EFFECTS OF FIVE WEEKS OF PRESCRIBED AND SELF-PACED HIGH-INTENSITY INTERVAL EXERCISE ON PERCEPTUAL RESPONSES AND HEALTH MARKERS IN OVERWEIGHT-TO-OBESE ADULTS

NUR ANIS LYANA BINTI AYOB

UNIVERSITI SAINS MALAYSIA

2023

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by

NUR ANIS LYANA BINTI AYOB

Thesis submitted in fulfilment of the requirements
for the degree of
Master of Science

August 2023

ACKNOWLEDGEMENT

First of all, I would like to thank God the Almighty for giving me opportunity, patience, strength, focus, abilities and ideas for completing my research project successfully. I would also like to express my deepest appreciation to my superb supervisors, Dr Adam Abdul Malik and my co-supervisor Professor Dr Hairul Anuar Hashim and Dr Ayu Suzailiana Muhamad who provided me the possibility to complete this project and also the write up of my thesis.

Furthermore, I would also like to acknowledge with much appreciation the staff of Exercise and Sport Science laboratory, for their assistance throughout my research. They definitely provided me with the tools that I needed to choose the right direction and successfully complete my research.

I would also like to thank my parents for their wise counsel. You are always there for me. Lastly, I would like to thank my friends for their moral support. We were not only able to support each other by deliberating over our problems, but also sharing things other than journal papers.

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ABSTRAK

Latar belakang: Kajian lepas telah menunjukkan bahawa apabila individu dewasa yang berlebihan berat badan/obes dibenarkan untuk mengawal intensiti senaman secara kendiri semasa protokol senaman berterusan, ia cenderung untuk menghasilkan tindak balas afektif positif yang lebih tinggi berbanding dengan senaman yang berintensiti kendiri. Namun kesan ini masih belum diterokai dalam konteks senaman sela berintensiti tinggi (HIIE) terutamanya dalam kalangan dewasa dengan berat badan berlebihan/obes. Oleh itu, tujuan tesis ini adalah untuk mengkaji kesan senaman berintensiti tinggi secara kendiri (S-HIIE) dan senaman berintensiti tinggi yang telah ditetapkan HIIE (P-HIIE) selama 5 minggu terhadap parameter kesihatan dan tindak balas persepsi dalam kalangan dewasa yang berlebihan berat badan/obes. Kaedah: Dua puluh orang dewasa berlebihan berat badan / obes (min ± SD; berumur 26.7±4.9 tahun; BMI = 27.5±4.2) telah dibahagikan kepada dua kumpulan secara rawak, iaitu, P-HIIE dan S-HIIE. Kedua-dua protokol terdiri daripada 7 hingga 9 ulangan sela kerja selama 1 minit yang berintensiti 90% kelajuan aerobik maksimum (P-HIIE) atau larian berintensiti kendiri dipisahkan oleh 75 saat sela masa rehat sepanjang intervensi selama 5 minggu (3 kali seminggu, 15 sesi). Parameter kesihatan (glukosa darah, jumlah kolesterol, trigliserida, HDL, LDL, jumlah kolesterol HDL dan bukan HDL) telah dikumpulkan sebelum dan selepas

intervensi. Manakala tindak balas persepsi (tindak balas afektif, tahap kesukaran dan keseronokan) diukur sebelum, semasa (sela kerja 1, 4 dan terakhir), dan selepas setiap sesi HIIE (sesi 1, 8, dan 15) bagi kedua-dua kumpulan. Keputusan: Kumpulan P-HIIE memperoleh kelajuan larian yang lebih tinggi berbanding kumpulan S-HIIE pada selang kerja 1 dan selang kerja 4 dalam sesi 1 [P<0.03, kesan perbezaan (ES) > 0.98]. Selain itu, kelajuan larian yang lebih besar terbukti dalam P-HIIE berbanding S-HIIE pada selang kerja 1 semasa sesi 8 (P<0.05; ES=0.92). Kumpulan P-HIIE juga menghasilkan tindak balas afektif yang lebih rendah yang diukur melalui skala perasaan (FS) pada sela kerja 1, 4 dan terakhir berbanding dengan S-HIIE dalam sesi 1 (P<0.03, ES>0.66). Kumpulan P-HIIE juga memperoleh FS yang lebih rendah pada penghujung sela kerja sesi 1 berbanding sesi 8 dan 15 (P<0.05, ES>0.78). Kedua-dua kumpulan menghasilkan pasca keseronokan yang serupa merentas semua sesi senaman. (P<0.02, ES>0.74). Kumpulan P-HIIE memperoleh RPE yang lebih tinggi merentas semua sela kerja pada sesi 1 berbanding sesi 8 dan 15 (P<0.01, ES>2.13). Kedua-dua kumpulan menambah V̇O2max (ES>0.71) dan kelajuan larian (ES=0.95 and 1.05), namun tiada perbezaan yang ketara merentas semua penanda darah antara bagi kedua-dua kumpulan. Kesimpulan: Dapatan menunjukan protokol S-HIIE dan P-HIIE menghasilkan kesan tindak balas persepsi dan penunjuk kesihatan yang sama merentasi 5 minggu intervensi senaman kalangan dewasa dengan berat badan berlebihan dan obes.

