Physiological and Perceptual Responses During Treadmill Walking at a Self-Selected Intensity in Young and Middle Age Women

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Physiological and Perceptual Responses During Treadmill Walking at a Self-Selected Intensity in Young and Middle Age Women

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of MSc is entirely my own work, that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

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Abbreviations

YW	Young Women
MW	Middle-aged women
HR	Heart rate
RPE	Rate of perceived exertion
RPE-O	Rate of perceived exertion – overall
RPE-C	Rate of perceived exertion – chest
RPE-L	Rate of perceived exertion – Leg
METs	Metabolic equivalents
HR	Heart rate
HRmax	Maximal heart rate
%HRmax	Percentage of maximal heart rate
VO_2	Oxygen uptake
VO_2max	Maximal oxygen uptake
%VO_2max	Percentage of maximal oxygen uptake
VCO_2	Carbon dioxide elimination
RR	Respiratory rate
VT	Ventilatory threshold
Ve	Minute ventilation
%HRVT	Percentage of maximal heart rate at ventilatory threshold
%VO_2VT	Percentage of maximal oxygen uptake at ventilatory threshold
kcal	Kilocalories

ABSTRACT

Purpose: To compare the physiological and perceptual responses during treadmill walking at a self-regulated intensity in women between 18-25 years and 40-55 years.

Methods: Ten young (18-25 y) women (YW) and eleven middle-aged (40-55 y) women (MW) participated in the study. Participants walked on a treadmill at a self-selected intensity until they expended 200 kcal. Expired gases and HR were continuously collected using open circuit spirometry and telemetry respectively. RPE was recorded, and blood samples were drawn at 5 min intervals and during the final min of exercise.

Results: The time required to expend 200 kcal during self-regulated treadmill exercise was significantly longer in MW than YW (31.4± 2.9 min vs. 27.1 ± 3.3 min). The treadmill velocity was significantly higher and the %VO_2 max was significantly lower in YW than MW women. Overall and differentiated rating ratings of perceived exertion for the legs and chest were similar in YW and MW, and were within the range of light to somewhat hard.

Conclusion: When allowed to self-select their exercise intensity both YW and MW select an intensity within the range considered safe and effective for the development and maintenance of health and cardiorespiratory fitness.

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CHAPTER 1

INTRODUCTION

Despite the fact that regular participation in moderate physical activity has consistently been shown to be associated with reduced all-cause mortality, even after controlling for other risk factors directly or indirectly associated with the modern lifestyle, such as smoking, obesity, adult-onset diabetes and hypertension(1)(2), a large proportion of the Irish population are currently inactive(3). A common misconception among the general population is that vigorous exercise is necessary to obtain substantial health benefits. There is now accumulating evidence that the amount of physical activity required to produce substantial health benefits is quite small(4-8). Current guidelines recommend that healthy adults 18 years or older should undertake 30 min or more of moderate-intensity aerobic physical activity 5 days per week or vigorous-intensity aerobic physical activity for 20 min or more for 3 days per week(9).

Exercise prescription within a defined range is primarily based on the recommendation of what is safe and will improve or maintain physical fitness and reduce the risk for chronic diseases. However, in many instances prescribed exercise based on objectively measured thresholds of caloric expenditure or percentage of HRmax or VO_2 max may be perceived as unpleasant or uncomfortable which may negatively impact on long term adherence. Indeed, exercise prescription is as much an art as a science, and there is a need to balance physiological effectiveness with enjoyment and pleasure in order to insure that adherence is sufficient to maintain or positively effect desired biological changes. According to the ACSM, the most effective exercise prescription for an individual is one that is most helpful in achieving behavioural change.

Participation in regular physical activity is influenced by a number of factors. These include demographic, psychological, behavioural, socio-cultural, environmental and activity characteristics(10). For example, a number of surveys involving women from various racial-ethnic groups have found that they prefer to exercise on their own (autonomously performed physical activity(11). The reasons are not well understood but may be related to the fact that activity is experienced as pleasant due to the greater sense of perceived autonomy in determining the mode, duration, frequency and intensity of exercise.

Allowing individuals to use effort perception to self-select their preferred intensity may encourage the development of intrinsic motivation, a central element in promoting adherence to exercise, and increase enjoyment and participation levels. In a recent study Johnson *et al*., found that 86% of women involved in aerobic exercise used effort perception exclusively to determine exercise intensity(12). This is not surprising considering that exertional feedback is commonly used to regulate the pace of many daily activities. This is often done without conscious awareness. Allowing individuals to use effort perception to self-select their preferred intensity may also help them to adjust their work rate to account for improvements in fitness.

Walking is the most popular mode of exercise among women(13). It is highly accessible, requires no special skills or facilities, can be easily accommodated into an existing lifestyle, can be undertaken at almost any age with little risk of injury and has been shown to positively impact on physical, psychological and cognitive function. Although effort perception is used to select exercise intensity during walking, few studies have systematically examined the physiological and perceptual responses in young and middle age women when walking at their preferred intensity.

Study Purpose

The purpose of this study is to compare the physiological and perceptual responses during treadmill walking at a self-regulated intensity in women between 18-25 years and 40-55 years

Aims of the Study

1. To compare the time required to expend 200 kcal in healthy young (18-25 y) women (YW) and middle aged (40-55 y) women (MW) during a single bout of walking on a treadmill at a self-selected intensity

2. To compare the treadmill velocity in healthy YW and MW during treadmill walking at a self-selected intensity

3. To compare the oxygen uptake, heart rate, respiratory rate, blood lactate levels, METs and the percentage of ventilatory threshold (%VT) during treadmill walking at a self-selected intensity in healthy YW and MW

4. To compare the rate of caloric expenditure during walking at a self-selected intensity in healthy YW and MW

5. To compare overall rating of perceived exertion (RPE-O), and differentiated rating of perceived exertion for the legs (RPE-L) and chest (RPE-C) during treadmill walking at a self-selected intensity in healthy YW and MW

Hypothesis

1. The time required to expend 200 Kcal during treadmill walking at a self-selected intensity will be significantly lower in YW than MW

2. The treadmill velocity will be significantly faster in healthy YW than MW during treadmill walking at a self-selected intensity

3. The %VO_2max, %HRmax, respiratory rate, blood lactate levels, MET value, and %VT will be lower in YW than MW during treadmill walking at a self-selected intensity

4. The rate of caloric expenditure will be higher in YW than MW during treadmill walking at a self-selected intensity

5. RPE-O, RPE-L and RPE-C will not be significantly different in YW than MW during treadmill walking at a self-selected intensity

CHAPTER II

REVIEW OF LITERATURE

Despite accumulating clinical and epidemiological evidence linking physical inactivity with cardiovascular and other chronic diseases, a high percentage of Irish adults continue to lead sedentary lifestyles(3). According to the Eurobarometer on Health and Food Survey almost 60% of Europeans undertake no vigorous physical activity in a typical week and more than 40% report no moderate physical activity in a typical week(14)(15).

The public health benefits of increasing physical activity levels within the general population are enormous and have led to the promotion of physical activity being identified as a public health priority within Ireland and the EU(16)(17). However, promoting physical activity and encouraging adults to change an established sedentary behavior pattern is challenging(17).

In 1978, the American College of Sports Medicine (ACSM) issued guidelines for physical activity that focused on the attainment of cardiorespiratory fitness. The guidelines recommended vigorous aerobic exercise (60-90% heart rate reserve) to be completed 3-5 days per week (d/wk), in bouts of 15-60 min per session(18). It is now widely accepted that the quantity and quality of physical activity needed to obtain health-related benefits differs from what is required for cardiorespiratory fitness enhancement(7).

Current physical activity recommendations have amended the traditional emphasis on developing cardiorespiratory fitness to include a broader public health prospective with a focus on reducing the risk for chronic diseases and disabilities, and preventing unhealthy weight gain. The recently published ACSM/AHA guidelines recommend that healthy adults 18 years or older should undertake 30 min or more of moderate-intensity aerobic physical activity 5 days per week or vigorous-intensity aerobic physical activity for 20 min or more 3 days per week(7). Alternativly, Haskell *et al.*, demonstrated that bouts of 10 min or more of moderate-intensity aerobic activity can be accumulated to achieve the 30-min minimum to promote and maintain health (7). The shift in emphasis was partly to encourage physical activity since moderate intensity activity is likely to be more attainable and sustainable than vigorous intensity exercise among sedentary individuals. The new recommendations emphasize the importance of individual goals and preferences in deciding upon the exercise intensity, but do not provide additional details or specific instructions.

Several recent studies have suggested that the relation between exercise intensity and adherence to a physical activity program might be mediated by the amount of pleasure that an individual experiences during exercise(19)(20-23). According to the hedonic theory of motivation people are likely to repeat an activity if they derive pleasure, sense of energy, or enjoyment from their participation in the activity(19). In contrast, if people derive displeasure, sense of exhaustion, pain, or discomfort from their physical activity, the chances of them repeating the activity would be reduced.

The culture of exercise prescription and programming can be perceived as highly controlling(24). Prescribed exercise that exceeds an individual's preferred level of intensity may establish a negative attitude toward physical activity(25) and may contribute to a low exercise adherence, especially among sedentary individuals(26). Longitudinal studies report that participants tend to deviate from prescribed levels of intensity in favour of their apparently preferred levels(26)(27). In contrast, allowing individuals to use effort perception to self-select(12) their preferred intensity may encourage the development of intrinsic motivation, a central element in promoting adherence to exercise, and increase enjoyment and participation levels. In a recent study Johnson *et al*., found that 86% of women involved in aerobic exercise used effort perception exclusively to determine exercise intensity(12). This is not surprising considering that exertional feedback is often used unconsciously to regulate the pace of many daily activities. The intensity of home, recreational, and even some occupational activities is often self-regulated, using exertional perceptions that reflect local and general fatigue and shortness of breath. In most cases, the pace with which these activities are undertaken allows their successful completion without undue physiological strain(28).

Allowing individuals to self-regulate their exercise intensity may also provide the individual with a sense of control over his or her own behavior, resulting in perceptions of autonomy(29). More autonomous forms of behavioral regulation have been shown to result in greater levels of enjoyment and positive affective experiences(30).

Rating of Perceived Exertion

The perception of exertion is defined as the subjective intensity of effort, strain, discomfort and/or fatigue that is experienced during physical exercise(31). The Borg 15-point category rating of perceived exertion (RPE) scale is the most commonly used method to assess exertional perceptions. This scale is composed of numerical categories which are associated with verbal descriptors that range from “fairly light” to “very very hard” (Figure 1).

Rating of Perceived Exertion (RPE)	
6	No exertion at all
7	
	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Vey hard
18	
19	Extremely hard
20	Maximal exertion

Figure 2.1. Borg 15-point category rating of perceived exertion (RPE) scale

An individual's perception of physical exertion can be viewed as a psychophysiological construct that represents the integration of multiple sensory inputs between external stimuli arising from physical work and internal responses reflecting physiological functions and situational and dispositional factors(28). The physiological functions that mediate perceptual signals of exertion can be respiratory-metabolic, peripheral or non-specific.

Respiratory Metabolic Mediators of RPE

Respiratory-metabolic signals of perceived exertion include minute ventilation ($\dot{V}_E$), respiratory rate (RR), oxygen consumption ($\dot{V}O_2$), and carbon dioxide production

($\dot{V}CO_2$). Pulmonary ventilation and respiratory rate consistently account for the greatest amount of variation in rating of perceived exertion (RPE) during treadmill and cycle ergometer exercise(31). Indeed, adjustments in respiratory rate during dynamic exercise appear to be one of the primary physiological mediators of respiratory metabolic signals of perceived exertion.

The relation between respiratory metabolic signals and RPE may vary depending on the exercise intensity. The correlation between $\dot{V}_E$ and RPE is not pronounced until moderate levels of exercise intensity are achieved(31). Furthermore, a functional link between $\dot{V}CO_2$ and RPE is more likely to occur at higher exercise intensities(31). This is probably due to the fact that at higher exercise intensities, a greater ventilatory drive in response to the increased demands for CO_2 elimination intensifies respiratory-metabolic signals of perceived exertion(32). The effect of $\dot{V}O_2$ on RPE is most notable when expressed in relative terms(31).

Peripheral Metabolic Mediators of RPE

The peripheral physiological processes that influence RPE include metabolic acidosis, muscle fiber type, blood flow in muscle and blood borne energy substrates such as glucose and free fatty acids. These peripheral physiological mediators are mostly regionalized to exercising muscles in the limbs, trunk and upper torso(31).

During submaximal exercise oxygen is readily available to the exercising muscles. As exercise intensity increases the oxygen supply may be unable to meet the metabolic demands and oxidative rephosphorylation of ADP may be supplemented by anaerobic glycolysis resulting in the accumulation of lactic acid in muscle and blood (Figure 2.2)(33). The lactic acid rapidly dissociates to form hydrogen ions and lactate. The blood lactate concentration at any given time reflects the interplay between the rate of lactate production in the muscle and the rate of uptake or clearance from the blood. The exercise intensity at which blood lactate begins to accumulate above resting levels has been identified as the lactate threshold (LT)(33).

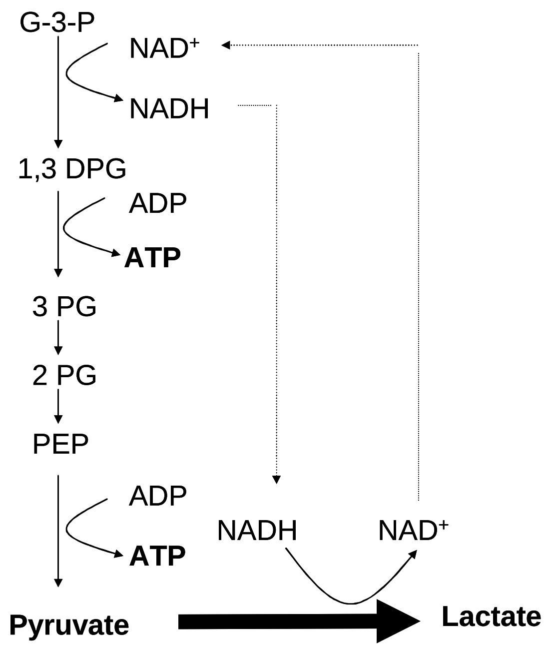

Figure 2.2. Anaerobic glycolysis

The detection of the lactate threshold requires an invasive method of blood sampling. The hydrogen ions that accumulate following the dissociation of lactic acid are buffered by the bicarbonate system, which provides a rapid first line of defense in maintaining pH homeostasis(34). Lactic acid is converted to sodium lactate by combining with sodium bicarbonate in the following reaction: - Lactic acid + $NaHCO_3$ $\rightarrow$ NA Lactate + carbonic acid (H_2CO_2)(34).

Carbonic acid is catalyzed to CO_2 and H_2O by the enzyme carbonic anhydrase(35). The increase in pCO_2 activates peripheral chemoreceptors, which in turn signal the inspiratory centre in the brain to increase ventilation. Small changes in pCO_2 result in large changes in $\dot{V}e$. The exercise intensity at which $\dot{V}e$ and $\dot{V}CO_2$ increase disproportionately in relation to oxygen uptake is called the ventilatory threshold (VT)(36). Several investigators have reported that the VT method is a valid non-invasive method for the detection of the onset of blood lactate accumulation, and may also be highly correlated with endurance performance(37)(38). While some studies have reported increases in ventilation to be independent of increases in blood lactate concentration, the majority of investigators have shown that changes in ventilation are accompanied by changes in blood lactate in response to exercise(39).

The VT can be determined using a variety of ventilatory parameters, many of which exhibit a threshold-like response during progressive exercise. The majority of techniques for identifying the VT rely on visual inspection for the identification of the threshold. The V-slope method (Vslope) is a reliable method of determining VT, based on the excess production of CO_2(40). It involves a regression analysis of the $\dot{V}CO_2$

versus $\dot{V}O_2$ slope. The Vebreak method identifies the VT as the breakaway point in minute ventilation(36).

Non-Specific Mediators

The mediators that are classed as nonspecific consist of physiological processes that are not directly linked to peripheral or respiratory metabolic perceptual signals and include hormonal and temperature regulation, pain reactivity and situation and dispositional factors(28). The majority of evidence supports the role of nonspecific mediators in influencing the intensity of exertional perceptions. Situational factors that may influence the intensity of exertional perceptions include time, environmental setting and exercise mode.

A recent study by DaSilva *et al.*, provides a useful insight into how environmental settings influence the selection of an individual pace as well as the associated physiological, perceptual and affective responses during exercise(41). Men and women between 18 and 30 years walked at a self-selected speed for 20 min on a treadmill and a standard outdoor 400 metre running track on separate days. Both men and women selected a faster walking speed and exercised at a higher $\%\dot{V}O_2$ reserve during overground walking than they did during treadmill walking. Perceived exertion responses to the self-paced walking bout performed on a treadmill were also significantly higher when compared with the self-paced overground session. Although affective valence decreased during both the treadmill and overground conditions, the reductions were greater during exercise on the treadmill. Participants reported a significantly less pleasant experience during treadmill walking than during overground walking, indicating that subtle increases in the self-selected exercise intensity, along with the characteristics of the laboratory setting, may negatively affect their exercise experience.

Dispositional factors are psychological traits that can predictably shape a person's response over a wide range of settings(28). An individual's preference of a level of physical activity intensity depends in part on his or her affective response (pleasure or displeasure) resulting from sensory experience from various parts of the body. Affect refers to a short duration, high intensity emotion or feeling. There is evidence that the amount of time individuals choose to spend in a specific situation is predicted by the affect experienced in that situation(42). When given a choice, individuals will generally adjust their effort intensity during exercise to maximize affect. A positive affective response generated by exercise may lead to greater enjoyment of the exercise session, promote a positive memory of that activity, and consequently, contribute to increased motivation for future physical activity behavior(43)(29)(44)(45). In contrast, activities that are perceived to be difficult are more likely to lead to withdrawal from the activity.

