

Original Article

Physical activity and environmental influences on adrenal fatigue of Saudi adults: biochemical analysis and questionnaire survey

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Abstract. [Purpose] This research work was performed to examine whether different levels of physical activity and environmental and social factors are associated with changes in adrenal hormones as markers of adrenal fatigue in Saudi adult volunteers. [Subjects and Methods] A total of 160 Saudi adults aged 15–22 years were included in this study. The adrenal fatigue score, sociodemographic attributes, and the level of physical activity were evaluated via pre-validated internet-based questionnaire surveys. Adrenal hormones such as ACTH and cortisol were measured using immunoassay techniques. [Results] Significant increases in the levels of ACTH and cortisol biomarkers were found in the participants with moderate to severe fatigue scores, poor environmental factors, and low physical activity. However, in physically active participants, significant decreases in ACTH and cortisol levels were found with remarkable improvement in adrenal fatigue status. The decrement in adrenal hormonal levels positively correlated ($r=0.976$) with the improvement in adrenal fatigue status in the physically active participants. [Conclusion] Our results suggest that the level of physical activity and environmental and social factors differentially influence the adrenal fatigue status via changes in the levels of adrenal hormones. Also, ACTH and cortisol biomarkers may be useful as markers measuring the severity of adrenal fatigue.

Key words: Adrenal fatigue, Depression, Physical activity

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INTRODUCTION

The major complaints in primary care settings are fatigue^{1, 2)}. It is commonly reported in (14–22%) of population studies³⁾, however a recent study found that 25% of employees report fatigue at work^{4, 5)}.

Fatigue is characterized by progressive withdrawal of attention from the environment and demands due to tiredness, dislike of the present activity, and unwillingness to continue, or perform the task at hand^{6, 7)}. Also, physical resources and the depletion of emotional resources are considered the basic parameters of feelings of being overextended and emotionally exhausted⁸⁾. It has been reported that fatigued persons show decrements in vigilance when performing a particular task via changes in vigilance, alertness, motivation, and subjective states that occur during this transition⁹⁾.

Previous studies have reported that both the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenocortical (HPA) axis are the most vital centers linking

stressor exposure to disease^{10, 11)}. Thus, significant increases in these hormones in line with cortisol are associated with stressful situations, such as caregiving and work strain, which may be diagnosed as adrenal fatigue^{12–14)}. Some studies have reported that the improvement of physical and psychological health is related to physical activity which is considered an effective preventive measure and treatment for stress-related diseases^{15–17)}.

Physically active people show higher resistance to physical stressors and nullifying susceptibility to various influences of life stress^{18, 19)}, and physical activity has protective effects on non physical stress, such as mental stress²⁰⁾.

Although the findings are not uniform²¹⁾, psychological stress protocols show lower responses of the sympathetic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis towards physical activity. A lower cortisol increase was reported in physically active subjects¹⁹⁾, as well as lower cardiovascular reactivity^{19, 22)}, and more rapid cardiovascular recovery²⁰⁾ to psychological laboratory stressors than less active controls. Also, it's more important to notice the variability of stress reactivity which extends to cover all states of physical activity including those who have less distinct differences in activity levels, such as a lower response of heart rate to mental stressors and the faster recovery of elite sportsmen than amateur sportsmen²³⁾. These inconsistent results may be related to the differential influence of physical activity on stress reactivity.

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The relationship between physical activity and stress reactivity may be linked to the personality traits of subjects which may be the most valued stress modulators. Depressed persons are physically inactive in daily life and have lower physical work capacity than healthy persons. This indicates that a depressive state is associated with physiological well being and may predispose an individual to diseases related to physical inactivity and limited functional capacity^{24, 25}. The rates of mortality and morbidity for the conditions of most diseases may be related to the negative outcome measures of occupation, income, and education which are characterized collectively as socioeconomic status (SES)^{26–31}. These measures are prevalent in countries with state-sponsored health care, suggesting that access to care is not the underlying causal mechanism.

It was proposed that persons with lower SES are exposed to conditions with higher levels of psychosocial disruption that increase the risk of disease through continuous provocation of stress eliciting dysregulation of key behavioral and biological systems^{32, 33}. In order to develop or maintain goals towards adequate behavior and performance, it is necessary to increase or minimize both personal competence and willingness^{34, 35}. This strategy was used in this present study, even though the assessment of fatigue has no definite methodology.

