Original Article

Effects of Tabata workouts on the immune cell response in physically inactive individuals

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Abstract

Background: High-intensity interval training (HIIT) is popular nowadays as it produces similar positive results to moderate-intensity exercise, and at the same time, it is time-efficient as it needs a shorter exercise duration. To date, immune responses following HIIT are not well documented.

Aim: To determine the effects of Tabata workouts on the immune cell response in physically inactive individuals.

Methods: A total of 12 physically inactive individuals (mean age = 22.0 ± 0.9 years) were recruited amongst students of Universiti Sains Malaysia in this training programme for 6 weeks (3 sessions/week). This programme consisted of four sets of Tabata workouts, with each set containing two types of exercise (20 s for each exercise) with rest intervals between exercises of 10 s. Heart rate and rate of perceived exertion were recorded during each exercise session. Bodyweight, body mass index (BMI), body fat percentage and blood samples (2 mL) were collected at baseline, at midtest and following the 6 weeks of intervention. Blood samples were analysed for total leucocyte, lymphocyte, neutrophil and monocyte counts.

Results: There were significant increases in total leucocyte ($P = 0.042$) and neutrophil counts ($P = 0.039$) following 6 weeks of Tabata workouts. An increasing trend was also observed for monocyte count ($P = 0.065$) but not for the lymphocyte count ($P = 0.304$). Participants' body weight, BMI and body fat percentage were maintained throughout the intervention period.

Conclusion: HIIT induced positive immune cell response in physically inactive individuals. Hence, it can be recommended and incorporated in exercise programme design for physically inactive individuals.

Key Words: High-intensity interval training, leucocytes, lymphocytes, monocytes, neutrophils

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Submitted: 06-Aug-2021 **Accepted in Revised form:** 03-Sep-2021 **Published:** 28-Dec-2021

INTRODUCTION

Physical inactivity in adults is rapidly increasing globally. It was found that one out of five adults engages in low levels of regular physical activity (Dumith et al. 2011). A sedentary lifestyle or lack of physical activity is associated with an increased risk of many health problems, including cardiovascular diseases, cancer and diabetes (Khaw et al. 2008; Cornelissen and Smart 2013). Leading an active lifestyle by engaging in regular physical activity prevents such pathologies and improves overall health and functional capacity.

Although various health organisations highlighted the importance of physical activity, the number of inactive individuals remains high and is attributed to a number of reasons, including lack of time. Thus, highintensity interval training (HIIT) is ideal as

Access this article online	
Quick Response Code:	Website: https://www.mohejournal.org
	DOI: 10.4103/mohe.mohe_21_21

How to cite this article: Noor, N. A., Muhamad, A. S., Malik, A. A. (2021). Effects of tabata workouts on the immune cell response in physically inactive individuals. *Malaysian Journal of Movement, Health and Exercise*, *10(2)*, 99-104.

it reduces the time commitment for exercise. In general, HIIT consists of a short duration of repeated highintensity exercises (≥80% of maximal heart rate [HR_{max}]) with short recovery periods (40%–50% of HR_{max}).

This study focused on Tabata, a type of HIIT, which was initially developed by Dr. Izumi Tabata (Tabata et al. 1996). This type of interval training commonly consists of seven to eight rounds of 20 s of all-out exercise bouts, interspersed by 10 s of rest or low-intensity exercise, and each workout lasts for 4 min. Findings showed that Tabata training could enhance anaerobic and aerobic capacity (Tabata et al. 1996; 1997). This type of exercise became popular nowadays; however, to date, no study has reported possible positive effects of Tabata workout on immune responses.

In general, exercise affects the immune system, and it depends on the intensity and duration of the exercise (Nieman et al. 2007). Previous research showed that immune cells respond to the effects of acute exercise either in terms of numbers and functions (Gabriel et al. 1992; Nieman and Nehlsen-Cannarella 1994; Pyne 1994). Nevertheless, reports regarding the effects of short periods of high-intensity exercise on immune function amongst physically inactive individuals have yet to be established.

MATERIALS AND METHODS

Study design

This is an experimental study with pre-, mid- and post-test measurements. This study has been approved by the Human Research Ethics Committee of Universiti Sains Malaysia (USM) (Approval code: USM/JEPEM/19020134) and has no conflict of interest.

