


Hormonal Function Responses to Moderate Aerobic Exercise in Older Adults with Depression

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Background: Poor daily life physical activities among older people were related to depressive mood especially memory loss. In addition to that, the change in physical ability is significantly associated with the score of depression among older age.

Objective: The present study aimed to evaluate the effects of a supervised aerobic training program with moderate intensity for 12 weeks on mood profiles and hormonal levels of the hypothalamus-pituitary-adrenal axis (HPA axis) of older adults.

Methods: A total of 80 individuals of both gender (90 males, 110 females) of ages ranged between 65 and 95 years were recruited for this study. Based upon the profile of mood states (POMS) analysis, the participants were classified into two groups: control group (n=30) and depressive group (n=50). Leisure-time physical activity (LTPA), adrenal hormones such as ACTH, corticosterone (CORT), cortisol, DHEA/S, and cortisol:DHEA/S ratio were measured at baseline and post-intervention of moderate aerobic exercise for 12 weeks.

Results: Older adults with higher depressive scores showed a remarkable change in the level of adrenal hormones compared to control. There was a significant increase in the level of ACTH, CORT, cortisol, and cortisol:DHEA/S ratio, and decrease in DHEA/S. Compared to females, males showed an improvement in depressive mood score along with an increase in LTPA, DHEA/S and decrease in ACTH, CORT, cortisol, cortisol:DHEA/S ratio following 12 weeks of supervised aerobic training, respectively.

Conclusion: The findings of this study showed that 12 weeks of supervised exercise interventions are promising non-drug therapeutic strategies in improving depression among older adults. The potential performance in a psychological state occurs physiologically via optimizing the levels of the hormones of the HPA axis.

Keywords: adrenal function, depression, LPTA, aerobic exercise, POMS

Introduction

Depression refers to many feelings that are enough to change social daily life and produce negative effects on the human mood.¹ Most studies revealed that human depression mainly related to disorder in concentration, memory loss, and other thinking abilities.²⁻⁴ The incidence of depression is doubly increased in both genders,⁵ whereas higher ratios of depression (15–30%) were reported among older adults.^{6,7} These ratios expose adults' people of both genders to more serious physical health problems, which in turn may lead to mortality.^{8,9}

Recent research works reported an association between the lower physical activities during daily life and depressive mood among older people especially memory loss,^{10,11} and that the change in physical ability significantly associated with the score of depression among older ages.¹² In addition to that, a remarkable

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relation was reported between age, mood behavior, and physical activity, which collectively affect an older adult's lifestyle.^{13,14}

Thus, for good health, it is more convenient to verify the mechanistic relations between physical activity and mood behaviors among older adults. Previously, it was reported that the improper adrenal function plays a significant link between human physical activity and depressive mood states.^{15,16}

Previous studies showed that the ability to respond to stress with aging was significantly reduced which might be related to abnormalities in the hypothalamus-pituitary-adrenal axis (HPA axis) function and subsequent release of large amounts of cortisol and other components of the HPA axis, such as the corticotrophin-releasing hormone.^{17,18} Because of stress, the produced abnormalities over-activate the HPA axis through neuroendocrine and autonomic pathways, and can badly affect the cellular immune response, glucose pathways, and lead to severe diabetic conditions.^{19,20}

In human bodies, stress showed to be controlled via the activity of the HPA which controls the release of cellular physiological adrenal hormones.^{21,22} It was reported that the adrenocorticotrophic hormones (ACTH) and corticosterone hormones expressed from the HPA axis into the plasma are considered as important stress indicator.^{21,22} In addition, the secretion of cortisol and rises its level was the most pronounced among older adults exposed to daily life stressors.^{15–22}

In most studies, cortisol levels appear to have varying functions according to age whereas, younger ages exhibiting a smaller the cortisol awakening response (CAR) compared to adults.^{23,24} These ultimately promote the HPA axis to utilize a complex interplay of neural and hormonal systems to release sufficient cortisol to respond to the demands of the environments. The interference within this complex system originate to a deficient in stress coping which might lead to stress-related psychopathology.^{24,25}

In addition, dehydroepiandrosterone (DHEA) and its sulfate form (DHEA-S) are the most abundant hormones regulated by the HPA axis along with cortisol. DHEA as anti-glucocorticoid showed to play potential significant roles in many body disorders such as immunity, obesity, and in stress processing.^{26–29} DHEA-S showed to have a long half-life and slower clearance rate thus; it serves as a reservoir for DHEA.³⁰ In stress, DHEA is primarily released from the adrenal in parallel with cortisol in response to HPA axis activation by ACTH.^{27,29} A strong regulatory influence of DHEA was reported on the HPA

upon release. A direct down regulatory impact on corticoid receptors,^{26,27} emotion regulation neurocircuitry,³¹ and enhanced behavioral activation associated with stress coping significantly appeared following the release of DHEA.³²

