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Original Article

The Effect of Short Term Time-Restricted Eating on Anthropometric Indices and Inflammation at Rest and Following Acute Exercise

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ABSTRACT

Background: The effect of some methods of time-restricted eating (TRE) on obesity has been investigated before, however its short term effect on obesity indices and physiological responses to exercise is not clear yet. This study aimed to evaluate the effect of TRE on anthropometric indices, as well as, resting and post-exercise responses of cortisol and erythrocyte sedimentation rate (ESR).

Methods: Sixteen healthy men aged 17-29 years with body mass index (BMI) of 17.2-33.5 kg/m^2 were voluntarily enrolled in this study. TRE was followed for two weeks; during this period of time, no food was consumed from 8 am to 4 pm, although water intake was allowed. Body weight, height, and waist were measured before and after TRE. Blood samples were provided before and after TRE following 10-11 hours of fasting, and after eating breakfast together with YoYo exercise test on the same day.

Results: BMI and waist-to-height ratio (WHtR) decreased following two weeks of TRE. Also, a significant reduction in resting cortisol and an increase in resting ESR were noticed. After TRE, acute exercise and intake of breakfast, an increase in erythrocyte sedimentation rate (ESR) and reduction in cortisol were observed.

Conclusion: Although two weeks TRE improved anthropometric indicators and resting cortisol as an anti-inflammatory response, ESR increased at rest and in response to acute exercise and intake of breakfast.

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Introduction

Body mass index (BMI) as an index of obesity can be associated with inflammation and other related diseases (1). Body composition and exercise/ physical activity can be correlated with changes in cortisol (2) as well as inflammatory factors such as erythrocyte sedimentation rate (ESR) (3). In this regard, some diets have been recommended to improve inflammation such as intermittent fasting (IF) (4). IF without any other food restrictions can result in weight loss (5). Time-restricted eating (TRE) is a form of IF which requires eating in a limited number of hours during a day. Previous findings have indicated positive effect of TRE with different duration of 12 weeks (6), 8 weeks (7), and 4 weeks (8), with different programs on body composition and some metabolic factors. A study revealed that two weeks of TRE can lead to a non-significant weight reduction (9). Considering the effect of TRE on inflammation, 12 months of combined TRE and resistance training were shown to reduce weight and inflammation (10). However, it was demonstrated that intense and long duration exercises can lead to higher levels of inflammatory mediators, and thus increase the risk of injury and chronic inflammation (11). No study has evaluated the effect of TRE on physiological parameters following exercise. While, some studies found that acute exercise can increase inflammation as a usual physiological mechanism in the range of natural level (12). Adherence to long-term TRE, especially in combination with exercise may be difficult for many individuals, so this study aimed to evaluate the effect of two weeks TRE on anthropometric indices [i.e., BMI, waist-to-height ratio (WHtR), ESR and cortisol] during resting and in response to exercise.

Materials and Methods

The study method was a form of quasi-experimental research with pre-test and post-test measurements. Before contributing in the research program, all participants signed an informed consent. The study proposal and procedures were approved by university ethic committee (no: 043.1400.REC.REHAB.SUMS.I) and the protocols were conducted in accordance with the Declaration of Helsinki for human participants. Participants in this study were 16 healthy and active young volunteer men, with ages of 17 to 29 years. Inclusion criteria were having the habit of three daily usual meals (e.g. morning breakfast at 7-9, lunch at 12-13, and dinner at 19-20) and lack of some characteristics such as having a sedentary lifestyle, cardiovascular health, having a special diet during the last month, smoking, taking anti-anxiety and anti-depressant drugs, taking hormonal or anti-inflammatory drugs, and suffering from physical problems that could limit their physical activity. Also, participants should not have experienced fasting during the last 3 months. Exclusion criteria were non-adherence to the TRE plan, being affected with any metabolic or infectious diseases that could impact the research variables. Participants completed a questionnaire related to their eating habits and physical activity in order to determine their basic information about the dietary and physical habits. The participants reported having an active lifestyle consistent to recreational physical activity and normal nutrition. The participants were recruited through announcement in university campus during autumn and winter 2022.