EFFECTS OF FIVE WEEKS OF PRESCRIBED AND SELF-PACED HIGH-INTENSITY INTERVAL EXERCISE ON PERCEPTUAL RESPONSES AND HEALTH MARKERS IN OVERWEIGHT-TO-OBESE ADULTS

ABSTRACT

Background: Previous studies have shown that when overweight/obese adults are permitted to self-pace their exercise intensity during a continuous exercise protocol, it tends to generate greater positive affective response (more pleasurable) compared to the prescribed based exercise, but these have yet to be explored in the context of high-intensity interval exercise (HIIE) in overweight-to-obese adults. Thus, the purpose of this thesis is to examine the effect of 5 weeks of self-paced HIIE (S-HIIE) and prescribed HIIE (P-HIIE) on health parameters and perceptual responses among overweight-to-obese adults. Method: Twenty overweight-to-obese adults (mean ± SD; aged 26.7 ± 4.9 years old; BMI = 27.5 ± 4.2) were randomly assigned to two groups, namely, P-HIIE and S-HIIE. Both protocols consisted of 7 to 9 repetitions of 1 minute work intervals performed at either 90% of maximal aerobic speed (P-HIIE) or self-paced running (S-HIIE) separated by 75 s of recovery interval across a 5-week intervention (triweekly, 15 sessions). Health parameters (blood glucose, total cholesterol, triglyceride, HDL, LDL, total cholesterol HDL, and non-HDL) were collected before and after intervention. Whereas perceptual responses (affective, perceived exertion, and enjoyment) were measured before, during, and after each HIIE session (sessions 1, 8, and 15) in both groups. Result: P-HIIE group elicited greater running speed compared to S-HIIE group at work-interval 1 and work-interval 4 in session 1 (all $P<0.03$, all effect size (ES)>0.98). Also, a greater running

speed was evident in P-HIIE compared to S-HIIE at work interval 1 during session 8 ($P<0.05$; ES= 0.92). P-HIIE group elicited lower affective responses measured via feeling scale (FS) at work interval 1, 4 and end work intervals compared to S-HIIE in session 1 (all $P< 0.03$, all ES> 0.66). Also, P-HIIE group also elicited lower FS at the end of work interval during session 1 than sessions 8 and 15 ($P<0.05$; ES>0.78). Both groups generated comparable post-enjoyment pattern across all exercise sessions (all $P<0.02$, all ES>0.74). P-HIIE group produced greater RPE across all work intervals in session 1 compared to session 8 and 15 (all $P< 0.01$, all ES>2.13). Both groups enhanced $\dot{V}O_2max$ (ES>0.71) and running speed (ES=0.95 and 1.05, respectively), but no significant difference was observed in all blood markers for both groups. Conclusion: Findings show that S-HIIE and P-HIIE protocols produce a comparable effect of perceptual responses and health indicator (i.e., $\dot{V}O_2max$) over a 5-week exercise intervention in the overweight and obese cohort.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The prevalence of overweight and obesity has reached global epidemic levels in many developing countries including Malaysia. Based on current National Health Morbidity Survey (NHMS) conducted in 2019 among Malaysian populations, the prevalence of overweight or obese adults continues to incline (30.4%, 19.7%) compared to NHMS 2015 (30.0%, 17.7%), NHMS 2011 (29.4%, 15.1%) and NHMS 2006 (28.6%, 14.2%). Available evidence demonstrates an inverse association between physical activity (PA) levels with the risks of overweight and/or obesity in adult (Church et al., 2011). These observations, however, contradict with the findings from Malaysia adult-based studies which have shown an increased number of moderate intensity PA participation, despite increasing incidence of overweight and obesity. This valuable finding may suggest that moderate intensity PA may not be sufficient to reduce the risk of overweight and obesity in adults. This is not surprising given the mechanism of body weight reduction, which requires a prolonged duration for low to moderate intensity activities. Consequently, there is a strong rationale to study alternative PA modalities in overweight and obese adults, with one strategy focusing on vigorous intensity PA.

One of the modalities that may be used to deliver vigorous intensity PA is high-intensity interval exercise (HIIE) (Gibala, 2007). HIIE involves with a brief repeated bursts of relatively intense or near maximal effort exercise interspersed by low-to moderate-intensity exercise (Buchheit & Laursen, 2013). This specific

exercise modality has attracted a lot of attention from exercise researchers given its time advantage. Specifically, HIIE can be delivered in a much shorter duration to achieve similar benefits of low to moderate exercise of longer duration. Indeed, a growing body of literature support the effectiveness of HIIE protocol as a time efficient strategy to improve multiple health benefits including cardiorespiratory fitness and cardiometabolic health (e.g. reduce blood lipid and blood glucose) across 2-12 weeks exercise interventions in overweight or obese adult (Andreato, Esteves, Coimbra, Moraes, & de Carvalho, 2019; Batacan, Duncan, Dalbo, Tucker, & Fenning, 2017; Wewege, van den Berg, Ward, & Keech, 2017).

