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Investigation of the reward value of exercise using discounting paradigm

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INVESTIGATION OF THE REWARD VALUE OF EXERCISE USING DISCOUNTING PARADIGM

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A Thesis submitted to the school of Sport, Health & Exercise Sciences, Bangor University in fulfilment of the requirements of the degree of Doctor of Philosophy April 2020

Supervisor: Dr. Hans-Peter Kubis & Prof. Robert Rogers

Yr wyf drwy hyn yn datgan mai canlyniad fy ymchwil fy hun yw'r thesis hwn, ac eithrio lle nodir yn wahanol. Caiff ffynonellau eraill eu cydnabod gan droednodiadau yn rhoi cyfeiriadau eglur. Nid yw sylwedd y gwaith hwn wedi cael ei dderbyn o'r blaen ar gyfer unrhyw radd, ac nid yw'n cael ei gyflwyno ar yr un pryd mewn ymgeisiaeth am unrhyw radd oni bai ei fod, fel y cytunwyd gan y Brifysgol, am gymwysterau deuol cymeradwy.

I hereby declare that this thesis is the results of my own investigations, except where otherwise stated. All other sources are acknowledged by bibliographic references. This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree unless, as agreed by the University, for approved dual awards.

ABSTRACT

Exercise is an important health behavior. Expressed reasons for participation are often delayed outcomes i.e. health threats and benefits, but also can be immediate like enjoyment. However, it was not known how people evaluate exercise as a reward. The value of rewards diminishes with delays, and the delay discounting effect can undermine decision-making. Delay discounting (assessed by discounting rate -k value) is defined as the decline in the subjective value of a reward with delay to its receipt. Exercise subjective reward valuation is a principal step in decision making. However, apart from the decision to participate in exercise, further decisions regarding specific parameters need to be made. The selection of exercise intensity might be influenced by visceral factors and motives related to goals, but the principal evaluation of exercise *per se* is yet to be explored. The general aim of this thesis was to investigate the delay discounting of exercise in comparison with food and money in healthy adults. It also aimed to investigate whether body characteristics, physical activity, and selected physiological and psychometric measures were associated with k values. In chapter 2, based on the above aims, self-paced exercise sessions on treadmill were conducted and the k values of exercise were compared with those of food and money. The outcomes show that young, moderately active participants (n=70) preferred walking/running intensity with low to moderate cardiovascular strain and light perceived exertion. k values indicated that exercise was discounted like consumable rewards as food and more rapidly than monetary rewards. Significant associations were detected of exercise k value with preferred speed and with extrinsic exercise motivation. High intensity exercise training (n=16) reduced exercise k values specifically and exercise k value was quicker in individuals who preferred lower speeds being less physically active. In chapter 3, the objectives were to investigate whether the visceral reward and self-selection of exercise are modifiable in connection to the exercise physiological strain through high intensity interval training. To accomplish this target, exercise training and evaluative conditioning (EC) were combined. Using a randomized control design (N=58). Pre, post three weeks interval training w/o conditioning, and after 4 weeks follow-up, participants were tested on self-paced speed selection on treadmill, delay discounting of exercise and food rewards. Outcomes revealed that delay discounting of self-paced exercise was specifically influenced by training but not by EC. However, selection of intensity was significantly increased by EC and physiological adaptation to training, revealing the importance of visceral factors. In agreement with effort discounting models, the choice for a self-selected intensity depended on the acutely perceived pleasantness of exercise, discounted against perceived effort. This suggests a separation of decision-making processes for the evaluation of exercise, based on cognitive processes, and intensity selection of self-paced exercise, based on rewarding visceral experience of physical strain. In chapter 4, an online survey was conducted to investigate the reward value of un-specific exercise experience to enable a wider spectrum of ecological and psychological characteristics with integrating aspects of passive sports consumption related screen time and reward preference. A cross sectional design through a Qualtrics online survey have been used to recruit 200 participants on Amazon's Mechanical Turk. Results show that un-specific exercise experience was found to be discounted as established rewards. Significant negative associations were detected of exercise discounting rates with extrinsic exercise motivation, physical activity levels, and positive association with sports-screen time. This suggests that reward valuation and discounting of exercise is not specific to a certain exercise type or intensity, and that passive consumption is linked to higher exercise discounting through reinforcing immediate enjoyment. Finally, chapter 5 provides a summary of the thesis findings and clarifies the novelty of the current thesis. It also outlines the future implications of the findings from research perspectives and addresses the strengths and limitations of the thesis as well as the general conclusion.