It was suggested that fatigue can be measured using objective and subjective outcome measures which are significantly different. Objective fatigue measures deal with physiological processes, or performance such as reaction time or number of errors³⁶, whereas subjective ways include diary studies, interviews, and questionnaires^{37, 38}.

Until about 10 years ago, fatigue questionnaires for particular studies were mainly developed on an ad hoc basis, and they were used in large scale studies because of their shortness and self-report format. Recently, it was shown that fatigue questionnaires should be developed for specific patient groups, such as patients with cancer^{39–42}, or ill persons in general^{43–46}. Although there are many benefit outcome measures for both patient and healthy populations, little is known about the suitability of these questionnaires for healthy populations, and only a few questionnaires such as the Fatigue Scale (FS) have been developed to measure fatigue outcomes among hospital and community populations^{47, 48}.

Before the start of the 1990s, fatigue was predominantly seen as a unidimensional construct. Nowadays, many researchers conceive of fatigue as a multidimensional construct. They have studied the effect of five components, general fatigue, physical fatigue, reduction in activity, reduction in motivation, and mental (cognitive) fatigue on depression and fatigue status^{48–50}. Also, other reviews have documented that multidimensional fatigue scales are seen as more comprehensive and hence as more adequate for providing a complete description of an individual's fatigue experience^{39, 40}. Accordingly, this study was designed to assess the effect of physical activity status and environmental factors on the levels of cortisol and ACTH, as markers of adrenal fatigue status, in a sample of Saudi adult volunteers using a questionnaire and biochemical analysis.

SUBJECTS AND METHODS

In the present cross-sectional study, the data were collected in 2012–2013 by supervised experienced data collectors. The research team collected detailed sociodemographic data of the 160 Saudi adults aged 15–22 years who participated in this study. All participants signed an informed consent form before answering the questionnaire. The present study received prior approval from the Ethics Committee of the Rehabilitation Research Chair (RRC), King Saud University, Riyadh, KSA.

Based on the physical activity of the participants, the sample size was calculated with an estimated difference of 5% between the three groups of mild, moderate, and vigorous exercise for estimating the correlation of cortisol and ACTH hormones with fatigue and physical activity status. So, in order to investigate cortisol and ACTH levels in the mild group a sample size of 45 or more was needed for a power of 90%, for the moderate group, a sample size of 37 or more was needed, and for the severe group, a sample size of 60 subjects was required to have the same power.

Blood samples were taken once from for all participants at 8:30 in the morning. After centrifugation, serum samples of all tests were stored at -80°C until assayed. Both cortisol and ACTH were measured in serum samples using immunoassay techniques following the instructions of the RIA-ELISA kit (DPC Inc., CA, USA), and the SIA-ELISA kit (MD Biosciences Inc, MN, USA) respectively.

A self-administered questionnaire was used to assess living conditions, household income level, employment and marital status, education level, gender, and age. Participants chose the most suitable answer from categories of employment status (office worker, independent businessman, professional, public official, student, housewife, part-time worker, not employed), marital status (married, unmarried), living conditions (number of people cohabitating with, living alone), and education level (university, two-year university, vocational college, high school, junior high school, graduate school).

The short-term International Physical Activity Questionnaire (IPAQ) was used to evaluate the level of physical activity of the participants^{51, 52}. The average number of minutes per day and days per week of physical activity were self-calculated by the participants with reference to the past month. The frequency and duration of walking for all purposes such as work, transport, or recreation, moderate physical activity, vigorous physical activity, and sedentary activity for a usual week were assessed via a self-administered questionnaire.

Finally, the total numbers of minutes of walking, moderate, and vigorous physical activity per week were computed according to the IPAQ scoring manual^{53, 54}.

The level of adrenal fatigue status was estimated using the Adrenal Fatigue test Questionnaire⁵⁵. The Adrenal Fatigue test assesses adrenal fatigue using a score: a score of ≤ 40 suggests no adrenal stress; 44–87 suggests mild adrenal stress; 88–130 suggests moderate adrenal fatigue; and ≥ 130 suggest significant adrenal fatigue problems.