Despite wealth of available evidence concerning the timesaving advantages of HIIE for health-enhancing adaptations in overweight and obese adults, the application of HIIE as a public health strategy is controversial. This is mainly due to the high-intensity nature of HIIE protocol will generate negative affective responses (feelings of displeasure) and greater exertional stress, thus leading to poor behavioural maintenance and engagement in long-term basis (Biddle & Batterham, 2015). Consequently, the adoption of HIIE to improve the health and well-being of overweight and obese adults is unclear. There is available evidence demonstrate the affective responses (i.e. feelings pleasure and displeasure) to HIIE in adults (B. R. R. Oliveira, Santos, Kilpatrick, Pires, & Deslandes, 2018; Stork, Banfield, Gibala, & Martin Ginis, 2017), but the observations are contradictory between studies. Some studies (Decker & Ekkekakis, 2016; F. B. D. Oliveira, Oliveira, Rizatto, & Denadai, 2013) have revealed that individuals may engage to HIIE because they will find it pleasant (positive affective response), while others (Jung, Bourne, & Little, 2014; Martinez, Kilpatrick, Salomon, Jung, & Little, 2015) find it unpleasant (negative

affect response) and therefore be unlikely to repeat the exercise behaviour. The dissimilar findings observed across studies may be attributed to the different work intensity employed within each study (e.g., 70% to 100% of maximal exercise capacities), indicating that the prescription of inappropriate work intensity may hamper the preservation of pleasurable feelings during HIIE. Therefore, it is pertinent to elucidate the role of work intensity for facilitating the maintenance and adoption of HIIE while fostering health adaptations in overweight and obese adults.

An important consideration in the formation of behavioural maintenance and exercise adherence is autonomy and a useful framework in understanding autonomous regulation is Self-Determination Theory (Dunn & Zimmer, 2020) (Deci & Ryan, 1985). This theory postulates that autonomous behavior is likely to be achieved when individual engage in behavior for intrinsic reasons out of inherent pleasure and interest in the activity. Indeed, consideration of preserving or maintaining pleasurable feelings during HIIE is important because negative affective responses (unpleasant feelings) may reduce the likelihood that individuals will continue it in future (Rhodes & Kates, 2015; Williams, 2008). Following this logic, provision of a self-paced activity, instead of externally enforced pace, is likely to enhance intrinsic motivation, and consequently perception of pleasure and enjoyment. Indeed, prior studies have shown that when overweight or obese individuals are permitted to self-pace their exercise intensity during a continuous exercise, it tends to generate greater positive affect compared to the researchers' prescribed intensity (Ekkekakis, 2009), but these have yet to be explored in the context of HIIE.

Therefore, the purpose of the current study is to investigate the effects of 5 weeks of self-paced HIIE and prescribed HIIE on perceptual responses (i.e. affective, enjoyment and perceived of exertion) and health markers (i.e. cardiorespiratory fitness, blood pressure, blood glucose, lipid profile, and body composition) in overweight men and women.

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1.2 Problem Statement

The application of high-intensity interval exercise (HIIE) protocol as a public health strategy is controversial among exercise science researchers. This is because its high-intensity exercise nature which may elicit greater exertional stress and feelings of displeasure among overweight and obese adults. Consideration of preserving positive affective responses (i.e., pleasurable feelings) during HIIE is important because negative affective response (feelings of displeasure) may reduce the likelihood that individuals will engage and continue exercise behaviour in future. There is evidence that demonstrates the effects of HIIE on affective, enjoyment and health outcomes, but the relevant research is limited to researchers' prescribed work intensity, and fewer studies have investigated the impact of self-paced HIIE, especially in overweight and obese adults.

1.3 Objective of The Study

1.3.1 General Objectives

To determine the effects of 5 weeks of self-paced HIIE (S-HIIE) and prescribed HIIE (P-HIIE) on perceptual responses and health parameters in overweight adults.

1.3.2 Specific Objectives

1) To compare the effects of S-HIIE and P-HIIE on affective, enjoyment, and rating of perceived exertion (RPE) responses in overweight and obese adults across 5 weeks exercise intervention.

2) To compare the effects of S-HIIE and P-HIIE on blood pressure, blood glucose level, lipid profile, body composition and cardiorespiratory fitness in overweight and obese adults across 5 weeks exercise intervention.

1.4 Hypotheses of The Study

H_{O1}: There is no significant different in affective, enjoyment and RPE responses between S-HIIE and P-HIIE across 5 weeks exercise intervention.

H_{A1}: There is a significant different in affective, enjoyment and RPE responses between S-HIIE and P-HIIE across 5 weeks exercise intervention.

H_{O2}: There is no significant different in the health parameters (blood pressure, blood glucose level, lipid profile, body composition and cardiorespiratory fitness) between S-HIIE and P-HIIE across 5 weeks exercise intervention.

H_{A2}: There is a significant different in the health parameters (blood pressure, blood glucose level, lipid profile, body composition and cardiorespiratory fitness) between S-HIIE and P-HIIE across 5 weeks exercise intervention.

1.5 Significance Of The Study

This study will provide potentially valuable information pertaining to the impact of allowing individuals to self-pace their work intensity during HIIE on their perceptual responses, cardiorespiratory fitness, and health outcomes in overweight and obese adults. This proposed study will potentially provide guidelines to exercise prescription that may promise greater behavioural engagement and adherence to exercise and PA.

1.6 Operational Definitions

1.6.1 Prescribed High Intensity Interval Exercise

An exercise protocol that are characterized by 7-9 repetitions (progressively increased into one repetition for every two weeks) of 1 minute work intervals at 90% maximal aerobic speed (MAS), interspersed with low- recovery exercise or no exercise between intervals.