In humans, the negative impact of high cortisol on episodic memory in older and young adult males were significantly attenuated by the release of DHEA,^{33,34} and improved decision-making competence was shown to be associated with greater stress reactive DHEA levels.³⁵ DHEAS was suggested to play a role as a marker of proper stress management against psychosocial stress including job-related stress.³⁶ During aging, the increase in the cortisol/DHEAS ratio refers significantly to an increase in the neurotoxicity and probably contributes to the occurrence of age-related neurodegenerative illnesses.^{37,38} Thus, higher secretions of DHEA/DHEAS considered of great importance in improving health outcomes,^{39–42} including psychological status, and reduced risk of death from cardiovascular disease.^{39–42} Similarly, corticosterone (CORT) levels were generally raised following stressful events and impairs in cognition/memory and stress coping which in turn lead to a reduction in the structural and functional plasticity of the brain.^{43,44} In healthy and diseased subjects, corticosterone is the major biosynthetic route of mineralocorticoid that it converted to aldosterone.^{45,46}

The physical exercise showed to produce a new situation of homeostasis in human bodies. It maintains the augmentation of the energetic demand via many countless physiological alterations,^{21–23} whereas, the promotion of the HPA axis with exercise produce increment in the level of ACTH from pituitary corticotrophin cells which in turn helps in the increase of cortisol,^{47–49} and most related adrenal hormones like androgens which may participate with human health.⁵⁰

Although drug therapy was the main choice for the treatment of patients with abnormal mood profiles particularly depression, Exercise interventions as alternative treatments have been used in research as well as in clinical practice, mainly due to response failure to drug treatment.^{51–53}

A significant reduction in depressive symptoms was observed in older patients with depression following physical exercise training,^{54–56} and signifies physical exercise as an effective non-pharmacological treatment for depression in older adults.^{56,57} The positive effect of physical exercise based on the physiological changes in the function of HPA, whereas physical exercise can modulate cortisol via the upregulation of the glucocorticoid receptors.^{55–61}

The effect of physical exercise of different intensities on depression and other related mood disorders was evaluated in many studies.^{62–68} Many of which showed that aerobic training significantly affects positively on depression.^{62,63}

In a systematic review and meta-analysis study, the physical exercise showed to promote the levels of cortisol among subjects with mild depression disorders (MDD), whoever these findings significantly controlled by the type of exercise, frequency, and the type of cortisol measurement.⁶⁹

Several studies performed on middle-aged/older adult individuals suggest beneficial positive effects on mood, well-being, and cognition.^{70–72} In a recent pilot study, the feasibility of aerobic exercise as an antidepressant treatment strategy was evaluated in young adults with MDD. In that study, a decrease in depression scores with a significant increase in VO_{2max} as a measure of good physical performance was predicted following exercise interventions for 12 weeks.⁷³

Although aerobic exercise may reflect neurobiological changes and produces antidepressant effects via physiological changes in VO_{2max} among younger ages,⁷³ little work has assessed the potential effects of moderate aerobic training on adrenal hormones and its required efficiency for alleviating symptoms in depressed older adults.^{74–79}

Considering, the potential role of physical activity in enhancing physiological adrenal function, and its effects on mood profiles among older adults as previously reviewed in the literature. Thus, the present study tried to evaluate the effects of supervised aerobic training interventions with moderate intensity for 12 weeks on adrenal hormonal levels such as DHEA, cortisol, ACTH, corticosterone among older adults with depression. In addition, the association between physical activity scores, adrenal hormones, and scores of mood profiles were evaluated following 12 weeks of supervised aerobic training.

Materials and Methods

Subjects

A total of 200 healthy subjects with an age range of 65–95 years old and mean age of (69.7 ± 5.91) were recruited for this study, between 15 January 2013 and 15 September 2013 via electoral roll randomized selection. Out of them, only 80 subjects who matched the inclusion criteria participated in this study. Based on the POMS analysis, the subjects were classified into two groups: the

control group ($n=30$) and the depressive group ($n=50$). The design of the experimental protocol containing two groups: the control group ($n=30$) and the depressive group ($n=50$) was evaluated as shown in the flow chart [Figure 1](#). Subjects with endocrine, immune, psychiatric illness, eating disorders, and taking glucocorticoid medication were excluded from this study. Standardized measures such as weight, height, and body mass index were calculated pre and post-exercise tests. The demographics and baseline characteristics of participants are shown in [\(Table 1\)](#). All study participants gave informed consent before participation. Regarding the ethical guidelines of the 1975 Declaration of Helsinki, the study protocol was reviewed and approved by the ethical committee of Rehabilitation Research Chair (RRC), King Saud University, Kingdom of Saudi Arabia, under file number (ID: RRC-2014-007).

