purwo sri rejeki <purwo-s-r@fk.unair.ac.id>

PDF built, requires approval

CEP Journal Office <em@editorialmanager.com> Sat, Oct 2, 2021 at 7:08 PM
Reply-To: CEP Journal Office <cepadmin@wageningenacademic.com>
To: Purwo Sri Rejeki <purwo-s-r@fk.unair.ac.id>

Dear Mrs Rejeki,

The PDF for your submission, "Inflammatory Markers In Response To Interval and Continuous Exercise In Obese Women" is ready for viewing.

Please go to https://www.editorialmanager.com/ecep/ to approve your submission and log in as an Author.
Username: purwosrirejeki
Your password can be (re)set by clicking the following link: https://www.editorialmanager.com/ecep/l.asp?i=32991&l=K0LIO0MK

Your submission must be approved in order to complete the submission process and send the manuscript to the Comparative Exercise Physiology editorial office. Please view the submission before approving it to be certain that your submission remains free of any errors.

This is an automated response; please ignore this message if you have already approved the PDF of your manuscript.

Kind regards,

Editorial Office
Comparative Exercise Physiology

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/ecep/login.asp?a=r). Please contact the publication office if you have any questions.

unair UNTUK INDONESIA ADIL & BERADAB

purwo sri rejeki <purwo-s-r@fk.unair.ac.id>

Decision for CEP-210038

CEP Journal Office <em@editorialmanager.com> Wed, Sep 29, 2021 at 10:11 PM
Reply-To: CEP Journal Office <cepadmin@wageningenacademic.com>
To: Purwo Sri Rejeki <purwo-s-r@fk.unair.ac.id>

Dear Mrs Rejeki,

Manuscript number: CEP-210038
Title: Inflammatory Markers In Response To Interval and Continuous Exercise In Obese Female
Editor's decision: Minor Revision

Reviewers have now commented on your paper, and you will see that they are advising you to make some changes to your manuscript. If you are prepared to undertake the work required I would be pleased to reconsider your paper. The reviewers' comments are appended below.

If you decide to revise the work, please submit a response to the reviewers' comments when you submit the revised manuscript.

Your revision is due by 20 Oct 2021.

To submit a revision, go to https://www.editorialmanager.com/ecep/ and log in as an Author. You will be able to find and revise your submission in the 'Submission Needing Revision' folder.

Kind regards,

David Marlin
Editor-in-Chief
Comparative Exercise Physiology

Comments to Author:

Reviewer #1: In general, this paper largely confirms findings by others while using obese women as the study subjects. The study, as presented, had a simple design that was tested and supported by the manuscript.

Throughout the abstract and manuscript, the units for TNFa and IL-6 quantification are incorrect as "pg" and "ng" are used interchangeably. The authors should review the entire manuscript to ensure the correct units are provided.

The reliance on G1, G2, and G3 is confusing to the reader. It is suggested that the authors consider a descriptor for the different groups, as they seemed to start using towards the end of the discussion.

There is a lack of line numbers in the review copy, so I have made an attempt to make it clear which section I'm referring to with regards to specific comments:

Introduction- There are more citations regarding the anti-inflammatory effect of exercise beyond Pederson 2017. The authors should include additional citations.

Statistical Analysis- Since the data being analyzed by ANOVA is repeated in the same individuals, a one-way REPEATED MEASURES ANOVA should be used.

Results- The second paragraph can be considerably condensed, especially considering that the data is provided in Figure 1. The authors may want to consider taking the numerical data in this paragraph and creating an additional Table so that it does not need to be included in the paragraph.

Discussion:
- " The results of our study was similar to the hypothesis in previous studies which stated that increased levels of IL-6 were followed by lower levels of muscle glycogen (Benatti and Pedersen, 2015)." This was not measured in the current study. This sentence should be modified or removed.

- "(IL1RA)" should be corrected.

- There is a sentence in red that starts "stated that after". This appears to be missing additional words and should be

corrected.

- The last two sentences in the third paragraph are a repeat from the first paragraph and should be modified or removed.

- The fourth paragraph is generally confusing and difficult to follow. Reorganizing the paragraph so that it follows a more logical path is recommended.

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/ecep/login.asp?a=r). Please contact the publication office if you have any questions.

purwo sri rejeki <purwo-s-r@fk.unair.ac.id>

Submission Confirmation for CEP-210038R2

CEP Journal Office <em@editorialmanager.com> Sun, Oct 17, 2021 at 6:44 PM
Reply-To: CEP Journal Office <cepadmin@wageningenacademic.com>
To: Purwo Sri Rejeki <purwo-s-r@fk.unair.ac.id>

Dear Mrs Rejeki,

Thank you for your revised submission of CEP-210038R2
Inflammatory Markers In Response To Interval and Continuous Exercise In Obese Women

You may check the status of your manuscript by logging onto Editorial Manager as an Author at https://www.editorialmanager.com/ecep/.

Kind regards,

Editorial Office
Comparative Exercise Physiology

____

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/ecep/login.asp?a=r). Please contact the publication office if you have any questions.

unair UNTUK INDONESIA ADIL & BERADAB

purwo sri rejeki <purwo-s-r@fk.unair.ac.id>

Decision for CEP-210038R2

CEP Journal Office <em@editorialmanager.com> Mon, Oct 18, 2021 at 9:09 PM
Reply-To: CEP Journal Office <cepadmin@wageningenacademic.com>
To: Purwo Sri Rejeki <purwo-s-r@fk.unair.ac.id>

Dear Mrs Rejeki,

I am pleased to inform you that your manuscript CEP-210038R2 entitled "Inflammatory Markers In Response To Interval and Continuous Exercise In Obese Women" is accepted for publication in Comparative Exercise Physiology, under condition that no problems arise during the editing stage at the publisher. The comments of the reviewer(s) who reviewed your manuscript are included at the foot of this letter. The manuscript was accepted on 18 Oct 2021.

Note that that the publisher needs a signed Copyright Transfer Agreement (CTA) from the first or the corresponding author before the manuscript can be published. Please fax (+31 317 453417) or send the CTA by email to the publisher (cep@wageningenacademic.com) as soon as possible if you have not done already. A blank CTA can be found at:
www.WageningenAcademic.com/pb-assets/wagen/files/cep/CTA%20Comparative%20Exercise%20Physiology.doc

I also would like to draw your attention to the possibility of publishing your manuscript as 'open access' for 1800 Euro in Comparative Exercise Physiology. With open access, your article will be free available online for everyone. Open access publishing significantly increases the exposure and citation of your work. Often research grants have funding available for dissemination of the results of the research.

Thank you for your fine contribution. On behalf of the Editors of the Comparative Exercise Physiology, we look forward to your continued contributions to the Journal.