1.6.2 Self-paced High Intensity Interval Exercise

An exercise protocol that are characterized by 7-9 repetitions of 1 minute work intervals at self-paced intensity, interspersed with low-intensity recovery exercise or no exercise between intervals.

1.6.3 Affective Responses

A subjective experience of the basic component of all valanced states (e.g., pleasant or unpleasant, positive or negative), including, but not limited to, the concepts of emotion and mood.

1.6.4 Enjoyment Responses

A positive affective state that occurs when an individual engages in an activity that satisfies a desire goal, including but not limited to the for belongingness, esteem or desire.

1.6.5 Rating of Perceived Exertion

Subjective tool use to monitor or evaluate individual effort or intensity.

CHAPTER 2

LITERATURE REVIEW

2.1 Prevalence Of Overweight/Obese

The prevalence of overweight/obesity has reached epidemic levels in many developing countries, including Malaysia. National Health and Morbidity Survey has reported an increasing trend of overweight and obesity from 14.5% to 30.0% between year 2006 and 2011 among Malaysian adults aged 18 years and above (NHMS, 2015). While systematic analysis of global data reveal that the prevalence of obesity in Malaysia (11.4% in males; 16.7% in females) was lower than that reported in Western countries, such as Australia (27.5% in males; 29.8% in females) and the United States (31.7% in males; 33.9% in females), but the prevalence is almost three to four times higher than in other Asian countries, such as India (3.7% in males; 4.2% in females), China (3.8% in males; 5.0% in females), and Japan (4.5% in males; 3.3% in females) (Vos, T., Barber, R.M., Bell., Bertozzi-Villa, A., Biryukov, S., Bolliger, I., Charlson, F., Davis, A., Degenhardt, L. and Dicker, 2015). Being overweight/obese may increases risk of all-cause mortality (e.g. cardiovascular and metabolic disorders) (Brown et al., 2009; Guh et al., 2009), reinforcing the needs for effective and sustainable strategy to overcome this alarming condition.

It is well documented that the most successful strategy to treat and prevent overweight/obese adult is to increase PA participation (Jakicic, 2009; Sharma et al., 2014). PA has been demonstrated to be an essential lifestyle behaviour for both weight reduction and weight maintenance following successful weight loss. Evidence has suggested that regular and adequate levels of PA in adults are key contributors to

energy expenditure and are essential for energy balance and weight control (Curioni & Lourenc, 2005). Indeed, previous studies have showed an inverse association between PA levels with the risks of overweight/obese in adult (Church et al., 2011).

Nevertheless, studies among Malaysian populations have shown some puzzling findings. Specifically, although PA participation has shown an increase from 56.3% to 64.3% between year 2006 and 2011 in adult, this does not translate into a decrease in the prevalence of overweight and obesity among Malaysian adults. Recent studies among overweight/obese Malaysian adults (aged 25–64 years) have reported that participants with a high level of vigorous PA were less likely to be overweight/obese compared to those with a high level of moderate intensity PA (Chan, Jones, Jamieson, & Albarraci, 2017). These observations may suggest that increasing PA participation in moderate PA may not be sufficient to reduce risk of overweight/obese in Malaysia adult. Collectively, the available evidence reinforces the need to evaluate the PA programs designed for overweight and obese populations that emphasize on vigorous-intensity PA. Furthermore, small doses of vigorous intensity PA has been adopted in PA guidelines for adults (18–64 years of age) as at least 150 minutes per week of moderate PA are recommended, but this falls to 75 minutes per week for vigorous intensity PA (WHO, 2010).

2.2 High-Intensity Interval Exercise

Researchers have commonly utilised exercise as a form of activity to improve PA levels while promoting health benefits in adults. Exercise is a subset of PA that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is an objective (Caspersen et al., 1985). One form of exercise that may be used to deliver short bouts of vigorous intensity the promotion of health in adults is high-intensity interval exercise (HIIE). HIIE typically involves alternating periods of high-intensity exercise with low-intensity recovery intervals. The main appeal of HIIE is that this type of training can be completed in a short period of time (compared to traditional continuous endurance training) and physical adaptations are comparable to those resulting from endurance training. Consequently, it has been proposed that HIIE can mitigate the most commonly cited barrier to physical activity which is 'lack of time' particularly in adult (Gibala, 2007).

Although the fundamental concepts of HIIE are linked to sports training for endurance athletes (Billat, 2001), such protocols have recently been designed and adapted for multiple populations including overweight and obese adults (Gibala et al., 2012). HIIE protocols can be created, by manipulating intensity, duration, and work-to-recovery ratios within sessions (Buchheit and Laursen, 2013). Given these variables, the numbers of protocols available is infinite and the delivery of HIIE can be in the form of traditional (e.g. running and cycling) or novel (e.g. invasion game-based exercise) forms of exercise (Valantine et al., 2017). Although a variety of HIIE protocols have emerged in the adult literature, they are primarily based on three different models that vary in terms of intensity, duration and total exercise duration. A

traditional HIIE model is based on repeated Wingate-style exercise intervals and is better known as sprint interval training (SIT). SIT typically consists of 4 - 6 repeated bouts of 'all-out' 30 s exercise, performed on a cycle ergometer, separated by recovery periods of 4 minutes of unloaded pedalling. This provides a total of ~ 120 to 180 s of high-intensity effort in an exercise session, lasting about 20 minutes in duration (Gibala et al., 2006). Previous studies with youth have also utilised other variations of SIT, characterised by very short work durations of SIT (≤ 10 s) separated by recovery intervals (Sedgwick et al., 2015, Baquet et al., 2001). However, as the repeated bouts of SIT require maximal effort, concerns related to the tolerability and acceptability of this form of exercise have been raised (Coyle, 2005).