Outcome Measures

Profile of Mood States (POMS)

Depressive mood score among studied subjects was performed using a validated short version of the POMS as previously reported.^{79–83} The POMS is a self-report 32 items questionnaire designed to evaluate mood states. It is designed to measure mood in five different domains: fatigue (6 items), irritation (7 items), vigor (5 items), tension (6 items), and depression (8 items). The answers are scored on a 5-point Likert scale,⁸³ ranging from “not at all” (0) to “extremely” (4). The reliability and validity of this scale are good ($\alpha=.76$ – $\alpha=.95$).^{79–83} In the current study, internal consistency for the different domains ranged from $\alpha=.85$ to $\alpha=.94$ respectively. Based on the POMS analysis, the subjects were classified into two groups control group ($n=30$), and the depressive group ($n=50$).

Leisure-Time Physical Activity (LTPA)

Physical activity scores in the form of a leisure-time physical activity (LTPA) were estimated for all participants by using a pre-validated global physical activity questionnaire as previously reported.⁸⁴ For each participant, the activity donated as energy expenditure rate was calculated weekly as metabolic equivalents per hour/week (T-LTPA-MET/H/W) as previously reported.^{84,85}

Training Procedure

Participants of both control and depressive groups performed the exercise test according to Karvonen’s formula,⁸⁵ three times per week for 12 weeks. The program of this study was designed in the form of a treadmill-walking mode. The

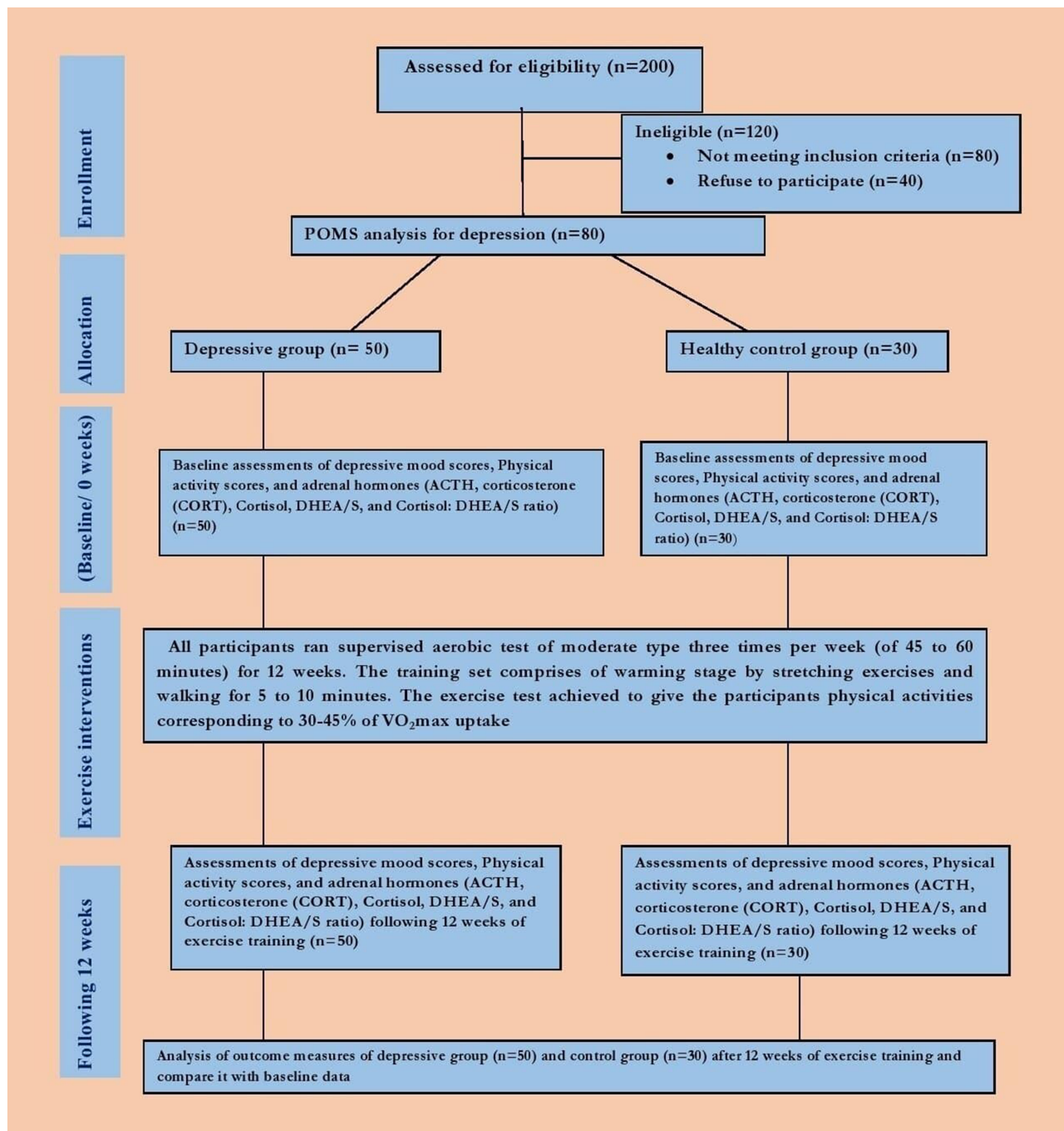


Figure 1 Flow diagram of the participants through the study. Participants classified according to POMS analysis and participated in supervised aerobic test of moderate type three times per week (of 45 to 60 minutes) for 12 weeks.