Screening and recruitment

A total of 12 healthy, physically inactive students from USM were recruited via poster advertisements placed in and around the campus. Participants selected were healthy males and females who were 20–25 years of age and physically inactive without having any exclusion criteria of smoking, having illnesses, being on medication or taking supplements to boost immune function, such as probiotics or Vitamin C.

Body composition and blood samples

Participants came to the laboratory at 8:00 am after an overnight fast from 10:00 pm. They were permitted to drink plain water during this fasting period. Upon arrival, participants' body weight, fat percentage and height were measured using a body composition analyser (Tanita, Japan). The calculation of body mass index (BMI) was done as follows:

BMI (kg/m) = Weight (kg)/height (m) × height (m)

Then, 2 mL of a blood sample was collected by the laboratory technologist in the Sports Science Laboratory into an EDTA tube for haematology analysis of leucocyte, neutrophil, monocyte and lymphocyte counts by using a haematology analyser (Sysmex XE-5000, America). Another body composition measurement and blood sample collection were carried out at mid-test (after 3 weeks of intervention) and post-test (after 6 weeks of intervention).

Intervention

The Tabata workouts were carried out for 3 sessions/week for 6 weeks (a total of 18 sessions). This training programme consisted of four sets of Tabata workouts, with each set containing two types of exercise (20 s for each exercise) with rest intervals of 10 s between exercises [Table 1]. A progressive load was employed in this study, whereby the number of rounds for each set of Tabata workouts was increased from two rounds in the first 2 weeks of intervention to three rounds for the next 2 weeks of intervention and four rounds for the last 2 weeks of intervention. Between each Tabata workout set, participants had one minute of rest. In total, the exercise session was ranging between 15 and 30 min.

Participants' heart rate (HR) and rating of perceived exertion (RPE) were recorded during each exercise session to ensure that the participants were trained at the correct pre-determined intensity (70%–85% HR_{max}; Borg scale = 15–20). This workout protocol has been shown as feasible and safe to be conducted in physically inactive individuals (Emberts et al. 2013). Participants were taught and shown the correct way to perform each exercise to reduce the risk of musculoskeletal injury. In addition, all the exercise sessions began with a warm-up for at least 5 min and ended with a cool-down. All the exercise sessions were conducted at Grey Square in USM (a spacious area suitable to conduct the exercise session), and each session was supervised by the supervisor.

Statistical analysis

All analyses were performed using the Statistical Package for the Social Science (SPSS) version 24 (IBM Corporation, Armonk, NY, USA). One-way repeated-measures analysis of variance was used to determine the significant difference

Table 1: Tabata workout programme (3 sessions/week for 6 weeks)

Warm-up for 5 min
Tabata workout 1* (20 s of squat jumps; 10 s rest; 20 s of lunge jumps)
Rest for 1 min
Tabata workout 2* (20 s of burpees; 10 s rest; 20 s of mountain climbers)
Rest for 1 min
Tabata workout 3* (20 s of lateral skaters; 10 s rest; 20 s of knee tucks)
Rest for 1 min
Tabata workout 4* (20 s of prisoner jacks; 10 s rest; 20 s of scissor skiers)
Cool-down for 5 min

*Progressive loading: Each Tabata workout was carried out as many as two rounds for weeks 1 and 2; 3 rounds for weeks 3 and 4; 4 rounds for weeks 5 and 6 between the three time points of measurement (pre-, mid- and post-test). The significant level was set at $p = 0.05$. Results were reported as mean ± standard deviation.

RESULTS

Physical and physiological characteristics

Twelve healthy, physically inactive individuals (eight men and four women; $n = 12$) participated and completed the Tabata workout for 6 weeks. Participants' physical and physiological characteristics are shown in Table 2.

Immune cell responses

There was a significant time effect on total leucocyte count ($F = 3.665$; $df = 2$; $p = 0.042$); the total leucocyte count significantly increased following 6 weeks of Tabata workouts [Figure 1]. Similarly, there was a significant time effect on neutrophil count ($F = 3.762$; $df = 2$; $p = 0.039$); it significantly increased following 6 weeks of Tabata workouts [Figure 2].

The monocyte count showed no significant effect of time during the intervention ($F = 3.103$; $df = 2$; $p = 0.065$). However, an increasing trend was observed for the monocyte count following 6 weeks of Tabata workouts [Figure 3]. In addition, there was no significant effect of time on the lymphocyte count during the intervention ($F = 1.256$; $df = 2$; $p = 0.304$), and no obvious trend was observed [Figure 4].

