Effect of 6 weeks of aerobic training with nanocurcumin consumption on IL1β, nitric oxide, and depression in women with metabolic syndrome

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Abstract

Backgrounds and Objectives The use of anti-inflammatory supplements is important in improving the executive function of obese people. This research aims to investigate the effect of 6 weeks of aerobic exercise with moderate intensity as well as the consumption of nanocurcumin on IL1β, nitric oxide (NO), and depression in women aged 60–65 with metabolic syndrome.

Materials and Methods Forty-four women with metabolic syndrome were randomly selected and divided into four groups of 10 based on their use of nanocurcumin supplement. The treatment included the training (T), nanocurcumin (N), training + nanocurcumin (TN), and the control groups. The groups exposed to training performed aerobic exercise for 6 weeks (three sessions per week). Blood samples were obtained before and after the training period for antioxidant indicators and lipid degradation measurement. Also, the Beck anxiety questionnaire was used for evaluating levels of anxiety. T-test and one-way analysis of variance (ANOVA) tests were used for the assessment of within-group and between-group differences, respectively.

Results There was a significant difference in IL1β, NO, and depression before and after exercise in all three experimental groups (p ≤ 0.05). Also, the results showed a significant difference in the level of NO and depression in the experimental groups. The highest decrease in these variables was observed in the T and TN groups (p ≤ 0.05).

Conclusion These findings indicated that 6-week nanocurcumin supplementation with aerobic training is a suitable method for reducing IL1β, NO, and depression, preventing metabolic, cardiovascular, and inflammatory diseases in women with metabolic syndrome.

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Trial registration number: IRCT2017082335857N1

Keywords Aerobic exercise · Inflammation · Depression · Metabolic syndrome · Nanocurcumin

Introduction

Aging is an inevitable fact. An increase in the elderly population around the world is an important concern. The World Health Organization estimated the total number of elderly people in the world in 2006 at about 700 million, and it will double in the next 40 years. In Iran, the population over the age of 60 reached about 10 million until 2020, and it will be more than 26 million by 2050 [1]. Depending on the social and family circumstances of the elderly, 12 to 16% of the elderly are likely to be depressed [1]. Depression reduces the quality of life of the elderly and increases their dependence on others [1]. Depression increases drug use, length of hospital stay, and care costs [1]. Currently, depression prevalence is expected to increase to more than 15–20% [1, 2]. Symptoms of depression include sadness, irritability,
decreased interest in fun activities, significant weight gain and loss, insomnia or excessive sleep, decreased memory, decreased libido, fatigue, loss of energy, worldly worthlessness, excessive guilt, decreased power of concentration, and increased suicidal ideation [2–4]. Some researchers have shown that long-term aerobic exercise increases the recall of fatty acids, and therefore the amount of free tryptophan in the blood increases due to the competitive binding of fatty acids and tryptophan to albumin. Therefore, the rate of serotonin synthesis increases in the brain [5–7]. Curcumin was used in China and India to treat some diseases [8]. Fundamental studies on the medicinal properties of curcumin have shown its effect on lowering blood sugar [9–11], anti-inflammation [2], and antioxidant properties [12] of turmeric [2]. Metabolic syndrome refers to the presence of at least 3 of 5 risk factors. These factors include waist fat of greater than 94 cm, triglyceride of higher than 150, HDL level of less than 40, hyperglycemia (glucose higher than 110), and blood pressure of higher than 85/130 [1]. Some researchers have suggested that a decrease in serotonin results in an increase in inflammation [13, 14]. The exercise and curcumin supplements both reduce inflammation, and these can be used as a treatment strategy to improve severe depression [15–18]. In this regard, some research has been done which will be briefly overviewed. Osali et al. (2017) found the positive effect of exercise and curcumin consumption on reducing inflammatory factors and depression [1]. Kulkarni et al. (2008) reported curcumin supplementation as effective in reducing depression [16]. Legrand et al. (2009) showed the effect of regular walking on reducing depressive symptoms in women [19]. Mokhtari et al. (2013) also reported the effect of 12 weeks of aerobic exercise on reducing depression [20]. Dey et al. (1994) stated that 4 weeks of moderate-intensity swimming is effective in improving the behavior of depressed people [21]. Donohue et al. (2004) reported the effect of exercise training on depression in young athletes [22].