training intensity of each participant was calculated according to Karvonen's formula,⁸⁵ as training heart rate (THR), which mainly based on both the predicted maximum heart rate and resting heart rate corresponding to respective age. The participants performed the exercise test for 45 to 60 minutes to gain physical activities corresponding to 30–45% of VO₂max uptake as previously reported,⁸⁵ and gradually

increased until they reach 65% to 75% of VO₂max for moderate intensity, which used in this study.

Design of the Exercise Program

The exercise test performed three times per week each exercise session consisted of three phases warm-up, active, and cool-down phases;

Table 1 The Demographics and Baseline Characteristics of Participants

Parameters	Control Group	Depressive Group	DF	t(p-value)
N	30	50	-	-
Male/Female	20/10	30/20	-	-
Age (years)	69.5 ± 4.85	69.7 ± 5.91	198	-0.231 (0.82)
BMI (kg/m ²)	22.7 ± 2.8	23.5 ± 3.5	198	-1.57(0.11)
Waist (cm)	76.5 ± 22.9	89.9 ± 15.7	198	-4.78(0.12)
Hips (cm)	92.3 ± 11.4	83.9 ± 23.5	198	2.64(0.09)
WHR	0.82±0.09	1.08±0.05	198	-26.1 (0.15)
Systolic BP (mmHg)	111.2 ± 9.5	108 ± 10.3	198	2.03(0.12)
Diastolic BP (mmHg)	72.5 ± 13.7	72.5 ± 11.3	198	-4.6(0.14)
VO ₂ max (mL/kg*min)	35.7 ± 4.6	38.6 ± 3.9	198	-4.6(0.08)
Leisure-time physical activity (MET-H/week)	124.8 ± 25.4	54 ± 9.7	198	28.5(0.0001)
Educational level (n=112)				
Under graduate degree	20	50	-	-
Higher education level	10	30	-	-
Average mood scores				
Depression	1.5 ± 0.9	7.3 ± 2.5	198	-17.5(0.0001)
Anger	3.5 ± 1.3	12.8 ± 1.2	198	-48.9(0.0001)
Fatigue	6.3 ± 0.9	8.6 ± 1.3	198	-12.5(0.0001)
Vigour	10.2 ± 1.2	13.8 ± 3.5	198	-7.76(0.0001)
Tension	2.9 ± 0.7	7.8 ± 0.9	198	-37.6(0.0001)
Total mood score	24.4 ± 3.7	50.3 ± 6.3	198	-29.7(0.0001)

Notes: Values are expressed as mean ±SD; Significance at p <0.05.

Warm-Up Phase

The subject performed a simple stretching exercise for all large muscle groups and walked for 5 to 10 minutes at a training fraction (TF) equal to 30%–40%.

Active Phase

The subject was allowed to reach his pre-calculated training heart rate (THR) in bouts with a total time of from 30 to 45 minutes.

Cool-Down Phase

In this phase, the workload decreased gradually within 10 to 15 minutes until the participant's HR and blood pressure returned nearly to the resting level. Throughout the entire training session, the heart rate of the participant was monitored using a portable heart rate monitor to maintain exercise intensity within the pre-calculated training heart rate (65% to 75%).

Assessment of Adrenal Hormones

Fasting blood samples were collected from all participants at 8.30 in the morning to avoid a probable diurnal influence at both pre-exercise and 5–10 minutes' post-exercise-training program. The proposed time for blood collection was selected for the control of the circadian hormonal

range as previously reported in the procedures of other studies.⁸⁶ After centrifugation, serum samples of all tests were stored at -80 °C until reused. Several adrenal hormones were considered in order to detect major adrenal pathways. Both cortisol and ACTH were measured in serum samples using immunoassay technique according to instructions of RIA-ELISA kit (DPC Inc., CA, USA), and SIA-ELISA kit (MD Biosciences Inc, MN, USA) respectively. Serum levels of DHEAS were measured by an immunoassay (Diagnostic Products Corporation, Immulite 1000) with an intra-assay CV of <5.2%. Serum levels of corticosterone (CORT) were measured by a quantitative competitive enzyme immunoassay technique that measures corticosterone (Assaypro LLC, St. Charles, Missouri, MO 63,304, USA).