With kind regards,

Kenneth Harrington McKeever, PhD, FACSM, FAPS
Editor in Chief
Comparative Exercise Physiology

Comments from the Editors and Reviewers:

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: https://www.editorialmanager.com/ecep/login.asp?a=r). Please contact the publication office if you have any questions.

purwo sri rejeki <purwo-s-r@fk.unair.ac.id>

CTA for CEP-210038R3

purwo sri rejeki <purwo-s-r@fk.unair.ac.id> Wed, Oct 20, 2021 at 2:48 AM
To: cep@wageningenacademic.com
Bcc: PURWO FAAL <purwo_faal@yahoo.com>, andre andarianto <andre.andarianto-2020@fk.unair.ac.id>, andariantoandre@gmail.com

Dear Editor

Thank you for good news for us that our manuscript CEP-210038R3 entitled "Inflammatory Markers in Response to Interval and Continuous Exercise in Obese Women" was accepted in your journal. We attached our CTA in this email

Best regards

Corresponding author

Purwo Sri Rejeki

CTA+Comparative+Exercise+Physiology.pdf
176K

Galley Proof

Inflammatory markers in response to interval and continuous exercise in obese women

A. Andarianto[1], P.S. Rejeki[1,2,3*], Sakina[2,4], A. Pranoto[5], T.W. Aga Seputra[1], Sugiharto[6] and M. Miftahussurur[7,8]

[1]Sport Health Science, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No.47 Street, Pacar Kembang, Kec. Tambaksari, 60131 Surabaya, Indonesia; [2]Medical Program, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No.47 Street, Pacar Kembang, Kec. Tambaksari, 60131 Surabaya, Indonesia; [3]Physiology Division, Department of Physiology and Medical Biochemistry, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No.47 Street, Pacar Kembang, Kec. Tambaksari, 60131 Surabaya, Indonesia; [4]Department of Anatomy, Histology, and Pharmacology, Faculty of Medicine Universitas Airlangga, Prof. Dr. Moestopo No.47 Street, Pacar Kembang, Kec. Tambaksari, 60131 Surabaya Indonesia; [5]Medical Science, Faculty of Medicine, Universitas Airlangga, Prof. Dr. Moestopo No.47 Street, Pacar Kembang, Kec. Tambaksari, 60131 Surabaya, Indonesia; [6]Department of Sport Science, Faculty of Sport Science, Universitas Negeri Malang, Jl. Semarang No.5, Sumbersari, Kec. Lowokwaru, 65145 Malang, Indonesia; [7]Institute of Tropical Disease, Universitas Airlangga, Kampus C, Jl. Unair, Mulyorejo, Kec. Gubeng, 60286 Surabaya, Indonesia; [8]Gastroentero-Hepatology Division, Department of Internal Medicine, Faculty of Medicine, Dr. Soetomo Teaching Hospital, Universitas Airlangga, Jalan Mayjen, Prof. Dr. Moestopo No. 6-8, 60286 Surabaya, Indonesia; purwo-s-r@fk.unair.ac.id

Received: 18 September 2021 / Accepted: 18 October 2021
© 2022 Wageningen Academic Publishers

RESEARCH ARTICLE

Abstract

Obesity is strongly associated with the degree of inflammation characterised by proinflammatory cytokines, such as tumour necrosis factor-α (TNF-α). Lifestyle modification with exercise is the right strategy because it can stimulate interleukin 6 (IL-6) secretion which acts as an anti-inflammatory. This study aimed to analyse the response of interval and continuous exercise to inflammatory markers in obese women. Twenty-four women participated in this study and were randomly divided into 3 groups: CONG (n=8, control group without any intervention): MCEG (n=8, continuous exercise group) and MIEG (n=8, interval exercise group). ELISA was used to measure the levels of IL-6 and TNF-α, pre-exercise and post-exercise. The data were analysed using the paired sample t-test. The mean levels of TNF-α, pre-exercise and post-exercise, were 19.35±2.73 vs 19.36±2.23 pg/ml (P=0.989) in CONG, 19.42±2.79 vs 16.63±0.82 pg/ml (P=0.017) in MCEG, and 19.46±3.08 vs 16.96±2.11 pg/ml (P=0.079) in MIEG. Mean levels of IL-6, pre-exercise and post-exercise, were 7.56±2.88 vs 7.66±4.12 pg/ml (P=0.957) for CONG, 7.68±3.41 vs 13.97±2.38 pg/ml (P=0.001) for MCEG, and 7.78±1.99 vs 13.66±3.55 pg/ml (P=0.001) for MIEG. We concluded that interval and continuous exercise decreased pro-inflammatory and increased anti-inflammatory cytokines.

Keywords: inflammatory markers, interval exercise, continuous exercise, obese women

1. Introduction

In 2016, more than 1.9 billion adults of 18 years and over were overweight and more than 650 million of them were obese (WHO, 2016). Obesity is more common in women than men (Rybnikova *et al.*, 2016). The increasing prevalence of obesity occurs in both developing and developed countries (Ng *et al.*, 2014; Norheim *et al.*, 2014). The prevalence of obesity in Indonesia in 2018 (21.8%) was higher than in 2013 (14.8%) (Basic Health Research, 2018). In addition, when social distancing was established due to the coronavirus disease (COVID-19) pandemic, more than 40% of American people were considered obese (body mass index (BMI) ≥30 kg/m^2) (Kass, 2020). The high increase in obesity prevalence is a serious problem that will threaten the quality of human resources and increase health problems in many countries (Oto *et al.*, 2014).

Obesity is a complex multifactorial disease (Chooi *et al.*, 2019) and considered as risk factor for non-communicable diseases (NCDs), such as type 2 diabetes mellitus, hypertension, dyslipidaemia, heart disease, and osteoarthritis (Hruby and Hu, 2015) that can cause early death (Hawley and McGarvey, 2015). Obesity is also

systematically related to the level of inflammation and the risk of developing cancer cells (Heikkilä *et al.*, 2008). It is characterised by high levels of inflammatory markers, such as tumour necrosis factor-α (TNF-α) in obese persons (De Lorenzo *et al.*, 2016). Obesity can be genetic or caused by lifestyle (Rybnikova *et al.*, 2016), but lifestyle (unhealthy diet and low physical activity) is the main triggering factor for obesity (Hernández Bautista *et al.*, 2019; Yaya and Ghose, 2019). Therefore, lifestyle modification with exercise is the right strategy (Murawska-Cialowicz *et al.*, 2015): increasing the recruitment of skeletal muscles to do mechanical work when the body does exercise is believed to have an anti-inflammatory effect (Dantas *et al.*, 2019; Gleeson *et al.*, 2011; Pedersen, 2017; Schmidt *et al.*, 2015). One of the cytokines secreted by skeletal muscles during exercise is interleukin 6 (IL-6) (Muñoz-Cánoves *et al.*, 2013). This cytokine is a multifunctional immunoregulatory cytokine that plays a role in the immune system (Bashashati *et al.*, 2017) and activates T cells as immunotherapy related to inflammation (Xu *et al.*, 2017).