Nitric oxide (NO) has multiple biological actions and can regulate physiology acutely or lead to long-term changes in cell function. The pleiotropic roles of NO include the regulation of long-term synaptic transmission, learning, memory, platelet aggregation, leukocyte-endothelial interactions, immune function, angiogenesis, and arteriogenesis [23]. The absorption of curcumin in turmeric is very low due to its lipophilic nature. The curcumin capsules contain nanocurcumin with a size of 10 nm, and its solubility in water is 100 times more than that of turmeric powder, and this factor causes its absorption. After oral consumption of the nanocurcumin soft gel capsule which contains nanocurcumin, it opens in less than 15 min in an acidic gastric medium and distributes in all of the gastric. These nanocurcumin in acidic gastric conditions are constant for at least 6 h, and they change the intestine intake manner. With regard to increasing the curcumin absorption when using it as a nano drug, the question raised is that “does the 80 mg consumption of nanocurcumin cause a significant decrease in depression, NO, and IL1β?”.

Methodology

This study adopted a quasi-experimental design. The research design included the pre-test and post-test with one control group and three experimental groups. Also, this research has been registered in the Clinical Trial Registration Center of Iran under the number IRCT2017082335857N1.

The statistical population of the present study was 250 wives of martyrs aged 50 to 65 in Zanjan. Sampling was purposeful. After distributing an advertisement in the General Office of the Martyr and Veterans Affairs Foundation of Zanjan Province and sending an invitation to the statistical community at the beginning of the research, 65 females volunteered to participate in the study. They were examined by a physician for their history of illness and physical distress, psychological problems, sleep, and blood pressure, and if necessary, some of them underwent heart-health screening. None of the subjects had a history of regular physical activity in the past year. It should be noted that, in this study, the ATP III (Adult treatment panel III) criterion was used to identify metabolic syndrome, which was considered in the presence of three of the five indicators (waist circumference more than 94 cm, blood triglyceride more than 150 mg/dL, blood HDL less than 40 mg/dL, blood pressure more than 130.85 mm Hg, and fasting blood glucose higher than 110 mg/dL). In other words, volunteers with three or more metabolic risk indices based on ATP III criteria were considered as subjects with metabolic syndrome [1].

Based on the type of the treatment, the subjects were assigned to four groups: the training group (T), nanocurcumin group (N), training + nanocurcumin group (TN), and the control group.

Training protocol and supplementation

The subjects exposed to training were allowed to practice from 9 a.m. to 12 p.m. The training period was 6 weeks. They practiced 3 days a week. Each session, the exercises were performed in the form of three consecutive sets with a break interval of 5 min between sets. The training set time in the first week was 12 min, and with the passing of each week, 1 min was added to the duration of the training sets, so that in the 6th week of the training, it reached three sets of 17 min. The exercise was performed at an intensity of
65 to 75% of the heart rate reserve. Resting heart rate was checked weekly, and the intensity of the exercise program was adjusted using a Polar (Finland) pacemaker. The whole training session started with 5 min of warming up (flexibility and stretching exercises) and ended with 5 min of cooling down. The control group avoided regular physical activity during this 6-week period. The stored heart rate was calculated using the Karvonen formula (1).

Sixty to 70% reserve heart rate = \( \frac{\text{Maximum heart rate} - \text{Resting heart rate} \times (60 \text{ to } 70\%)}{\text{Maximum heart rate} - \text{Resting heart rate}} + \text{Resting heart rate} \)

Heart rate when waking up and lying down before getting out of bed = resting heart rate.

Beck Depression Inventory (BDI)

The (BDI) is a 21-item, self-rated scale that evaluates key symptoms of depression, including mood, sense of failure, self-dissatisfaction, guilt, punishment, self-dislike, self-accusation, suicidal ideas, crying, irritability, social withdrawal, indecisiveness, body image change, work difficulty, insomnia, fatigability, loss of appetite, weight loss, somatic preoccupation, and loss of libido [26].

Amount and method of receiving nanocurcumin

The subjects received an 80 mg of nanocurcumin tablet each morning. The total amount of calories received was calculated through food software.