Statistical Analysis

Power calculations of the selected sample size of 80 subjects showed to give an estimated power of 95% and a significance level of 0.05 with an expected frequency of 6.5%. An SPSS statistical program (SPSS, IBM Statistics V.17) was used to analyze all data produced in this study. The data of continuous variables are expressed as mean±SD, while those of

categorical variables are described as counts and percentages. A non-parametric test (Mann–Whitney–Wilcoxon test) and the χ^2 test were used to analyze frequency differences between the groups. In all groups' pre- and post-exercise training, two independent sample t-tests were used for comparison between the studied variables such as depressive mood score (dependent variable), physical activity, and adrenal hormones (independent variables). In addition, multiple stepwise regressions and Pearson's correlations analysis were used to estimate the associations between physical activity scores (LPTA-MET-H/W) and those of Adrenal hormones; cortisol, DHEA, cortisol:DHEA ratio, ACTH, and Corticosterone serum concentrations in older subjects with depression and in controls. All tests were two-tailed; because of multiple assessments, results were only considered statistically significant at a value of $p < 0.01$.

Results

A total of 80 subjects were involved in this study, most of them are males ($n=50$; 62.5%). They are classified according to mood profile score into normal ($n=30$) and depressive ($n=50$). Compared to controls, subjects with depression showed no significance in all demographic parameters; BMI ($p=0.11$), WHR ($p=0.15$), waist ($p=0.012$), hips ($p=0.09$), Age ($p=0.82$), and VO_2 max ($P=0.08$) as shown in Table 1.

In the baseline state, participants of the depressive group showed a significant difference in all average mood scores ($p=0.0001$) compared to the control group. In addition, a significant decrease ($P=0.0001$) in leisure-time physical activity scores was reported among subjects with depression compared to those of the control group (Table 1).

In this experiment, a significant improvement in depressive mood profile was achieved in the subjects of both control and depressive groups following 12 weeks of moderate aerobic training as shown in Table 2. Compared to pre-test

results, all parameters of mood profiles; anger, fatigue, vigor, tension, and total mood score were significantly improved in the subjects of control and depressive groups following exercise training for 12 weeks respectively as shown in Table 2.

The change in the expression levels of the adrenal hormones; cortisol, DHEA, cortisol:DHEA ratio, ACTH, and Corticosterone serum concentrations were estimated in this study. There was a significant increase in DHEA and a decrease in the serum levels of cortisol, cortisol:DHEA ratio, ACTH, and Corticosterone of depressive participants compared to the control group following 12 weeks of moderate aerobic training (Table 3). There was a significantly higher change in LPTA in normal and depressive older adults following 12 weeks of aerobic training ($P=0.0001$) (Table 3).

According to physical activity status, the depressive participants are classified into two groups low LPTA group ($n=20$) and high LPTA ($n=120$). The data obtained showed that the improvement in serum levels of adrenal hormones significantly correlated with the status of physical activity (LPTA-MET-H/W) in all depressive participants as reported in a Table 4.

Regarding gender, a significant difference in physical activity profile (LPTA-MET-H/W), adrenal blood hormones, and total mood profile was reported in female and male participants. There was a higher mood profile associated with a higher change in adrenal hormones and lower LPTA status in female compared to male participants pre- and post-exercise program (Figures 2 and 3).

Physical activity ($p=0.05$) showed to be higher in males compared to females at baseline (Figure 2A), whoever both genders showed a significant increase ($p=0.001$) in the scores of physical activity after exercise test as shown in Figure 2A. Also, total depressive scores (TMscores) were significantly higher ($p=0.05$) in females compared to males (Figure 2B). In both genders, TM-scores were significantly ($p=0.001$) reduced following exercise test for 12 weeks,

Table 2 Mood Scores in Studied Subjects Following 12 Weeks Supervised Aerobic Training Program (Means \pm SD)

Parameters	Control Group (n=30)				Depressive Group (n=50)			
	Pre	Post	DF	t(P-value)	Pre	Post	DF	t(P-value)
Depression	1.5 \pm 0.9	1.23 \pm 0.6	118	1.93(0.05)	7.3 \pm 2.5	5.2 \pm 1.8	278	8.1(0.0001)
Anger	3.5 \pm 1.3	2.7 \pm 1.1	118	3.64(0.0004)	12.8 \pm 1.2	9.6 \pm 1.5	278	19.7(0.0001)
Fatigue	6.3 \pm 0.9	5.9 \pm 1.2	118	2.06(0.04)	8.6 \pm 1.3	5.2 \pm 0.93	278	25.2(0.0001)
Vigor	10.2 \pm 1.2	7.9 \pm 1.6	118	8.91(0.0001)	13.8 \pm 3.5	10.1 \pm 2.8	278	9.8(0.0001)
Tension	2.9 \pm 0.7	1.85 \pm 0.5	118	9.45(0.0001)	7.8 \pm 0.9	4.7 \pm 1.2	278	24.45(0.0001)
Total mood score	24.4 \pm 3.7	19.65 \pm 2.9	118	7.83(0.0001)	50.3 \pm 6.3	34.8 \pm 4.8	278	23.16(0.0001)

Notes: Values are expressed as mean \pm SD; Significance at $p < 0.05$.

