang zwischen Arbeitsbelastungen und Rückenschmerzaktivität?. [Salutogenetic factors contributing to back aches: do social support, job satisfaction and exercise moderate the relationship between job strain and back aches?] *Zeitschrift für Klinische Psychologie und Psychotherapie, 31*, 159–168.

King, A. C., Taylor, C. B., & Haskell, W. L. (1993). Effects of differing intensities and formats of 12 months of exercise training on psychological outcomes in older adults. *Health Psychology, 12*, 292–300. doi:10.1037/0278-6133.12.5.405.

Kobasa, S. C., Maddi, S. R., & Puccetti, M. C. (1982). Personality and exercise as buffers in the stress–illness-relationship. *Journal of Behavioral Medicine, 5*, 391–404.

Kobasa, S. C., Maddi, S. R., Puccetti, M. C., & Zola, M. A. (1985). Effectiveness of hardiness, exercise and social support as resources against illness. *Journal of Psychosomatic Research, 29*, 525–533.

Kouvonen, A., Kivimaki, M., Elovainio, M., Virtanen, M., Linna, A., & Vahtera, J. (2005). Job strain and leisure-time physical activity in female and male public sector employees. *Preventive Medicine, 41*, 532–539. doi:10.1016/j.ypmed.2005.01.004.

LeBlanc, V. R., Regehr, C., Jelley, R. B., & Barath, I. (2008). The relationship between coping styles, performance, and responses to stressful scenarios in police recruits. *International Journal of Stress Management, 15*, 76–93. doi:10.1037/1072-5245.15.1.76.

Leka, S., Griffiths, A., & Cox, T. (2003). *Work organisation and stress. Systematic problem approaches for employers, managers and trade union representatives (Protecting Workers' Health Series No. 3)*. Geneva: Word Health Organization.

Livingstone, M. B. E., Robson, P. J., Wallace, J. M. W., & McKinley, M. C. (2003). How active are we? Levels of routine physical activity in children and adults. *Proceedings of the Nutrition Society, 62*, 681–701. doi:10.1079/PNS2003291.

Lochbaum, M. R., Lutz, R. S., Sells, S., Ready, A., & Carson, T. (2004). Perceived stress and health complaints: an examination of the moderating roles of personality and physical activity. *Perceptual and Motor Skills, 99*, 909–912.

Mäder, U., Martin, B. W., Schutz, Y., & Marti, B. (2006). Validity of four short physical activity questionnaires in middle-aged persons. *Medicine and Science in Sports and Exercise, 38*, 1255–1266. doi:10.1249/01.mss.0000227310.18902.28.

Manning, M. R., & Fusilier, M. R. (1999). The relationship between stress and health care use: an investigation of the buffering roles of personality, social support and exercise. *Journal of Psychosomatic Research, 47*, 159–173.

McClelland, G. H., & Judd, C. M. (1993). Statistical difficulties of detecting interactions and moderator effects. *Psychological Bulletin, 114*, 376–390.

Meeusen, R. (2006). Physical activity and neurotransmitter release. In E. O. Acevedo, & P. Ekkekakis (Eds.), *Psychobiology of physical activity* (pp. 129–144). Champaign: Human Kinetics.

Nabeel, I., Baker, B. A., McGrail, M. P., Jr., & Flottemesch, T. J. (2007). Correlation between physical activity, fitness, and musculoskeletal injuries in police officers. *Minnesota Medicine, 90*, 40–43.

Norris, R., Carroll, D., & Cochrane, R. (1992). The effects of physical activity and exercise training on psychological stress and well-being in an adolescent population. *Journal of Psychosomatic Research, 36*, 55–65. doi:10.1016/0022-3999(92)90114-H.

Plante, T. G., Lantis, A., & Checa, G. (1998). The influence of perceived versus aerobic fitness on psychological health and physiological stress responsitivity. *International Journal of Stress Management, 5*, 141–156. doi:10.1023/A:1022936930992.

Plante, T. G., LeCaptain, S. E., & McLain, H. C. (2000). Perceived fitness predicts daily coping better than physical activity. *Journal of Applied Biobehavioral Research, 5*, 66–79. doi:10.1023/A:1009514214782.