One day before initiating the study intervention program, as well as 48 hours following the last session, the participants' weight, height and waist circumference were measured in standard positions and any dietary or supplements were recorded too. BMI was calculated as weight (kg)/height(cm)^2 and WHtR was estimated using waist (cm)/height (cm). During the two-week TRE intervention, participants were not allowed to eat any food from 8 am to 4 pm, and they were allowed to drink only water. The three daily meals (50-60% carbohydrate, 25-35% fat, and 10-20% protein resulting in daily energy intake of 2137-2456 Kcal) were reported by participants and they were recommended to maintain three meals in restricted time with quantity and quality similar before TRE. The participants were also requested to maintain their daily physical activity and sleep habits during intervention. Participants' adherence to these recommendations was measured by comparing eating and physical activity one week before and during TRE which were recorded every 3 days. Any kind of psychological/physical stress or illnesses were also recorded. All of participants reported adhering to the instructions to maintain their normal lifestyle, while none of them were excluded.

The YoYo test was used to estimate cardiorespiratory fitness (13) of participants and also to evaluate the effect of exercise on ESR and cortisol. Participants completed a familiarization session for the Yo-Yo test before the main session of TRE program. Blood samples were taken at 8-8:30 am, after 10-11 hours of fasting. Then, participants ate similar breakfast in two sessions consisted of one medium loaf of white bread, a small mold of cheese and 3 walnuts and rested for 45 minutes after breakfast. Then, they began warming up for 5 minutes with jugging and stretching exercises and performed the YoYo endurance test. Within two minutes after the YoYo test, blood samples were taken again. To measure blood variables, 6 mL of blood were taken from each participant in each stage. To measure ESR, Westergren method was used; while 2 mL of the venous blood sample were poured into Westergren tube containing 0.5 mL of sodium citrate. The tube was left upright for two hours at room temperature. The distance from the lowest point of the surface meniscus to the upper limit of the red cell sediment was measured. To determine the amount of cortisol, ELISA kit (ZellBio, 9648H-1003-ZB: No. Cat GmbH) was used.

The collected data were analyzed by SPSS software (version 26, Chicago, IL, USA). The normality of distribution of findings was evaluated by Shapiro–Wilk test, ANOVA with repeated measures and paired t tests to compare normally distributed variables and Friedman's test to evaluate non-normal distributed variables. A p value less than 0.05 was considered statistically significant.

Results

Participants of this study were young men aged 17-29 years (22.63±3.50 years) with BMI of 17.2-33.5 kg/m^2 (23.46±5.61). ANOVA with repeated measures showed significant differences between several measurements of cortisol [F=15.69 (1, 15), *p*<0.001, eta^2=0.78]. Also, There was a significant difference for ESR values between repeated measures [F (1, 15)=6.66, *p*=0.006]. Paired measurement comparisons showed that cortisol level of T3 (13.34±0.32) significantly decreased compared to T1 (15.01±0.42) (MD=1.66, *p*<0.001, CI: 0.1.06-2.27). Cortisol levels demonstrated a significant decrease in T2 (9.71±0.82) when compared to T1 (15.01±0.42) (MD=5.04, *p*=0.044, CI: 9.46-0.12). Also, cortisol decreased in T4 (10.61±0.77) in comparison to T3 (13.34±0.32) (MD=2.67, *p*=0.013, CI: 0.62-4.71). Cortisol changes (post- and pre exercise) before TRE (5.04±3.69) was greater than after TRE (2.67±3.81) (t=3.57, *p*=0.002) (Figure 1).

Paired measurement comparisons illustrated that ESR levels in T3 (2.50±0.33) increased significantly when compared to T1 (2.00±0.22) (MD=0.70, *p*=0.034, CI: 0.04-0.95). ESR levels exhibited no significant change in T2 (1.66±0.10) in comparison to T1 (2.00±0.22) (MD=0.33, *p*=0.198, CI: 0.19-0.86. Also, ESR increased in T4 (3.83±0.39) when compared to T3 (2.50±0.33) (MD=1.33, *p*=0.020, CI: 0.24-2.42). ESR changes (post- and pre exercise) after TRE (1.33±0.33) was greater than before TRE (0.33±0.98) (t=3.26, *p*=0.005) (Figure 1). Paired t test indicated that following TRE, BMI (MD=0.35, *p*=0.049, CI=0.002–0.71), and WHtR (MD=0.009, *p*=0.04, CI=0.00044–0.017) decreased significantly (Figure 2).