Table 3 Change in the Level of Adrenal Hormones and Leisure-Time Physical Activity (LTPA) Score of Participants Following 12 Weeks Supervised Aerobic Training Program (Means \pm SD)

Parameters	Control Group (n=30)				Depressive Group (n=50)			
	Pre	Post	DF	t (P-value)	Pre	Post	DF	t(P-value)
Cortisol ($\mu\text{g/mL}$)	6.8 \pm 0.85	4.3 \pm 0.65	118	18.1(0.0001)	10.6 \pm 3.7	7.6 \pm 1.8	278	8.83(0.0001)
DHEA ($\mu\text{g/mL}$)	2.0 \pm 0.89	2.6 \pm 0.96	118	-3.55(0.0006)	1.9 \pm 0.56	2.9 \pm 0.85	278	-11.62(0.0001)
Cortisol:DHEA ratio	3.4 \pm 0.89	1.65 \pm 0.75	118	11.65(0.0001)	5.6 \pm 0.76	2.62 \pm 0.95	278	29 (0.0001)
ACTH (pg/mL))	16.9 \pm 11.7	12.7 \pm 5.8	118	2.49(0.014)	31.6 \pm 12.5	19.8 \pm 6.8	278	9.81(0.0001)
Corticosterone (ng/mL.)	9.6 \pm 1.6	7.4 \pm 1.3	118	8.27(0.0001)	38.5 \pm 4.9	25.7 \pm 2.9	278	26.6(0.0001)
LTPA (MET-H/week)	124.8 \pm 25.4	175.2 \pm 30.8	118	-9.93(0.0001)	54 \pm 9.7	165 \pm 18.9	278	-61.8(0.0001)

Notes: Values are expressed as mean \pm SD; Significance at $p < 0.05$.

Table 4 Post Training Correlation Analysis of Adrenal Hormones and Depressive-Related Variables According to the Level of Leisure-Time Physical Activity (LPTA-MET-H/Week) After 12 Weeks of Exercise

Parameters	Depressive Group (n=50); (Means \pm SD) (R)			
	(Low LTPA) (n=20)		(High LTPA) (n=30)	
	Means \pm SD	R	Means \pm SD	R
Total mood score	32.4 \pm 1.7	-0.635*	38.3 \pm 3.9	-0.785**
Cortisol	8.5 \pm 2.6	0.356*	7.6 \pm 1.8	0.537**
DHEA	2.3 \pm 0.85	0.345*	3.1 \pm 0.85	0.78**
Cortisol:DHEA ratio	2.7 \pm 0.76	0.741*	2.5 \pm 1.7	0.237**
ACTH	20.2 \pm 5.7	0.245*	18.7 \pm 4.3	0.124**
Corticosterone	24.3 \pm 1.2	0.765*	21.9 \pm 2.0	0.564**

Notes: Data presented as coefficient (R); *Denotes significance at <0.05 ; **Denotes significance at <0.01 .

however, more improvement in the scores of TMS was reported in males than females ($p=0.01$) (Figure 2B).

Adrenal hormones significantly improved ($p=0.001$) in all participants following exercise training (Figure 3). A significant decrease in the levels of cortisol, ACTH,

and Corticosterone with a significant increase in the levels of DHEA was reported in both genders after exercise test as shown in Figure 3A–D. However, males showed more improvements than females ($p=0.01$).

Discussions

In older populations, the occurrence of psychological and depressive disorders significantly attributed to physical inability.¹² The drastic effects of physical problems increase the incidence of depression criteria among older people.¹³ It was reported that exercise plays a significant role as a means of physical rehabilitation to conserve the fitness and health of the human body. Previously, most studies showed that physically active bodies showed a remarkable decrease in depression states via a change in all parameters of their lifestyle,^{87,88} however, the exact mechanism of action is unknown.⁸⁹

Therefore, in this current research work, we examined the mechanistic role performed by the supervised aerobic exercise of moderate intensity in reducing depressive mood side effects in older ages. We proposed that the