The affective responses to a single bout of moderate-intensity activity can also predict exercise participation up to 6 and 12 months later(43). However, the relation between affective responses and future exercise participation is no longer significant after controlling for perceived exertion. An ideal strategy would be to maximize the positive affective response while minimizing perceived exertion in order to enhance adherence to physical activity programs.

Cabanac examined the effect of allowing subjects self-regulate speed or grade during treadmill exercise(46). Healthy young adult men were given the task to climb a 300 m elevation on a treadmill, at 5 X 5 combinations of speed and grade. If the grade was imposed and speed self-adjusted, or speed imposed and grade self-adjusted, the men spontaneously climbed the 300 m in a constant time due to reciprocal adjustments in speed and grade that resulted in the maintenance of an approximately constant power. The individual choices could be predicted from the sum of ratings for displeasure in the chest and lower limbs. The authors speculated that the affect resulting from sensory inputs from the chest and limb muscles were responsible for optimizing muscular work.

Ekkekakis *et al.*, proposed the dual-mode model to explain the exercise-affect relation(47). The dual-mode model proposes that there are different mechanisms through which affective responses are generated during exercise and that these are based upon the interplay of relevant cognitive processes and interoceptive cues prior to and following the transition from aerobic to anaerobic metabolism. According to this theory, cognitive processes predominate in determining the acute affective responses at intensities below the ventilatory threshold. Above the VT, interoceptive cues (signals from the baroreceptors, thermoreceptors, visceroreceptors in the muscles, heart, and lungs, etc.) generated by the physiological symptoms of the exercise intensity, gain salience and become the primary determinant of the affective responses.

Since the cognitive processes are shaped by personal experience, individual personality, personal goals, etc., there is likely to be greater variability in individual affective responses below the VT. Exercise intensity that exceeds the VT precludes the maintenance of a physiological steady state, results in a systematic decrease in self-ratings of pleasure and is likely to be perceived as aversive(48). The affective response is uniformly negative with less inter-individual variability as the interoceptive cues lead to an affective response triggered by the physiological cues that threaten physical harm. It is also possible that the negative affective response to a bout of exercise above the VT may, over time, lead to aversion and avoidance of regular physical activity participation. Interestingly, recent studies have found that individuals exercising at a self-selected pace tend to choose an intensity near the ventilatory threshold, and the interindividual variability in the affective responses is reduced(29).

Walking

Individuals are more likely to make behavioral choices that increase their pleasure and, conversely, tend to avoid behavioral choices that consistently decrease their pleasure or induce displeasure. Allowing individuals to use their cognitive appraisal processes during self-regulated exercise intensity may contribute to improved affective and perceptual responses.

Walking (4.8-6.4 $km \cdot h^{-1}$) is promoted as a moderate intensity (~3-6 METS) activity that is highly accessible, requires no special skills or facilities, can be easily accommodated into an existing lifestyle and can be undertaken at almost any age with little risk of injury. Walking programs have been shown to favorably alter aerobic capacity(49), improve lipid profiles(50), decrease adiposity(13), and blood pressure(51)(52), enhance psychological well-being and prevent cognitive decline in older community-dwelling adults(53), improve quality of life in patients with heart failure(54), reduce the risk of T2DM(55), reduce anxiety and tension(49), assist with weight loss(56), and reduce death from cancer(57). Recent studies have linked low to moderate intensity walking with reduced likelihood of developing coronary heart disease in women(58). Women who walked at least 1 h per week or whose usual walking pace was at least 3.0 mph experienced about half the CHD risk of women who did not walk regularly.

Table 2.1: Summary of studies involving self-selected intensity walking

Author	Year	Subject	Age (y)	Speed (km)	RPE	VO_2max (%)	HRmax (%)
Spelman[59]	1993	M/F (n=7/22)	35	6.4	10.9	52	70
Murtagh[60]	2002	F (n=11)	40	5.63	11.5	59	67
Porcari[61]	1988	M/F (n=19/17)	37	6.28	11.7	44	62
Parfitt[62]	2000	M (n=12)	36.5		11.7	54	
Parfitt[44]	2006	(n=26)	20.5			71.0	
Glass[63]	2001	M/F (n=18)	19.8		12.5	53.7	74.8
Lind[64]	2005	F	MA		13.4	66	81
Brooks[33]	2004	F (n=36)	39.9	5.5	11.0		
Rose & Parfitt[45]	2007	F (n=19)	39.4		11.5	60.2	68.4

MA = Middle-aged

Most individuals prefer to walk alone and unsupervised, self-regulating their own intensity(29). Spelman *et al.*,covertly measured the walking velocity during a typical walking session in 29 adult habitual walkers (22 women and 7 men) with a mean age of 35 yr(59). The subjects subsequently performed an 8-minute level treadmill walk at the velocity determined in the typical walking session to determine physiological, metabolic, perceptual and treadmill speed responses. The mean walking speed was 1.78 $m \cdot s^{-1}$ and the effort was perceived to be “fairly light” (10.9) on Borg scale. The average metabolic cost of walking at a self-selected pace was 5.2 METS and corresponded to 52% $\dot{V}O_2max$ and 70% HRmax. Spellman estimated that the subjects expended approximately 257 kcal, or 3.8 kcal/kg of body weight, during a typical walking session, reaching a level associated with improvements in health and longevity. Using a similar design Murtagh *et al.*,covertly observed the walking velocity in 11 women with a mean age of 40 years(60). They found a mean walking velocity of 1.56 $m \cdot s^{-1}$ which corresponded to 59% $\dot{V}O_2max$ and 67% HRmax. The RPE was 11.5 (fairly light). When asked to demonstrate their interpretation of “brisk” walking over the same course the velocity increased significantly to 1.79 $m \cdot s^{-1}$, which corresponded to 69% $\dot{V}O_2max$ and 79% HRmax and an RPE of 13.6. These findings indicate that when walking for exercise, adults self-select speeds and intensities that meet definitions of moderate intensity activity, and instructing them to walk briskly encourages vigorous exercise.

Porcari *et al*., evaluated the treadmill velocity among 17 men and 19 women (37.4 ± 5.1 years) during 40 min of treadmill walking at a self-selected intensity(61). The mean walking velocity was 1.73 ± 0.21 $m{\cdot}s^{-1}$ (3.9 mph). This corresponded to 44 %$\dot{V}O_2$max and 63 %HRmax. The treadmill velocity was similar to that selected by the women in the Spelman *et al*., study (1.78 $miles{\cdot}h^{-1}$).

Parfitt *et al*., compared the affective and physiological responses to 20 min of exercise when the exercise intensity was prescribed above the lactate threshold (4 $mmol{\cdot}L^{-1}$, 72.6 % $\dot{V}O_2$max), below the lactate threshold (2 $mmol{\cdot}L^{-1}$, 39.8 % $\dot{V}O_2$max), or at a self-selected pace (54.1 % $\dot{V}O_2$max) among 12 sedentary men with a mean age of 36.5 years and $\dot{V}O_2$max of 34.1 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$(44). Participants were instructed to self-select an intensity that they preferred and would make them feel happy to do regularly and could be sustained for 20 min. They were allowed to change the intensity after 5, 10, and 15 min. Participants self-selected an intensity that allowed them to maintain a physiological steady state, and a steady and positive affective state. The self-selected intensity corresponded to 54.1 %$\dot{V}O_2$max, and an RPE of 11.7 ± 1.8. Blood lactate levels ranged between 3.7–4.3 mmol L^{-1} and did not significantly increase over the 20 min of exercise.

Blood lactate levels were similar between the 2 $mmol{\cdot}L^{-1}$, lactate condition and the self-selected condition and did not change significantly during the 20 min exercise bout. In both conditions, lactate was significantly lower than the 4 $mmol{\cdot}L^{-1}$, lactate condition, during which there was a significant increase over time (culminating at 7.17 $mmol \cdot L^{-1}$), suggesting an inability to maintain steady state. Ratings of pleasure-displeasure remained stable and positive during exercise at 2 $mmol \cdot L^{-1}$ blood lactate and at self-selected intensity, but declined significantly and eventually became negative during the bout of prescribed exercise at a blood lactate concentration of 4 $mmol \cdot L^{-1}$. Interestingly, 11 of the 12 participants stated that they preferred the 'self-selected' condition because it gave them a sense of control.

In a earlier study, Parfitt *et al.*, compared the effects of 20 min of treadmill exercise at a prescribed intensity (65% $\dot{V}O_2max$) and at a self-selected intensity in 26 active college students (20.5 years) with an estimated $\dot{V}O_2max$ of 51.0 $mL \cdot kg^{-1} \cdot min^{-1}$(62). The mean self-selected intensity was 71.0% $\dot{V}O_2max$. Although the metabolic work rates differed between the prescribed and self-selected exercise sessions, there was no difference in RPE, psychological affect or enjoyment between the two exercise sessions.

Glass *et al.*, compared the treadmill velocity, perceptual and physiological responses in 18 men and women (age 19.8 ± 2.0 years; $\dot{V}O_2max$ 4.04 ± 5.7 $L \cdot min^{-1}$) during a 20-min bout of self selected treadmill exercise(63). After the warm-up participants set the initial speed and were allowed to make adjustments after 5, 10, and 15 min. Participants exercised at an intensity corresponding to 53.7 ± 18.4%

$\dot{V}O_2$max, 74.8% ± 13.1 %HRR and an RPE of 12.5 ± 2.9. There was a significant increase in %$\dot{V}O_2$max, %HRR and RPE during the 20 min exercise bout.

Lind *et al*., reported that %HRmax, %$\dot{V}O_2$max, and RPE during the final 10 min of a 20 min walk at a preferred intensity in sedentary middle-aged women was 81%, 66% and 13.4 respectively(64). This intensity was accompanied by stable, positive ratings of affective valence. It should be noted that the %HR max, and %$\dot{V}O_2$max increased from 74% and 55% respectively at 5 min to 83% HR max, and 67% $\dot{V}O_2$max at 20 min.

In a series of studies Ekkekakis *et al*., found that college age men and women, with an average age of 20 years, self-select a walking speed between 1.20 and 1.24 $m{\cdot}s^{-1.}$ during 8 to 10 min bouts of indoor and outdoor walking(65). The RPE and %HRR were approximately 10 and 25% respectively. Using a similar design the same authors reported that men and women between the age of 35 and 70 years exercised at 65% and 55% HRM during and at the end of a 15 min walk at a self-selected intensity. The RPE was 11.3 and 11.8 at minute 7 and minute 15 respectively.

Brooks *et al*., compared the physiological and metabolic response during 15 min of self-selected moderate pace over-ground walking in 36 sedentary middle-aged women (age 39.9 ± 2.8 years; heart rate max 180.0 ± 2.0 $beats{\cdot}min^{-1}$)(66). Participants self-selected a walking speed of 5.5 ± 0.5 km h^{-1} (1.53 m s^{-1}). This equated to 4.1 ± 0.7 MET's and an RPE of 11.0 ± 2.0. When allowed to self-select the intensity during 30 min of treadmill exercise college-age women (age 21.0 ± 0.3 years) exercised at 64%

HRmax. The RPE was 10.2 ± 2.4 and ranged between 9 (very light) and 11 (fairly light)(67).

Using a similar design Rose and Parfitt *et al.*, compared physiological and affective responses during 20 min bouts of treadmill exercise at speeds below LT, at LT, above LT and at a self-selected intensity in 19 sedentary women (age 39.4 ± 10.3 years; $\dot{V}O_2$max 36.1 ± 3.0 mL·kg^{-1}min^{-1})(68). In each condition, the treadmill velocity was set at 5.4 km·h^{-1} and the gradient was altered to provide the exercise intensity that related to the specified exercise condition. Participants self-selected an intensity that corresponded to 60.2% $\dot{V}O_2$max, 68.4 % HRmax and an RPE of 11.5. The %$\dot{V}O_2$max increased significantly from 5 to 10 min and the %HRmax increased significantly from 5 to 10 min and 15 to 20 min. The RPE increased from 5-10 min and remained stable thereafter. Circulating levels of blood lactate were similar at 10 min and 20 min and averaged 2.3 mmol L^{-1}. Participants felt that they had more control and were better able to cope during the self-selected exercise session.

Lactate levels were significantly higher during treadmill exercise above LT than during the other 3 conditions. Self-ratings of pleasure-displeasure declined significantly during the condition above LT but remained stable and positive in the other three conditions. Exercise at a self-regulated intensity led to more positive affective responses compared with exercise above and at lactate threshold, and equally positive responses compared to those below lactate threshold.

Lind *et al*., compared the affective responses in 25 sedentary middle-aged women (age 43.7 ± 4.8 years; $\dot{V}O_2max$ 23.0 ± 5.7 $mL \cdot kg^{-1} \cdot min^{-1}$) during a 20-min bout of treadmill exercise at a self-selected intensity (1.65 ± 0.40 $m \cdot sec^{-1}$) and when the speed exceeded the self-selected level by 10%(69). The treadmill grade was kept at 0% during the self-selected exercise bout. After the warm-up participants set the initial speed and were allowed to make adjustments after 5, 10, and 15 min. No preference to an exact modality (walk, jog, run) was made.

Participants self-selected a treadmill velocity of 1.65 ± 0.40 m sec^{-1} (3.7 ± 0.90 miles h^{-1}). This equated to an oxygen uptake associated with the 98% VT, lactate level of 3.14 mmol L^{-1} and 84.2% HRmax. On the other hand, when the treadmill speed was accelerated by just 10% (by 0.16 m sec^{-1}), $\%\dot{V}O_2$ was 15% of the level that corresponded to the VT, lactate was 4.8 mmol L^{-1}, and 91% HRmax. Affective responses remained positive and stable during the exercise bout at the self-selected intensity, but showed a continuous and significant decline during the bout at the imposed intensity. These findings indicate that when allowed to self-select their exercise intensity, sedentary middle age women choose a level that approximates their ventilatory (or lactate) threshold in order to allow them to maintain a stable and positive affective state. It was not possible from the study design to determine whether the affective decline was due to the increased intensity or due to the loss of perceived autonomy.

To address this question, Vazou-Ekkekakis and Ekkekakis examined the effect of perceived autonomy on affective response during two 30 min bouts of treadmill exercise in 19 college-age women (age 21.0 ± 0.3 years)(67). Participants self-selected the treadmill speed (autonomous condition) or were blinded to a speed that was set by the experimenter (controlled condition). The controlled speed was identical to self-selected speed. Participants exercised at 64% HRmax during the self-selected intensity bout. The peak RPE was 10.2 ± 2.4 during the autonomous condition and 10.2 ± 2.6 during the controlled condition. These averages correspond to an RPE between 9 (very light) and 11 (fairly light). The experimental manipulation was effective in lowering all three components of perceived autonomy (i.e. locus of causality, volition, and perceived choice). In addition, interest/enjoyment and perceived choice, two components of intrinsic motivation were lower following the control than the autonomous condition. Participants gave significantly higher scores in interest/enjoyment and perceived choice after the autonomous than after the controlled condition, indicating a higher degree of intrinsic motivation.

Sheppard *et al*., tracked the temporal dynamics of affective responses during and after exercise at different intensities in young adolescent boys and girls with a mean age of 13.3 years(24). Participants cycled for 15 min at a low intensity (80% of ventilatory threshold power output), high intensity (130% of ventilatory threshold power output) and a self-selected intensity. The mean workrate was 121 ± 21 W, 75 ± 15 W, and 83 ± 22 W, for the high intensity, low intensity and self-selected condition respectively. Affective valence assessed using the Feeling Scale was positive during exercise in the low intensity and self-selected condition and declined in the high intensity condition. However, the divergent trends between intensity conditions were diminished post exercise due to a rebound in response in the high-intensity condition. Solomon proposed the opponent-process theory to explain this rebound effect(71). The theory implies that if the exercise stimulus is perceived as aversive, then the affective state in the post exercise would be relatively positive. Conversely, the affective state during recovery could be relatively negative if the work stimulus was perceived as enjoyable and the cessation of exercise was seen as a "letdown".

Body Weight and Self-Regulated Walking

Variations in levels of body weight and fitness appear to influence self-regulated exercise intensity and cardiorespiratory responses while walking at a self-regulated intensity. Gluteal fat increases the friction on clothing and skin, the chafing creates sores, making it more painful to walk. In addition, many obese individuals may find walking difficult due to lower extremity arthritis and low exercise tolerance.

Larsson and Mattsson examined the effect of a 12 week weight reduction program on velocity, heart rate and O_2 uptake during self-selected walking ability in obese women (44.1 ± 10.7 yr, BMI 37.1 ± 3.4 $kg \cdot m^{-2}$)(72). Self-selected walking speed ($m \cdot min^{-1}$) and $\%\dot{V}O_2max$ were 71.6 and 59.3 respectively, at baseline. At week 12, body weight decreased ($p<0.001$) by 10%, walking velocity increased ($p<0.001$) to 75.9

m·min^{-1} and %$\dot{V}O_2$max decreased ($p<0.001$) to 47.6. An improvement in mechanical efficiency may help to explain the reduction in %$\dot{V}O_2$max in association with an increase in self-regulated walking speed(73). A limitation of the study was the fact that $\dot{V}O_2$max was predicted from a submaximal cycle ergometer test, in order to limit musculoskeletal pain.

Hills *et al*., compared the walking speed, physiological and perceptual responses in 30 obese (age; 47.8 ± 10.8 yr;) and 20 non-obese (age; 36.9 ± 10.8 years) individuals while walking on a level 2-km grass track at a self-selected intensity at a pace consistent with "walking for pleasure"(74). The walking speed was significantly lower in the obese group than the non-obese group (1.47 vs. 1.61 m·sec^{-1}). RPE and absolute and relative heart rate were significantly higher in the obese than the non-obese group.