In an attempt to remain relatively time efficient but also to expand the application of low-volume HIIE to a wider spectrum of users, a less intense and more practical model of HIIE was developed by reducing the work intensity and increasing the duration and number of work intervals (Little et al., 2011). This recent and more practical protocol has shifted towards prescribing the work interval intensity based on maximal performance achieved during an incremental test to exhaustion (e.g. % of peak power output (PPO) for cycling or % of maximal aerobic speed (MAS) for running) rather than power output elicited during an 'all out' sprint (Little et al., 2011). A commonly used version of this practical HIIE model in the adult literature includes 8 - 10 repeated bouts of work intervals performed at 90% PPO/MAS determined from a prior incremental test to exhaustion, interspersed with active recovery intervals of 60 - 75 s duration. This protocol is considered ''low-volume'' HIIE because the total time spent performing high-intensity exercise is <10 minutes and the total exercise commitment is typically between 20 to 25 minutes.

Another HIIE protocol adopted in adult studies incorporates 4 repeated bouts of 4 minutes intervals, separated by a recovery of 3 - 4 minutes of duration (Tjonna et al., 2009, Ingul et al., 2010). This HIIE model is known as the 'Scandinavian Model' and was initially developed for clinical populations (e.g. cardiac patients or people who are obese). This HIIE model is performed below the HRmax (e.g. at 90% of HRmax) and is therefore less intense than SIT. However, this protocol is considered ''high-volume'' HIIE because the total time spent performing high-intensity exercise is ~ 16 minutes and the total exercise commitment is typically ~ 28 minutes, meaning the total time commitment is similar to traditional endurance training approaches.

Recent investigations have suggested that HIIE, regardless of the protocol used, produces equal if not superior health benefits at considerably lower volumes of total work, when compared with continuous exercise at a lower intensity (Andreato et al., 2019; Batacan et al., 2017; Wewege et al., 2017). The multiple health benefits of HIIE in overweight/obese adult has recently been compiled in published reviews (Andreato et al., 2019; Batacan et al., 2017; Wewege et al., 2017), showing that HIIE protocols are effective at improving cardiometabolic health markers (e.g. body composition, blood lipids, glucose and insulin) and augmenting cardiorespiratory fitness in overweight/obese adult. These review papers also suggest that the average length of HIIE training intervention to generate multiple health benefits is between 2-12 weeks, supporting the time efficient of this HIIE protocol. Collectively, the aforementioned review papers provide some support for HIIE as a potentially efficacious form of exercise for the improvement of health outcomes in overweight/obese adult.

2.3 Affective Responses to High-Intensity Interval Exercise

Despite the effectiveness of HIIE to promote health benefits and well-being in overweight and obese adults, its high-intensity nature has limited its utility, especially among those who are not habituated to exercise and overweight and obese individuals (Biddle and Batterham, 2015, Hardcastle et al., 2014). Specifically, Biddle and others have argued that the intense work intervals performed during HIIE may evoke negative affect responses (feelings of displeasure) and a greater perception of exertion, which may lead to poor engagement and subsequently exercise adherence (Biddle and Batterham, 2015, Hardcastle et al., 2014). Research shows that optimizing affective (e.g. an increase in pleasant feelings) responses during exercise may be one solution to improving PA levels, as affective responses may be the first link in the exercise adherence chain (Schneider et al., 2009, Williams, 2008). Affect is a generic term that characterises the evaluation of a subjective experience of the basic component of all valenced states (e.g., pleasant or unpleasant, positive or negative), including, but not limited to, the concepts of emotion and mood (Ekkekakis et al., 2005). Indeed, positive affective responses generated during exercise facilitate future exercise engagement in adults. A positive affective response (i.e. feelings of pleasure) during exercise, as opposed to a negative affective response (i.e. feelings of displeasure), has an impact upon an individual's motivation and behaviour (Parfitt et al., 2006), which may influence any decisions made, regarding whether or not to re-engage in the behaviour in the future (Williams et al., 2008, Kiviniemi et al., 2007).

A theoretical model known as dual-mode theory (DMT; Ekkekakis et al., 2005), provides a framework to explain individual variability in affective responses at different relative intensities. (see Figure 1). The DMT predicts that, at high-intensity

exercise, there is a predominance of interoceptive cues (physiological factors) associated with bodily stress responses (e.g. muscle pain, fatigue) due to the increased contribution of anaerobic sources, where a physiological steady state can no longer be maintained. In contrast, at low to moderate intensity, cognitive/psychological factors (individual's self-efficacy, motivation, and personality) have a strong influence, with interoceptive cues having a minimal influence. Thus, the predominance of cognitive factors is related to pleasurable feelings, whereas the predominance of interoceptive cues is related to unpleasant feelings. Therefore, it is vital to understand the pattern of affective responses during HIIE, as previous research has indicated that the affect experienced during exercise can influence future PA motivation and behaviour in adults.