DISCUSSION

Physical and physiological characteristics

Overall, there was no significant difference in body composition after 6 weeks of the Tabata training sessions [Table 2]. Participants' body weight, BMI and fat percentage were maintained throughout the intervention period in which their BMI values were within the normal range, but the body fat percentage was slightly higher. The mean HR and RPE scores during the Tabata workouts were 151.67 ± 9.91 bpm and 13.33 ± 0.89, respectively. RPE is often used as a quantitative measure of perceived exertion by participants during physical activity. In this study, the score of 13.33 ± 0.89 was considered as 'somewhat hard'. Heart rate is also a measure of the amount of effort a person exerts during exercise, with a higher HR indicating a higher level of physical activity. Both HR and RPE measurements were important to determine the exercise intensity of the HIIT protocol. Heart rate measurement is not as subjective as the RPE; hence, it is more reliable than RPE in determining exercise intensity.

Table 2: Physical and physiological characteristics

Variables	Mean±SD (n=12)	P
Age (years)	22.08±0.90	-
Height (cm)	166.67±8.08	-
Weight (kg)		
Pre-test	65.53±12.45	0.659
Mid-test	65.22±12.17	
Post-test	65.59±12.18	
BMI (kg/m^2)		
Pre-test	23.49±3.58	0.587
Mid-test	23.40±3.71	
Post-test	23.56±3.71	
Fat (%)		
Pre-test	26.40±6.26	0.364
Mid-test	26.91±5.95	
Post-test	26.59±5.85	
Mean HR$_{max}$ (bpm)	197.92±0.90	-
Mean HR during Tabata workout (bpm)	151.67±9.91	-
Mean RPE during Tabata workout (Borg Scale)	13.33±0.89	-

SD: Standard deviation, BMI: Body mass index, HR: Heart rate, RPE: Rate of perceived exertion

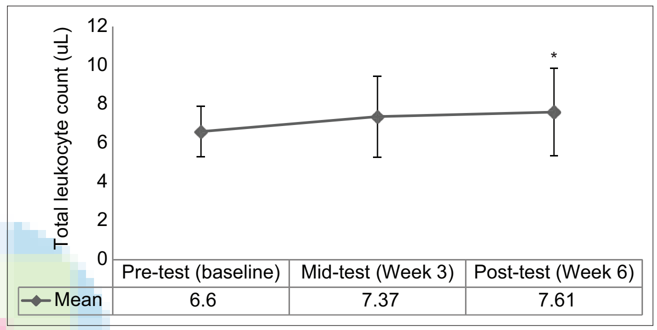

Figure 1: Total leucocyte count following 6 weeks of Tabata workouts. *Significantly different compared to the baseline value, $p < 0.05$

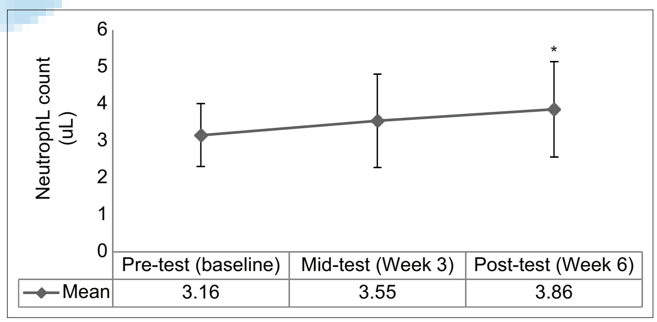

Figure 2: Neutrophil count following 6 weeks of Tabata workouts. *Significantly different compared to the baseline value, $p < 0.05$