Discussion

Findings of the present study indicated reductions of BMI and WHtR following two weeks of TRE, which were accompanied by a significant reduction in resting cortisol and increase in resting ESR. ESR changes (post- pre-exercise) was greater following TRE which means that following TRE, ESR increased while cortisol decreased following exercise together with intake of breakfast. No harms

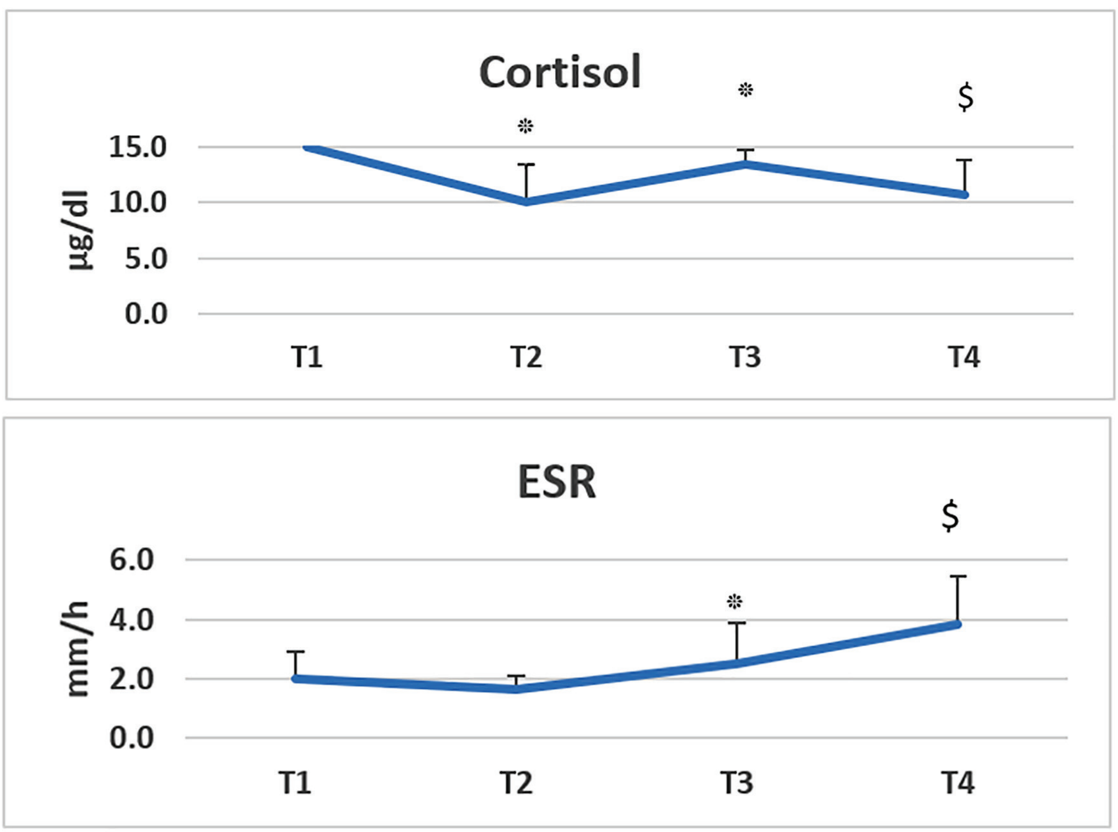

Figure 1: Comparison of cortisol and ESR between measurements. T1: Before TRE during rest, T2: Before TRE following exercise, T3: After TRE during rest, T4: After TRE following exercise (*Significant difference with T1, $ Significant difference with T3: *p*<0.05). ESR: Erythrocyte sedimentation rate, TRE: Time-restricted eating.