A seven-day test-retest reliability was conducted (test-retest), with an interval of 7 days between the two assessments (Time 1 and 2). Internal consistency was calculated

using Cronbach's alpha (α) for seven general adrenal fatigue test items (Predisposing Factors, Key Signs and Symptoms, Energy Patterns, Frequently Observed Events, Food Patterns, Aggravating Factors, Relieving Factors). The 7-day test-retest reliability was estimated using Pearson's r and Spearman's ρ statistics. It has been proposed that test-retest reliability coefficients of 0.80 or higher for these statistics are indicative of acceptable test-retest reliability⁵⁶.

The Severity Index was calculated by simply dividing the total number of points by the total number of questions answered by each participant in the affirmative. It gives an indication of how severely the signs and symptoms are experienced, with ≤ 1.0 being normal, 1.1–1.6 being mild, 1.7–2.3 being moderate, and ≥ 2.4 being severe⁵⁵.

All statistical analyses were performed using the SPSS statistical package v. 12.0 for Windows (SPSS Software, Inc., Chicago, IL, USA). Repeated measures ANOVA followed by the Bonferroni correction for multiple comparisons was applied for normally distributed parameters, and the Wilcoxon test, for nonparametric parameters.

Exploratory factor analysis of the items of adrenal fatigue and severity scores were conducted to investigate what common components of the scale more effectively respond to physical exercise treatment. Data are presented as mean \pm SD. The null hypothesis was rejected at values of $p < 0.05$, the level of significance.

RESULTS

Table 1 shows the characteristics of the participants. The mean age (standard deviation; SD) of the participants was 20.22 (2.89) years. The percentage of individuals with higher education individuals was 41.0%. The percentage of those who were married was 37.5%, that of those living with another person was 71.9%, and that of those who were employed was 53.0%. The mean number of minutes of walking per week (SD) was 260.1 (462.3), for moderate intensity activity excluding walking it was 120.6 (390.7), and for vigorous-intensity activity it was 75.4 (260.6).

Table 2 shows Cronbach's α internal consistency for all adrenal fatigue measures. The internal consistency was acceptable for all measures. Overall, internal consistency was

lower at Time 1 than at Time 2 which remained acceptable at both time points for all participants. Internal consistency was consistently higher ($\alpha = 0.96$ for time 2 Vs $\alpha = 0.85$ for time 1).

Also, reliability was excellent for all adrenal fatigue measures (Pearson $r = 90$; Spearman's $\rho = 0.80$ at Time 1 and Pearson $r = 96$; Spearman's $\rho = 0.93$ at Time 2). The results show the questionnaire had good reliability with better results for the investigation of adrenal fatigue stress among the studied participants.

Table 1. Demographic characteristics of the study sample (N = 160)

Variables	n, (M \pm SD)	%
Sample size	160	100
Gender		
Male	120	75
Female	40	25
Age (yrs)	20.22 \pm 2.89	-
Height (cm)	167.95 \pm 13.0	-
Weight (kg)	67.32 \pm 12.25	-
BMI (kg/m ²)	23.43 \pm 3.76	-
Marital status		
Unmarried	100	62.5
Married	60	37.5
Living condition		
Living with others	115	71.9
Living alone	45	28.1
Educational level		
4-years university or greater	65	41
2-years university	50	31
High school or junior high	45	28
Employment status		
Employed	85	53
Not employed	75	47
Walking, min/week	91 (260.1 \pm 462.3)	-
Moderate-intensity activity, min/week	59 (120.6 \pm 390.7)	-
Vigorous-intensity activity, min/week	10 (75.4 \pm 260.6)	-

Table 2. Test re-test reliability for adrenal fatigue -Q measures for participants with an interval of 7 days between the two assessments (Times 1 and 2)

Adrenal fatigue -Q measures	Item	Full sample (N=160)					
		Time 1			Time 2		
		Pearson r	Spearman's rho	Cronbach's alpha	Pearson r	Spearman's rho	Cronbach's alpha
Predisposing factors	13	0.81	0.82	0.80 (0.64–0.87)	0.89	0.81	0.85 (0.60–0.87)
Key signs & symptoms	31	0.9	0.80	0.81 (0.63–0.96)	0.88	0.93	0.88 (0.66–0.90)
Energy Patterns	13	0.86	0.91	0.87 (0.66–0.97)	0.92	0.85	0.95 (0.65–0.95)
Frequently observed events	22	0.89	0.85	0.82 (0.66–0.86)	0.91	0.89	0.88 (0.68–0.97)
Food patterns	9	0.87	0.92	0.86 (0.55–0.95)	0.85	0.80	0.91 (0.82–0.92)
Aggravating factors	10	0.96	0.89	0.91 (0.66–0.97)	0.98	0.96	0.96 (0.86–0.98)
Relieving factors	5	0.81	0.82	0.81 (0.64–0.87)	0.89	0.81	0.89 (0.60–0.97)
Overall	103	0.90	0.80	0.85 (0.63–0.96)	0.96	0.93	0.96 (0.66–0.98)