Pintar *et al*., determined the influence of aerobic fitness and body weight on physiological and perceptual responses and preferred treadmill walking speeds in 60 women between 18-30 years of age(75). The women were non-habitual walkers. There was no difference in preferred treadmill speed, RPE or HR between normal-weight and overweight subjects. Similarly, there was no effect of fitness level on RPE, HR, energy expenditure or treadmill speed at a preferred walking intensity. Lower fit subjects did however, exercise at a higher %$\dot{V}O_2$max than higher-fitness subjects. In contrast, Mattson *et al*., found that obese women (44.1 ±10.7 yr; BMI 37) self-selected walking velocity was 1.19 km·h^{-1}, which equated to 56% $\dot{V}O_2$max(76). Surprisingly, they reported that normal weight subjects exercised at only 35% $\dot{V}O_2$max. The $\dot{V}O_2$max was estimated from a submaximal cycle ergometer test.

Browning *et al.*, compared the preferred outdoor walking speed and the metabolic rate (watts·kg) and energy cost per distance (J·kg^{-1} m^{-1}) at 6 different treadmill velocities (0.50, 0.75, 1.0, 1.25, 1.5, and 1.75 m/s) in 10 normal weight (26.5 ± 5.5 yr; 38.7 ±4.4 ml·kg^{-1} min^{-1}) and 10 obese (25.5 ± 6.9 yr; 25.8 ± 3.1 ml·kg^{-1} min^{-1}) women(77). The net metabolic rate increased with walking speed in both groups and was significantly greater for the obese at 0.75, 1.25, 1.5, and 1.75 m·sec^{-1}). Although the mean net metabolic rate was 11% higher for the obese than the normal weight women (2.81 vs 2.54 W·kg^{-1}), the preferred walking velocity was similar in both groups (1.40 vs. 1.47 m·sec^{-1}, $p = 0.07$). In addition, both groups selected a walking speed at which their gross energy cost per distance was almost minimized, but statistically different (3.07 vs. 3.00 J·kg^{-1}·metre^{-1} for obese, $p = 0.003$; 3.06 vs. 3.01 J·kg^{-1}·metre for normal weight, $p = 0.02$). Since the obese women had a smaller $\dot{V}O_2$max (ml·kg^{-1} min^{-1}), their relative aerobic effort required to walk at the preferred speed was greater than the normal weight group (51% vs. 36%, $p = 0.001$). The preferred walking speed was measured over a distance of only 50 metres and is likely that some women, particularly those who are obese may actually reduce their relative aerobic effort during longer duration exercise. In a follow up study Browning *et al.*, found no difference in the preferred walking speed between class II obese and normal-weight men and women(78). The preferred walking speed corresponded to the speed that minimized the gross energy cost per distance. However, obese women had a 10% greater net metabolic rate than obese men and normal-weight women and a 20% greater net metabolic rate compared with normal-weight men.

Significant health benefits can be achieved by accumulating 200 $kcal \cdot d^{-1}$ of moderate-intensity physical activity. Moyna *et al*., estimated the time required to expend 200 kcal a day on six different exercise machines at intensities perceived to be fairly light (RPE-11), somewhat hard (RPE-13) and hard (RPE-15) (79)(Table 2.2). The estimated time for women to expend 200 kcal during treadmill exercise at an intensity of effort that was perceived to be fairly light (RPE-11) was 22 min. To our knowledge no studies have evaluated the time required to expend 200 kcal when walking at a self-selected treadmill intensity. Hence, there is a need to investigate if self-selcted exercise can use effectively and accurately used as an alternative method to traditional exercise prescriptions.

Table 2.2 Time (min) required to expend 200 kcal at three produced RPEs

		RPE		
Machine	**Group**	**RPE-11**	**RPE-13**	**RPE-15**
Treadmill	Men	14.2 ± 1.9	12.5 ± 1.9	11.5 ± 1.4
	Women	22.0 ± 5.0	18.5 ± 3.6	17.4 ± 2.6
Ski Simulator	Men	16.1 ± 3.9	13.1 ± 1.2	12.0 ± 1.0
	Women	22.9 ± 4.2	21.1 ± 4.0	15.9 ± 4.6
Stair-stepper	Men	19.5 ± 2.5	15.4 ± 1.6	13.3 ± 1.5
	Women	36.5 ± 8.4	23.8 ± 4.6	17.5 ±5.4
Rowing ergometer	Men	21.2 ± 3.5	16.9 ± 2.9	13.7 ± 1.7
	Women	24.7 ± 4.5	21.1 ±4.7	16.0 ± 3.9
Rider	Men	27.0 ± 7.5	24.1 ± 7.7	113.7 ± 1.7
	Women	36.4 ± 5.6	30.0 ± 4.3	16.0 ± 3.9
Cycle ergometer	Men	29.2 ± 7.0	22.7 ±4.4	21.7 ±6.5
	Women	44.1 ± 7.7	32.0 ± 8.4	24.4 ±5.9

CHAPTER III

METHODOLOGY

Subjects

Ten young (18-25 yr) and eleven middle-aged (40-55 yr) healthy women volunteered for the study. Exclusion criteria included smoking, diabetes, anemia, history of heart disease, liver dysfunction, and any other medical conditions that may contraindicate exercise participation. Subjects responded to a recruitment advertisement that was displayed and e-mailed to staff and students in Dublin City University (DCU).

Subjects completed three separate test sessions. Subjects made three separate visits to the Clinical Exercise Physiology Laboratory at Dublin City University (Figure 3.1). The first visit was used to screen potential participants, assess maximal aerobic capacity ($\dot{V}O_2max$) and anchor the Borg 16 point category scale. The second visit was used to orientate subjects to the treadmill protocol and the process of self-regulating exercise intensity. During the third visit the subjects exercised on a treadmill at a self-regulated intensity until they burned 200 kcal. Subjects fasted for 4 h, abstained from alcohol for 3 d and refrained from strenuous physical activity for 24 h prior to each visit. The third visit was undertaken within 5 d of the beginning of menstruation for women with regular menses.

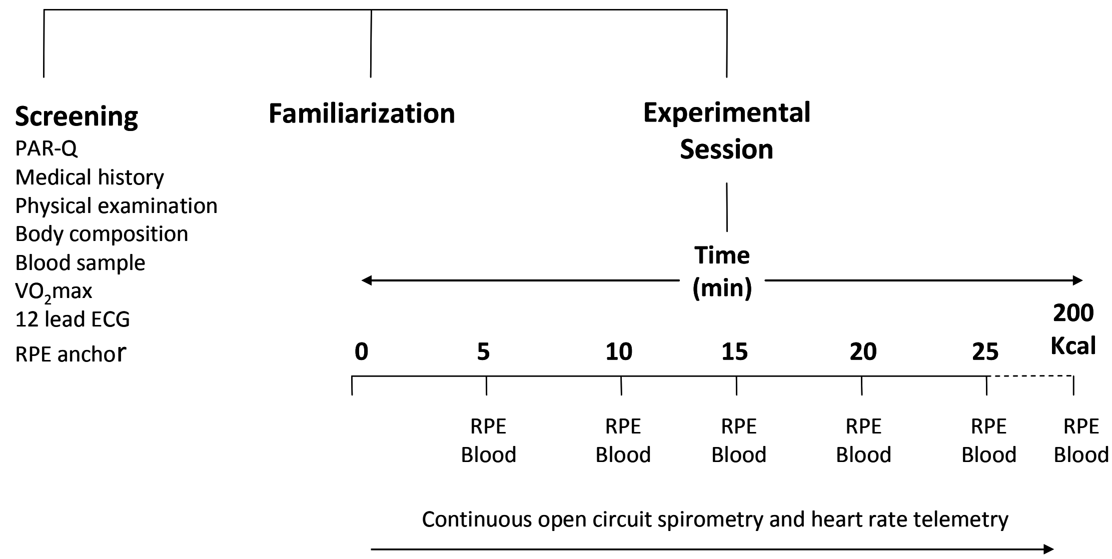

Figure 3.1: Research study design

Screening Session

The nature and risks of the study were explained. A plain language statement was read and informed consent was obtained in accordance with the Research Ethics Committee at Dublin City University (appendix 1). Subjects then completed a physical activity readiness questionnaire (PAR-Q) (appendix 2), underwent a brief physical examination and body composition assessment and performed an exercise test with 12-lead ECG monitoring to determine $\dot{V}O_2max$ and anchor the Borg 15 point category scale.

Familiarization Session

The familiarization session was used to orientate subjects to the treadmill protocol and the process of self-regulating exercise intensity.

Experimental Trial

The experimental trial consisted of continuous walking at a constant 1.0% grade until the subjects expended 200 kcal. Subjects were told that the test would be 20-40 min in duration. Prior to testing a 21 G indwelling catheter was inserted in a forearm vein to facilitate the collection of blood samples. Following a 5 min rest, heart rate was recorded and a baseline blood sample was collected.

The initial treadmill velocity was 3.2 $km \cdot h^{-1}$ and a grade of 1% was selected to provide the subjects with biomechanical speed/grade combinations that allowed a greater opportunity to self-regulate metabolic walking intensities. The treadmill speed was concealed from subjects view. However, the speed control arrows were kept visible to allow subjects alter the treadmill velocity when signalled by the research assistant. Subjects were allowed to alter the treadmill speed during the initial 3 min of exercise and subsequently during the first 30 sec of every 6th minute. The selected speed was viewed only by the investigator and recorded. Participants were asked to “select an intensity that you prefer….that you fell happy to do regularly”. Metabolic measurements and heart rate were recorded continuously throughout the trial using open circuit spirometry (Sensormedics Vmax 229 metabolic system, SensorMedics

Corp., Yorba Linda CA) and telemetery (Polar Vantage NV™ Polar, Port Washington, NY) respectively. Blood samples were drawn and RPE values recorded during the final 15 sec of each 5 min interval.

Differential Ratings of Perceived Exertion (RPE)

A poster-sized Borg 15-point category scale was placed in full view of the subjects. Overall rating of perceived exertion (RPE-O), effort sensation in the legs (RPE-L) and ventilatory/chest effort (RPE-C) were determined in random order by the subjects' signalling with a raised thumb when the research assistant called the number of the scale. Subjects were instructed to focus only on leg effort or on shortness of breath when assigning differentiated ratings of perceived exertion in the legs and chest and to make their subjective assessments of RPE relative to the low and high perceptual anchors established during the maximal exercise test.

Maximal Aerobic Capacity

The maximal exercise test was undertaken on a treadmill (Woodway ELG 55 55, Waukesha, WI) using 1 of 3 ramp protocols, depending on subjects activity levels. The protocols were designed to allow subjects reach volitional fatigue in 8 - 12 min. Each test was preceded by a 2 min warm-up. Breath by breath expired O_2 and CO_2 were measured using open circuit spirometry (Sensormedics Vmax 229 metabolic system, SensorMedics Corp., Yorba Linda CA). Maximal oxygen uptake was determined by averaging the 2 highest consecutive 30 s values. The test was deemed to be maximal if it satisfied at least 3 of the following criteria: a plateau of $\dot{V}O_2$ values indicated by a difference of < 2.1 $ml{\cdot}kg{\cdot}min^{-1}$ between the final two stages, RER > 1.1 and heart rate within ± 10 beats of the age-predicted max.

Perceptual Scale Anchoring

The low and high rating standards or perceptual scale anchors were established during the $\dot{V}O_2$max test. Prior to the test the subjects read a standard set of perceptual scaling instructions. These instructions followed an established format used in previous investigations(79). Low and high rating standards or “perceptual anchors” were established by assigning a rating of 7 (low anchor) to the lowest exercise intensity and 19 (high anchor) to the highest exercise intensity established during the initial maximal exercise test.

Electrocardiographic Monitoring

Heart rate (HR) was measured continuously by the ECG monitor throughout the $\dot{V}O_2$max test. The signal to noise ratio at the skin electrode interface was reduced by cleansing the area with an alcohol saturated gauze pad. The superficial layer of skin was then removed using light abrasion with fine grain emery paper. The electrodes were placed on 10 standard anatomical landmarks.

Ventilatory Threshold

The V-slope method described by Beaver *et al.,* was used for the determination of ventilatory threshold (VT)(33). This method involves the analysis of the CO_2 elimination ($\dot{V}CO_2$) in relation to O_2 uptake ($\dot{V}O_2$). By plotting $\dot{V}CO_2$ against $\dot{V}O_2$ the initial slope of 1.0 is followed by a steeper slope when lactic acid is buffered by bicarbonate and CO_2 is formed. When VT could not be determined using V-slope method, the ventilatory breakpoint method was employed Davis *et al.,* 1979(33). This involved plotting $\dot{V}O_2$ and minute ventilation ($\dot{V}e$). The $\dot{V}O_2$ of which $\dot{V}e$ increased non-linearly was used to determine the point of the VT. An individual linear regression equation was used to predict RPE at VT for each subject. In this procedure $\dot{V}O_2$ was regressed against corresponding RPE. The RPE at VT was calculated by entering each subject's $\dot{V}O_2$ at VT into the equation and then solving for RPE.

Energy Expenditure

Respiratory metabolic measures were obtained during the last min of each 5 min stage. The energy equivalent of steady state absolute $\dot{V}O_2$ ($L \cdot min^{-1}$) was corrected for differential substrate utilisation using the respiratory exchange ratio and expressed as $kcal \cdot min^{-1}$.

Blood Assays

Blood lactate was determined using an automated analyzer (YSI 2300 STAT Plus). Samples were analysed in duplicate and expressed in mmol L^{-1}. The system was auto-calibrated prior to sampling and after each run of 20 samples or every 15 min. A manual calibration was completed each day using a known solute (mmol L^{-1}) value. Complete blood count (CBC) was assessed using an automated analyser (Beckman Coulter A^{c} Tdiff2 Analyser).

Athropometrics

Height and body mass were measured using a wall stadiometer and electronic balance (Seca 797, USA) respectively. Footwear was removed prior to the measurement. Body mass was measured to the nearest cm, and weight was measured to the nearest 0.1 kg.

Lange skin fold callipers (Cambridge Scientific Industries, MD) were used to measure double thickness subcutaneous adipose tissue on the dominant side of the body. The following anatomical sites were used: triceps, pectorals, mid-axillary, subscapular, abdomen, suprailium, and thigh. A minimum of 2 measurements were taken at each site. If the measurements varied by more than 2 mm, a third was taken. Body density and percent body fat were determined using the Jackson and Pollock equation(80).

Blood Pressure (BP)

Blood pressure was measured using a mercury sphygmomanometer. The first and fifth karotkoff sounds represented the systolic (BP) and diastolic (BP) values (mm Hg) respectively.

Mass Flow Sensor Calibration

A mass flow sensor (Sensormedics, Loma Linda, CA, USA) was used to collect breath-by-breath measurements of ventilation. The sensor responds to instantaneous flow rates between 0-16 $L\cdot sec^{-1}$ and integrated flow between 0-350 $L\cdot min^{-1}$ with flow resistance <1.5 cmH_2O L^{-1} sec^{-1}. The mass flow sensor was outputted to the analyser module of the Vmax 229 and was sampled at a rate of 125 Hz.

A 3-litre volume syringe (Sensormedics, Loma Linda, CA, USA) was used to calibrate the mass flow sensor prior to each test. The syringe was connected to the mass flow sensor, and stroked four times in order to measure inspired and expired volumes. The volumes were calculated by expressing 3 litres as a fraction of each measured inspired and expired volume achieved during calibration. An average correction factor was calculated for inspired and expired volumes, and used to fine-tune the volume measurement. A verification procedure was performed. This involved stroking the 3-litre volume syringe four times. Inspired and expired volumes were measured using the newly calculated correction factors. In order to pass the calibration procedure one of the four strokes had to have an average flow rate <0.5 L·sec^{-1}, and at least one of the four strokes had to have an average flow > 3.0 L·sec^{-1}.

Open Circuit Spriometry

A Vmax 229 Metabolic cart (Sensormedics, Loma Linda, CA, USA) was used to assess the respiratory metabolic responses during the exercise test. The Vmax 229 utilizes a rapid response non-dispersive infrared measurement technique. An O_2 and CO_2 analyser is integrated within the Vmax 229. The CO_2 analyser uses an optical sensor and is linearly scaled across the 0-100% range with a resolution of 0.01 %CO_2, and a response time of <130ms (10-90 %) at 500 ml·min^{-1} flow. The O_2 analyser is based on the high paramagnetic susceptibility of O_2. A diamagnetic glass dumbbell suspended in a magnetic field rotates in proportion to the PO_2.

Following a 15 min warm-up the gas analysers were calibrated with standard gases of known concentration (BOC gases, Dublin, Ireland). The first calibration gas contained 26.00 $\pm$ 0.02% oxygen (O_2) and the balance nitrogen (N_2). The second calibration gas contained 4.00 $\pm$ 0.02% carbon dioxide (CO_2), 16.00 $\pm$ 0.02%O_2, and the balance N_2. A small bore drying tube connected to the CO_2 and O_2 analysers samples the calibration gases and inhaled/exhaled air by the subjects. The absorption and evaporative properties of the drying tube ensured that the relative humidity in the inhaled/exhaled gas and in the calibration gas was equilibrated to ambient conditions before the analysers sampled them. Samples of both calibration gas and gas inhaled by subjects were taken at a rate of 125 Hz. The response time of the CO_2 analyser was synchronised with that of the O_2 analyser.

Statistical Analysis

Descriptive statistics and physiological responses at maximal exercise were compared using parametric and non-parametric independent t-tests. There was considerable inter-individual variation in the total exercise time due to the fact that participants were required to expend 200 kcal during the exercise session. Since all of the participants in the MW group and 6 of the 8 participants in the YW group exercised for at least 25 min, the physiological, metabolic and perceptual responses were compared at each 5 min interval up to min 25 using a 2 way (group x time) repeated measured ANOVA with Bonferroni adjustments from multiple comparisons. Open circuit spirometry and heart rate values during the final min of each 5 min period were averaged and used for statistical analysis. The two participants in the YW group who expended 200 Kcal in <25 min exercised for 23 and 24 min. Their open circuit spirometry and heart rate values were averaged during the final min of exercise and used for statistical analysis.