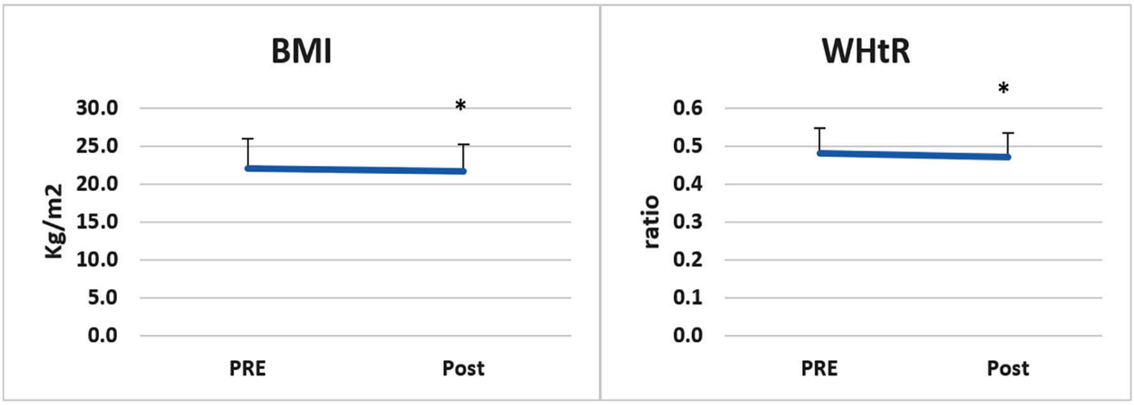

Figure 2: Comparison of BMI and WHtR before and after TRE, PRE: Before time restricted eating period, POST: After time restricted eating period (*Significant difference: $p<0.05$). BMI: Body Mass Index, TRE: Time-restricted eating.

were reported during the study by participants. Some studies have confirmed the positive effect of exercise on weight loss too (14). Additionally, a study revealed TRE in 11 participants over 4 days could reduce swings in hunger and increased fat and protein oxidization (15).

Reduction of body composition indices can be due to a decline in calorie intake or increase in calorie expenditure. However, according to our evaluation, no changes were visible in participants' nutrition and daily physical activity. So it seems that other components of energy expenditure including basal metabolic rate may have changed, although this was not directly evaluated. It is also possible that reduction of obesity indices was influenced by several hormonal changes. Although the present study indicated a decrease in cortisol level following TRE and a reduction in BMI, but other researchers did not support the strong relationship between systemic cortisol and obesity (16). Another study demonstrated that cortisol was negatively associated with obesity (17).

Another finding of this study was in contrast to cortisol, resting ESR increased significantly (in normal range) following TRE. It seems that cortisol change was correlated negatively with ESR. Also, considering the significant effect of exercise, findings of the present study showed an increased ESR and decreased cortisol when compared before exercise with breakfast intake and following TRE. Although exercise can increase cortisol and testosterone levels (18) due to breakfast intake following fasting blood sampling, an increase of blood glucose happened and could suppress cortisol following exercise. Reduction of cortisol following breakfast intake has been reported before (19). The reason for the increase in ESR in response to exercise and following TER can be related to the decrease in cortisol following TRE. Cortisol-induced anti-inflammatory effect and its reduction impact can increase inflammatory factors such as ESR. However this increase was in normal level (<15 mm/h) and can be regarded as a positive exercise response for related adaptations.

Following TRE, exercise and breakfast intake, more reduction in cortisol and increase in ESR happened and this change was greater than before TRE. So following exercise (after TRE), cortisol level decreased significantly following breakfast intake and exercise and similarly ESR level significantly increased too. Regarding the cortisol response to exercise, TRE may have dampened cortisol responses to exercise. Available studies demonstrate a large degree of variability in hormonal changes during exercise which may be due to numerous factors, such as (i) types of exercise, (ii) training intensity, (iii) study populations and (iv) time of blood sampling (20). This study had limitations such as small number of participants, and not measuring several other markers of inflammation. Nonetheless, the present findings contribute to the growing body of literature surrounding intermittent fasting and TRE.

Conclusion

In summary, although TRE improved cortisol and body anthropometric indices while inducing no significant effect on ESR at rest, we can conclude that adaptation to TRE could reduce resting and exercise responses to cortisol as anti-inflammatory factors, and this reduction can cause an increase in ESR as an inflammatory factor. Decreased cortisol and increased ESR levels at rest and in response to exercise was in normal range and was associated with physiological adaptations to TRE. Future research is needed to explore these findings, as well as, to clarify the long-term implications of the present study.

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Authors' Contribution

AD, MH, MKJ and GT contributed in the study design, MKJ supervised the study, AD, MH and MG performed the study.GT, AN, AD, and MKJ cooperated in writing the first draft of manuscript. All authors read the manuscript and approved or revised the final version of the manuscript.

Conflict of Interest

None declared.

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