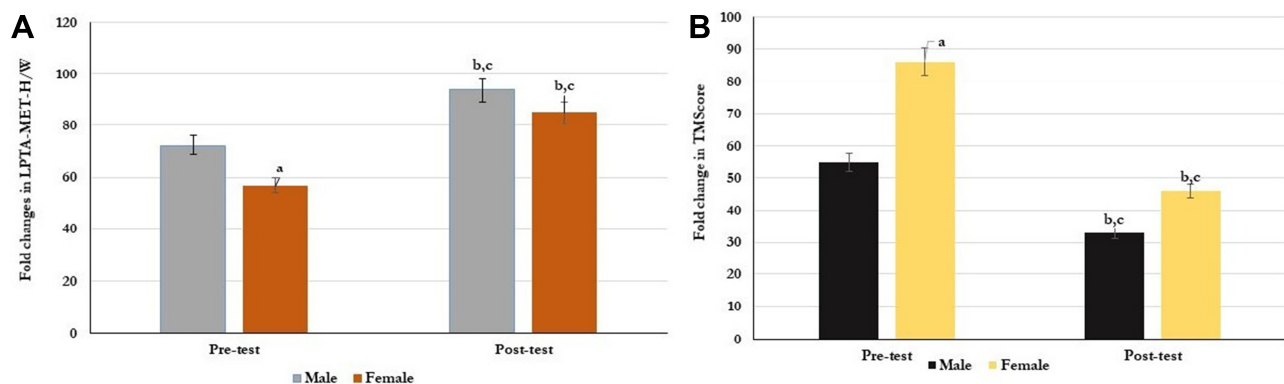


Figure 2 Association between gender, Physical activity (LPTA) (A), depression (total mood score; Score) (B) in older adults at Pre- and Post-exercise training. Significant improve in physical activity (A) and depression (B) was reported in males compared to females following 12 week of exercise training. ^a $p=0.05$ (male vs female at baseline), ^b $p=0.01$ (male vs female after 12 week of exercise training), ^c $p=0.001$ (pre-test vs post-test for male/female).

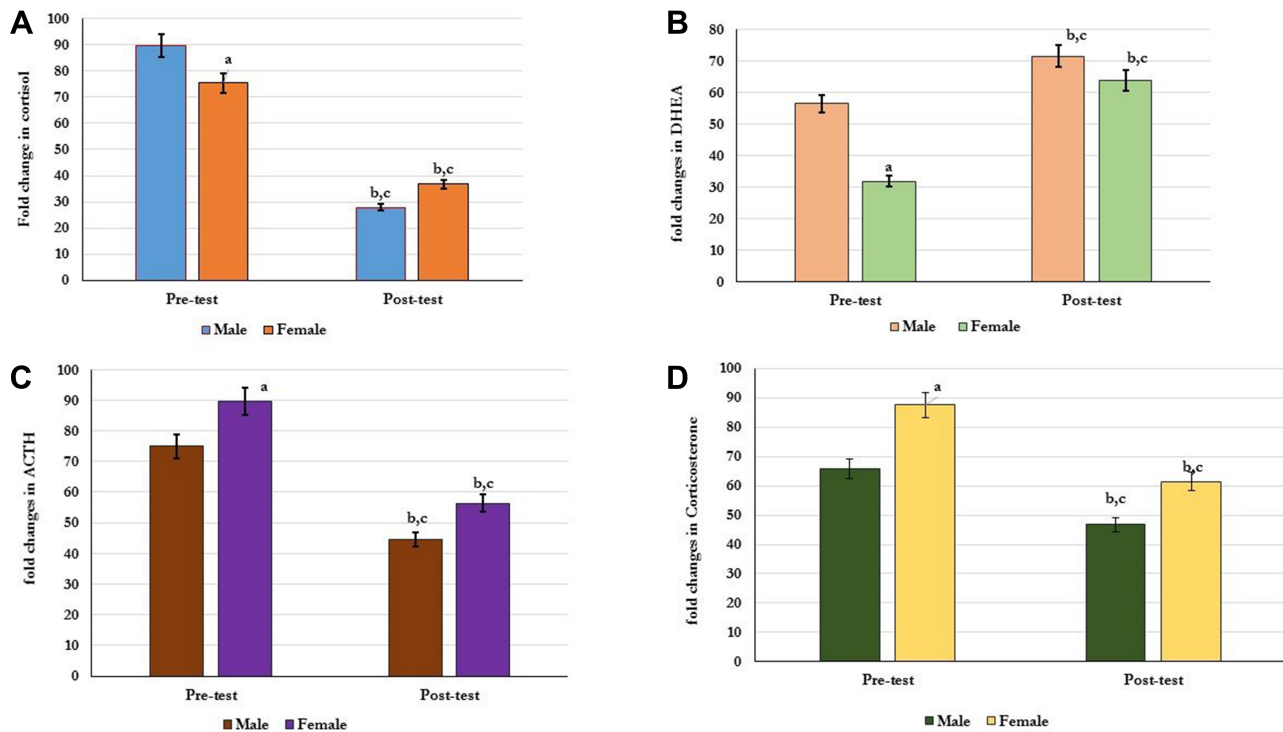


Figure 3 Association between gender and the profile of adrenal hormones in older adults at Pre- and Post-exercise training. Following 12 week of exercise training, males showed significant improve in the levels of cortisol (A), DHEA (B), ACTH (C), and corticosterone (D) compared to females. ^a $p=0.05$ (male vs female at baseline), ^b $p=0.01$ (male vs female after 12 week of exercise training), ^c $p=0.001$ (pre-test vs post-test for male/female).

improvement of physical fitness could change the depressive mood of older adults via the buffering of adrenal hormones.