Rejeski, W. J., Brawley, L. R., & Schumaker, S. A. (1996). Physical activity and health-related quality of life. *Exercise and Sport Sciences Review, 24*, 71–108.

Rhodes, E. C., & Farenholtz, D. W. (1992). Police officer's physical abilities test compared to measures of physical fitness. *Canadian Journal of Sport Science, 17*, 228–233.

Rostad, F. G., & Long, B. C. (1996). Exercise as a coping strategy for stress: a review. *International Journal of Sport Psychology, 27*, 197–222.

Roth, D. L., Wiebe, D. J., Fillingim, R. B., & Shay, K. A. (1989). Life events, fitness, hardiness, and health: a simultaneous analysis of proposed stress-resistance effects. *Journal of Personality and Social Psychology, 57*, 136–142.

Sallis, J. F., & Owen, N. (1999). *Physical activity and behavioral medicine*. Thousand Oaks: Sage.

Schnohr, P., Kristensen, T. S., Prescott, E., & Scharling, H. (2005). Stress and life dissatisfaction are inversely associated with jogging and other types of physical activity in leisure time – the Copenhagen City Heart Study. *Scandinavian Journal of Medicine and Science in Sports, 15*, 107–112. doi:10.1111/j.1600-0838.2004.00394.x.

Schulz, P., Schlotz, W., & Becker, P. (2003). *TICS. Trierer Inventar zum chronischen Stress*. [*Trier inventory for the assessment of chronic stress*]. Göttingen: Hogrefe.

Seelig, H., & Fuchs, R. (2006). Messung der sport- und bewegungsbezogenen Selbstkonkordanz. [Measurement of exercise-related self-concordance]. *Zeitschrift für Sportpsychologie, 13*, 121–139.

Siu, O., Cooper, C. L., & Leung, T. (2000). Three-wave trend study of managerial stress in Hong Kong: the role of type A behavior and exercise. *International Journal of Stress Management, 7*, 153–157.

Skirka, N. (2000). The relationship of hardiness, sense of coherence, sport participation, and gender to perceived stress and psychological symptoms among college students. *The Journal of Sports Medicine and Physical Fitness, 40*, 63–70.

Sorensen, L., Smolander, J., Louhevaara, V., Korhonen, O., & Oja, P. (2000). Physical activity, fitness and body composition of Finnish police officers: a 15-year follow-up study. *Occupational Medicine, 50*, 3–10.

Sothmann, M. S. (2006). The cross-stressor adaptation hypothesis and exercise training. In E. O. Acevedo, & P. Ekkekakis (Eds.), *Psychobiology of physical activity* (pp. 149–160). Champaign: Human Kinetics.

Swanson, C. R., Territo, L., & Taylor, R. W. (1998). Stress and police personnel. In C. R. Swanson, L. Territo, & R. W. Walker (Eds.), *Police administration: structures, processes, and behavior* (pp. 297–326). Englewood Cliffs: Prentice Hall.

Violanti, J. M., & Aron, F. (1993). Sources of police stressors, job attitudes, and psychological distress. *Psychological Reports, 72*, 899–904.

Violanti, J. M., & Aron, F. (1995). Police stressors: variations in perception among police personnel. *Journal of Criminal Justice, 23*, 287–294.

Violanti, J. M., Burchfiel, C. M., Miller, D. B., Andrew, M. E., Dorn, J., Wactawski-Wende, J., et al. (2006). The Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) pilot study: methods and participant characteristics. *Annals of Epidemiology, 16*, 148–156. doi:10.1016/j.annepidem.2005.07.054.

Young, D. R. (1994). Can cardiorespiratory fitness moderate the negative effects of stress on coronary artery disease risk factors. *Journal of Psychosomatic Research, 38*, 451–459.

Zuzanek, J., Robinson, J. P., & Iwasaki, Y. (1998). The relationships between stress, health, and physically active leisure as a function of life-cycle. *Leisure Sciences, 20*, 253–275.