Since the treadmill velocity did not change in the either the YM or MW between 5 min and 25 min, the physiological, metabolic and perceptual responses were averaged over the 20 min period and compared to the responses averaged over the final minute of exercise using 2 way (group x time) repeated measured ANOVA with Bonforoni adjustments from multiple comparisons.

SPSS for Windows statistical software (ver 12.0.1) was used to perform the statistical analysis. Statistical significance was accepted at the $p<0.05$ level of confidence.

CHAPTER IV

RESULTS

Subject Characteristics

Subject characteristics are presented in Table 1. With the exception of age, there was no difference in any of the measured characteristics between the two groups (Table 4.1).

Physiological Responses during the Maximal Exercise Test

The physiological responses during the maximal exercise test are outlined in Table 4.2. The YW had a significantly higher relative $\dot{V}O_2max$, absolute $\dot{V}O_2max$, HR max, $\dot{V}E$ max and $\dot{V}O_2$ corresponding to the ventilatory threshold than the MW (Table 4.2). There was no group difference in the % $\dot{V}O_2max$ corresponding to the ventilatory threshold or RER and RPE at maximal exercise (Table 4.2).

Caloric Expenditure and Substrate Utilization

The time required to expend 200 kcal during self-regulated treadmill exercise was significantly longer ($p<0.019$) in the MW than the YW (31.6 ± 4.0 min vs. 26.7 ± 3.3 min), and ranged from 23-33 minutes and 29-36 min in the YW and MW respectively (Table 4.3). There was no difference in the rate of caloric expenditure, or the percent carbohydrate and fat oxidation between YW and MW (Table 4.3).

Treadmill Velocity and Physiological Responses - Within Group Comparisons

The treadmill velocity and physiological responses are summarized in Table 4.4. Compared to 5 min, the treadmill velocity, heart rate and %HRmax were significantly higher in both the YW and MW at 10, 15, 20, and 25 min. The respiratory rate was significantly higher in the YW at 10, 15, 20 and 25 min than at 5 min, and at 25 min than 15 min. Compared to 10 min, heart rate was also higher ($p<0.05$) in YW at 15 and 25 min and %HRmax was higher in YW at 25 min. The %HRVT was significantly higher in both YW and MW at 15, 20 and 25 min than at 5 min. Compared to min 10, the $\dot{V}O_2$ and METs were higher ($p<0.05$) in the YW at 15 and 25 min. Blood lactate, % $\dot{V}O_2$max, % $\dot{V}O_2$VT and energy expenditure did not change significantly in either group throughout the exercise trial.

Perceptual Responses - Within Group Comparisons

Perceptual responses, caloric expenditure and physiological responses are summarized in Table 4.5. With the exception of RPE-C at 10 min, RPE-O, RPE-L and RPE-C were significantly higher in both YW and MW at all time points compared to 5 min. Compared to 10 min, RPE-O, RPE-L and RPE-C were significantly higher in both YW and MW at 20 min and 25 min, at 15 min than 10 min and in both the YW and OW at 20 min and 25 min than 10 min. Compared to 5 min, RPE-C was higher ($p<0.05$) in the YW at 10, 15, 20, and 25 min, and in the MW at 15, 20 and 25 min and during the final minute of exercise. RPE-O was higher ($p<0.01$) in YW at 25 min than at 15 min. RPE-O and RPE-C were significantly higher in MW at 20 min and 25 min than at 15 min.

Treadmill Velocity and Physiological Responses - Between Group Comparisons

The treadmill velocity, $\%\dot{V}O_2VT$ and energy expenditure ($kcal \cdot min^{-1}$) were significantly different between YW and MW at 5, 10, 15, 20 and 25 min (Table 4.4, Table 4.5). The $\dot{V}O_2$ and METS were significantly higher in YW and MW at 15, 20 and 25 min (Table 4.4) and the % $\dot{V}O_2max$ was significantly higher in MW than YW at 5, 10 and 20 min. There was no difference in heart rate, %HRmax, blood lactate, %HRVT, respiratory rate or energy expenditure ($kcal \cdot kg^{-1} \cdot min^{-1}$) between YW and MW.

Perceptual Responses - Between Group Comparisons

There was no difference in RPE-O, RPE-L or RPE-C at any time between the YW and MW (Table 4.5)

Comparison of Perceptual and Physiological Responses Averaged Between 10 Min and 25 Min and During the Final Min of Exercise

With the exception of heart rate and %HRmax there was no difference in any of the measured physiological parameters averaged between 5 min and 25 min compared to the final minute of exercise in YM and MW (Table 4.6). The $\%\dot{V}O_2VT$ was significantly higher in the MW during the final min compared to average value between 5 min and 25 min. The perceptual responses (RPE-O, RPE-L and RPE-C) were significantly higher in YM and MW during the final minute of exercise compared to values averaged between 5 min and 25 min (Table 4.7). The treadmill velocity, $\dot{V}O_2$, and METs were significantly higher and $\%\dot{V}O_2VT$ significantly lower in the YM than the MW between min 10 and min 25 and during the final minute of exercise (Table 4.7).

Table 4.1 Subject characteristics

	Experimental Group	
	YW	MW
Age (years)	21.6 ± 1.8	47.1 ± 5.1‡
Height (cm)	167.0 ± 8.1	162.7 ± 5.2
Mass (kg)	61.8 ± 5.8	60.9 ± 4.3
BMI ($kg \cdot m^{-2}$)	22.2 ± 1.2	23.0 ± 0.9
Body fat (%)	30.1 ± 5.3	30.6 ± 4.0
Systolic blood pressure (mmHg)	120.3 ± 7.9	123.6 ± 16.3
Diastolic blood pressure (mmHg)	79.0 ± 1.9	78.6 ± 8.8
Glucose ($mmol \cdot L^{-1}$)	3.9 ± 0.4	4.1 ± 0.4
Total leukocytes (µL)	7.2 ± 2.2	6.4 ± 1.5
Haemoglobin (g/dl)	13.1 ± 0.9	12.3 ± 1.5
Hematocrit (%)	0.4 ± 0.03	0.4 ± 0.05

Values are means ± SD; ‡$p < 0.001$ vs YW

Table 4.2 Physiological responses during the maximal exercise test

	Experimental Group	
	YW	MW
$\dot{V}O_2$max ($L \cdot min^{-1}$)	2.9 ± 0.3	2.2 ± 0.4‡
$\dot{V}O_2$max ($ml \cdot kg^{-1} \cdot min^{-1}$)	47.7 ± 3.3	36.1 ± 4.7‡
Heart rate ($b \cdot min^{-1}$)	192.8 ± 6.2	182.3 ± 5.3†
Respiratory exchange ratio	1.2 ± 0.1	1.2 ± 0.1
Minute ventilation (max) ($L \cdot min^{-1}$)	85.5 ± 7.7	65.8 ± 9.8‡
RPE max	19.3 ± 1.3	18.5 ± 1.6
$\dot{V}O_2$ at VT ($ml \cdot kg^{-1} \cdot min^{-1}$)	40.2 ± 4.9	28.3 ± 3.4‡
%$\dot{V}O_2$max at VT	82.5. ± 6.9	80.6 ± 4.4

Values are means ± SD; †p < 0.01 vs YW, ‡p < 0.001 vs YW.

Table 4.3. Caloric expenditure and substrate utilization

	Group	
	YW	MW
kcal/min	7.3 ± 1.2	6.8 ± 1.6
Time to burn 200kcal	27.1 ± 3.3	31.4 ± 2.9*
CHO oxidation (%)	63.9 ± 13.8	55.6 ± 9.0
Fat oxidation (%)	36.1 ± 13.8	44.4 ± 9.0

Values are means ± SD, *p < 0.05 vs. YW

Table 4.4. Treadmill velocity and physiological responses during the initial 25 min of self regulated exercise

		Time (min)				
		5	10	15	20	25
Treadmill velocity ($km \cdot h^{-1}$)	YW	6.0 ± 0.6	6.7 ± 0.4[c]	6.9 ± 0.2[c]	7.0 ± 0.1[b]	7.0 ± 0.2[b]
	MW	5.3 ± 0.6*	6.0 ± 0.5†[c]	6.1 ± 0.5†[b]	6.2 ± 0.6†[b]	6.2 ± 0.7†[a]
$\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	YW	22.2 ± 3.3	23.6 ± 2.8	25.0 ± 2.6[d]	24.7 ± 2.3	25.3 ± 2.6[d]
	MW	20.1 ± 1.2	21 5 ± 1.9	21.8 ± 1.6†	22.5 ± 1.8*	22.2 ± 2.4*
%$\dot{V}O_2$max	YW	47.0 ± 9.2	50.0 ± 8.1	52.8 ± 7.4	52.1 ± 6.6	53.5 ± 7.6
	MW	56.8 ± 9.0*	60.9 ± 11.7*	61.5 ± 10.1	63.5 ± 11.6*	62.6 ± 11.5
Heart rate ($beats \cdot min^{-1}$)	YW	117.9 ± 13.6	133.1 ± 17.9[a]	139.6 ± 15.6[c,]	143.9 ± 14.3[c]	148.3 ± 14.4[c,d]
	MW	112.5 ± 8.1	127.0 ± 5.6[a]	131.5 ± 8.9[b]	134.4 ±9.9[c]	138.6 ± 15.1[b]
%HRmax	YW	61.4 ± 9.0	69.3 ± 10.2[a]	72.7 ± 9.3[c]	74.8 ± 8.1[c]	77.1 ± 8.2[c,d]
	MW	61.7 ± 4.2	69.7 ± 3.1[b]	72.2 ± 5.0[c]	73.7 ± 4.9[c]	76.1 ± 8.1[c]
MET	YW	6.3 ± 0.9	6.7 ± 0.8	7.1 ± 0.8[d]	7.1 ± 0.7	7.2 ± 0.7[d]
	MW	5.8 ± 0.3	6.2 ± 0.5	6.2 ± 0.4†	6.4 ± 0.5*	6.4 ± 0.7*
Respiratory rate ($breaths \cdot min^{-1}$)	YW	25.0 ± 4.9	27.3 ± 5.1[a]	28.2 ± 5.8[a]	29.0 ± 6.3[a]	30.0 ± 5.3[b,g]
	MW	28.2 ± 7.0	29.5 ± 7.5	29.7 ± 6.4	30.6 ± 7.1	30.2 ± 6.3
Lactate ($mmol \cdot L^{-1}$)	YW	0.9 ± 0.3	1.0 ± 0.4	1.1 ± 0.4	1.1 ± 0.5	1.2 ± 0.5
	MW	0.7 ± 0.1	0.8 ± 0.2	0.9 ± 0.3	0.9 ± 0.3	1.1 ± 0.6
%$\dot{V}O_2$VT	YW	52.6 ± 10.3	56.0 ± 7.8	60.2 ± 6.7	59.8 ± 5.7	60.7 ± 5.3
	MW	71.5 ± 11.8*	74.8 ± 13.0*	77.2 ± 12.8*	78.4 ± 14.1*	76.4 ± 13.0*
%HRVT	YW	63.8 ± 6.8	70.9 ± 9.0	75.4 ± 8.6[b]	78.2 ± 7.7[c]	80.5 ± 8.2[b]
	MW	69.4 ± 6.7	76.1 ± 6.0	79.2 ± 8.0[a]	81.2 ± 7.3[b]	81.2 ± 8.0[a]

Values are means ± SD, *$p < 0.05$ vs. YW; †$p < 0.01$ vs. YW; ‡$p < 0.001$ vs. YW; [a]$p < 0.05$ vs. 5 min; [b]$p < 0.01$ vs. 5 min; [c]$p < 0.001$ vs. 5 min, [d]$p < 0.05$ vs. 10 min

Table 4.5: Perceptual responses and energy expenditure during the initial 25 min of self regulated exercise

		Time (min)				
		5	10	15	20	25
RPE-O	YW	8.1 ± 1.7	10.3 ± 1.8[b]	11.9 ± 0.4[c,d]	12.6 ± 0.9[c,e]	13.0 ± 0.5[c,e,h]
	MW	7.4 ± 1.3	9.5 ± 2.1[b]	10.4 ± 2.0[b]	11.8 ± 1.8[c,d,h]	12.9 ± 1.4[c,f,i]
RPE-L	YW	7.9 ± 1.8	10.1 ± 2.2[c]	12.3 ± 0.7[cd]	13.1 ± 0.6[c,e]	13.3 ± 0.9[c,f]
	MW	7.5 ± 2.3	9.4 ± 2.3[b]	11.0 ± 2.3[c]	12.0 ± 1.9[c,d]	12.6 ± 1.4[c,e]
RPE-C	YW	7.9 ± 1.6	10.0 ± 1.7[b]	11.25 ± 0.7[c]	11.9 ± 1.0[c,d]	12.4 ± 0.7[c,d]
	MW	7.1 ± 1.1	8.6 ± 1.4	10.1 ± 1.4[c]	11.3 ± 1.4[c,e,h]	11.6 ± 1.4[c,f,h]
Energy Expenditure ($kcal\cdot min^{-1}$)	YW	6.8 ± 1.2	7.2 ± 1.0	7.7 ± 0.9	7.6 ± 0.8	7.7 ± 1.0
	MW	5.9 ± 0.7	6.2 ± 0.9*	6.2 ± 0.7†	6.4 ± 0.9†	6.6 ± 0.9*
Energy Expenditure ($kcal\cdot kg^{-1}\cdot km^{-1}$)	YW	0.7 ± 0.05	0.7 ± 0.05	0.7 ± 0.07	0.7 ± 0.06	0.7 ± 0.07
	MW	0.7 ± 0.05	0.6 ± 0.08	0.6 ± 0.07	0.6 ± 0.07	0.7 ± 0.06

Values are means ± SD; [a]p < 0.05 vs. 5 min; [b]p < 0.01 vs. 5 min; [c]p < 0.001 vs. 5 min,[d]p < 0.05 vs. 10 min; [e]p < 0.01 vs. 10 min; [f]p < 0.001 vs. 10 min; [g]p < 0.05 vs. 15 min; [h]p < 0.01 vs. 15 min; [i]p < 0.001 vs. 15 min, *p < 0.05 vs. YW; †p < 0.01 vs. YW; ‡p < 0.001 vs. YW;

Table 4.6. Treadmill velocity and physiological responses averaged between 5 min and 25 min and during the final min of exercise

		Time	
		Minute 5-25	**Final Minute**
Treadmill velocity ($km \cdot h^{-1}$)	YW	6.9 ± 0.2 [b]	7.0 ± 0.2 [a]
	MW	6.1 ± 0.5	6.3 ± 0.7
$\dot{V}O_2$ ($ml \cdot kg \cdot min^{-1}$)	YW	24.7 ± 2.5 [a]	25.3 ± 2.6 [a]
	MW	22.0 ± 1.7	22.2 ± 2.0
$\dot{V}O_2$ ($L \cdot min^{-1}$)	YW	1.5 ± 0.2 [a]	1.6 ± 0.3[a]
	MW	1.3± 0.2	1.3 ± 0.2
%$\dot{V}O_2$max	YW	52.0 ± 7.2[a]	53.5 ± 7.6
	MW	62.1 ± 10.9	62.4 ± 10.2
METs	YW	7.0 ± 0.7 [a]	7.2 ± 0.7[a]
	MW	6.3 ± 0.5	6.3 ± 0.6
Heart rate ($beats \cdot min^{-1}$)	YW	141.2 ± 14.5	149.6 ±16.1†
	MW	132.9 ± 9.3	140.4 ± 13.0†
% HRmax	YW	73.5 ± 8.5	77.8 ± 9.0†
	MW	72.9 ± 4.9	77.0 ± 6.3†
Respiratory rate ($breaths \cdot min^{-1}$)	YW	28.6 ± 5.5	30.9 ± 6.7
	MW	29.2 ± 3.9	31.4 ± 6.7
%$\dot{V}O_2$VT	YW	59.2 ± 6.1 [b]	60.7 ± 5.8 [b]
	MW	76.7 ± 12.6†	78.1 ± 12.8†
%HRVT	YW	76.2 ± 7.5	81.5 ± 9.8
	MW	79.4 ± 7.0	83.2 ± 6.6
Lactate ($mmol \cdot L^{-1}$)	YW	1.1 ± 0.4	1.2 ± 0.4
	MW	0.9 ± 0.3	1.1 ± 0.5
Energy expenditure ($Kcal \cdot min^{-1}$)	YW	7.6 ± 0.9	7.8 ± 1.3
	MW	6.4 ± 0.8	6.5 ± 0.8
Energy expenditure ($Kcal \cdot kg^{-1} \cdot km^{-1}$)	YW	0.7 ± 0.06	0.7 ± 0.08
	MW	0.6 ± 0.07	0.6 ± 0.1

Values are means ± SD, *$p < 0.05$ vs. 5-25; †$p < 0.01$ vs. 5-25, [a]$p < 0.05$ vs. MW; [b]$p < 0.01$ vs. MW

Table 4.7. Perceptual and metabolic responses averaged between 5 min and 25 min and during the final min of exercise

		Time	
		Minute 5-25	**Final Minute**
RPE-O	YW	11.9 ± 0.7	13.4 ± 0.9†
	MW	11.0 ± 1.7	13.5 ± 2.2‡
RPE-L	YW	12.2 ± 0.7	13.6 ± 1.1†
	MW	11.2 ± 1.8	13.8 ± 1.7‡
RPE-C	YW	11.4 ± 0.8	12.6 ±0.9†
	MW	10.4 ± 1.2	12.5 ± 2.3‡

Values are means ± SD, *p < 0.05 vs. 5-25; †p < 0.01 vs. 5-25
‡p < 0.001 vs.5-25[a]p < 0.05 vs. MW; [b]p < 0.01 vs. MW

Chapter V

Discussion

Exercise prescription involves identifying a range of physical activity options that are effective in improving fitness and health while ensuing that risk is minimized and, optimizing the conditions for a sustained behavioural change(29). Exercise intensity is a crucial component of an exercise prescription and has a major influence on the extent to which exercise participation can lead to health and fitness benefits. Standard exercise prescription procedures normally involve the titration of exercise intensity, to elicit a predetermined heart rate, $\dot{V}O_2$, RPE or blood lactate level. However, the culture of exercise prescription can be perceived as highly controlling and aversive, and in many instances may decrease pleasure or interest/enjoyment and establish a negative attitude toward physical activity. Allowing individuals to self-regulate their exercise intensity may provide a sense of control over their behavior, resulting in perceptions of autonomy(29). and greater levels of enjoyment. The purpose of this study was to compare the physiological, metabolic and perceptual responses during self-regulated exercise in YW and MW.