Measurement of biochemical parameters

All subjects underwent fasting blood sampling at 9 am (to measure plasma levels of IL1β and serum glucose, triglyceride, and plasma doped lipoprotein) in two phases, including the pre-test and the post-test (after 6 weeks). In order to eliminate the acute effects of exercise such as delayed contusion and small possible injuries to the muscle structure on the serum level of IL1β, blood sampling was performed in the post-test phase 4 days after the last training session [23, 24]. At each blood sampling, blood vessels of the brachial vein were collected in tubes without EDTA anticoagulant. After centrifugation (12 min at 3000 rpm) and separation of serum, serum IL1β levels were measured by ELISA, a special kit for measuring IL1β (eBioscience, Vienna, Austria) with a sensitivity of 0.05 pg/mL. Blood glucose was then measured by glucose oxidase, and fat levels were measured by a standard enzymatic method (Pars Kit test, Karaj, Iran) using Kubas Mira biochemical AutoAnalyzer. The coefficient of variation of this kit in each assay and across assays (inter-assay variation) was equal to 1.82% and 1.6% for triglycerides, 1.74% and 1.19% for blood sugar, and 2.15% and 1.28% for HDL, respectively. NO is extremely unstable and undergoes rapid oxidative degradation to stable nitrite (NO2-) and nitrate (NO3-), which react with the colorant and produce an azo-pink composition, and it is quantified spectrophotometrically [27]. Serum levels of metabolites were measured by colorimetric Griess assay. During the colorimetric assay, the nitrite concentration was determined by measuring the absorbance at 450 nm.

The calculation of body fat percentage

The percentage of body fat of the subjects was calculated by the pneumatic composite device, model OMRON BF500 made in Germany.

The calculation of calorie intake

Subjects recorded their daily food intake in a notebook before starting the training protocol (beginning, middle, and end of the week), and then the calories of food consumed for breakfast, snacks, lunch, and dinner were calculated by N4 software. The results showed no significant difference in the number of calories consumed between the groups [1].

Statistical analysis

Data were gathered and analyzed using descriptive and referential statistics. Levene’s test was used to test the homogeneity of variances in the pre-test. The Kolmogorov–Smirnov test was used to ensure that the distribution of the variables was normal. After verifying the normality of data, paired sample t-test was used to compare the pre-test and post-test means for each group, and the one-way analysis of variance test (ANOVA) (difference between test and post-test) was used to compare the means of the groups. Also, to check where the exact differences lie, Bonferroni’s post hoc test was used. All data analysis was performed using SPSS software version 24, and the significance level was set at 0.05.

Results

The physical qualities of subjects were measured twice: at the first and the last sessions. The measures in the last session were age (62.3 ± 1.23 years), height, (164 ± 7 cm), body weight (81.2 ± 2.4 kg), and body mass index (BMI = 29.5 ± 1.2 kg/m²). The results of
comparison of the groups’ means in terms of metabolic syndrome, weight, fat percentage, BMI, IL1β, NO, and depression are listed in Tables 1 and 2. Intragroup and intergroup comparison shows that there is no significant difference in calorie intake before and after the test (Table 3). The results of paired sample t-test showed that IL1β levels in the T (p = 0.003), N (p = 0.05), and TN groups (p = 0.002) decreased significantly in the post-test compared to the pretest. IL1β did not change significantly in the post-test of the control group compared to the pre-test (p = 0.8). Also, NO levels in the T (p = 0.002), N (p = 0.002), and TN (p = 0.002) groups increase significantly in the post-test compared to the pre-test. NO did not change significantly in the post-test in comparison with the pre-test in the control group (p = 0.5) (Table 2). The results of the one-way ANOVA showed that levels of IL1β in all the experimental groups were significantly lower than that for the control group (p = 0.002) (Table 2). The results of the Bonferroni post hoc test of IL1β showed no difference between T and TN groups (p = 0.1), but there was a difference between N and T groups (p = 0.000), T and control groups (p = 0.000), TN and N groups (p = 0.002), N and control groups (p = 0.000), and TN and control groups (p = 0.002). Also, levels of NO in T, N, and TN groups were significantly lower than that of the control group (p = 0.002). The results of the Bonferroni post hoc NO test showed no difference between T and N groups (p = 0.1). But differences were found between T and TN groups (p = 0.006), T and control groups (p = 0.02), TN and N groups (p = 0.001), N and control groups (p = 0.007), TN and control groups (p = 0.002). Also, T and TN groups revealed the highest decrease in depression compared with the other groups, and this difference was statistically significant.