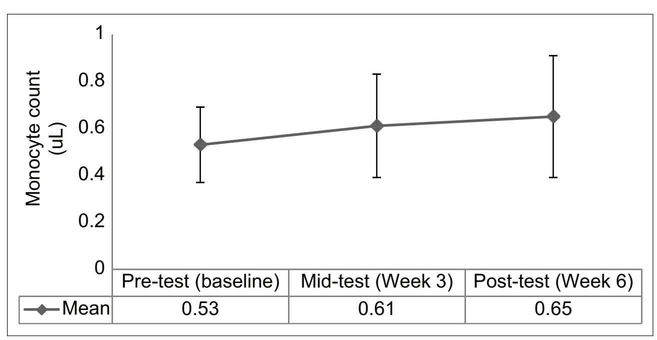

Figure 3: Monocyte count following 6 weeks of Tabata workouts

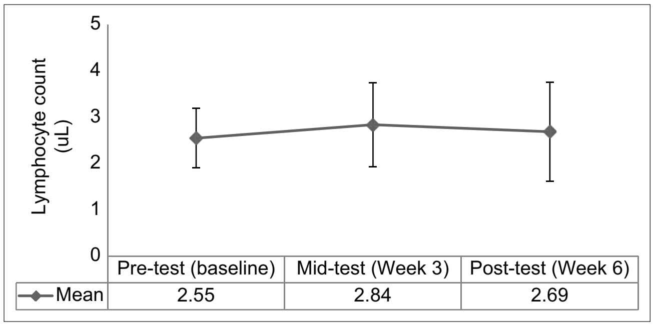

Figure 4: Lymphocyte count following 6 weeks of Tabata workouts

In a previous HIIT study in adults, HR_{max} of adultious HIIT studPE in determining exercise intensity (Gibala et al. 2014; Weston et al. 2014). In this study, although the mean HR of the participants during the Tabata workouts was 151.67 ± 9.91 bpm (77% of HR_{max}), each participant completed Tabata workout sessions at 90%–95% of their age-predicted HR_{max}. This observation may indicate that all the participants complied with the HIIT protocol in the form of a Tabata workout. Furthermore, Malik et al. (2019) suggested that in-depth observation of the participants' compliance with the HIIT HR_{max} using average HR for the entire HIIT protocol is not accurate.

Total leucocyte count

In this study, a significant increase in total leucocytes was observed following 6 weeks of Tabata workouts [Figure 1]. Similar to our results, previous studies have reported alterations in leucocyte and subset counts in response to high-intensity exercise (Nemet et al. 2004; Radom-Aizik et al. 2008; Sand et al. 2013; Shin and Lee 2013). Most studies have demonstrated leucocytosis during exercise, which may begin soon after the activity is initiated (Katz 1994). In addition, several studies have suggested that the degree of leucocytosis may be inversely related to fitness level, with greater changes observed in less well trained (Soppi et al. 1982). However, these previous studies involved acute effects of high-intensity exercise on leucocyte count. To our knowledge, the present study is the first to investigate the chronic effects of HIIT on immune cell count.

It has been suggested that stress causes the release of neuroendocrine mediators from the brain, which helps the immune system in an organism. In the same way, exercise (a type of stress) causes an increase in sympathetic activity, e.g., release of catecholamine, and is dependent on the exercise intensity (Krüger et al. 2008). Thus, the greater the intensity of exercise, the higher the increase in the circulating levels of epinephrine and norepinephrine with subsequent mobilisation of white immune cells (Natale et al. 2003). In addition, elevated cortisol levels may be one of the causes of leucocytosis.

Neves et al. (2015) in their study demonstrated that high-intensity exercise is capable of altering the count of leucocytes and their subsets (i.e. neutrophil, monocytes and lymphocytes) immediately after and 2 h after exercise without any interpersonal variation, suggesting that the short-term effects of exercise on the immune system are intensity dependent. Furthermore, a recent study by Belviranli et al. (2017) found that leucocyte count significantly increased immediately and 3 h after exercise, observing a 75% increase in the leucocyte count. This finding was conducted to determine the effects of acute high-intensity interval on haematological parameters in sedentary men. This finding was in agreement with Heidari et al. (2016) finding, which also showed that leucocyte count increased even 30 min after a single session of anaerobic exercise. Moreover, in the study of Kappel et al. (1998), it was found that acute exercise conducted in the sedentary group reported an increase in the number of leucocytes.