Both YW and MW were within the normal weight range based on BMI values. Systolic and diastolic blood pressure, blood glucose, circulating leukocytes, haematocrit and haemoglobin levels were in the normal range for both YW and MW. As expected the $\dot{V}O_2$peak values expressed in absolute terms and relative to body mass, were lower in the MW than YW.

Participants were required to exercise until they burned 200 kcal during a single bout of self-regulated treadmill walking. On average the MW required approximately 4 min longer than YW to expend 200 kcal. This was due primarily to the fact that the treadmill velocity and the average rate of caloric expenditure were significantly lower in MW than YW between 5 min and 25 min and during the final min of the exercise bout.

The treadmill velocity increased in both YW and MW during the first 10 min of exercise and thereafter did not change significantly until the end of the exercise bout. Previous studies that allowed participants to self-regulate their exercise intensity also found that they tended to increase the intensity during the initial 5-10 min of exercise(63, 64, 68). It has been speculated that when allowed to self-regulated exercise intensity participants may employ an unsolicited warm-up strategy(44, 62). Lind *et al.,* found that speed, blood lactate, $\dot{V}O_2$ and HR values did not reach steady-state for 5-10 min during 20 min of self-regulated treadmill exercise in sedentary middle-aged women(64)(42). Participants may also employ an exploratory strategy to search for the level of intensity, beyond which any additional increase in intensity would be perceived as hard and would potentially bring about a decrease in enjoyment. This is supported by the fact that blood lactate levels remained constant at approximately 1.0 $mmol \cdot L^{-1}$ in both YM and MW from 5 min until the end of the exercise bout.

Current physical activity guidelines recommend that all healthy adults ≥18 yr should undertake moderate-intensity aerobic (endurance) physical activity for 30 min or more for 5 days per week or vigorous-intensity aerobic physical activity for 20 min or more for 3 days per week. Specifically, physical activity should be performed within a range of intensity that extends between a low of 50 and 80%VO_2max and 55-90% HRmax, and RPE of 12-16 on the Borg scale. Both YW and MW selected an exercise intensity within the range considered safe and effective for the development and maintenance of health and cardiorespiratory fitness. The %VO_2max was higher in MW than YW despite the fact that they self-selected a lower treadmill velocity. This can be explained by the lower $\dot{V}O_2$max in the MW than the YW. The majority of previous studies have also found that when individuals are left to self-select their exercise intensity during treadmill and outdoor walking they select an intensity of physical activity that is well within the recommended range for the development and maintenance of cardiorespiratory fitness and/or health.

Although all of the YW and MW selected a workrate within the desired intensity range there was a large inter-individual variation (Figure 5.1). Two of the MW selected an intensity >75 %$\dot{V}O_2$peak while three others selected an intensity between 52-54 %VO_2peak. The exercise intensity range was smaller in the YW. The average metabolic cost was 7.0 and 6.3 METS and corresponded to a caloric expenditure of 7.6 and 6.4 $kcal \cdot min^{-1}$ in the YW and MW respectively.

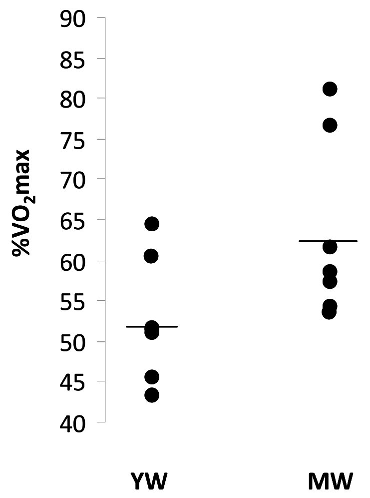

Figure 5.1 Mean individual $\dot{V}O_2max$ values during treadmill walking at a self-selected intensity in YW and MW.

Walking at speeds ranging from 4.8 to 6.4 km·h^{-1} is promoted as a moderate intensity (~3-6 METS) activity that is highly accessible, requires no special skills or facilities, can be easily accommodated into an existing lifestyle and can be undertaken at almost any age with little risk of injury. The fact that the self-selected treadmill velocity was faster in the YW than the MW at each 5 min interval and during the final minute of exercise was not surprising considering the age difference between the two groups and the fact that the YW had a significantly higher $\dot{V}O_2max$ than MW.

The treadmill velocity ranged from 1.91 to 1.94 m·sec^{-1} in the YW and 1.69 to 1.75 m·sec^{-1} in the MW. However, the majority of studies to have measured walking velocity during self-selected exercise have reported values between 1.3 – 1.5 m·sec^{-1}. Differences in participant fitness levels may help to explain the different findings. The fact that the $\dot{V}O_2peak$ values were in the 89th and 70th percentile for the YW and MW respectively indicates that they had a relatively high fitness level(81). In contrast, the $\dot{V}O_2peak$ values are considerably lower in the majority of previous studies that evaluated velocity during treadmill walking at a self-selected intensity. The duration of the exercise bout and the instructions provided to participants may also have influenced the treadmill velocity that participants selected. Examples of instructions provided to participants include "walk at the same pace you usually select when walking for exercise"(82) and "walk at a brisk but comfortable pace"(83).

An individual's perception of physical exertion can be viewed as a psychophysiological construct that represents the integration of multiple sensory inputs between external stimuli arising from physical work and internal responses reflecting physiological functions and situational and dispositional factors(28). The RPE-O values in both YW and MW were within a narrow range (Figure 5.2) and indicate that when allowed to self-regulate their exercise intensity healthy YW and MW will exercise at an intensity that they perceive to be fairly light to somewhat hard. These values are very similar to those found in previous studies involving women between age of 18 and 45 years.

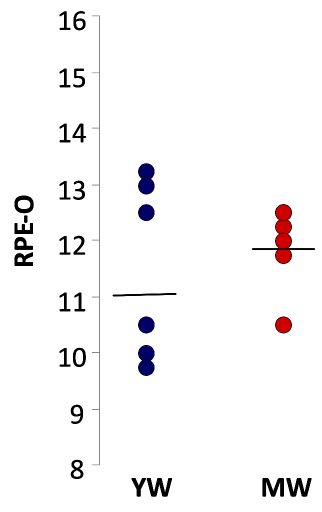

Figure 5.2 Mean individual RPE-O values during treadmill walking at a self-selected intensity in YW (young women) and MW (middle-aged women)

Although affect was not measured in the present study, it is worth noting that when given a choice, individuals will generally adjust their effort intensity during exercise to maximize affect. This is important considering that a positive affective response may lead to greater enjoyment of the exercise session, promote a positive memory of that activity, and, consequently, contribute to increased motivation for future physical activity behavior(29, 44, 45). In contrast, activities that are perceived to be difficult are more likely to lead to withdrawal from the activity. However, the relation between affective responses and future exercise participation is no longer significant after controlling for perceived exertion. An ideal strategy would be to maximize the positive affective response while minimizing perceived exertion in order to enhance adherence to physical activity programs.

Relatively few studies examining the perceptual responses during self-regulated exercise have measured the differentiated RPE arising from the legs and chest in order to assess peripheral signals and respiratory metabolic signals respectively. With one exception, the RPE-C and RPE-L values in both YW and MW were between 9 and 13 respectively (Figure 5.3). These findings indicate that both peripheral signals and respiratory metabolic signals are equally important in determining the overall perceptual responses during treadmill walking at a self-selected intensity in YW and MW.

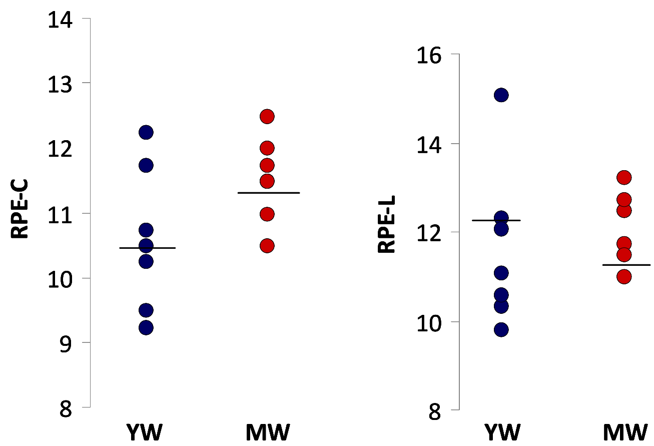

Figure 5.3 Mean individual RPE-C and RPE-L values during treadmill walking at a self-selected intensity in YW and MW

The mean RPE-O, RPE-C and RPE-L was significantly higher in both YW and MW during the final minute of exercise compared to the average values between 5 min and 25 min. This finding is difficult to explain considering that the treadmill velocity did not increase significantly between 10 min and the final min of the exercise bout.

There is a general consensus that the ventilatory threshold indicates the point of transition from aerobic to anaerobic metabolism during exercise(36). Although some studies have reported increases in ventilation above VT during exercise to be independent of increases in blood lactate concentration, the majority of investigators have shown that changes in ventilation are accompanied by changes in blood lactate response to exercise(38). Exercise intensities that exceed the VT preclude the maintenance of a physiological steady state and result in a decrease in self-ratings of pleasure and is likely to be perceived as aversive(29). Interestingly, recent studies have found that individuals exercising at a self-selected pace tend to choose an intensity near the ventilatory threshold(44, 64). It is has been hypothesized that the negative affective response to a bout of exercise above the VT may, over time leads to aversion and avoidance of regular physical activity participation(29).

It was hypothesized that when allowed to self-regulate exercise intensity the majority of YW and MW would exercise at an intensity at or slightly below the $\dot{V}O_2$@VT. The mean exercise intensity in the YW was >40% below the mean %$\dot{V}O_2$@VT (82.5) with little variation (Figure 5.4). In contrast the exercise intensity selected by the MW women was closer to their VT with a larger inter-individual variation (Figure 5.4).

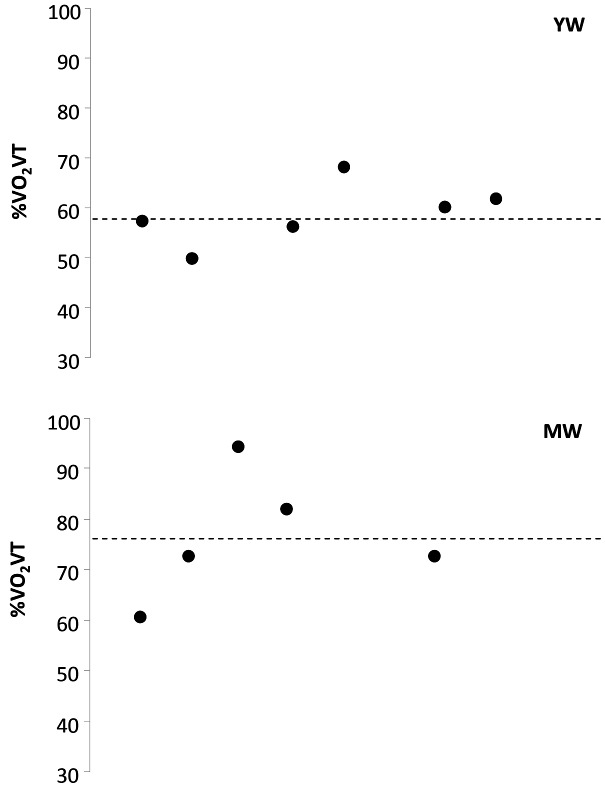

Figure 5.4 Percent of VT for each subject during self-regulated exercise

Study Limitations

When interpreting the results of this study, it is important to consider the limitations inherent in the study design and methodology. The study findings cannot be generalized to other populations (adolescents, men, obese, unfit adults > 55 yr) or other ecological settings (outdoors). The exercise bout was continuous in nature and was approximately 30 min in duration. Furthermore, enjoyment levels and affective responses were not measured.

Summary

The study findings indicate that when healthy YW and MW are allowed to self-select their preferred exercise intensity during a single bout of treadmill walking they select an intensity of physical activity that is well within the recommended range for the development and maintenance of cardiorespiratory fitness and/or health and is perceived to be light to somewhat hard. Both YW and MW adjust their exercise intensity during the initial 10 min in order to achieve a physiological steady state during continuous exercise.

Future Work

There are obviously superior physiological and metabolic benefits to exercise prescription involving higher intensities and longer durations. Unfortunately, higher intensities and longer durations tend to result in lower adherence and eventually dropout, especially in the long term. Exercise specialists need to understand and assess the needs of their clientele. Improving and maintaining health benefits is ultimately the end goal, so discovering the optimal method of exercise prescription is of the utmost importance.

Research studies involving self-selected intensities believe the self-selection can increase enjoyent and affective state. The majority of studies that have used self-selected exercise, to date, have involved a single bout of exercise. No study has examined the effect of allowing individuals to self-select exercise intensity over a longer period of time. Future research should compare the physiological, metabolic, perceptual and affective responses to exercise training when using self-selected intensity and versus prescribed exercise intensity. Studies should also compare the effect of self-selected versus prescribed exercise intensity on long term exercise adherence. Investigations should include a broad spectrum of populations, including healthy and diseased individuals across a variety of age groups. Establishing the optimal duration of self-selected intensity exercise to achieve health benefits and to improve adherence also warrants further research.

It is important to investigate the role of self-selected intensity exercise in younger individuals, to ensure they develop and adopt a physically active lifestyle, that they enjoy and will maintain throughout their life.

To date, no study has examined the effectiveness of achieving the minimum, daily physical activity recommendation through the accumulation of intermittent bouts of self-selected intensity exercise.

Bibliography

1. Nocon M, Hiemann T, Muller-Riemenshneider F, Thalau F, Roll S, Willich SN. Association of physical activity with all-cause and cardiovascular mortality: A systematic and meta-analysis. european Journal of Cardiovascular Prevention and Rehabilitation. 2008;15(3):239-46.

2. Oguma Y, Sesso HD, Paffenbarger RSJ, Lee I. Physical activity and all cause mortality in women: A review of the evidence. Br j Sports Med. 2002;36:162-72.

3. Morgan K, McGee H, Watson D, Perry I, Barry M, Shelley E, et al. Survey of lifestyle, attitudes and nutrition in ireland. 2007.

4. Quell KJ, Porcari JP, Franklin BA, Foster C, Andreuzzi RA, Anthony RM. Is brisk walking an adequate aerobic training stimulus for cardiac patients? Chest. 2002 Nov;122(5):1852-6.

5. Manson JE, FAU - Greenland P, Greenland P, FAU - LaCroix AZ, LaCroix AZ, FAU - Stefanick ML, et al. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. - N Engl J Med.2002 Sep 5;347(10):716-25.

6. Taylor A, Katomeri M. Effects of a brisk walk on blood pressure response to stroop, a speech task and a smoking cue among temporarily abstinent smokers. Psychopharmacology. 2006;184:284-53.

7. Haskell WL, Lee I, Pate RR, Powell KE, Blair SN, Franklin BA, et al. Physical activity and public health. updated recommendation for adults from the american college of sports medicine and the american heart association. Circulation. 2007;116:1081-93.

8. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, et al. Physical activity and public health in older adults- recommendation from the american college of sports Meetmedicine and the american heart association. Circulation. 2007;116:1094-105.

9. American Heart Association and American College of Sports Medicine. Joint position statement: Exercise and acute cardiovascular events: Placing the risks into percpective. Med Sci Sports Exerc. 2007;39:886-97.

10. Trost SG, Owen N, Bauman AE, Sallis JF, Brown W. Correlates of adults participation in physical activity: Review and update. Medicine and Science in Sports and Exercise. 2002;34(12):1996 - 2001, 2002.

11. King GA, Torres N, Potter C, Brooks TJ, Coleman KJ. Comparison of activity monitors to estimate energy cost of treadmill exercise. Med Sci Sports Exerc. 2004 Jul;36(7):1244-51.

12. Johnson JH, Phipps LK. Preferred method of selecting exercise intensity in adult women. J Strength Cond Res. 2006 May;20(2):446-9.

13. Thompson DL, FAU - Rakow J, Rakow J, FAU - Perdue SM, Perdue SM. Relationship between accumulated walking and body composition in middle-aged women. - Med Sci Sports Exerc.2004 May;36(5):911-4.

14. Http://ec.europa.eu/health/ph_publication/eb_food_en.pdf [Internet].

15. Special eurobarometer. health and food [Internet].; 2006. Available from: http://ec.europa.eu/health/ph_publication/eb_food_en.pdf.

16. Cavill N, Kahlmeier S, Racioppi F. Physical activity and health in europe: Evidence for action ; 2006.

17. Brawley LR, FAU - Rejeski WJ, Rejeski WJ, FAU - King AC, King AC. Promoting physical activity for older adults: The challenges for changing behavior. - Am J Prev Med.2003 Oct;25(3 Suppl 2):172-83.