Table 1 The anthropometric indices, body composition of subjects before and after the study

| Variable          | Group                | Pre-test Mean ± SD | post-test Mean ± SD | p-value |
|-------------------|----------------------|--------------------|---------------------|---------|
|                   |                      |                    |                     |         |
| Weight (kg)       | Training             | 80.04 ± 06.31      | 70.83 ± 04.01       | 0.004e  |
|                   | Training + Supplement| 81.13 ± 07.23      | 68.68 ± 04.31       |         |
|                   | Supplement           | 80.71 ± 07.73      | 69.75 ± 03.02       |         |
|                   | Control              | 79.08 ± 07.73      | 80.88 ± 09.68       |         |
| BMI (kg/m²)       | Training             | 33.63 ± 04.54      | 27.43 ± 03.62       | 0.008e  |
|                   | Training + Supplement| 34.69 ± 05.61      | 26.73 ± 04.77       |         |
|                   | Supplement           | 33.56 ± 07.63      | 27.24 ± 05.73       |         |
|                   | Control              | 34.49 ± 05.38      | 34.32 ± 08.35       |         |
| WH R              | Training             | 104.78 ± 05.32     | 93.52 ± 03.61       | 0.006e  |
|                   | Training + Supplement| 102.56 ± 06.43     | 92.63 ± 03.67       |         |
|                   | Supplement           | 103.42 ± 05.56     | 93.63 ± 02.43       |         |
|                   | Control              | 103.98 ± 04.84     | 104.21 ± 05.75      |         |
| SBP (mmHg)        | Training             | 158.37 ± 07.32     | 121.43 ± 03.71      | 0.007e  |
|                   | Training + Supplement| 160.37 ± 06.61     | 120.43 ± 2.99       |         |
|                   | Supplement           | 157.36 ± 06.76     | 122.43 ± 2.87       |         |
|                   | Control              | 161.26 ± 05.63     | 159.87 ± 07.58      |         |
| Triglyceride (mg/dl)| Training            | 256.32 ± 73.34     | 142.82 ± 11.89      | 0.008e  |
|                   | Training + Supplement| 264.08 ± 45.53     | 141.98 ± 12.11      |         |
|                   | Supplement           | 256.32 ± 74.34     | 144.54 ± 12.63      |         |
|                   | Control              | 264.08 ± 45.53     | 260.87 ± 68.74      |         |
| HDL (mg/dl)       | Training             | 41.36 ± 12.45      | 53.47 ± 04.82       | 0.001e  |
|                   | Training + Supplement| 41.86 ± 11.56      | 54.56 ± 09.56       |         |
|                   | Supplement           | 42.34 ± 10.37      | 54.89 ± 08.66       |         |
|                   | Control              | 45.23 ± 04.46      | 46.64 ± 06.84       |         |
| Glucose (mg/dl)   | Training             | 182.84 ± 32.65     | 115.63 ± 10.73      | 0.000e  |
|                   | Training + Supplement| 185.98 ± 32.87     | 114.65 ± 11.01      |         |
|                   | Supplement           | 184.54 ± 31.43     | 113.65 ± 12.06      |         |
|                   | Control              | 174.58 ± 4.27      | 170.98 ± 64.03      |         |

BMI, body mass index; WHR, waist hip ratio; SBP; systolic blood pressure; HDL, high-density lipoprotein
Discussion

The reduction in depression, IL1β, and NO was significant after 6 weeks of aerobic exercise and nanocurcumin use. This is consistent with the results of Dimeo et al. (2001), Hematfar et al. (2012), HekmatiPour et al. (2013), Mokhtari et al. (2013), and Osali et al. (2017) [1, 15, 18, 20, 25]. HekmatiPour et al. (2013) reported the effect of 4 weeks of training, 4 sessions per week for 25 min, on reducing depression in the elderly [26]. Hematfar et al. reported that 8 weeks of aerobic exercise was effective in reducing depression and increasing serotonin in students aged 18–25 years [15]. Mokhtari et al. (2013) also found that 12 weeks of aerobic exercise was effective in improving balance and significantly reducing depression in older women aged 62–80 [20]. Osali et al. (2017) reported that 3 months of moderate-intensity aerobic exercise was effective in reducing depression and IL-6 in elderly women with metabolic syndrome [1]. In another study, Osali (2017) investigated the effect of eight weeks of turmeric consumption and aerobic exercise with an intensity of 75–85% of stored heart rate on IL-6 plasma levels and depression in elderly women with metabolic syndrome [18]. The results reported by Osali et al. (2017) are similar to the results of the present study [1]. The same result was obtained when the amount and duration of curcumin used in the present study were less than what used in the previous study [1]. Curcumin used in the present study was in the form of 80 mg nanocurcumin tablets, but in the previous study (2017), the daily consumption of curcumin was 20 mg per kg of body weight. The reduction of depression in this study is not consistent with the results of Donohue et al. (2004) [22]. Donohue et al. (2004) found that young people who exercised regularly were more likely than other non-athlete youths to have impulsive, neurotic, and psychotic disorders [22]. Considering the age of the subjects and the purpose of the exercise at this age, it can be said that the attitude towards exercise is effective in reducing