Exercise can significantly increase IL-6 levels both in plasma (Costello *et al.*, 2018; Cullen *et al.*, 2015; Ellingsgaard *et al.*, 2019), and in blood serum (Briken *et al.*, 2016; Deveci and Şanlıer, 2018; Luna *et al.*, 2011). This increase correlates with muscle contraction. Signalling of IL-6 also correlates with stimulation of muscle hypertrophy and myogenesis through regulation of the proliferative capacity of muscle stem cells (Muñoz-Cánoves *et al.*, 2013), as well as stimulating the secretion of anti-inflammatory cytokines, such as interleukin 1 receptor antagonist (IL1RA) in order to decrease pro-inflammatory cytokines (Benatti and Pedersen, 2015). This mechanism indirectly explains that exercise can prevent TNF-α increase mediated by IL-6 increase (Mauer *et al.*, 2014). However, several studies have reported controversial results. Research by Newlin *et al.* (2012) reported that treadmill exercise with an intensity of 65% VO_{2max} significantly increased IL-6 levels. Meanwhile, the results of Lira *et al.* (2017) showed that immediately after moderate-intensity treadmill exercise IL-6 levels will decrease. Research conducted by Bernecker *et al.* (2013) revealed that during a marathon race the TNF-α levels increase. However, research by Hoseini *et al.* (2018) reported that aerobic exercise with an intensity of 70% HR_{max} can reduce TNF-α levels. So far, the effect of exercise on obesity related to IL-6 and TNF-α parameters has not been explored. Therefore, this study aims to reveal the response of inflammatory markers as a result of moderate-intensity interval and continuous exercise in obese women aged 18-23 years with a BMI of 25-35 kg/m^2. The results of this study can be used as a strategy to reduce the prevalence and level of inflammation in obesity.

2. Material and methods

Experimental design

This study used the Randomized Pretest-Posttest Control Group Design with 24 obese women aged 19-23 years as subjects. The subjects had a body mass index (BMI) of 27-32 kg/m^2, maximal oxygen volume (VO_{2max}) 26-30 ml/kg/min examined using the Astrand 6-min cycle test, normal blood pressure (110/70 to 120/80 mmHg), normal resting heart rate (RHR) (60-80 bpm), fasting blood glucose (FBG) ≤100 mg/dl, normal haemoglobin (Hb) (13-18 g/dl), normal oxygen saturation (SpO_2) (95-100%). The subjects were randomly divided into 3 groups, namely CONG (n=8, control group without intervention): MCEG (n=8, moderate-intensity continuous exercise group) and MIEG (n=8, moderate-intensity interval exercise group). All subjects received verbal or written information about the research. Subjects filled out and signed an informed consent before participating in the study. All research procedures have been approved by the Health Research Ethics Commission, Faculty of Medicine, Universitas Airlangga Surabaya, number 309/EC/KEPK/FKUA/2019.

Exercise protocol

Continuous exercise was done by running on a treadmill with an intensity of 60-70% HR_{max} for 40 min, and consisted of 5 min of warming up (50-60% HR_{max}), 30 min of core exercise (60-70% HR_{max}) and 5 min of cooling (50-60% HR_{max}). Interval exercise was done by running on a treadmill with moderate intensity 60-70% HR_{max} for 45 min, and consisted of 5 min of warm-up (50-60% HR_{max}), 35 min of core exercise (5 min of work at 60-70% HR_{max} interspersed with active recovery on a treadmill for 2.5 min at 50-60% HR_{max} in 5 repetitions) and 5 min of cooling down (50-60% HR_{max}) (Dias *et al.*, 2018; Norton *et al.*, 2010; Rejeki *et al.*, 2021; Wewege *et al.*, 2017). Continuous intervention and interval exercise were performed at 7:00-09:00 am (Kraemer *et al.*, 2014; Nygaard *et al.*, 2015) using a Pulsar 4.0 HP Cosmos Sports & Medical treadmill (Nussdorf-Traunstein, Germany) (Nedić *et al.*, 2017). During exercise, heart rate was monitored using a polar heart rate monitor (Polar H10 Heart Rate Sensor; Polar, Kempele, Finland).

Data collection

Measurement of height was done using a stadiometer (SECA, Chino, CA, USA). Body weight was measured using a digital scale (Omron HN-289, Kyoto, Japan). BMI is calculated as weight in kilograms divided by height squared in meters. VO_{2max} was measured using the Astrand 6-min cycle test method using an ergocycle tool (Monark 828 E, Version 1010; Monark, Vansbro, Sweden). Measurement of RHR used a Pulse Oximeter (PO 30 Pulse Oximeter, Beurer,

Galley proof

Germany). Blood pressure was measured using an Omron HEM-7130 L automated device at the nondominant arm 3 times consecutively with a 1-2 min interval between two measurements while participants were in a seated position.

Blood collection and blood analysis

Blood sampling was performed in a cubital vein, and about 4 ml were taken after a 12 h overnight fasting (Daskalopoulou *et al.*, 2014; Elizondo-Montemayor *et al.*, 2017). Sampling was done 30 min before and 10 min after exercise. Blood was centrifuged for 15 min at 3,000 rpm. Serum was separated and stored at -80 °C for analysis of TNF-α and IL-6 levels during the next day (Daskalopoulou *et al.*, 2014; Tsuchiya *et al.*, 2014, 2015). The TNF-α level was measured using an ELISA kit (E-EL-H0109; Human TNF-α ELISA Kit; Elabscience, Houston, TX, USA) with kit sensitivity of 4.69 pg/ml and detection range 7.81-500 pg/ml. The IL-6 level was measured using an ELISA kit (E-EL-H0102; Human IL-6 ELISA Kit; Elabscience) with a kit sensitivity of 4.69 pg/ml and a detection range of 7.81-500 pg/ml. Measurement of fasting blood glucose (FBG) was done with an Accu-Chek Performa (Roche Diagnostics, Mannheim, Germany) with a concentration unit of mg/dl, while measurement of Hb was done using Mission Hb Test Strips, (ACON laboratories, Inc., San Diego, CA, USA) with a concentration unit of g/dl.

Statistical analysis

Statistical analysis using SPSS software version 21 (Chicago, IL, USA). The normality test used the Shapiro-Wilk test, while the homogeneity test used the Levene test. Difference test used the paired sample t-test, one-way repeated measures ANOVA, followed by Tukey's Honestly Significant Difference (HSD) post hoc test. All data are shown with mean ± standard deviation (SD). All statistical analyses used a significant level set at $P \leq 0.05$.

3. Results

The basic profiles of the samples, including age, height, weight, body mass index, haemoglobin, fasting blood glucose, systolic blood pressure, diastolic blood pressure, resting heart rate, maximal oxygen volume, oxygen saturation, are displayed in Table 1. Table 1 shows that the average data of research subjects including age, height, weight, body mass index, haemoglobin, fasting blood glucose, systolic blood pressure, diastolic blood pressure, resting heart rate, maximal oxygen volume, did not show significant differences in each. group ($P \geq 0.05$).