18. American college of sports medicine position statement on the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. - Med Sci Sports.1978 Fall;10(3):vii-x.

19. Kahneman D, Diener E, Schwarz N. Well-being: The foundations of hedonic psychology. ; 1999.

20. Carels RA, FAU - Berger B, Berger B, FAU - Darby L, Darby L. The association between mood states and physical activity in postmenopausal, obese, sedentary women. - J Aging Phys Act.2006 Jan;14(1):12-28.

21. Karvonen M, Kentala E, Mustala O. The effects of training on heart rate; a longitudinal study. - Ann Med Exp Biol Fenn.1957;35(3):307-15.

22. Wilcox S, King AC, Brassington GS. Physical activity preferences of middle-aged and older adults: A community analysis. J Aging Phys Act. 1999;7:386-99.

23. Miller BM, Bartholomew JB, Springer BA. Post-exercise affect: The effect of post mode preference. J Appl Sport Psychol. 2005;17:263-72.

24. Sheppard KE, Parfitt G. Acute affective responses to prescribed and self-selected exercise intensities in young adolescent boys and girls. Pediatr Exerc Sci. 2008 May;20(2):129-41.

25. Perri MG, Anton SD, Durning PE, Ketterson TU, Sydeman SJ, Berlant NE, et al. Adherence to exercise prescriptions: Effects of prescribing moderate versus higher levels of intensity and frequency. Health Psychology. 2002;21(5):452-8.

26. Cox KL, FAU - Burke V, Burke V, FAU - Gorely TJ, Gorely TJ, FAU - Beilin LJ, et al. Controlled comparison of retention and adherence in home- vs center-initiated exercise interventions in women ages 40-65 years: The S.W.E.A.T. study (sedentary women exercise adherence trial). - Prev Med.2003 Jan;36(1):17-29.

27. Kang J, FAU - Schweitzer JS, Schweitzer JS, FAU - Hoffman JR, Hoffman JR. Effect of order of exercise intensity upon cardiorespiratory, metabolic, and perceptual responses during exercise of mixed intensity. - Eur J Appl Physiol.2003 Nov;90(5-6):569-74.Epub 2003 Aug

28. Noble BJ, Robertson RR. Perceived exertion. Champaign, IL Human Kinetics; 1996.

29. Ekkekakis P. Let them roam free? physiological and psychological evidence for the potential of self-selected exercise intensity in public health Sports Med. 2009;39(10):857-88.

30. Vallerand RJ, Rousseau FL. Intrinsic and extrinsic motivation in sport and exercise: A review using the hierarchical model of intrinsic and extrinsic motivation. ; 2001.

31. Robertson RJ, FAU - Noble BJ, Noble BJ. Perception of physical exertion: Methods, mediators, and applications. - Exerc Sport Sci Rev.1997;25:407-52.

32. Cafarelli E, FAU - Noble BJ, Noble BJ. The effect of inspired carbon dioxide on subjective estimates of exertion during exercise. - Ergonomics.1976 Sep;19(5):581-9.

33. Brooks GA, Fahey TD, Baldwin KM. Exercise physiology: Human bioenergetics and its application. NY, USA: McGraw Hill; 2005.

34. Robergs RA, FAU - Ghiasvand F, Ghiasvand F, FAU - Parker D, Parker D. Biochemistry of exercise-induced metabolic acidosis. - Am J Physiol Regul Integr Comp Physiol.2004 Sep;287(3):R502-16.

35. Champe PC, Harvey RA. Biochemistry. NY, USA: JB Lippincott Company; 1987.

36. Wasserman K, FAU - Whipp BJ, Whipp BJ, FAU - Koyl SN, Koyl SN, FAU - Beaver WL, et al. Anaerobic threshold and respiratory gas exchange during exercise. - J Appl Physiol.1973 Aug;35(2):236-43.

37. Amann M, FAU - Subudhi AW, Subudhi AW, FAU - Foster C, Foster C. Predictive validity of ventilatory and lactate thresholds for cycling time trial performance. - Scand J Med Sci Sports.2006 Feb;16(1):27-34.).

38. Loat CE, FAU - Rhodes EC, Rhodes EC. Relationship between the lactate and ventilatory thresholds during prolonged exercise. - Sports Med.1993 Feb;15(2):104-15.

39. Binder RK, FAU - Wonisch M, Wonisch M, FAU - Corra U, Corra U, FAU - Cohen-Solal A, et al. Methodological approach to the first and second lactate threshold in incremental cardiopulmonary exercise testing. - Eur J Cardiovasc Prev Rehabil.2008 Dec;15(6):726-34.

40. Beaver WL, FAU - Wasserman K, Wasserman K, FAU - Whipp BJ, Whipp BJ. A new method for detecting anaerobic threshold by gas exchange. - J Appl Physiol.1986 Jun;60(6):2020-7.

41. Dasilva SG, FAU - Guidetti L, Guidetti L, FAU - Buzzachera CF, Buzzachera CF, FAU - Elsangedy HM, et al. Psychophysiological responses to self-paced treadmill and overground exercise. - Med Sci Sports Exerc.2011 Jun;43(6):1114-24.

42. Emmons RA, Diener E. A goal-effect analysis of everyday situational choices. Journal of Research in Personality;20(3):309-26.

43. Williams DA, Dunsiger S, Ciccolo JT, Lewis BA, Albrecht AE, Marcus BH. Acute affective response to a moderate-intensity exercise stimulus predicts physical activity participation 6 and 12 months later. Psychology of Sport and Exercise. 2008;9:231-45.

44. Parfitt G, Rose EA, Burgess WM. The psychological and physiological responses of sedentary individuals to prescribed and preferred intensity exercise. Br J Health Psychol. 2006 Feb;11(Pt 1):39-53.

45. Rose EA, FAU - Parfitt G, Parfitt G. Can the feeling scale be used to regulate exercise intensity? - Med Sci Sports Exerc.2008 Oct;40(10):1852-60.

46. Cabanac M. Performance and perception at various combinations of treadmill speed and slope. - Physiol Behav.1986;38(6):839-43.</pre>(0031-9384

47. Ekkekakis P. Pleasure and displeasure from the body: Perspectives from exercise. Cognition and Emotion. 2003;17(2):213-39.

48. Ekkekakis P, FAU - Hall EE, Hall EE, FAU - Petruzzello SJ, Petruzzello SJ. Practical markers of the transition from aerobic to anaerobic metabolism during exercise: Rationale and a case for affect-based exercise prescription. - Prev Med.2004 Feb;38(2):149-59.

49. Murphy M, FAU - Nevill A, Nevill A, FAU - Neville C, Neville C, FAU - Biddle S, et al. Accumulating brisk walking for fitness, cardiovascular risk, and psychological health. - Med Sci Sports Exerc.2002 Sep;34(9):1468-74.

50. Kelley GA, FAU - Kelley KS, Kelley KS, FAU - Tran ZV, Tran ZV. Walking, lipids, and lipoproteins: A meta-analysis of randomized controlled trials. - Prev Med.2004 May;38(5):651-61.

51. Kelley GA, FAU - Kelley KS, Kelley KS, FAU - Tran ZV, Tran ZV. Walking and resting blood pressure in adults: A meta-analysis. - Prev Med.2001 Aug;33(2 Pt 1):120-7.

52. Moreau KL, FAU - Degarmo R, Degarmo R, FAU - Langley J, Langley J, FAU - McMahon C, et al. Increasing daily walking lowers blood pressure in postmenopausal women. - Med Sci Sports Exerc.2001 Nov;33(11):1825-31.

53. Morgan AL, FAU - Tobar DA, Tobar DA, FAU - Snyder L, Snyder L. Walking toward a new me: The impact of prescribed walking 10,000 steps/day on physical and psychological well-being. - J Phys Act Health.2010 May;7(3):299-307.

54. Oka RK, FAU - De Marco T, De Marco T, FAU - Haskell WL, Haskell WL, FAU - Botvinick E, et al. Impact of a home-based walking and resistance training program on quality of life in patients with heart failure. - Am J Cardiol.2000 Feb 1;85(3):365-9.

55. Hu FB, FAU - Sigal RJ, Sigal RJ, FAU - Rich-Edwards JW, Rich-Edwards JW, FAU - Colditz GA, et al. Walking compared with vigorous physical activity and risk of type 2 diabetes in women: A prospective study. - JAMA.1999 Oct 20;282(15):1433-9.

56. Jakicic JM, FAU - Marcus BH, Marcus BH, FAU - Gallagher KI, Gallagher KI, FAU - Napolitano M, et al. Effect of exercise duration and intensity on weight loss in overweight, sedentary women: A randomized trial. - JAMA.2003 Sep 10;290(10):1323-30.

57. Holmes MD, FAU - Chen WY, Chen WY, FAU - Feskanich D, Feskanich D, FAU - Kroenke CH, et al. Physical activity and survival after breast cancer diagnosis. - JAMA.2005 May 25;293(20):2479-86.

58. Manson EJ, Greenland P, LaCroix AZ, Stefanick ML, Mouton CP, Oberman A, et al. A prospective study of walking as compared with vigorous exercise in the prevention of coronary heart disease in women. The New England Journal of Medicine. 1999;347(10):716-25.

59. Spelman CC, Pate RR, Macera CA, Ward DS. Self-selected exercise intensity of habitual walkers. Med Sci Sports Exerc. 1993 Oct;25(10):1174-9.

60. Murtagh EM, Boreham CA, Murphy MH. Speed and exercise intensity of recreational walkers. Prev Med. 2002 Oct;35(4):397-400.

61. Porcari JP, Ward A, Morgan WP, Ebbeling S, O'Hanley S, Rippe JM. Self-selected exercise intensity of habitual walkers.

62. Parfitt G, Elaine, A. Rose, & David Markland. The effect of prescribed and preferred intensity exercise on psychological affect and the influence of baseline measures of affect. Journal of Health Psychology. 2000;5(2):231-40.

63. Glass SC, Chvala AM. Preferred exertion across three common modes of exercise training. J Strength Cond Res. 2001 Nov;15(4):474-9.

64. Lind E, Joens-Matre RR, Ekkekakis P. What intensity of physical activity do previously sedentary middle-aged women select? evidence of a coherent pattern from physiological, perceptual, and affective markers. Prev Med. 2005 Apr;40(4):407-19.

65. Ekkekakis P, Hall Ee, VanLanduyt LM, Petruzzello SJ. Walking in (affective) circles: Ca short walks enhance affect? Journal of Behavioural Medicine. 2000;23(3):245-75.

66. Brooks AG, FAU - Withers RT, Withers RT, FAU - Gore CJ, Gore CJ, FAU - Vogler AJ, et al. Measurement and prediction of METs during household activities in 35- to 45-year-old females. - Eur J Appl Physiol.2004 May;91(5-6):638-48.

67. Vazou-Ekkekakis S, Ekkekakis P. Affective consequences of imposing the intensity of physical activity does the loss of perceived autonomy matter? Hellenic Journal of Psychology. 2009;6:125-44.

68. Rose EA, Parfitt G. A quantitative analysis and qualitative explanation of the individual differences in affective responses to prescribed and self-selected exercise intensities Journal of Sport and Exercise Psychology. 2007;29:281-309.

69. Lind E, FAU - Ekkekakis P, Ekkekakis P, FAU - Vazou S, Vazou S. The affective impact of exercise intensity that slightly exceeds the preferred level: 'pain' for no additional 'gain'. - J Health Psychol.2008 May;13(4):464-8.

70. Lind E, Ekkekakis P, Vazou S. The Affective Impact of Exercise Intensity that Slightly Exceeds the Preferred Level: 'Pain' for no Additional 'Gain'. Preventive Medicine. 2005;40:407-19.

71. Solomon RL. The opponent-process theory of acquired motivation: The costs of pleasure and the benefits of pain. - Am Psychol.1980 Aug;35(8):691-712.

72. Larsson UE, FAU - Mattsson E, Mattsson E. Influence of weight loss programmes on walking speed and relative oxygen cost (%VO2max) in obese women during walking. - J Rehabil Med.2003 Mar;35(2):91-7..

73. Freyschuss U, FAU - Melcher A, Melcher A. Exercise energy expenditure in extreme obesity: Influence of ergometry type and weight loss. - Scand J Clin Lab Invest.1978 Dec;38(8):753-9.

74. Hills AP, Byrne NM, Wearing S, Armstrong T. Validation of the intensity of walking for pleasure in obese adults. Prev Med. 2006 Jan;42(1):47-50.

75. Pintar JA, Robertson RJ, Kriska AM, Nagle E, Goss FL. The influence of fitness and body weight on preferred exercise intensity. Med Sci Sports Exerc. 2006 May;38(5):981-8.

76. Mattsson E, Larsson UE, Rossner S. Is walking for exercise too exhausting for obese women? Int J Obes Relat Metab Disord. 1997 May;21(5):380-6.

77. Browning RC, FAU - Kram R, Kram R. Energetic cost and preferred speed of walking in obese vs. normal weight women. - Obes Res.2005 May;13(5):891-9.

78. Browning RC, Baker EA, Herron JA, Kram R. Effects of obesity and sex on the energetic cost and preferred speed of walking. J Appl Physiol. 2006;100:390-8.

79. Moyna NM, FAU - Robertson RJ, Robertson RJ, FAU - Meckes CL, Meckes CL, FAU - Peoples JA, et al. Intermodal comparison of energy expenditure at exercise intensities corresponding to the perceptual preference range. - Med Sci Sports Exerc.2001 Aug;33(8):1404-10.

80. Jackson AS, FAU - Pollock ML, Pollock ML, FAU - Ward A, Ward A. Generalized equations for predicting body density of women. - Med Sci Sports Exerc.1980;12(3):175-81.

81. American College of Sports Medicine, editor. ACMS's guidelines for exercise testing and prescription (8th ed). New York: Lippincott Williams & Wilkins; 2010.

82. Ekkekakis P, Backhouse SH, Gray C, Lind E. Walking is popular among adults but is it pleasant? A framework for clarifying the link between walking and affect as illustrated in two studies. Psychology of Sport and Exercise. 2007:246-64.

83. Grant S, FAU - Corbett K, Corbett K, FAU - Todd K, Todd K, FAU - Davies C, et al. A comparison of physiological responses and rating of perceived exertion in two modes of aerobic exercise in men and women over 50 years of age. - Br J Sports Med.2002 Aug;36(4):276-80;

Appendices

Submission to Ethics Committee

Dublin City University
RESEARCH ETHICS COMMITTEE

APPLICATION FOR APPROVAL OF A PROJECT INVOLVING HUMAN PARTICIPANTS

Application No. *(office use only)* DCUREC/2005/ ☐☐☐

Period of Approval *(office use only)* ....../....../...... to ....../....../....

Effect of self-selected exercise intensity on caloric expenditure in women.

PROJECT TITLE

PRINCIPAL INVESTIGATOR(S) **Prof. N. Moyna**

1. ADMINISTRATIVE DETAILS

THIS PROJECT IS:

☐ Research Project
☐ Practical Class
☒ Student Research Project *(please give details)*
  ☐ Masters ☒ Undergraduate
  ☐ PhD
☐ Funded Consultancy
☐ Clinical Trial
☐ Other - *Please Describe:*

Project Start Date: 01/02/05 **Project End date: 14/03/05**

1.1 INVESTIGATOR CONTACT DETAILS

PRINCIPAL INVESTIGATOR(S):

TITLE	*SURNAME*	*FIRST NAME*	*PHONE*	*FAX*	*EMAIL*
Prof	Moyna	Niall	7008802	7008888	Niall.moyna@dcu.ie

OTHER INVESTIGATORS:

TITLE	*SURNAME*	*FIRST NAME*	*PHONE*	*FAX*	*EMAIL*
Ms.	Hamel	Myriam			Myriam.hamel2@mail.dcu.ie
Ms.	Riordan	Lisa			Lisa.riordan2@mail.dcu.ie
Ms.	Mc Kenna	Caroline			Caroline.mckenna7@mail.dcu.ie

Ms.	Hughes	Sarah			Sarah.hughes3@mail.dcu.ie

FACULTY/DEPARTMENT/SCHOOL/ CENTRE: School of Health and Human Performance

1.2 WILL THE RESEARCH BE UNDERTAKEN ON-SITE AT DUBLIN CITY UNIVERSITY?

☒ YES ☐ NO

1.3 IS THIS PROTOCOL BEING SUBMITTED TO ANOTHER ETHICS COMMITTEE, OR HAS IT BEEN PREVIOUSLY SUBMITTED TO AN ETHICS COMMITTEE?)

☐ YES ☒ NO

DECLARATION BY INVESTIGATORS

The information contained herein is, to the best of my knowledge and belief, accurate. I have read the University's current research ethics guidelines, and accept responsibility for the conduct of the procedures set out in the attached application in accordance with the guidelines, the University's policy on Conflict of Interest and any other condition laid down by the Dublin City University Research Ethics Committee or its Sub-Committees. I have attempted to identify all risks related to the research that may arise in conducting this research and acknowledge my obligations and the rights of the participants.

If there any affiliation or financial interest for researcher(s) in this research or its outcomes or any other circumstances which might represent a perceived, potential or actual conflict of interest this should be declared in accordance with Dublin City University policy on Conflicts of Interest.

I and my co-investigators or supporting staff have the appropriate qualifications, experience and facilities to conduct the research set out in the attached application and to deal with any emergencies and contingencies related to the research that may arise.

Signature(s): ______________________________

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Principal investigator(s): ______________________________

Print name(s) in block letters: ______________________________

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Date: ______________________________

2. PROJECT OUTLINE

2.1 LAY DESCRIPTION

It is well know that people who exercise regularly have a lower risk for chronic diseases and have a better quality of life than those who are sedentary. In order to achieve these health benefits, it is recommended that adults should burn 200 calories per day doing some form of physical activity (1, 2) such as gardening, housework, walking etc. There is evidence that individuals will find exercise more enjoyable if they are allowed to determine how hard they exercise (4, 10). The aim of this study is to determine how long it takes to burn 200 calories while exercising on a treadmill at a self-chosen speed.