Table 3 shows the results of environmental and social influences on adrenal fatigue status. Environmental factors and social influences were seen to directly affect the score of adrenal fatigue status in all states, normal, mild, moderate, and severe, of adrenal fatigue. Participants who were unmarried ($p=0.001$), had low educational levels ($p=0.05$), were not employed ($p=0.001$), or were living alone ($p=0.05$) had significantly higher adrenal fatigue scores. These parameters of environmental and social factors had the greatest effect on the status of adrenal fatigue. Levels of adrenal hormones such as cortisol and ACTH were also investigated in this study. There were significant increases in the levels of cortisol ($p=0.001$) and ACTH ($p=0.001$), markers of adrenal fatigue, in participants with moderate to severe adrenal fatigue scores compared to those with normal and mild scores (Table 3). The changes in adrenal hormones significantly correlated with the severity of adrenal fatigue.

Based on physical activity, the participants were classi-

fied into three groups: mild ($n=50$), moderate ($n=40$), and vigorous ($n=70$).

Table 4 shows the influence of mild, moderate, and vigorous physical activities on adrenal fatigue severity. All physical activity intensities were seen to directly affect adrenal fatigue. Participants reporting moderate and vigorous exercise intensities showed significant ($p =0.01$ and $p =0.001$) decreases in adrenal fatigue severity compared to those reporting mild activities. However, there was significant increase in the ratio (75%) of subjects with a normal fatigue score in the moderate intensity exercise group compared to the vigorous intensity exercise group. The findings of this study suggest that physical activity especially that of moderate intensity may be effective for improving depressive adrenal fatigue. The participants in the moderate and vigorous exercise groups showed significant decreases ($p=0.01$ and $p=0.001$) in the severity index score of adrenal fatigue compared to those of mild exercise group (Table 5).

Table 3. Changes in the level of adrenal hormones, social, and environmental factors according to the adrenal fatigue scores of the participants (N = 160)

Variables	Adrenal fatigue score							
	Normal (≤ 40)		Mild (44-87)		Moderate (88-130)		Severe (≥ 130)	
Adrenal hormones_								
Cortisol ($\mu\text{g/ml}$)	6.2 \pm 0.75	**	10.5 \pm 1.9	**	16.9 \pm 3.6	**	28.5 \pm 3.9	**
ACTH (pg/ml))	16.9 \pm 11.7		27.9 \pm 7.3		36.3 \pm 14.2		42.7 \pm 9.5	
Marital status:								
Unmarried	19.6 \pm 6.3	**	45.9 \pm 12.1	**	92.9 \pm 18.3	**	142.3 \pm 10.4	**
Married	10.2 \pm 2.7		58.2 \pm 7.4		98.8 \pm 5.7		152.2 \pm 6.8	
Educational level:								
4-years university or greater	9.1 \pm 3.4	*	51.3 \pm 1.2	*	100.1 \pm 3.1	*	165.3 \pm 2.4	*
2-years university	12.1 \pm 2.9		54.5 \pm 4.8		96.7 \pm 7.2		175.3 \pm 7.2	
High school or junior high	15.3 \pm 4.3		48.6 \pm 5.9		122.8 \pm 9.2		181.8 \pm 11.6	
Employment status:								
Employed	6.1 \pm 3.6	**	49.3 \pm 2.3	**	102.3 \pm 2.3	**	170.3 \pm 4.5	**
Not employed	9.7 \pm 1.3		51.7 \pm 3.6		95.4 \pm 3.6		190.3 \pm 5.7	
Living condition:								
Living with others	5.8 \pm 2.7	*	49.3 \pm 1.5	*	110.5 \pm 3.7	*	165.8 \pm 5.6	*
Living alone	13.9 \pm 5.1		58.7 \pm 6.4		108.3 \pm 4.3		175.5 \pm 7.4	

Except where indicated otherwise, values are expressed as the mean. ** $p < 0.001$ significant for unmarried versus married status and employed versus not-employed; * $p < 0.05$ significant for university degree versus 2 year university degree or high school degree and living with others versus living alone for all adrenal fatigue scores.