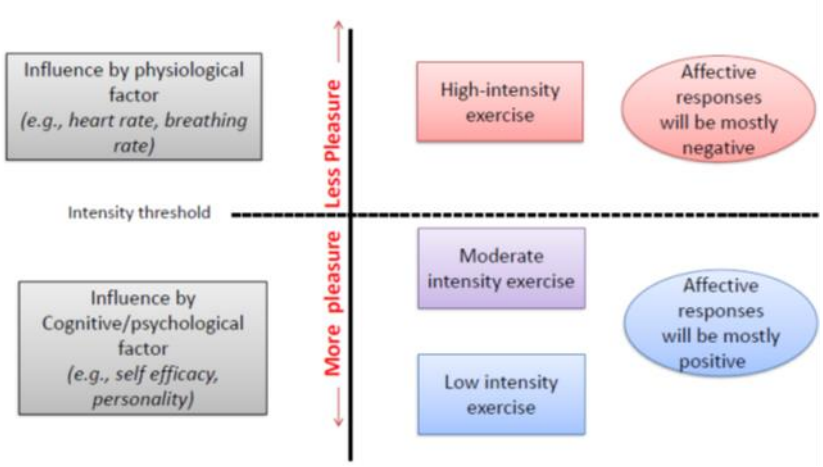

Figure 2.1: Relationship between affect responses and exercise intensity

During high-intensity exercise, a decrease in force production associated with internal body sensation (e.g. muscle fatigue or pain) can be regarded as a safety mechanism. Similarly, Hall and colleagues (2002) proposed that affective responses (pleasure and displeasure feelings) to high-intensity exercise may represent as an 'alarming' function, which, much like pain, is aimed to stop the individual and have them withdraw from the activity that is causing severe disruptions to their body

homeostasis (Hall et al. (2002). Therefore, the challenge posed during HIIE could potentially attenuate the positive affective responses (pleasurable feelings) in overweight and obese populations.

A recent systematic review of 33 studies by Niven and colleagues (2021) was conducted to compare the affective and enjoyment responses measured via feeling scale (FS) to three different exercise modes, namely, HIIE, continuous vigorous intensity exercise (CVIE), and continuous moderate intensity exercise (CMIE) in adults. The authors reported that positive affective responses were greater during CMIE as compared to HIIE and CVIE, but greater positive affective response was observed in HIIE compared to CVIE. Despite these valuable observations, comparisons between three different exercise mode does not reflects the overall evaluations of affective responses to HIIE. This is mainly because systematic review of 8 studies conducted by Oliviera et al., (2018) have reported that some studies (Decker & Ekkekakis, 2016; Oliveira et al., 2013) have revealed that individuals may engage to HIIE because they will find it pleasant (positive affective response), while others (Jung, Bourne, & Little, 2014; Martinez et al., 2015) find it unpleasant (negative affect response) and therefore be unlikely to repeat the exercise behaviour. Indeed, previous study has shown that the link between exercise adherence and affective responses during exercise are related to the intensity of the exercise itself (Rhodes and Kates, 2015).

From both systematic review perspectives as highlighted above (Niven et al., 2021; Oliviera et al., 2018), it is plausible to suggest that the different work intensity employed within each study (e.g., 70% to 100% of maximal exercise capacities) may

lead to a dissimilar finding observed across studies which then appear as a limitation for the evaluation of affective responses to HIIE in adults. Moreover, research in this area also limited to the normal weight individual rather than overweight and obese individuals. Therefore, research involving comparisons of affective responses to similar protocol of HIIE but different in work intensity is warranted to allow comprehensive evaluation of affective responses to HIIE in overweight and obese adults.

Additionally, it is unclear whether affective responses and other perceptual responses variable (enjoyment and perceived exertion) will be improved across a chronic exercise intervention (2-10-week of HIIE intervention) in overweight and obese adults. This is mainly because majority of the study employed the acute based studies rather than chronic type of studies (2-10 weeks). This is important given that short term and unsustainable change has been an issue in PA and exercise intervention. For example, in a systematic review of the effect of HIIE on body composition in adults, Wewege et al. (2010) found that at least more than 10 weeks of HIIE intervention may be required to produce significant outcome for weight reduction in adults. However, at least two studies have reported that in the reviews that 5 weeks of HIIE intervention sufficient to produce enhancement in body composition among adults (Wewege et al., 2010). Despite the aforementioned studies, currently less study has been conducted to investigate the regulations of affective responses to HIIE in overweight to obese adults. Documentation of this finding is important to facilitate engagement and maintenance for future exercise behaviour.

2.4 Affective Responses to Self-Paced High-Intensity Interval Exercise

An important consideration in the formation of behavioural maintenance and exercise adherence is autonomy and a useful framework in understanding autonomous regulation is self-determination theory. This theory postulates that autonomous behavior is likely to be achieved when individual engage in behavior for intrinsic reasons out of inherent pleasure and interest in the activity. Following this logic, provision of self-paced activity, instead of externally enforced pace, is likely to enhance intrinsic motivation, and consequently pleasure and enjoyment. Individuals who participate in an exercise regimen tend to exercise at a self-selected intensity rather than a prescribed intensity (Galloway, 2016), and the benefits of a self-selected workload are associated with positive parameters of perceived physical exertion, which aids in individual motivation (Freitas et al. 2015). These advantages are more constant and evident in overweight and obese people as well as those who are sedentary (Freitas et al. 2015).