The analysis of the paired sample t-test on CONG show that there was no significant difference in the mean TNF-α levels between pre-exercise vs post-exercise ($P>0.05$) (Figure 1). Likewise, this was found for MIEG ($P>0.05$). However, MCEG showed a significant difference in the mean TNF-α levels between pre-exercise vs post-exercise ($P \leq 0.05$) (Figure 1). The analysis of the IL-6 levels between pre-exercise vs post-exercise in each group is shown in Figure 2. The analysis of the paired sample t-test showed that there was no significant difference in the mean levels of IL-6 on CONG between pre-exercise vs post-exercise ($P>0.05$) (Figure 2). However, MIEG and MCEG both showed a significant difference in the mean IL-6 levels between pre-exercise vs post-exercise ($P \leq 0.01$) (Figure 2).

Table 1. Characteristics of study subjects.[1,2]

Parameter	Group			*P*-value
	CONG (n=8)	MCEG (n=8)	MIEG (n=8)	
Age (yrs)	21.12±1.46	21.37±1.41	21.25±1.75	0.949
Height (m)	1.58±0.04	1.57±0.05	1.59±0.06	0.851
Weight (kg)	73.87±6.84	71.94±7.54	72.64±8.36	0.876
BMI (kg/m^2)	29.55±1.76	28.94±1.45	28.82±1.76	0.650
Hb (g/dl)	15.76±1.88	15.02±0.97	15.07±1.01	0.489
FBG (mg/dl)	91.00±6.69	89.62±7.56	89.37±5.71	0.873
SBP (mmHg)	114.75±4.56	113.12±3.23	114.62±4.27	0.677
DBP (mmHg)	75.75±4.27	75.62±4.31	75.87±4.02	0.993
RHR (bpm)	73.12±6.79	72.12±4.85	72.62±5.21	0.940
VO_{2max} (ml/kg/min)	27.21±2.12	28.53±3.13	26.19±0.97	0.139
SpO_2 (%)	97.62±1.51	97.50±1.41	97.25±1.28	0.863

[1] BMI = body mass index; Hb = haemoglobin; FBG = fasting blood glucose; SBP = systolic blood pressure; DBP = diastolic blood pressure; RHR = resting heart rate; VO_{2max} = maximum oxygen volume; SpO_2 = oxygen saturation; CONG = control group; MCEG = moderate-intensity continuous exercise group; MIEG = moderate-intensity interval exercise group.

[2] Data are presented as mean ± standard deviation. *P*-value were obtained using one way-ANOVA.

Please cite this article as 'in press'

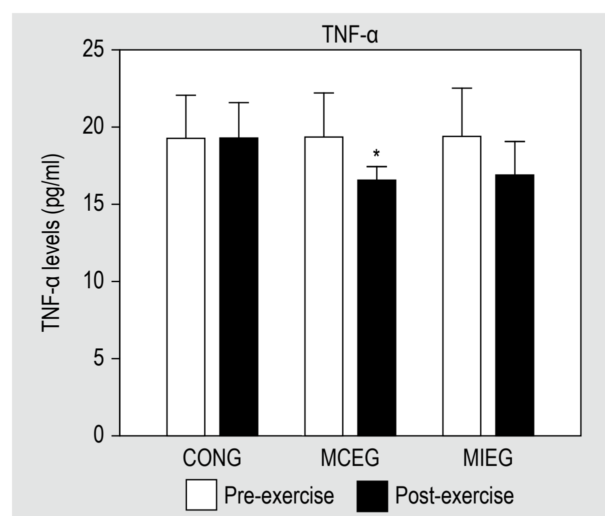

Figure 1. Tumour necrosis factor (TNF)-α levels pre-exercise versus post-exercise. CONG = control group; MCEG = moderate-intensity continuous exercise group; MIEG = moderate-intensity interval exercise group. Data are presented as mean ± standard deviation. *P*-value were obtained using paired samples t-test to compare post-exercise vs pre-exercise. * *P*≤0.05.

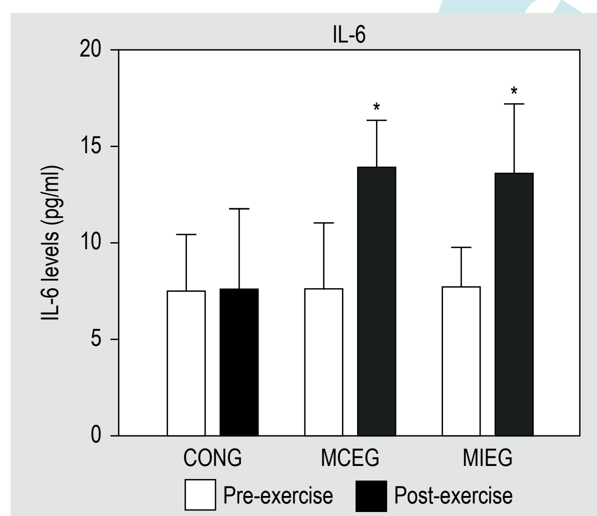

Figure 2. Interleukin 6 (IL-6) levels pre-exercise versus post-exercise. CONG = control group; MCEG = moderate-intensity continuous exercise group; MIEG = moderate-intensity interval exercise group. Data are presented as mean ± standard deviation. *P*-value were obtained using paired samples t-test to compare post-exercise vs pre-exercise. * *P*≤0.05.

Table 2. Tumour necrosis factor (TNF)-α and interleukin (IL)-6 levels in each group based on the blood collection time.[1]

Parameter	Time	Group			*P*-value
		CONG (n=8)	MCEG (n=8)	MIEG (n=8)	
TNF-α (pg/ml)	pre-exercise	19.35±2.73	19.42±2.79	19.46±3.08	0.997
	post-exercise	19.36±2.23	16.63±0.82*	16.96±2.11*	0.014
IL-6 (pg/ml)	pre-exercise	7.56±2.88	7.68±3.41	7.78±1.99	0.988
	post-exercise	7.66±4.12	13.97±2.38*	13.66±3.55*	0.002

[1] CONG = control group; MCEG = moderate-intensity continuous exercise group; MIEG = moderate-intensity interval exercise group.
[2] Data are presented as mean ± standard deviation. One way-ANOVA, followed by Tukey's HSD post hoc test, was used to compare the differences among groups. * significant vs control group (CONG) (*P*≤0.05).

The analysis of TNF-α and IL-6 levels in each group based on the blood collection time is shown in Table 2.

The results of the one-way repeated measures ANOVA test showed no significant difference in the mean TNF-α levels of each group when measured in pre-exercise blood (*P*>0.05), while the post-exercise showed a significant difference in the mean TNF-α levels (*P*≤0.05) (Table 2). The results of the Tukey's HSD post hoc test showed significant difference in the mean post-exercise TNF-α levels between MCEG and CONG (*P*=0.019), MIEG and CONG (*P*=0.041), while MCEG and MIEG did not show a significant difference (*P*>0.05). The results of the one-way repeated measures ANOVA showed no significant difference in the mean levels of IL-6 of each group when measured in pre-exercise blood (*P*≥0.05), whereas in the post-exercise there was a significant difference in the mean levels of IL-6 (*P*≤0.05). The results of the Tukey's HSD post hoc test showed that there was a significant difference in the mean post-exercise IL-6 levels between MCEG and CONG (*P*=0.004), MIEG and CONG (*P*=0.006), while MCEG and MIEG did not show a significant difference *P*>0.05).