Neutrophil count

In the present study, the neutrophil count [Figure 2] significantly increased following 6 weeks of Tabata workouts. In general, exercise causes augmentation in the number of circulating neutrophils due to the emargination of cells from endothelial tissues and bone marrow. This response is mediated by catecholamines and cortisol, respectively, or as part of the phagocytic and inflammatory response to exercise-induced tissue damage (Pyne 1994). To date, no studies have reported chronic effects of HIIT on the neutrophil count, as well as neutrophil function. Nevertheless, Syu et al. (2012) observed that acute high-intensity exercise and chronic moderate exercise, but not acute moderate exercise, improve neutrophil function. In addition, a previous study reported no acute effect of high-intensity exercise on neutrophils (Neves et al. 2015). However, there was an increase in neutrophils (neutrophilia) after 2 h of exercise. Previously, the neutrophil function was reported to be enhanced by low-volume high-intensity interval walking (Bartlet et al. 2020). In this previous study, ten older adults at risk for type 2 diabetes mellitus performed 10 weeks of low-volume HIIT. It was found that neutrophil chemotaxis, phagocytosis and mitochondrial functions, as well as $VO_{2\ max,}$ were significantly improved compared to baseline. Thus, this suggests that HIIT might as well improve not only neutrophil count but its function as well. Unfortunately, the present study did not measure neutrophil function.

Monocyte count

The present study showed that there was no significant time effect on monocyte count [Figure 3]. However, there was an increasing trend of monocyte count following 6 weeks of Tabata workouts. Although there are limited reports on the chronic effects of HIIT on monocyte count to date, a similar trend was also observed by Belviranli et al. (2017), where mean monocyte count and other leucocyte subgroups increased immediately after the acute HIIT, and their values began to return to resting levels 3 h after exercise, and completely returned to resting levels 6 h after exercise. In this study, Belviranli et al. recruited ten sedentary men who performed four Wingate tests with 4-min intervals between the tests.

A recent study by de Matos et al. (2019) found that HIIT reduces monocyte activation in obese adults. It is known that individuals with obesity have a higher percentage of non-classical monocytes and an imbalance amongst the CD16+ monocyte subsets.

Furthermore, the expression of Human Leukocyte Antigen – DR isotype (HLADR) by intermediate monocytes is higher in insulinresistant obese individuals, which indicates monocyte activation in obesity. In this study, it was found that 8 weeks of HIIT significantly reduced the percentage of non-classical monocytes and restoring the balance amongst the CD16+ monocytes in obese individuals. Furthermore, the expression of HLA-DR by intermediate monocytes in insulin-resistant obese subjects was lower after HIIT. Thus, these findings indicate that HIIT can be considered a time-efficient strategy to manage obesity-related monocyte alterations and strengthen the immunomodulatory potential of HIIT.

Lymphocyte count

In the present study, there was no significant main effect of time on lymphocyte count [Figure 4], indicating that there is no effect of regular HIIT on lymphocyte count amongst physically inactive individuals. As mention previously, no studies have reported the chronic effect of HIIT on immune cell count.

Lymphocyte count commonly decreases to below the pre-exercise value within as little as 30 min following prolonged and/or high-intensity exercise (Walsh et al. 2011). Several studies investigated the lymphocyte proliferative response to either intense, long-endurance exercise (Shinkai et al. 1993; Henson et al. 1998) or heavy resistance exercise (Koch et al. 2001; Nieman et al. 2004), which showed a temporary impairment in the lymphocyte proliferative response following exercise. The decrease in lymphocyte concentration in the post-exercise may be at least due to a result of apoptosis (programmed cell death) mechanism (Navalta et al. 2007). A previous study by Mars et al. (1998) found that lymphocyte apoptosis after intense exercise occurred, which may reduce immunity, influenced by high volume and intensity of exercise. However, there is less evidence regarding lymphocyte count in response to chronic HIIT.

There are some limitations that should be considered when interpreting the results of this study. First, due to unforeseen circumstances, this study was carried out as a one-arm experimental study with pre-, mid- and post-test measurements. Future studies should consider conducting a randomised controlled trial. Another limitation in this study is that this study only measures immune cell count, leucocytes and its subgroups. For a better understanding of the effects of HIIT on immune responses, measuring other components of the immune system such as cells' function and cytokine level is needed.

CONCLUSIONS

In summary, 6 weeks of Tabata workouts induced a significant increment in the total leucocytes count. This increment is mostly due to increased neutrophils and monocytes count. As highlighted before, to our knowledge, this is the first study carried out to investigate the chronic effects of HIIT, especially the Tabata workouts, on immune cell count changes. In conclusion, the present study found that chronic HIIT induced beneficial effects on the response of the immune cells in physically inactive individuals. Hence, it can be recommended and incorporated in exercise programme design for physically inactive individuals.

Acknowledgement

The authors are grateful to the participants who are voluntarily participated in this 6 weeks of Tabata workout and to the laboratory staff of the Exercise and Sports Science Laboratory, Health Campus, USM, for their help.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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