### Table 2 Comparison of IL-1β, CRP before and after training

| Groups       | Variable   | Control | Training + Supplement | Supplement | Training | p (Between Group) |
|--------------|------------|---------|-----------------------|------------|----------|-------------------|
|              | IL1β (pg/ml) | Pre-test | 4.87 ± 1.45 | 4.99 ± 1.33 | 4.77 ± 1.89 | 4.80 ± 1.45 | 0.002 |
|              |            | Post-test| 4.82 ± 1.36 | 2.33 ± 1.27 | 2.99 ± 1.34 | 2.67 ± 1.51 | 0.003 |
|              | P (within group) | 0.9 | *0.002 | *0.05 | *0.003 |  |
|              | NO (ng/ml)  | Pre-test | 0.108 ± 0.095 | 0.120 ± 0.03 | 0.125 ± 0.074 | 0.120 ± 0.023 | 0.002 |
|              |            | Post-test| 0.111 ± 0.090 | 0.151 ± 0.019 | 0.147 ± 0.026 | 0.146 ± 0.084 | 0.002 |
|              | P (within group) | 0.4 | *0.002 | *0.002 | *0.002 |  |
|              | Depression  | Pre-test | 22.87 ± 5.23 | 22.65 ± 4.33 | 20.46 ± 4.45 | 21.98 ± 5.56 | 0.001 |
|              |            | Post-test| 21.93 ± 5.15 | 11.76 ± 2.11 | 10.11 ± 2.17 | 12.57 ± 5.02 | 0.001 |

IL1β, interleukin 1 beta; NO, nitric oxide

### Table 3 Comparison of total calories received

| Groups       | Variable   | Control | Training + Supplement | Supplement | Training | p (Between Group) |
|--------------|------------|---------|-----------------------|------------|----------|-------------------|
|              | Total calories received | Pre-test | 2483.75 ± 145.29 | 2501.65 ± 145.29 | 2495.54 ± 95.12 | 2490.67 ± 102.18 | 0.653 |
|              |            | Post-test| 2441.83 ± 118.17 | 2541.63 ± 108.11 | 2509.79 ± 93.16 | 2492.75 ± 99.41 | 0.903 |
|              | P (within group) | 0.259 | 0.342 | 0.105 | 0.903 |  |
and increasing depression and behavioral disorders. In the present study, exercise was performed to treat and reduce depression, which showed a significant reduction in blood pressure, body fat percentage, weight, waist size, and triglyceride. But in the study by Donohue et al. (2004), exercise was aimed at achieving aims (championships), which is likely to increase behavioral disorders [22]. Differences in the age of subjects, body composition, and purpose of the exercise are among the reasons for inconsistent results.