4. Discussion

This study aimed to analyse the response of interval and continuous exercise to inflammatory markers in obese women. Based on the one-way repeated measures ANOVA test, the characteristics of the research subjects showed no significant difference (*P*>0.05). These prove that the

subject is in the same physical condition before doing the exercise. The main finding in this study was an increase in IL-6 levels and a decrease in TNF-α levels in the interval and continuous groups 10 min post-exercise. During exercise, there is an increase in muscle contraction that causes muscle fibre damage and low glycogen, thereby triggering a response from skeletal muscles to repair muscle fibres (myogenesis) and replenish muscle glycogen by secreting IL-6 cytokines. Muñoz-Cánoves *et al.* (2013) stated that IL-6 signalling has been associated with stimulation of muscle hypertrophy and myogenesis through regulation of the proliferative capacity of muscle stem cells. Santos *et al.* (2019) in his research using obese adolescent subjects who were given an exercise intervention for 30 min, stated that there was a significant increase in IL-6 levels ($P \leq 0.05$). Similar results with this study in relation to TNF-α parameters have been carried out by Mauer *et al.* (2014) who demonstrated a low-grade inflammatory effect by administering a low dose of *Escherichia coli* endotoxin (0.06 ng/kg) to healthy volunteers, who were randomised to rest or exercise prior to infusion. The results show that in resting individuals, endotoxin has induced a 2- to 3-fold increase in circulating TNF-α. On the other hand, in participants who did 3 h of cycling the ergometer showed that exercise inhibited TNF-α production. An increase in IL-6 and a decrease in TNF-α during exercise certainly has a special relationship, because in addition to trigger glycogenolysis and lipolysis processes as energy reserves (Benatti and Pedersen, 2015), IL-6 secreted by muscles during exercise has an anti-inflammatory effect (Muñoz-Cánoves *et al.*, 2013) by stimulating IL-10 in circulation, interleukin 1 receptor antagonist (IL1RA), and the level of tumour necrosis factor-soluble receptor (sTNFr) which causing decrease in pro-inflammatory factors (Brandt and Pedersen, 2010; Cabral-Santos *et al.*, 2015; Lira *et al.*, 2015) like TNF-α (Metsios *et al.*, 2020). In addition, exercise is also believed to stimulate a phenotypic switch from M1-type macrophages that produce TNF, IL-6, and nitric oxide to M2-type macrophages, which release arginase and anti-inflammatory cytokines (Kawanishi *et al.*, 2010; Oliveira *et al.*, 2013). Kawanishi *et al.* (2010) stated that after exercise it will result in a decrease in tissue expression of intercellular adhesion molecule-1 (ICAM-1): which is involved in the adhesion of inflammatory cells to the endothelium and conveys the interaction of T cells with target cells, thereby inhibiting the migration of pro-inflammatory M1-type macrophages in adipose tissue.

Based on the analysis, no significant difference was found in the levels of IL-6 and TNF-α between the interval group and the continuous group, although when viewed from the mean levels of IL-6 and TNF-α in the continuous exercise group, it was shown to be more effective in increasing IL-6 and reduce TNF-α levels. However, when compared to the control group, IL-6 levels in the interval and continuous groups were higher and TNF-α levels were lower after exercise. This is similar to the research conducted by Newlin *et al.* (2012) which reported that moderate-intensity continuous exercise (65% VO_{2max}) significantly increased IL-6 levels. Results related to TNF-α parameters in this study are similar to the research conducted by Hoseini *et al.* (2018) in which male smokers and non-smokers were given a continuous aerobic exercise intervention for 40 min with an intensity of 70% HR_{max}; the result was that TNF-α levels decreased. In addition, Lira *et al.* (2017) have also proven in their research with active male subjects, performing aerobic exercise using a treadmill continuously with a distance of 5 km and a speed of 70% of the maximum aerobic capacity, that IL-6 levels increased 60 min post-exercise and TNF-α levels decreased post-exercise. The high increase in IL-6 and decrease in TNF-α in continuous exercise correlated with a higher rate of muscle contraction in continuous exercise compared to interval training. When muscle contraction increases, it causes muscle fibre damage and low glycogen, thereby triggering a response from skeletal muscle to repair muscle fibres (myogenesis) (Muñoz-Cánoves *et al.*, 2013) and replenish muscle glycogen by secreting the cytokine IL-6 (Benatti and Pedersen, 2015). High levels of IL-6 cause TNF-α decrease by stimulating an increase in circulating IL-10, IL1RA, and sTNFr levels that specifically reduce pro-inflammatory factors (Brandt and Pedersen, 2010; Cabral-Santos *et al.*, 2015; Lira *et al.*, 2015).

IL-6 is the myokine prototype, although most rheumatologists may view IL-6 as a proinflammatory cytokine. There is evidence that IL-6 released from muscle during exercise has an anti-inflammatory function (Muñoz-Cánoves *et al.*, 2013; Pal *et al.*, 2014). This is because the signalling pathways for IL 6 secreted by myocytes with macrophages are very different (Pedersen and Febbraio, 2008). Unlike IL-6 signalling in macrophages, which depend on activation of the nuclear factor-κB (NF-κB) signalling pathway, intramuscular IL-6 expression is regulated by a network signalling cascade involving crosstalk between Ca^{2+} and nuclear factor of activated T-cells (Muñoz-Cánoves *et al.*, 2013). Therefore, when IL-6 is activated by macrophages, a proinflammatory response will be created, while the increase in IL-6 secreted by myocytes does not depend on the TNF-α response or by NF-κB activation (Muñoz-Cánoves *et al.*, 2013) so it is anti-inflammatory because it can stimulate an increase in anti-inflammatory cytokines, i.e. IL1RA and IL-10, so that it can decrease pro-inflammatory cytokines (Pedersen, 2009). In addition, during inflammatory conditions IL-6 has also been shown to limit the expression of genes encoding inflammatory cytokines (e.g. TNF-α, IL-1β, nitric oxide synthase 2) and activation of terminal c-Jun N kinase which then enhances macrophage responsiveness to IL-4, thereby greatly supporting the idea that IL-6 can reduce inflammation levels (Mauer *et al.*, 2014). This is very different from the signalling pathway of TNF-α, which is only mediated by macrophage activation so that the high increase in TNF-α

Galley Proof

only occurs in chronic inflammation (Vijayaraghava and Doreswamy, 2017).

Limitations to the current study include (1) the small sample size, (2) determination of obesity using only BMI, and (3) subjects only performing acute exercise. Firstly, in this study, we only used a small sample size with the total number of subjects 24 obese women. Therefore, a future study should include a larger number of women obese subjects. Secondly, the use of BMI to determine obesity has low accuracy because it does not describe human composition, such as free fat mass, fat mass, and fat distribution (Akpinar *et al.*, 2007). Therefore, further research is recommended to measure free fat mass, fat mass, percentage body fat, and muscle mass using dual-energy absorptiometry (DEXA) as a determinant of obesity. Thirdly, this study only studied acute intervention (exercise), so that further research is needed to determine the effect of the chronic intervention (training) on obese women. The results are expected to be useful for stabilising optimal exercise programmes in obesity management in the future.