The study will take place in the School of Health and Human Performance at DCU. Normal weight and overweight women between 18-25 years and 40-55 years will be recruited to take part in the study. Subjects will visit the laboratory on 3 separate occasions. This will involve one screening visit and two experimental trials. During the screening visit the nature and risks of the study will be explained, and informed consent will be obtained. Subjects will then undergo a brief physical examination, and have their fitness levels assessed by undertaking a special test on a treadmill that will involve walking and or running up gradual hill. Subjects will also have a 12-lead ECG during this test.

During the experimental trials the subjects will be asked to exercise on a treadmill at a self-selected intensity until they burn 200 calories. The number of calories that are burned during exercise will be determined by having the subjects wear a special mouthpiece that is connected to a machine that measures how much oxygen they are consuming. The results of this study may have significant public health implications.

2.2 AIMS OF AND JUSTIFICATION FOR THE RESEARCH

Regular physical activity is associated with many health benefits; including improvement in cardiovascular and respiratory function, reduction of coronary artery disease risk factors, decreased anxiety and depression, enhanced feelings of well being and decreased mortality and morbidity (1,2,3). Even with the accumulating clinical evidence linking physical inactivity with cardiovascular and other chronic diseases (3) a large proportion of Irish men and women continue to lead sedentary lifestyles (5).

Participation in regular physical activity is influenced by a number of factors. These include demographic, psychological, behavioural, socio-cultural, environmental and activity characteristics (12). A common misconception among the general population is that vigorous exercise is necessary to obtain substantial health benefits. There is now accumulating evidence to suggest that the amount of physical activity required to produce substantial health benefits is quite small (1, 9, 10, 17). It is recommend that adults engage in moderate-intensity, daily physical activity that requires approximately 200 kcals (1, 2, 5). The 2003 SLAN survey of lifestyle, attitudes and nutrition (16) reported that one third of 30% of men and 25% of women report doing no physical activity at all in an average week. Furthermore, more than 50% of all persons who begin an exercise program drop out within the first 6 months (6, 11, 14).

From a behavioural standpoint, the more enjoyable the exercise experience, the greater the adherence to a physical activity program will be. This is not surprising considering that we use exertional feedback to regulate the pace of many daily activities, often doing so without conscious awareness (12). The intensity of home, recreational, and even some occupational activities is often self-regulated, using exertional perceptions that reflect local and general fatigue and shortness of breath (18). In most cases, the pace with which these activities are undertaken allows their successful completion without undue physiological strain (13). Feelings related to well being and enjoyment seem more important in maintaining activity than concerns about health (7, 8)."

Walking/jogging is a common mode of exercise among women (17). To our knowledge, no studies have determined the time required to expend 200 calories while exercising on a treadmill at a self-selected intensity. The purpose of this investigation is to determine the time required to expend 200 calories while exercising on a treadmill at a self-selected intensity in normal weight and overweight women between 18-25 years and 40-55 years.

2.3 PROPOSED METHOD

Study Overview

The study will take place in the School of Health and Human Performance at DCU. Normal weight and overweight women between 18-25 years and 40-55 years will be recruited to take part in the study. Subjects will visit the laboratory on 3 separate occasions. This will involve one screening visit and two experimental trials.

During the screening visit, the nature and risks of the study will be explained and written informed consent will be obtained. In addition, subjects will undergo a brief physical examination, body composition assessment, measurement of maximal oxygen consumption (VO_2max) and a 12-lead ECG.

During the experimental trials the subjects will be asked to exercise on a treadmill at a self-selected intensity until they burn 200 calories. Each trial will be separated by at least 48 h. Open circuit spirometry will be used to determine caloric expenditure. Heart rate, blood lactate and rating of perceived exertion will be determined every 5 min during the exercise session.

Independent Variables: BMI and age.

Dependent Variables: Treadmill velocity (mph), percent VO_2max (%VO_2max), percent heart rate max (%HRM), differential ratings of perceived exertion (RPE-O, RPE-L and RPE-C), %VO_2 above or below the ventilation threshold, %HR above or below the ventilation threshold, blood lactate and energy expenditure (EE).

Preparation: Subjects will abstain from alcohol for 3 d, fast for 4 h and refrain from strenuous physical activity for 24 h prior to each experimental trial.

Screening Session: During the screening visit, the nature and risks of the study will be explained and written informed consent will be obtained. Subjects will then undergo a brief physical examination, body composition assessment, measurement of maximal oxygen consumption (VO_2max) and a 12-lead ECG.

Experimental Trials: Experimental trials will be undertaken within 5 d of the beginning of menstruation in order to reduce the confounding effects of the menstrual cycle. Subjects will exercise on a treadmill at a self-selected intensity until they burn 200 calories. The treadmill gradient will be set at 1.0% in order to simulate outdoor wind resistance. They will be allowed to alter the treadmill speed by selecting + and – buttons on the arm of the treadmill. The option to alter the speed will then be given at 5 min intervals until the end of the test. All speed changes will be recorded. Metabolic measurements will be recorded continuously throughout each trial. HR will be recorded continuously using a wireless Polar heart rate monitor (Polar Vantage NV™ Polar, Port Washington, NY)., and RPE and blood lactate will be assessed every 5 min throughout each trial.

LABORATORY PROCEDURES

Maximal Aerobic Capacity Assessment: Maximal aerobic capacity will be determined on a treadmill (Woodway ELG 55, Waukesha, WI) using a ramp protocol. Subjects will warm-up at 3.6 mph for 2 min. Following the warm-up, the gradient will be increased at a rate of 0.2% every 12 sec until the subject reaches volitional exhaustion. The test will be deemed to be maximal if it satisfies at least 3 of the following criteria; levelling of oxygen consumption, volitional exhaustion, RER > 1.1 and heart rate within ± 10 beats of the age predicted max. HR will be recorded continuously, and blood lactate will be assessed each minute.

12-Lead ECG:
Electrodes will be placed on 12 sites which have been swabbed with an alcohol wipe in preparation for the ECG test. Electrical events, heart rate, rhythm and the hearts response to maximal exercise will be monitored through the test.

Respiratory Metabolic Measures: Expired oxygen, carbon dioxide, ventilatory volume and respiratory exchange ratios (RER) will be determined using a Sensormedics Vmax 229 metabolic system (SensorMedics Corp., Yorba Linda CA). Prior to testing, the gas analysers will be calibrated with standard gases of known concentration.

Energy Expenditure Calculation:
Energy (kcal/min) = VE (stpd) x Oi-Oe/20
VE (stpd) is the volume of air expired in litres per minutes
FIO_2 and FEO_2 are the percentages of oxygen in inspired and expired air (19).

Ratings of Perceived Exertion (RPE): RPE will be obtained using the 15-point Borg category RPE scale (13). Subjects will read a standard set of perceptual scaling instructions prior to the maximal exercise test. These instructions will follow an established format used in previous investigations (1, 13, 15). The low and high rating standards or "perceptual anchors" will be established during the maximal exercise test. This involves asking subjects to assign a rating of 7 (low anchor) to the lowest exercise intensity and 19 (high anchor) to the highest exercise intensity. During each experimental session subjects will be instructed to make their subjective assessments of perceived exertion relative to these minimum and maximum standards (perceptual anchors).

Percent Body Fat: Lange skinfold calliper (Cambridge Scientific Industries, MD) will be used to measure double thickness subcutaneous adipose tissue on the right side of the body. The following anatomical sites will be used: suprailiac, triceps and thigh. A minimum of 2 measurements will be taken at each site. If the measurements vary by more than 1 mm a third measurement will be taken. The Jackson, Pollock and Ward sum of three skinfold equation for women will be used to calculate body density and percent body fat will be calculated using the equation by Brozek et al (1).

Blood Sampling: Prior to each exercise test, subjects will have a 21 G indwelling catheter inserted into a prominent vein in the forearm in order to facilitate the collection of blood samples.

Statistical Analysis

A 2 x 2 ANOVA will be used to compare data between the independent variables (BMI and age). Repeated measures ANOVA will be used to compare within and between group data during sub-maximal tests. SPSS for Windows statistical software will be used to perform the statistical analysis. Statistical significance will be accepted at the $P < 0.05$ level of confidence.

2.4 PARTICIPANT PROFILE

<u>Inclusion Criteria</u>: A total of 60 women will be recruited as follows: 15 normal weight women between the age of 18-25 yr, 15 normal weight women between the age of 40-55 yr, 15 overweight women between the age of 18-25 yr and 15 overweight women between the age of 40-55 yr.

Normal weight women (BMI = 18.0-24.9) Overweight women (BMI = 25.0-29.9)

<u>Exclusion Criteria</u>: Subjects will be excluded if they smoke, have anaemia, diabetes, history of heart disease, liver dysfunction and other medical conditions that may contraindicate exercise participation.

<u>Requirements</u>; Each subject will be required to dedicate 3 separate hours to the testing procedures. They will be required to fast for 4 hours, abstain from alcohol for 3 days and refrain from strenuous physical activity for 24 hours prior to each test.

2.5 MEANS BY WHICH PARTICIPANTS ARE TO BE RECRUITED

A recruitment advertisement will be emailed to DCU staff and students. In addition, a recruitment advertisement will be posted on campus in DCU. Permission will be sought from the relevant authorities prior to posting the advertisement. Contact details for the research team will be included on the advertisement. Volunteers will be screened through a telephone interview.

2.6 PLEASE EXPLAIN WHEN, HOW, WHERE, AND TO WHOM RESULTS WILL BE DISSEMINATED, INCLUDING WHETHER PARTICIPANTS WILL BE PROVIDED WITH ANY INFORMATION AS TO THE FINDINGS OR OUTCOMES OF THE PROJECT?

The study findings may be presented at scientific meetings and published in scientific journals. Participants will receive a written report outlining the principle findings of the study. Study participants will be invited to a presentation that will describe the principle findings of the study. They will also receive a one-page report summarizing their results from the tests undertaken during their visits.

2.7 OTHER APPROVALS REQUIRED

☐ YES ☐ NO ☒ NOT APPLICABLE

3. RISK AND RISK MANAGEMENT

3.1 ARE THE RISKS TO SUBJECTS AND/OR RESEARCHERS ASSOCIATED WITH YOUR PROJECT GREATER THAN THOSE ENCOUNTERED IN EVERYDAY LIFE?

☒ YES ☐ NO

3.2 DOES THE RESEARCH INVOLVE?

	YES	**NO**
use of a questionnaire? (attach copy)?	☒	☐
interviews (attach interview questions)?	☐	☒
observation of participants without their knowledge?	☐	☒
participant observation (provide details in section 2)?	☐	☒
audio- or video-taping interviewees or events?	☐	☒
access to personal and/or confidential data (including student, patient or client data) without the participant's specific consent?	☐	☒
administration of any stimuli, tasks, investigations or procedures which may be experienced by participants as physically or mentally painful, stressful or unpleasant during or after the research process?	☒	☐
performance of any acts which might diminish the self-esteem of participants or cause them to experience embarrassment, regret or depression?	☐	☒
investigation of participants involved in illegal activities?	☐	☒
procedures that involve deception of participants?	☐	☒
administration of any substance or agent?	☐	☒
use of non-treatment of placebo control conditions?	☐	☒
collection of body tissues or fluid samples?	☒	☐
collection and/or testing of DNA samples?	☐	☒
participation in a clinical trial?	☐	☒
administration of ionising radiation to participants?	☐	☒

3.2 POTENTIAL RISKS TO PARTICIPANTS AND RISK MANAGEMENT PROCEDURES

The nature and risks involved in the study will be explained prior to starting the study, and a contact number will be provided.
Subjects may experience some muscle soreness in their arms and legs or nausea following the maximal exercise test. Exercise testing carries with it a very small risk of abnormal

heart rhythms, heart attack, or death in less than one in 30,000 patients. The pre-test likelihood of these risks in asymptomatic females < 55 years of age is very low.
The laboratory is equipped with an emergency crash cart and a defibrillator. An individual trained in resuscitation will be present during each test. Subjects with diabetes**,** anaemia, history of heart disease, liver dysfunction and other major signs or symptoms suggestive of cardiovascular and pulmonary disease (angina, dizziness, or syncope, orthopnea or paroxysmal dyspnea, ankle oedema, palpitations, tachycardia, intermittent claudication heart murmur or unusual fatigue or shortness of breath with usual exercise) will be excluded from participating in the study.

Blood samples will be taken at regular intervals during the sub maximal and maximal exercise tests. An individual trained in phlebotomy (Prof Niall Moyna) will insert the IV catheter. Subjects may feel a slight pain when the catheter is inserted and may develop a bruise where the blood samples are taken. Subjects may also feel light-headed or faint during catheter insertion. In the event of an individual fainting or feeling light-headed, they will be placed lying on their back with their feet elevated. The total amount of blood taken during the entire study will be approximately 90 ml. This is 480 ml less than the 570 ml (pint) of blood that is usually donated at blood banks.

3.3 ARE THERE LIKELY TO BE ANY BENEFITS (DIRECT OR INDIRECT) TO PARTICIPANTS FROM THIS RESEARCH?

☒ YES ☐ NO

This study will access the time it takes for participants to burn 200 calories while exercising on a treadmill at a self-selected intensity. This information can be used to make informed decisions when exercising independently. Volunteers will also undergo a 12-lead ECG stress test, and will receive a report detailing their aerobic fitness and body composition.

3.4 ARE THERE ANY SPECIFIC RISKS TO RESEARCHERS?

☒ YES ☐ NO

There is a small risk of infection from needle and blood samples. Standard safety procedures will be strictly adhered to.

3.5 ADVERSE/UNEXPECTED OUTCOMES

The laboratory is equipped with an emergency crash cart and defibrillator. A minimum of one member of the research team will be trained in First Aid. Emergency contact details are posted on the wall in the laboratory. Standard operating procedures will be followed if outside emergency assistance is required.

3.6 MONITORING

Weekly meetings will take place between Prof. N. Moyna (principal investigator) and the rest of the research team. These meetings will provide opportunities to access progress, give feedback, and monitor the development of the research.

3.7 SUPPORT FOR PARTICIPANTS

Not Applicable

3.8 DO YOU PROPOSE TO OFFER PAYMENTS OR INCENTIVES TO PARTICIPANTS?

☐ YES ☒ NO

4. INVESTIGATORS' QUALIFICATIONS, EXPERIENCE AND SKILLS

Prof. Moyna is an exercise physiologist and head of the School of Health and Human Performance at Dublin City University. He was Director of the Applied Physiology Laboratory in the Division of Cardiology at the University of Pittsburg Medical Centre Senior Research Scientist and Director of the Clinical Research Laboratory in the Division of Cardiology at Hartford Hospital, Connecticut, USA. Prof. Moyna is currently Assoc. Director of the Vascular Health Research Centre at DCU.

Ms. Sarah Hughes (BSc) is a graduate student in the School of Health and Human Performance. This study will form part of her Masters thesis. She has experience with metabolic, body composition and 12-lead ECG testing. She has Occupational First Aid qualifications.

Ms. Caroline Mc Kenna is a fourth year undergraduate student in the School of Health and Human Performance. She has experience with metabolic, body composition and 12-lead ECG testing. She has level one NCEF (National Certificate in Exercise and Fitness) and Occupational First Aid qualifications.

Ms Myriam Hamel is a fourth year undergraduate student in the School of Health and Human Performance. She has a National Certificate in Applied Physiology and Health. She has level one NCEF (National Certificate in Exercise and Fitness). She has experience with metabolic, body composition and 12-lead ECG testing.

Ms. Lisa Riordan is a fourth year undergraduate student in the School of Health and Human Performance. She has experience with metabolic, body composition and 12-lead ECG testing. She has Occupational First Aid qualifications.

5. CONFIDENTIALITY/ANONYMITY

5.1 WILL THE IDENTITY OF THE PARTICIPANTS BE PROTECTED?

☒ YES ☐ NO

5.2 HOW WILL THE ANONYMITY OF THE PARTICIPANTS BE ENSURED?

Confidentiality is an important issue during data collection. Participant's identity and other personal information will not be revealed, published or used in further studies. Subjects will be assigned an ID number under which all personal information will be stored in a secure file and saved in a password-protected file in a computer at DCU. The principal investigator, and collaborators listed on this ethics application will have access to the data.

5.3 LEGAL LIMITATIONS TO DATA CONFIDENTIALITY:

☒ YES ☐ NO

***6* DATA/SAMPLE STORAGE, SECURITY AND DISPOSAL**

6.1 HOW WILL THE DATA/SAMPLES BE STORED?

Stored at DCU ☒
Stored at another site ☐

6.2 WHO WILL HAVE ACCESS TO DATA/SAMPLES?

Access by named researchers only ☒
Access by people other than named researcher(s) ☐
Other *:* ☐

IF DATA/SAMPLES ARE TO BE DISPOSED OF, PLEASE EXPLAIN HOW, WHEN AND BY WHOM THIS WILL BE DONE?

The principal investigator will be responsible for security of data collected. The data will be kept in locked facilities in the department through which the project is being conducted. Access to the data will only be attainable by the named researchers. Data will be kept for a minimum of five years from the date of publication of the research. Aside from the named researchers, no others will have access to the raw data. Data will be shredded after five years and Prof. Moyna will carry this out.

7. FUNDING

7.1 HOW IS THIS WORK BEING FUNDED?

Not applicable

7.2 PROJECT GRANT NUMBER

Not applicable

7.3 DOES THE PROJECT REQUIRE APPROVAL BEFORE CONSIDERATION FOR FUNDING BY A GRANTING BODY?

☐ YES ☒ NO

HOW WILL PARTICIPANTS BE INFORMED OF THE SOURCE OF THE FUNDING?