The results from our analyses showed an increase in depressive mood scores and significant change in the level of adrenal hormones among older adults with physical inactivity. The data obtained are in line with those who reported a link of mood disorders such as anxiety and depression with disability and loss of health among older adults of both genders.⁹⁰ However, more emotional benefits and low depression were clearly reported in subjects with physically active and could confront physical health challenges.^{12,81}

In this current study, the data showed a significant difference between male and female participants in depressive mood score, physical activity, and change in the level of adrenal hormones. This matched with other studies, which confirmed a higher incidence of depression among females with longer age rather than males.⁹¹ This may be related to higher neural disorders among the female gender, especially in older ages.⁹² In addition, the previous study concluded that women have a higher response to HPA disorders under daily life stress than males, which facilitate the development of depression via the elevation of cortisol levels.⁹³

Regarding the change in adrenal hormones, our data showed a significant increase in serum cortisol, corticosterone (CORT), ACTH, cortisol:DHEA/S ratio, and decrease in DHEA in older adults with depression. The data are in agreement with other studies that reported that patients with higher depressive and stress incidence scores showed an abnormality in adrenal hormones such as an increase in serum levels of cortisol, corticosterone (CORT), ACTH, cortisol:DHEA ratio, and decrease in DHEA/S.^{94–98} In addition, the results support the potential roles of cortisol and corticosterone (CORT) in the expression of aldosterone that aids in the prognosis of psychological stress and cardiovascular outcomes.^{95,99}

Favorable positive effects on physiological, psychological, and immunological functions were reported following regular exercise interventions,¹⁰⁰ therefore it necessary to study the relationship between physical activity status, depressive mood, and subsequent alteration in the secretion of adrenal hormones in older adults.

In the present study, a significant improvement in mood profile, the levels of adrenal hormones, and a significant increase in physical activity (LPTA=MET-H/W) were observed among all participants of control and depressive groups. However, in relation to gender, significant

improvement in depression mood profile with optimizing response in the levels of adrenal hormones and an increase in LPTA status was reported in males more than females' participants following 12 weeks of supervised moderate aerobic exercise. These observations were in accordance with previous results which showed greater improvements in depression, anxiety and stress following 12-week aerobic training program,^{101,102} or at 6 month's follow-up,¹⁰² or after 10-weeks of walking intervention on participants with depression, anxiety, and obsessive-compulsive disorders.¹⁰⁴

The results of the current study are in harmony with previous studies, which focused upon the effect of physical activity on depression via controlling adrenal hormones secretion.^{104–107} It was shown that physical exercise interventions were proposed to protect against changes in the adrenal system with aging.¹⁰⁵

The current study demonstrated that the level of DHEA hormone was elevated significantly after exercise in both control and depressive groups of our adult participants as compared to the pre-exercise level respectively. After exercise interventions for 12 weeks, the results showed that there was a highly significant correlation ($P= 0.01$, $r= 0.78$) between the level of DHEA/S hormone and physical activity level (LPTA). This result matched with previous studies, which had shown that DHEA/S levels increase in response to exercise.¹⁰⁸ Exercise increased the production of DHEAS from the adrenal cortex through the hypothalamus-pituitary-adrenal axis.¹⁰⁹ In addition, most studies reported that the change in the level of DHEA depends mainly upon the type and intensity of exercise test,^{110–112} however, our study showed contrary results with those who not able to define any increase in the level of DHEA/S in older adults.¹¹²

In this study, a reduction in the level of the adrenal hormones was reported in both healthy control and adults with depressive mood following supervised exercise interventions for 12 weeks. The data showed a significant decrease in the levels of cortisol, ACTH, and corticosterone in control and depressive groups of our adult participants as compared to the pre-exercise level respectively. In relation to the decrease in cortisol, cortisol:DHEA/S ratio of the studied older subjects significantly decreased immediately post-exercise.

The data of the present study were in line with Heaney et al,⁹⁷ who showed a significant decrease in serum cortisol, cortisol:DHEA/S ratio and increase in DHEA/S levels in older adults who regularly participated in aerobic exercise compared to adrenal hormones of sedentary individuals with higher stress incidence scores. In addition, the change in ACTH and corticosterone levels was in

accordance with those who reported decreased plasma ACTH and corticosterone levels following physical exercise.^{113,114} The obtained data signify the role of supervised aerobic exercise interventions in modulating the effects of the HPA axis, which mediate the reactivity of the human body against depression disorders.^{115–117}

Conclusions

The findings of this study showed that 12 weeks of supervised exercise interventions are promising non-drug therapeutic strategies in improving depression among older adults. The potential performance in a psychological state occurs physiologically via optimizing the levels of the hormones of the HPA axis.

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Disclosure

The authors report no conflicts of interest in this work.

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