The mechanism of the effect of exercise and nanocurcumin consumption on reducing depression in women aged 60–65 with metabolic syndrome can be investigated through several pathways. The first pathway is the effect of exercise and nanocurcumin consumption on IL1β reduction. In the present study, the decrease in IL1β can be attributed to a significant decrease in blood pressure, triglyceride, and waist size as well as a significant increase in HDL. This is consistent with Zorilla et al. (2001) and Mossner et al. (2007) who argued that an increase in inflammatory factors is associated with a decrease in serotonin [13, 14]. The reduced depression can be attributed to a decrease in IL1β, and a decrease in IL1β is effective in increasing serotonin [17]. The second pathway is the effect of exercise on increasing tryptophan levels. Tryptophan is a precursor to the synthesis of serotonin, which is increased by prolonged aerobic exercise. The mechanism of an increase in tryptophan involves the transportation of fatty acids and tryptophan in the blood by albumin, both of which have the same binding site on albumin. While training, the amount of fatty acids increases, and this increase leads to a decrease in the albumin site for the binding of tryptophan to albumin. Increased free tryptophan in the blood leads to more tryptophan entering the brain, and the presence of tryptophan in the central nervous system leads to more synthesis of serotonin and relief from depression [5–7]. Curcumin also inhibits both monoamine oxidase A and B activity. Monoamine oxidases A and B are oxidizers of dopamine, norepinephrine, and serotonin whose oxidation is reduced by curcumin and consequently, the levels of dopamine, norepinephrine, and serotonin are reduced [2, 16, 27]. Previous studies concerning serum or plasma cytokine levels and their concentrations have evaluated the acute effects of exercise. Based on the findings reported in previous as well as the present study, it could be hypothesized that major weight loss connected to exercise training is necessary to modulate inflammatory indicators levels. Also, we found a significant reduction of IL-6 and CRP in women with metabolic syndrome. In this regard, some of the previous studies have shown significant reductions in C-reactive protein concentration, which is another important indicator of systemic inflammation, following nano-curcumin intake and supplementation [28]. Increased expression of inflammatory factors causes the activity of nuclear factor kappa B (NF-κB). NF-κB binds to DNA to block the expression of BDNF (brain-derived neurotrophic factor). Curcumin reduces IL1β expression and NF-κB transcription, which in turn increases BDNF expression [2, 17]. BDNF is a neurotrophic factor that causes both neurogenesis and neuroplasticity [28–30].

Since neurotransmission is biologically impaired in depressed people [15], a significant decrease in waist circumference, blood pressure, and triglyceride as well as an increase in HDL due to 2 months of moderate-intensity aerobic exercise significantly reduced IL1β and decreased NF-κB activity and binding to DNA. This process leads to increased BDNF expression, and increased BDNF levels also improve neurotransmission and relieve depression [2, 31]. The present study showed that doing exercises for 6 weeks with nanocurcumin supplementation had a significant effect on NO levels in women aged 60–65 with metabolic syndrome. Changes in NOS3 or NO involves the following ones: (A) Decreased NOS3 expression commonly occurs in obese and diabetic states. The mechanisms proposed for diminished expression include TNF-α-mediated destabilization of NOS3 mRNA, which may involve eEF1A1. High levels of NO may regulate NOS3 abundance through cGMP-mediated or via NF-κB-SNO feedback regulatory pathways. A small 27-nt RNA regulates NOS3 expression; nevertheless, it is not known whether this mechanism is invoked in obesity or diabetes. (B) Decreased NOS3 activity in obesity and diabetes is largely attributed to insulin resistance, which may be mediated by free fatty acid (FFA)–induced activation of TLR2, TLR4, and NF-κB. In addition, activation of PKCβII may diminish Akt signaling, which normally promotes phosphorylation of NOS3 on Ser1177. Phosphorylation at this site increases NO output by the enzyme. Hyperglycemia may also lead to increased O-GlcNAcylation of NOS3, which decreases Ser1177 phosphorylation and inhibits its activity. In addition, conditions leading to obesity promote upregulation of Cav-1, which is a negative regulator of NOS3, and ceramide accumulation disrupts the NOS3-Akt-HSP90 complex, diminishing the activity of the enzyme. (C) NOS3 may also be uncoupled or NO quenched in obese and diabetic states. Diminished levels of substrates and cofactors, such as L-arginine or tetrahydrobiopterin (BH4), lead to uncoupling of the enzyme, which is commonly associated with the presence of NOS3 monomers rather than dimers and can produce superoxide instead of NO. Endogenous inhibitors of NOS3 such as ADMA also increase in obese conditions and can promote NOS uncoupling. Elevated production of reactive oxygen species such as superoxide can quench NO and result in its oxidation to highly reactive peroxynitrite, which damages biomolecules and can oxidize BH4 to BH2 [23].
Conclusion

Six weeks of moderate-intensity training and nanocurcumin consumption decreased IL1β, NO, and depression and led to the improvement of metabolic syndrome. This study thus suggests aerobic exercise with nanocurcumin use as a non-invasive strategy in the treatment of depression in women aged 60–65 with metabolic syndrome. Finally, it is suggested to conduct research with different intensity and duration of training on the target community.

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Declarations

Ethics approval and consent to participate The University of Bonab Review Board for the protection of human subjects approved this study (Approval date: 2018-July-17).

Consent for publication All subjects were aware during the informed consent process that the results of this study may be published.

Conflict of interests The authors declare no competing interests.

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