5. Conclusions

Based on the study results, it can be concluded that single sessions of moderate-intensity continuous and interval exercise performed for 30-35 min significantly reduced pro-inflammatory and increased anti-inflammatory cytokines.

Acknowledgements

We would like to express our gratitude to Faculty of Sport Science State University of Malang that has provided facilities in the screening process of a prospective research subject and Fitness Center of Health Ministry of Malang that has provided facilities well. We gratefully acknowledge the research participants for their participation in this study.

Conflict of interest

The authors declare that they have no competing interests.

References

Akpinar, E., Bashan, I., Bozdemir, N. and Saatci, E., 2007. Which is the best anthropometric technique to identify obesity: body mass index, waist circumference or waist-hip ratio? Collegium Antropologicum 31: 387-393.

Bashashati, M., Moradi, M. and Sarosiek, I., 2017. Interleukin-6 in irritable bowel syndrome: a systematic review and meta-analysis of IL-6 (-G174C) and circulating IL-6 levels. Cytokine 99: 132-138. https://doi.org/10.1016/j.cyto.2017.08.017

Basic Health Research (Riskesdas), 2018. National report on basic health research. Ministry of Health Indonesia, Jakarta, Indonesia. Available at: http://www.kesmas.kemkes.go.id

Benatti, F.B. and Pedersen, B.K., 2015. Exercise as an anti-inflammatory therapy for rheumatic diseases-myokine regulation. Nature Reviews Rheumatology 11: 86-97. https://doi.org/10.1038/nrrheum.2014.193

Bernecker, C., Scherr, J., Schinner, S., Braun, S., Scherbaum, W.A. and Halle, M., 2013. Evidence for an exercise induced increase of TNF-α and IL-6 in marathon runners. Scandinavian Journal of Medicine and Science in Sports 23: 207-214. https://doi.org/10.1111/j.1600-0838.2011.01372.x

Brandt, C. and Pedersen, B.K., 2010. The role of exercise-induced myokines in muscle homeostasis and the defense against chronic diseases. Journal of Biomedicine and Biotechnology 2010: 520258. https://doi.org/10.1155/2010/520258

Briken, S., Rosenkranz, S.C., Keminer, O., Patra, S., Ketels, G., Heesen, C., Hellweg, R., Pless, O., Schulz, K.H. and Gold, S.M., 2016. Effects of exercise on irisin, BDNF and IL-6 serum levels in patients with progressive multiple sclerosis. Journal of Neuroimmunology 299: 53-58. https://doi.org/10.1016/j.jneuroim.2016.08.007

Cabral-Santos, C., Gerosa-Neto, J., Inoue, D.S., Panissa, V.L., Gobbo, L.A., Zagatto, A.M., Campos, E.Z. and Lira, F.S., 2015. Similar anti-inflammatory acute responses from moderate-intensity continuous and high-intensity intermittent exercise. Journal of Sports Science and Medicine 14: 849-856.

Chooi, Y.C., Ding, C. and Magkos, F., 2019. The epidemiology of obesity. Metabolism: Clinical and Experimental 92: 6-10. https://doi.org/10.1016/j.metabol.2018.09.005

Costello, J.T., Rendell, R.A., Furber, M., Massey, H.C., Tipton, M.J., Young, J.S. and Corbett, J., 2018. Effects of acute or chronic heat exposure, exercise and dehydration on plasma cortisol, IL-6 and CRP levels in trained males. Cytokine 110: 277-283. https://doi.org/10.1016/j.cyto.2018.01.018

Cullen, T., Thomas, A.W., Webb, R. and Hughes, M.G., 2015. The relationship between interleukin-6 in saliva, venous and capillary plasma, at rest and in response to exercise. Cytokine 71: 397-400. https://doi.org/10.1016/j.cyto.2014.10.011

Dantas, W.S., Neves, W.D., Gil, S., Barcellos, C., Rocha, M.P., De Sá-Pinto, A.L., Roschel, H. and Gualano, B., 2019. Exercise-induced anti-inflammatory effects in overweight/obese women with polycystic ovary syndrome. Cytokine 120: 66-70. https://doi.org/10.1016/j.cyto.2019.04.006

Daskalopoulou, S.S., Cooke, A.B., Gomez, Y.H., Mutter, A.F., Filippaios, A., Mesfum, E.T. and Mantzoros, C.S., 2014. Plasma irisin levels progressively increase in response to increasing exercise workloads in young, healthy, active subjects. European Journal of Endocrinology 171: 343-352. https://doi.org/10.1530/EJE-14-0204

De Lorenzo, A., Soldati, L., Sarlo, F., Calvani, M., Di Lorenzo, N. and Di Renzo, L., 2016. New obesity classification criteria as a tool for bariatric surgery indication. World Journal of Gastroenterology 22: 681-703. https://doi.org/10.3748/wjg.v22.i2.681

Deveci, G. and Şanlıer, N., 2018. Sitting time, walking, moderate and intensity exercise may effect serum il-4 and il-6 levels in colorectal cancer patients. Clinical Nutrition 37: S83-S84. https://doi.org/1016/j.clnu.2018.06.1330

Galley proof

Dias, K.A., Ingul, C.B., Tjønna, A.E., Keating, S.E., Gomersall, S.R., Follestad, T., Hosseini, M.S., Hollekim-Strand, S.M., Ro, T.B., Haram, M., Huuse, E.M., Davies, P., Cain, P.A., Leong, G.M. and Coombes, J.S., 2018. Effect of high-intensity interval training on fitness, fat mass and cardiometabolic biomarkers in children with obesity: a randomised controlled trial. Sports Medicine 48: 733-746. https://doi.org/10.1007/s40279-017-0777-0

Elizondo-Montemayor, L., Castillo, E.C., Rodríguez-López, C., Villarreal-Calderón, J.R., Gómez-Carmona, M., Tenorio-Martínez, S., Nieblas, B. and García-Rivas, G., 2017. Seasonal variation in Vitamin D in association with age, inflammatory cytokines, anthropometric parameters, and lifestyle factors in older adults. Mediators of Inflammation 2017: 5719461. https://doi.org/10.1155/2017/5719461

Ellingsgaard, H., Hojman, P. and Pedersen, B.K., 2019. Exercise and health-emerging roles of IL-6. Current Opinion in Physiology 10: 49-54. https://doi.org/10.1016/j.cophys.2019.03.009

Gleeson, M., Bishop, N.C., Stensel, D.J., Lindley, M.R., Mastana, S.S. and Nimmo, M.A., 2011. The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. Nature Reviews Immunology 11: 607-615. https://doi.org/10.1038/nri3041

Hawley, N.L. and McGarvey, S.T., 2015. Obesity and diabetes in Pacific Islanders: the current burden and the need for urgent action. Current Diabetes Reports 15: 29. https://doi.org/10.1007/s11892-015-0594-5

Heikkilä, K., Ebrahim, S. and Lawlor, D.A., 2008. Systematic review of the association between circulating interleukin-6 (IL-6) and cancer. European Journal of Cancer 44: 937-945. https://doi.org/10.1016/j.ejca.2008.02.047

Hernández Bautista, R.J., Mahmoud, A.M., Königsberg, M. and López Díaz Guerrero, N.E., 2019. Obesity: pathophysiology, monosodium glutamate-induced model and anti-obesity medicinal plants. Biomedicine and Pharmacotherapy 111: 503-516. https://doi.org/10.1016/j.biopha.2018.12.108

Hoseini, M.A.S., Eizadi, M., Amini, A. and Mirakhori, Z., 2018. Acute and recovery changes of TNF-α and IL-1β in response to aerobic exercise in smokers and non-smokers. International Journal of Basic Science in Medicine 3: 109-113.