Table 4. Interaction effect between frequency of adrenal fatigue and physical activity of the participants (N = 160)

Adrenal fatigue score (M \pm SD)	Physical activity (IPAQ score) (n=160)					
	Mild (n= 50)		Moderate (n= 40)		Vigorous (n= 70)	
Normal (Score, ≤ 40); n (%)	38.761 \pm 3.6 ; 3(6)	22.161 \pm 1.9 ; 30 (75)	*	12.8 \pm 4.8; 41(6)	**	
Mild (Score, 44–87); n (%)	55.7 \pm 5.9 ; 5(10)	48.7 \pm 2.6; 5(11)	*	44.9 \pm 3.8; 11(16)	**	
Moderate (Score, 88–130); n (%)	98.75 \pm 4.6; 13 (26)	91.4 \pm 3.7 ; 3 (8)	*	88.9 \pm 3.8; 9(13)	**	
Severe (Score, ≥ 130); n (%)	148 \pm 8.2 ; 29 (58)	135.7 \pm 2.9; 2(5)	*	131.5 \pm 1.5 ; 9(13)	**	

Except where indicated otherwise, values are expressed as the mean \pm SD. Improvement in adrenal fatigue status noticed in participants with moderate (* $p < 0.01$) and vigorous activities (** $p < 0.001$) compared to the mild group

Also, based on biochemical analysis, there were significant correlations between the levels of adrenal hormones and physical activity. Significant decreases in the levels of cortisol ($p=0.001$) and ACTH ($p=0.001$) were found in the participants with moderate to high physical activity compared to those with mild or sedentary activity. The decrement in adrenal hormonal levels positively correlated ($p=0.01$, $r=0.976$) with improvements in the adrenal fatigue status and severity index, especially in the physically active participants (Table 6).

DISCUSSION

In recent years, depression has become increasingly more prevalent among adolescent females on a worldwide scale^{57, 58}, and it is considered to be a disease which has a greater worldwide burden than ischaemic heart disease, cerebrovascular disease or tuberculosis⁵⁹.

In this study, the potential influences of environmental and social factors as well as different levels of physical activity on adrenal fatigue stress and reactivity were investigated.

This study evaluated the reliability of the adrenal fatigue questionnaire used to investigate the importance of fatigue stress in physical activity using the test-retest reliability method. The results show the questionnaire had good reliability with better results for the investigation of fatigue stress among the studied participants.

The present study investigated the environmental and social factors that affect adrenal fatigue stress in males and females aged from 15 to 22 years. Environmental and social factors were the most influential factors that directly affected

adrenal fatigue, and moderate to severe adrenal fatigue stress was significantly associated with unmarried status, low level education, not in employment, and living alone. This was consistent with a study that reported depression, anxiety, and stress are three common mental health problems worldwide⁶⁰, and other studies that investigated the psychometric properties of these questionnaires^{61, 62}. It has also been reported that subclinical depression in adolescence is related to depressive episodes, substance abuse, higher levels of neuroticism, academic underachievement, unemployment, and early parenthood⁶³. The ecological perspective suggests that physical activity is influenced by an interaction of demographic, psychological, social, and environmental factors⁶⁴. In the present study, the relation between physical activity and the status of adrenal fatigue was investigated, and the results show that, pattern of stress responses was related to the level of physical activity. A significant improvement in the stress fatigue status was also shown by participants with moderate physical activity compared to mild and vigorous physical intensity. Our findings indicate that higher levels of physical activity are associated with lower stress reactivity suggesting that higher levels of physical activity might be protective against the development of stress related diseases. These results are supported by our measurements of cortisol and ACTH as markers of adrenal fatigue status. There was significant change in serum adrenal hormones among participants with physical inactivity and higher fatigue scores. There were significant increases in serum cortisol and ACTH levels among participants with lower physical activity and higher adrenal fatigue scores. However, in participants with moderate to high physical activity, the decrease in the level