Allowing individuals to pace themselves during exercise has been shown to evoke greater perceived autonomy, and consequently enjoyment and adherence. For instance, a review paper of 31 studies by Ekkekakis (2009) has shown that by allowing individuals to self-select their own exercise intensity compared to an external person prescribing an intensity elicits more positive affective responses. The authors concluded that self-selected intensity may generate more pleasure compared to prescribed exercise intensity. These data are consistent with Self Determination Theory (SDT; Deci and Ryan, 1985). According to SDT, the degree of pleasure and enjoyment that an individual experience when they act autonomously is likely to be higher than that experienced when behavior is externally controlled, suggesting that

under autonomous conditions, positive affect is more likely to occur. However, the available data are limited to the comparison of affect responses during continuous type of exercise, which would enable the role of self-selected intensity on affect responses to be evaluated from the interval exercise perspective.

Available evidence suggests that self-paced HIIE enhanced cardiorespiratory fitness, resting HR, blood pressure, submaximal HR and body mass adaptations in insufficiently active women (Connolly et al., 2017), but the impact of self-paced HIIE on health benefits in overweight/obese adult has been less studied. This is important given that higher autonomous motivation (i.e. degree of freedom that an individual perceives to have to perform the behaviour of his or her own choice) is one of the consistent predictors of beneficial weight and PA outcomes, and represents a modifiable target for lifestyle interventions in overweight/obese populations (Teixeira et al., 2015). It is currently unknown how self-selected work intensity during HIIE may influence the intensity-affect responses particularly in overweight/obese individuals.

CHAPTER 3

METHODOLOGY

This chapter outline all the procedures involved in the present study. The methodological aspects consist of participant, instrument, data collection procedure and data analysis which are presented in detail under the specific subheading.

3.1 Ethics Approval

The study procedures presented in this study received ethics approval by the Human Research Ethics Committee of Universiti Sains Malaysia (USM) (JEPeM Code: USM/JEPeM/19120848), see **Appendix A**). For the ethics approval purposes, participants were informed of the potential risks of the exercise sessions and performing maximal exercise (e.g., muscle soreness, syncope) However, the associated risks were low, and are typical with performing vigorous exercise (e.g. HIIE and maximal exercise). To help minimize these risks however, researchers ensured that the protocols and procedures were undertaken professionally, and the participants' health and well-being were treated as priority. Information about participants' health status was obtained before the commencement of exercise using a standard health screening form for adult (**Appendix B**). All equipment were stored and maintained accordingly to a high-standard, and operating procedures were adhered to for all measurements performed. Before commencement, participants were fully familiarized with the experimental protocol and measurement tools. Warm-up and cool-down periods were incorporated within each exercise condition. All participants were also free to cease from the exercise testing at any stage, and testing was terminated if participants showed unusual signs of discomfort. A qualified first aider was available throughout the testing procedures for each experimental study.

Participants were also able to withdraw from the study at any time without having any reason. This was clearly stated on the informed consent/assent forms.

All data obtained from each study was stored electronically (in coded form and anonymized) on the student drive space. Data in hardcopy form were also stored in an individualized folder in a secure location which can only be accessed by the researchers involved in the study. Participants were informed that the outcome of the study may be published but that any data would be anonymized. Written informed consent from all the participants were obtained.

3.2 Study Design

The present study utilised a repeated measure, within-subjects, parallel group design in which each participant was assigned into S-HIIE or P-HIIE using simple randomization (Random Allocation Software, 1.0.0) in the first visit. The first visit (pre-test measurements and familiarization) was to measure anthropometric variables, metabolic outcomes (i.e., blood glucose and lipid profile), determine cardiorespiratory fitness and familiarization of experimental protocol. Subsequently participants completed a 5-week exercise intervention consisting of S-HIIE and P-HIIE, with three exercise sessions per week (total of 15 sessions) in the laboratory-based setting and separated by a minimum two-day rest period (48 hours). Perceptual responses consisting of affective responses (feelings of pleasure and displeasure), enjoyment and perceived exertion were measured during each HIIE session. All exercise sessions were performed on motorized treadmill (h/p/cosmos, Nussdorf-Traun- stein, Germany) at the same time of the day between the hours of 08:00 to 13:00 in order to minimize the effects of diurnal biological variation. After the 5-week intervention period, all the measurements highlighted in the first visit were repeated with ultimately no less than four days (96 hours) following the final exercise training session.

3.3 Sample Size Calculation

A power analysis was calculated by using G*Power version 3.1.9.2. The sample size was a reflection of related research (Astorino et al., 2019) for the primary outcome of feeling scale (FS) and other variables (perceived exertion) during HIIE which has been shown to have an effect size ranging from medium to large (ES= 0.40-0.80). For the purpose of the current study, where two conditions and three repeated measurement points (Session 1, session 8 and session 15; pre- and post-intervention) were analyzed using a two-factor mixed analysis of variance (ANOVA), a sample size of 20 participants would be required to detect a moderate effect using a power of 0.8, an alpha of 0.05 with medium effect size (F=0.30). Therefore, assuming a dropout of four participants, for the current study we propose to recruit a sample of 24 participants (12 participants for each group).