Hruby, A. and Hu, F.B., 2015. The epidemiology of obesity: a big picture. Pharmaco Economics 33: 673-689. https://doi.org/10.1007/s40273-014-0243-x

Kass, D.A., 2020. COVID-19 and severe obesity: a big problem? Annals of Internal Medicine 173: 840-841. https://doi.org/10.7326/M20-5677

Kawanishi, N., Yano, H., Yokogawa, Y. and Suzuki, K., 2010. Exercise training inhibits inflammation in adipose tissue via both suppression of macrophage infiltration and acceleration of phenotypic switching from M1 to M2 macrophages in high-fat-diet-induced obese mice. Exercise Immunology Review 16: 105-118.

Kraemer, R.R., Shockett, P., Webb, N.D., Shah, U. and Castracane, V.D., 2014. A transient elevated irisin blood concentration in response to prolonged, moderate aerobic exercise in young men and women. Hormone and Metabolic Research 46: 150-154. https://doi.org/10.1055/s-0033-1355381

Lira, F.S., Dos Santos, T., Caldeira, R.S., Inoue, D.S., Panissa, V., Cabral-Santos, C., Campos, E.Z., Rodrigues, B. and Monteiro, P.A., 2017. Short-term high- and moderate-intensity training modifies inflammatory and metabolic factors in response to acute exercise. Frontiers in Physiology 8: 856. https://doi.org/10.3389/fphys.2017.00856

Lira, F.S., Panissa, V.L., Julio, U.F. and Franchini, E., 2015. Differences in metabolic and inflammatory responses in lower and upper body high-intensity intermittent exercise. European Journal of Applied Physiology 115: 1467-1474. https://doi.org/10.1007/s00421-015-3127-7

Luna Jr, L.A., Bachi, A.L., Novaes e Brito, R.R., Eid, R.G., Suguri, V.M., Oliveira, P.W., Gregorio, L.C. and Vaisberg, M., 2011. Immune responses induced by Pelargonium sidoides extract in serum and nasal mucosa of athletes after exhaustive exercise: modulation of secretory IgA, IL-6 and IL-15. Phytomedicine: International Journal of Phytotherapy and Phytopharmacology 18: 303-308. https://doi.org/10.1016/j.phymed.2010.08.003

Mauer, J., Chaurasia, B., Goldau, J., Vogt, M.C., Ruud, J., Nguyen, K.D., Theurich, S., Hausen, A.C., Schmitz, J., Brönneke, H.S., Estevez, E., Allen, T.L., Mesaros, A., Partridge, L., Febbraio, M.A., Chawla, A., Wunderlich, F.T. and Brüning, J.C., 2014. Signaling by IL-6 promotes alternative activation of macrophages to limit endotoxemia and obesity-associated resistance to insulin. Nature Immunology 15: 423-430. https://doi.org/10.1038/ni.2865

Metsios, G.S., Moe, R.H. and Kitas, G.D., 2020. Exercise and inflammation. Best Practice and Research Clinical Rheumatology 34: 101-504. https://doi.org/10.1016/j.berh.2020.101504

Muñoz-Cánoves, P., Scheele, C., Pedersen, B.K. and Serrano, A.L., 2013. Interleukin-6 myokine signaling in skeletal muscle: a double-edged sword? FEBS Journal 280: 4131-4148. https://doi.org/10.1111/febs.12338

Murawska-Cialowicz, E., Wojna, J. and Zuwala-Jagiello, J., 2015. Crossfit training changes brain-derived neurotrophic factor and irisin levels at rest, after wingate and progressive tests, and improves aerobic capacity and body composition of young physically active men and women. Journal of Physiology and Pharmacology 66: 811-821.

Nedić, O., Šunderić, M., Miljuš, G., Valdevit, Z., Jakovljević, V., Glibetić, M. and Vučić, V., 2017. Preparatory training attenuates drastic response of the insulin-like growth factor binding protein 1 at the point of maximal oxygen consumption in handball players. Journal of Sport and Health Science 6: 372-377. https://doi.org/10.1016/j.jshs.2016.01.014

Newlin, M.K., Williams, S., McNamara, T., Tjalsma, H., Swinkels, D.W. and Haymes, E.M., 2012. The effects of acute exercise bouts on hepcidin in women. International Journal of Sport Nutrition and Exercise Metabolism 22: 79-88. https://doi.org/10.1123/ijsnem.22.2.79

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E.C., Biryukov, S., Abbafati, C., Abera, S.F., Abraham, J.P., Abu-Rmeileh, N.M.E., Achoki, T., AlBuhairan, F.S., Alemu, Z.A., Alfonso, R., Ali, M.K., Ali, R., Guzman, N.A., Ammar, W., Anwari, P., Banerjee, A., Barquera, S., Basu, S., Bennett, D.A., Bhutta, Z., Blore, J., Cabral, N., Nonato, I.C., Chang, J., Chowdhury, R., Courville, K.J., Criqui, M.H., Cundiff, D.K., Dabhadkar, K.C.,