Table 5. Interaction effect between adrenal fatigue severity index and physical activity status of the participants (N = 160)

Fatigue severity index score (M ± SD)	Physical activity (IPAQ score) (n=160)		
	Mild (n= 50)	Moderate (n= 40)	Vigorous (n= 70)
Normal (Score, ≤ 1.0); n (%)	1.0 ± 0.6 ; 6 (12)	0.86 ± 0.6 ; 25 (62.5)	* 0.65± 0.5 ; 46(66) **
Mild (Score, 1.1-1.6); n (%)	1.5 ± 0.75 ; 6(12)	1.4 ± 0.6; 6(15)	* 1.32 ± 0.8; 12(17) **
Moderate (Score, 1.7-2.3); n (%)	2.28± 0.92; 8 (16)	2.2 ± 0.75 ; 5 (12.5)	* 1.9 ± 0.71; 9(13) **
Severe (Score, ≥2.4); n (%)	5.7 ±3.2 ; 30(60)	3.9 ± 2.9; 4(10)	* 131.5 ± 1.5 ; 3 (4) **

Except where indicated otherwise, values are expressed as the mean± SD. Significant decrease in adrenal fatigue severity noticed in participants with moderate (* $p < 0.01$) and vigorous activities (** $p < 0.001$) compared to the mild group

Table 6. Correlation between the level of cortisol and ATCH adrenal hormones and physical activity status of the participants (N = 160).

Adrenal hormones (M ± SD)	Physical Activity (IPAQ score) (n=160)		
	Mild (n= 50)	Moderate (n= 40)	Vigorous (n=70)
Cortisol (µg/ml)	28.6 ± 4.8	12.7 ± 3.2	* 17.3 ± 2.8 **
ACTH (pg/ml)	34.8 ± 6.8	15.9 ± 6.4	* 22.7 ± 3.8 **

Except where indicated otherwise, values are expressed as the mean± SD. A significant decrease was found in the levels of cortisol and ATCH as markers of adrenal fatigue status in participants with moderate (* $p < 0.01$) and vigorous activities (** $p < 0.001$) compared to the mild group. The decrement positively correlated with the improvement in adrenal fatigue status and severity index in physically active participants ($p=0.01$; $r=0.976$)

of cortisol and ACTH positively correlated with improvement in the severity index and adrenal fatigue score. This indicates the beneficial effect of physical activity on adrenal fatigue status. The results are in agreement with previous studies which focused on the effect of physical activity on depression via the control of adrenal hormones secretion^{65–68}). Another study proposed physical exercise interventions to protect against changes in the adrenal system with ageing⁶⁹).

Increased susceptibility to immunosuppression and infection has been linked with extreme levels of exercise⁷⁰).

Thus, it may be that physical activity of an intermediate level is the most effective level for stress protection. Furthermore, in general, depressive persons are physically sedentary in their daily life and have lower physical work capacity than healthy individuals⁷¹). Similarly, in the present study, the severity index of fatigue status showed that physical activity plays a pivotal role in reducing the severity of adrenal fatigue status. Psychosocial stress increases the risk of developing cardiovascular and mental diseases, such as hypertension or depression^{72, 73}). Physical activity is commonly regarded as beneficial for both physical and psychological health, and is seen as an effective preventive measure and treatment for stress-related diseases⁷⁴). Physically active people show reduced reactivity to physical stressors as well as reduced susceptibility to the adverse influences of life stress¹⁹). Recently, it was reported that the environment has long-term effects on population-based health behavior, and there was a direct relationship between environmental characteristics and physical activity as previously reported in the literature^{74, 75}). Interestingly, there are distinct variations in stress reactivity not only between extreme groups of physically active and inactive controls, but also between groups with less distinct differences in activity levels¹⁹). Thus, the level of physical activity might differentially affect stress reactivity. Finally, the findings of the present study imply that intervention strategies to promote more engagement in physical activity for population based health promotion may be necessary.

In conclusion, our data suggest that the level of physical activity and environmental and social factors differentially influence the adrenal fatigue status via changes in adrenal hormone levels. Interestingly, the reactivity of adrenal fatigue status was revealed to be sensitive to higher levels of physical activity, unfavorable environmental and social factors. Future studies should evaluate whether the level of physical activity might induce an optimal stress protective effect against stress-related diseases.

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