Not Applicable

8. PLAIN LANGUAGE STATEMENT

DUBLIN CITY UNIVERSITY

DCU

Project Title

Effect of self-selected exercise intensity on caloric expenditure in women

The research study will take place in the School for Health and Human Performance, DCU. The principal investigator is Prof. N. Moyna, phone number 7008802, fax 7008888, email niall.moyna@dcu.ie. The following students will be co-investigators; Caroline Mc Kenna, Myriam Hamel, Lisa Riordan, Sarah Hughes.

I. **Introduction to the Research Study**

People who exercise regularly have a lower risk for developing chronic diseases and a better quality of life than those who are inactive. It is recommended that every adult should burn 200 calories per day doing some form of physical activity such as gardening, housework, walking etc. There is evidence that individuals will find exercise more enjoyable if they are allowed to select how hard they exercise. The aim of this study is to determine how long it takes to burn 200 calories while exercising on a treadmill at a self-chosen speed. Normal and overweight women between 18-25 and 40-55 years of age will be eligible to take part in this study.

II. Details of what involvement in the Research Study will require

You will visit the Clinical Exercise Physiology Laboratory in DCU on 3 separate occasions. This will involve one screening visit where you will undergo a physical examination; this will include; height, weight, blood pressure measurements, resting blood lactate and glucose and resting Electrocardiograph (ECG) recording. A maximal exercise test will be undertaken to assess how fit you are. Two experimental trials will take place during your menstruation. These trials will involve you exercising on a treadmill at your own preferred pace until you burn 200 calories. Each time you arrive in the laboratory you will have a plastic tube called a catheter will be placed in your arm to allow the researchers draw blood samples during exercise.

III. Potential risks to participants from involvement in the Research Study

If any abnormal measurements are obtained during the physical examination, or during the exercise tests, you will be referred to a General Practitioner (G.P.).
You may experience some muscle soreness in your legs or nausea following each exercise test. Exercise testing carries with it a very small risk of abnormal heart rhythms, heart attack, or death. The likelihood of these risks in females under the age of 55 years of age who have no known heart disease is very low.

IV. Benefits (direct or indirect) to participants from involvement in the Research Study

You will receive a 12-lead ECG stress test, and a report detailing your aerobic fitness and body composition.

V. Advice as to arrangements to be made to protect confidentiality of data, including that confidentiality of information provided is subject to legal limitations.

Your identity and other personal information will not be revealed, published or used in further studies. You will be assigned an ID number under which all personal information will be stored in a secure file and saved in a password protected file in a computer at DCU. The principal investigator, and collaborators listed on this ethics application will have access to the data. You need to be aware that confidentiality of information provided can only be protected within the limitations of the law - i.e., it is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions.

VI. Advice as to whether or not data is to be destroyed after a minimum period

The original documentation and blood samples will be stored for a maximum of 5 years. Thereafter the blood samples will be disposed of as biohazard waste, and the documentation will be shredded.

VII. Statement that involvement in the Research Study is voluntary

Involvement in this study is completely voluntary. You may withdraw from the Research Study at any point.

Any other relevant information

If you have concerns about this study and wish to contact an independent person, please contact: The Secretary, Dublin City University Research Ethics Committee, c/o Office of the Vice-President for Research, Dublin City University, Dublin 9. Tel 01-7008000

9. **INFORMED CONSENT FORM**

DUBLIN CITY UNIVERSITY

Project Title:
Effect of self-selected exercise intensity on caloric expenditure in women.

Principle Investigator:
Prof. Niall M. Moyna

Investigators:
Ms. Sarah Hughes (BSc.), Ms. Lisa Riordan, Ms. Myriam Hamel, Ms. Caroline Mc Kenna.

Introduction to this study:

The purpose of this study is to determine how long it takes to burn 200 calories while exercising on a treadmill at a self-chosen speed.

Participant Requirements:

1. I will report to the Clinical Exercise Physiology Laboratory in DCU on 3 separate occasions. The duration of each visit will be less than 1hr.

2. During the first visit I will complete 2 questionnaires and I will undergo a brief physical examination (height, weight, body composition, blood pressure, blood glucose and lactate) and measurement of maximal oxygen uptake (VO_2max).

3. I will complete a maximal exercise test on a treadmill. For this test, I will be fitted with a mouthpiece, and a 12-lead ECG. Following a 2 min warm-up at 3.6mph, the grade will increase every 12sec at a rate of 0.2%. Blood will be drawn via a catheter from my forearm at intervals during the test. I will be asked to give an overall feeling of how hard I am working using a 15 point scale (Rate of perceived exertion-RPE) at each stage. The test will end when I reach exhaustion.

4. I will be required to complete the 2 sub-maximal trials within 5 days of the beginning of menstruation. For these trials I will be fitted with a mouthpiece, heart rate monitor and I will select my own preferred speed. The trial will end when I have burned 200 calories. I will have blood drawn every 5min via the catheter in my arm, I will be asked to give an overall feeling of how hard I am working (RPE) at each stage.

5. There will be at least 7days between the maximal and sub-maximal tests. Sub-maximal tests will be separated by at least 48 hours. Sub-maximal tests will take place within 5days of the onset of

menstruation (does not apply if menopausal). I will be required to fast for 4 hours, abstain from alcohol for 3 days, and refrain from strenuous physical activity for 24 hours prior to each test.

<u>Potential risks to participants from involvement in the Research Study</u>

I may experience some muscle soreness in my legs or nausea following the maximal exercise test. Exercise testing carries with it a very small risk of abnormal heart rhythms, heart attack, or death. The pre-test likelihood of these risks in females with no known history of heart disease < 55 years of age is very low.

I may feel a slight pain when the catheter is inserted and I may develop a bruise where the blood sample is obtained. The pain and bruising is usually mild and a person trained in blood drawing will obtain my blood. The amount of blood drawn is not harmful; however if I have a history of anaemia, I should inform the investigator.

<u>Benefits (direct or indirect) to participants from involvement in the Research Study</u>

I will receive a summary of my results of the screening visit; this will include VO_2max, ventilatory threshold, maximal heart rate, resting lactate and blood glucose levels. The commercial rate of these tests is in excess of €500.00. I will also be informed of how long it takes me to burn 200 calories on a treadmill at a self-selected intensity. No other benefits have been promised to me.

Participant – please complete the following (circle Yes or No for each question)

Have you read or had read to you the Plain Language Statement?	Yes / No
Do you understand the information provided?	Yes / No
Have you had an opportunity to ask questions and discuss this study?	Yes / No
Have you received satisfactory answers to all your questions?	Yes / No

Conformation that involvement in the Research study is voluntary

If I do agree to take part in this study I may withdraw at any point, including during an exercise test. There will be no penalty if I withdraw before I have completed all stages of the study however, once I have completed the study, I will not be able to remove my personal information and results from the database or study reports.

Advice as to arrangements to be made to protect confidentiality of data, including that confidentiality of information provided is subject to legal limitations.

My identity and other personal information will not be revealed, published or used in further studies. I will be assigned an ID number under which all personal information will be stored in a secure file and saved in a password protected file in a computer at DCU. The principal investigator, a graduate student and medical director will have access to the data. Data will be shredded after five years by Prof. Moyna.
Confidentiality is insured, but I must be aware that confidentiality of information provided can only be protected within the limitations of the law - i.e., it is possible for data to be subject to subpoena, freedom of information claim or mandated reporting by some professions.

<u>Any other relevant information:</u>

If I am in a dependent relationship with any of the researchers my involvement in the project will not affect ongoing assessment/grades/management or treatment of health at DCU.

Signature:

I have read and understood the information in this form. The researchers have answered my questions and concerns, and I have a copy of this consent form. Therefore, I consent to take part in this research project entitled Effect of self-selected intensity on caloric expenditure in women.

Participant's Signature: ______________________________

Name in Block Capitals ______________________________

Witness: ______________________________

Date: ______________________________

Recruitment Advertisement

Want to know how YOU can burn 200 calories???

We are seeking Normal weight women between 18-25 years and 40-55 years.

This study will examine the time taken to burn 200 calories at a self-chosen speed on the treadmill.

The Study Involves

- **Exercising on a treadmill at DCU on three separate occasions- one screening visit and two experimental trials.**
- **The screening visit will include a brief physical examination, a fitness test on a treadmill and a 12-lead ECG.**
- **Experimental trials will include exercising at a self-chosen intensity until 200 calories are burned.**
- **Blood samples will be drawn throughout the testing**

For Participating, you will receive:

- **12-lead ECG stress test and an evaluation analysis detailing aerobic fitness and body composition.**
- **Specific personalised report to make informed decisions when exercising independently.**

FOR FURTHER DETAILS PLEASE CONTACT:

Hughes	Sarah	0868673608	Sarah.hughes3@mail.dcu.ie

PAR-Q & YOU (A Questionnaire for People Aged 15 to 69)

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
		Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
		Do you feel pain in your chest when you do physical activity?
		In the past month, have you had chest pain when you were not doing physical activity?
		Do you lose your balance because of dizziness or do you ever lose consciousness?
		Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
		Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
		Do you know of any other reason why you should not do physical activity?

If you answered Yes to one or more questions:

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those that are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

Find out which community programs are safe and helpful for you.

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

DELAY BECOMING MUCH MORE ACTIVE:

If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or

If you are or may be pregnant – talk to your doctor before you start becoming more active.

It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

Please Note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME: ____

SIGNATURE:

DATE: ____

VO_2max Test Protocols

Protocol 1 Low Active

Phase / Stage	Stage Time	Speed (km/hr)	Grade (%)	12 Lead Report
Warm-up	2.00	5.5	0.0	
Stage 1	0.30	5.7	0.0	00:15
Stage 1	0.30	5.7	1.0	
Stage 2	0.30	5.9	1.5	00:15
Stage 2	0.30	5.9	2.0	
Stage 3	0.30	6.1	2.5	00:15
Stage 3	0.30	6.1	3.0	
Stage 4	0.30	6.2	3.5	00:15
Stage 4	0.30	6.2	4.0	
Stage 5	0.30	6.3	4.5	00:15
Stage 5	0.30	6.3	5.0	
Stage 6	0.30	6.4	5.5	00:15
Stage 6	0.30	6.4	6.0	
Stage 7	0.30	6.4	6.5	00:15
Stage 7	0.30	6.4	7.0	
Stage 8	0.30	6.4	7.5	00:15
Stage 8	0.30	6.4	8.0	
Stage 9	0.30	6.4	8.5	00:15
Stage 9	0.30	6.4	9.0	
Stage 10	0.30	6.6	9.0	00:15
Stage 10	0.30	6.6	9.0	
Stage 11	0.30	6.7	9.0	00:15
Stage 11	0.30	6.7	9.0	
Stage 12	0.30	6.8	9.0	00:15
Stage 12	0.30	6.8	9.0	
Stage 13	0.30	6.9	9.0	
Stage 13	0.30	6.9	9.0	00:15
Stage 14	0.30	7.0	10.0	
Stage 14	0.30	7.0	10.0	00:15
Stage 15	0.30	7.2	10.0	
Stage 15	0.30	7.2	10.0	00:15
Stage 16	0.30	7.4	10.0	
Stage 16	0.30	7.4	10.0	00:15
Stage 17	0.30	7.6	10.0	
Stage 17	0.30	7.6	10.0	00:15
Stage 18	0.30	7.8	10.0	
Stage 19	0.30	7.8	14.0	00:15
Stage 19	0.30	8.0	14.0	
Stage 20	0.30	8.0	14.0	00:15
Stage 20	0.30	8.2	14.0	

Protocol 2 Moderately Active

Phase / Stage	Stage Time	Speed (km/hr)	Grade (%)	12 Lead Report
Warm-up	2.00	6.6	0.0	
Stage 1	0.30	7.0	0.5	00:15
Stage 1	0.30	7.0	1.0	
Stage 2	0.30	7.0	1.5	00:15
Stage 2	0.30	7.0	2.0	
Stage 3	0.30	7.0	2.5	00:15
Stage 3	0.30	7.0	3.0	
Stage 4	0.30	7.0	3.5	00:15
Stage 4	0.30	7.0	4.0	
Stage 5	0.30	7.0	4.5	00:15
Stage 5	0.30	7.0	5.0	
Stage 6	0.30	7.0	5.5	00:15
Stage 6	0.30	7.0	6.0	
Stage 7	0.30	7.0	6.5	00:15
Stage 7	0.30	7.0	7.0	
Stage 8	0.30	7.0	7.5	00:15
Stage 8	0.30	7.0	8.0	
Stage 9	0.30	7.1	8.5	00:15
Stage 9	0.30	7.1	9.0	
Stage 10	0.30	7.2	9.5	00:15
Stage 10	0.30	7.2	10.0	
Stage 11	0.30	7.2	10.5	00:15
Stage 11	0.30	7.2	11.0	
Stage 12	0.30	7.2	11.5	00:15
Stage 12	0.30	7.2	12.0	
Stage 13	0.30	7.2	12.5	00:15
Stage 13	0.30	7.2	13.0	
Stage 14	0.30	7.2	13.5	00:15
Stage 14	0.30	7.2	14.0	
Stage 15	0.30	7.2	14.5	00:15
Stage 15	0.30	7.2	15.0	
Stage 16	0.30	7.2	15.5	00:15
Stage 17	0.30	7.4	16.0	
Stage 17	0.30	7.6	16.5	00:15

Protocol 3 High Active

Phase / Stage	Stage Time	Speed (km/hr)	Grade (%)	12 Lead Report
Warm-up	2.00	7.4	0.0	
Stage 1	0.30	8.0	0.0	00:15
Stage 1	0.30	8.0	0.0	
Stage 2	0.30	8.5	0.5	00:15
Stage 2	0.30	8.5	1.0	
Stage 3	0.30	8.8	1.5	00:15
Stage 3	0.30	8.8	2.0	
Stage 4	0.30	9.0	2.5	00:15
Stage 4	0.30	9.0	3.0	
Stage 5	0.30	9.0	3.5	00:15
Stage 5	0.30	9.0	4.0	
Stage 6	0.30	9.0	4.5	00:15
Stage 6	0.30	9.0	5.0	
Stage 7	0.30	9.0	5.5	00:15
Stage 7	0.30	9.0	6.0	
Stage 8	0.30	9.0	6.5	00:15
Stage 8	0.30	9.0	7.0	
Stage 9	0.30	9.0	7.5	00:15
Stage 9	0.30	9.0	8.0	
Stage 10	0.30	9.0	8.5	00:15
Stage 10	0.30	9.0	9.0	
Stage 11	0.30	9.0	9.5	00:15
Stage 11	0.30	9.0	10.0	
Stage 12	0.30	9.0	10.5	00:15
Stage 12	0.30	9.0	11.0	
Stage 13	0.30	9.0	11.5	00:15
Stage 13	0.30	9.0	12.0	
Stage 14	0.30	9.0	12.5	00:15
Stage 14	0.30	9.0	13.0	
Stage 15	0.30	9.0	13.5	00:15
Stage 15	0.30	9.0	14.0	
Stage 16	0.30	9.0	14.5	00:15
Stage 16	0.30	9.0	15.0	
Stage 17	5.00	9.0	15.5	00:15

Subject Information Sheet

Subject Id: ______________

Date: ________/_____/_____________ Time: __________________

Last Name: ____________________________ DOB: ___/____/__

First Name: ____________________________ Age: ____________yrs___

Height (cm): ____________________________ Weight (kg): ____________

BMI: ______________________ kg/m^2 % Body Fat: ____________

RHR: ________________________ bpm APHRM: ________________

BP mmHg:1) _______/_________mmHg 2) _______/_________mmHg

Body Circumferences:

Site:	**(mm)**	**(mm)**	**Mean**
Tricep			
Pectoral			
Midaxillary			
Subscapular			
Abdomen			
Suprailiac			
Thigh			

	Yes	***No***
Consent Signed:	[ ]	[ ]
Par-Q & Medical Hx:	[ ]	[ ]

Comments:

VO$_2$max Data Collection Sheet

Date: __/______/_______

Name: ________________________________

Id: ____

Test Protocol: Active ☐ Sedentary ☐

Resting Blood Glucose: ____________mmol

Resting HR:__________

Time (mins)	**RPE- L**	**RPE -C**	**RPE -O**	**HR** (bpm)	**[HLa]** (mmol)	
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						

Time Test Terminated: __________________________

HR at time test terminated: ________________bpm___

Comments:____

Sub Maximal Data Collection Sheet

Submax Test #: __________

Subject ID: _______________

Name: _________________

Date: ____/___/____

Weight (kg): ____________

Time (mins)	**Speed** (kph)	**RPE- L**	**RPE -C**	**RPE -O**	**[HLa]** (mmol)		**HR**(bpm)
0							
5							
10							
15							
20							
25							
30							
35							
40							
45							
50							
60							

End of Test Data:

Time (mins)	**Speed** (kph)	**RPE- L**	**RPE -C**	**RPE -O**	**[HLa]** (mmol)	**HR**(bpm)

Comments:

Borg RPE Scale

6	
7	VERY VERY LIGHT
8	
9	VERY LIGHT
10	
11	FAIRLY LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	VERY VERY HARD
20	

Table 4. Thermal Equivalents of Oxygen for the Non protein RQ. Adapted from (33 pp 183)

Non Protein RQ	$Kcal^{\cdot}lO_2$
0.707	4.686
0.71	4.690
0.72	4.702
0.73	4.714
0.74	4.727
0.75	4.739
0.76	4.750
0.77	4.764
0.78	4.776
0.79	4.788
0.80	4.801
0.81	4.813
0.82	4.825
0.83	4.838
0.84	4.850
0.85	4.862
0.86	4.875
0.87	4.887
0.88	4.899
0.89	4.911
0.90	4.924
0.91	4.936
0.92	4.948
0.93	4.961
0.94	4.973
0.95	4.985
0.96	4.998
0.97	5.010
0.98	5.022
0.99	5.035
1.00	5.047