3.4 Study Location

The present study adopted laboratory-based study protocol whereby all the data collection in the present study was conducted at Exercise and Sport Science Laboratory of School of Health Sciences, Universiti Sains Malaysia.

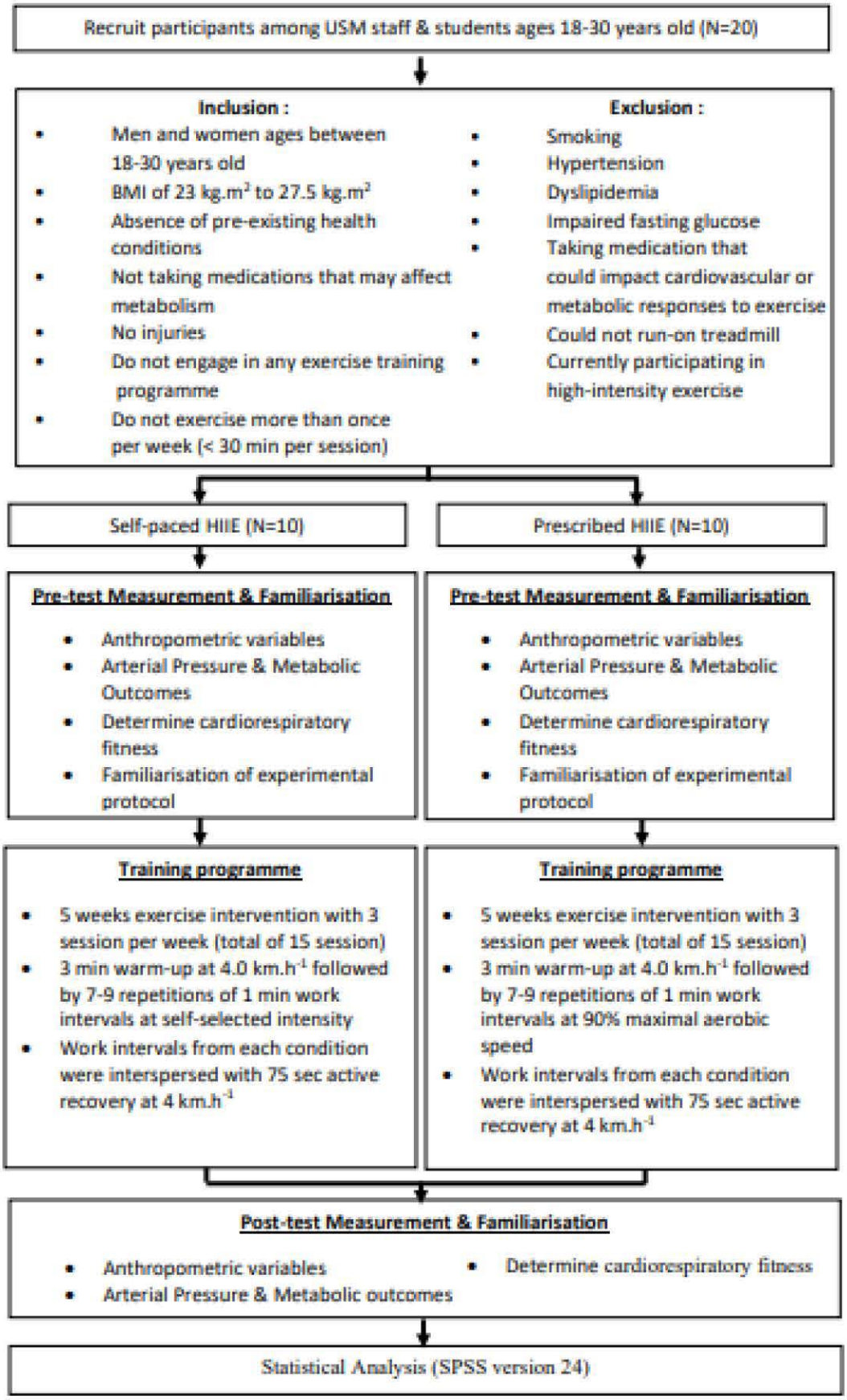

Figure 3.1: Flow chart of the experimental design

3.5 Participants

A total of 24 overweight/obese male and female volunteered to participate in this study (participants characteristics are presented in **Table 3.1**). All the participants were among students or staff of Universiti Sains Malaysia recruited via WhatsApp or poster advertisement that posted throughout the Health Campus in Universiti Sains Malaysia. Also, participants were selected based on the inclusion and exclusion criteria established for this study as highlighted in the section 3.5.1

3.5.1 Inclusion and exclusion criteria of the participants

Table 3.1: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
• Men and women ages between 18-30 years old • BMI of 23 kg.m² to 27.5 kg.m^2 • Absence of pre-existing health conditions • Not taking medications that may affect metabolism • No injuries • Do not engage in any exercise training programme • Do not exercise more than once per week (< 30 min per session)	• Smoking • Hypertension • Dyslipidemia • Impaired fasting glucose • Taking medication that could impact cardiovascular or metabolic responses to exercise • Could not run on treadmill • Currently participating in high-intensity exercise