Galley proof

Dandona, L., Davis, A., Dayama, A., Dharmaratne, S.D., Ding, E.L., Durrani, A.M., Esteghamati, A., Farzadfar, F., Fay, D.F.J., Feigin, V.L., Flaxman, A., Forouzanfar, M.H., Goto, A., Green, M.A., Gupta, R., Hafezi-Nejad, N., Hankey, G.J., Harewood, H.C., Havmoeller, R., Hay, S., Hernandez, L., Husseini, A., Idrisov, B.T., Ikeda, N., Islami, F., Jahangir, E., Jassal, S.K., Jee, S.H., Jeffreys, M., Jonas, J.B., Kabagambe, E.K., Khalifa, S.E.A.H., Kengne, A.P., Khader, Y.S., Khang, Y., Kim, D., Kimokoti, R.W., Kinge, J.M., Kokubo, Y., Kosen, S., Kwan, G., Lai, T., Leinsalu, M., Li, Y., Liang, X., Liu, S., Logroscino, G., Lotufo, P.A., Lu, Y., Ma, J., Mainoo, N.K., Mensah, G.A., Merriman, T.R., Mokdad, A.H., Moschandreas, J., Naghavi, M., Naheed, A., Nand, D., Narayan, K.M.V., Nelson, E.L., Neuhouser, M.L., Nisar, M.I., Ohkubo, T., Oti, S.O., Pedroza, A., Prabhakaran, D., Roy, N., Sampson, U., Seo, H., Sepanlou, S.G., Shibuya, K., Shiri, R., Shiue, I., Singh, G.M., Singh, J.A., Skirbekk, V., Stapelberg, N.J.C., Sturua, L., Sykes, B.L., Tobias, M., Tran, B.X., Trasande, L., Toyoshima, H., Van de Vijver, S., Vasankari, T.J., Veerman, J.L., Velasquez-Melendez, G., Vlassov, V.V., Vollset, S.E., Vos, T., Wang, C., Wang, S.X., Weiderpass, E., Werdecker, A., Wright, J.L., Yang, Y.C.,Yatsuya, H., Yoon, J., Yoon, S., Zhao, Y., Zhou, M., Zhu, S., Lopez, A.D., Murray, C.J.L. and Gakidou, E., 2014. Global regional and national prevalence of overweight and obesity in children and adults 1980-2013: a systematic analysis. The Lancet 384: 766-781. https://doi.org/10.1016/S0140-6736(14)60460-8

Norheim, F., Langleite, T.M., Hjorth, M., Holen, T., Kielland, A., Stadheim, H.K., Gulseth, H.L., Birkeland, K.I., Jensen, J. and Drevon, C.A., 2014. The effects of acute and chronic exercise on PGC-1α, irisin and browning of subcutaneous adipose tissue in humans. FEBS Journal 281: 739-749. https://doi.org/10.1111/febs.12619

Norton, K., Norton, L. and Sadgrove, D., 2010. Position statement on physical activity and exercise intensity terminology. Journal of Science and Medicine in Sport 13: 496-502. https://doi.org/10.1016/j.jsams.2009.09.008

Nygaard, H., Slettaløkken, G., Vegge, G., Hollan, I., Whist, J.E., Strand, T., Rønnestad, B.R. and Ellefsen, S., 2015. Irisin in blood increases transiently after single sessions of intense endurance exercise and heavy strength training. PLoS ONE 10: e0121367. https://doi.org/10.1371/journal.pone.0121367

Oliveira, A.G., Araujo, T.G., Carvalho, B.M., Guadagnini, D., Rocha, G.Z., Bagarolli, R.A., Carvalheira, J.B. and Saad, M.J., 2013. Acute exercise induces a phenotypic switch in adipose tissue macrophage polarization in diet-induced obese rats. Obesity 21: 2545-2556. https://doi.org/10.1002/oby.20402

Oto, Y., Tanaka, Y., Abe, Y., Obata, K., Tsuchiya, T., Yoshino, A., Murakami, N. and Nagai, T., 2014. Exacerbation of BMI after cessation of growth hormone therapy in patients with Prader-Willi syndrome. American Journal of Medical Genetics, Part A, 164A: 671-675. https://doi.org/10.1002/ajmg.a.36355

Pal, M., Febbraio, M.A. and Whitham, M., 2014. From cytokine to myokine: the emerging role of interleukin-6 in metabolic regulation. Immunology and Cell Biology 92: 331-339. https://doi.org/10.1038/icb.2014.16

Pedersen, B.K., 2009. The diseasome of physical inactivity – and the role of myokines in muscle-fat cross talk. Journal of Physiology 587: 5559-5568. https://doi.org/10.1113/jphysiol.2009.179515

Pedersen, B.K., 2017. Anti-inflammatory effects of exercise: role in diabetes and cardiovascular disease. European Journal of Clinical Investigation 47: 600-611. https://doi.org/10.1111/eci.12781

Pedersen, B.K. and Febbraio, M.A., 2008. Muscle as an endocrine organ: focus on muscle-derived interleukin-6. Physiological Reviews 88: 1379-1406. https://doi.org/10.1152/physrev.90100.2007

Rejeki, P.S., Pranoto, A., Prasetya, R.E. and Sugiharto, S., 2021. Irisin serum increasing pattern is higher at moderate-intensity continuous exercise than at moderate-intensity interval exercise in obese females. Comparative Exercise Physiology 17: 475-484. https://doi.org/10.3920/CEP200050

Rybnikova, N.A., Haim, A. and Portnov, B.A., 2016. Does artificial light-at-night exposure contribute to the worldwide obesity pandemic? International Journal of Obesity 40: 815-823. https://doi.org/10.1038/ijo.2015.255

Santos, G.C.D., Faria, W.F., Sasaki, J.E., Elias, R.M.G. and Stabelini Neto, A., 2019. Acute effects of physical exercise at different intensities on inflammatory markers in obese adolescents. Journal of Physical Education 30: e-3014. https://doi.org/10.4025/jphyseduc.v30i1.3014

Schmidt, F.M., Weschenfelder, J., Sander, C., Minkwitz, J., Thormann, J., Chittka, T., Mergl, R., Kirkby, K.C., Faßhauer, M., Stumvoll, M., Holdt, L.M., Teupser, D., Hegerl, U. and Himmerich, H., 2015. Inflammatory cytokines in general and central obesity and modulating effects of physical activity. PLoS ONE 10: e0121971. https://doi.org/10.1371/journal.pone.0121971

Tsuchiya, Y., Ando, D., Goto, K., Kiuchi, M., Yamakita, M. and Koyama, K., 2014. High-intensity exercise causes greater irisin response compared with low-intensity exercise under similar energy consumption. Tohoku Journal of Experimental Medicine 233: 135-140. https://doi.org/10.1620/tjem.233.135

Tsuchiya, Y., Ando, D., Takamatsu, K. and Goto, K., 2015. Resistance exercise induces a greater irisin response than endurance exercise. Metabolism: Clinical and Experimental 64: 1042-1050. https://doi.org/10.1016/j.metabol.2015.05.010

Vijayaraghava, A. and Doreswamy, V., 2017. Exercise and the cytokines-interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α): a review. Annals of Medical Physiology 1: 3-8.

Wewege, M., Van den Berg, R., Ward, R.E. and Keech, A., 2017. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis. Obesity Reviews 18: 635-646. https://doi.org/10.1111/obr.12532

World Health Organization (WHO), 2016. Global report on diabetes: executive summary. WHO, Geneva, Switzerland. Available at: https://www.who.int/gho/ncd/risk_factors/overweight/en/

Xu, E., Pereira, M., Karakasilioti, I., Theurich, S., Al-Maarri, M., Rappl, G., Waisman, A., Wunderlich, F.T. and Brüning, J.C., 2017. Temporal and tissue-specific requirements for T-lymphocyte IL-6 signalling in obesity-associated inflammation and insulin resistance. Nature Communications 8: 14803. https://doi.org/10.1038/ncomms14803

Yaya, S. and Ghose, B., 2019. Trend in overweight and obesity among women of reproductive age in Uganda: 1995-2016. Obesity Science and Practice 5: 312-323. https://doi.org/10.1002/osp4.351

Galley Proof