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List of Abbreviations

PA: Physical Activity

DD: Delay Discounting

ED: Effort Discounting

k_{ex}: Delay discounting constant exercise discounting rate

k_{m}: Delay discounting constant money discounting rate

k_{fo}: Delay discounting constant for food discounting rate

k_{effort}: Effort Discounting constant

k_{Kirby}: Monetary Choice Questionnaire score

FCQ-T: Trait Food Craving Questionnaire

FCQ-S: State Food Craving Questionnaire

EMI-2: Exercise Motivation Inventory-2

PANAS-G: Positive and Negative Affect Scale-General

PANAS-M: Positive and Negative Affect Scale-Moment

BIS II: Barratt Impulsiveness Scale II

IPAQ: International Physical Activity Questionnaire

IPAQ-SF: International Physical Activity Questionnaire-Short Form

BIS/BAS: Behavioural Inhibition/Avoidance Scales

BISRewad: Reward Responsiveness Subscale of BIS/BAS scales.

EC: Evaluative Conditioning

HIIT: High Intensity Interval Training

HR_{max}: Age-calculated maximum heart rate.

HR/Speed: Heart rate per speed.

The Thesis Structure:

This PhD thesis is entirely my own including research design, co-ordination, data collection, analysis, overall responsibility for thesis writing; with my supervisors' guidance in areas such as research design, statistical analysis and in manuscript preparation for publication. Few undergraduate and post graduate students have assisted in data collection under my direct guidance and supervision as part of their academic research projects.

This PhD thesis consists of three research papers, which is standard procedure within the School of Sport, Health and Exercise Sciences at Bangor University. The three papers are each free standing but are on related themes. Each of the three papers include introduction to the overall topic, methods, results, discussion, and conclusion, which is the reason for some repetition seen in places within the introduction and methods sections.

Contributions

Publications

Chapter 2: Albelwi, T. A., Rogers, R. D., & Kubis, H.-P. (2019). Exercise as a reward: Self-paced exercise perception and delay discounting in comparison with food and money. *Physiology & behavior, 199,* 333-342.

Published abstracts

Chapter 2:

1. T. Albelwi, H.-P. Kubis, R. Rogers,

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2. Albelwi A, Rogers R, Kubis H

INVESTIGATION OF THE REWARD VALUE OF EXERCISE IN COMPARISON WITH FOOD AND MONEY, *British Journal of Sports Medicine* 2016;50:e4.

(https://bjsm.bmj.com/content/50/22/e4.25)

Website articles:

Chapter 2:

Why We Should Think of Exercise as Its Own Reward

https://www.psychologytoday.com/us/blog/minding-the-body/201903/why-we-should-think-exercise-its-own-reward

DECLARATION

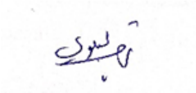
This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed  (candidate)

Date 30 April 2020

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s). Other sources are acknowledged by footnotes giving explicit references. A bibliography is appended.

Signed  (candidate)

Date 30 April 2020

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I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

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Date 30 April 2020

ACKNOWLEDGMENTS

I would like to thank my family for always being there for me, To my Dad, whom I lost 13 years ago, I wish that you were here to celebrate this achievement together, I hope that I make you proud even if you are not around anymore..

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Chapter 1

General Introduction

Physical activity (PA) is an important behaviour for health-related outcomes and decreasing morbidity and mortality including cardiovascular disease, stroke, some cancers, type 2 diabetes, hypertension, high cholesterol, obesity, and all-cause mortality (Allen & Morey, 2010). Additionally, PA has been consistently found to improve mental well-being (Haskell et al., 2007; Lees & Hopkins, 2013) through enhancing mood (Barnes, Coombes, Armstrong, Higgins, & Janelle, 2010; Sylvia et al., 2013), decreasing anxiety (Mochcovitch, Deslandes, Freire, Garcia, & Nardi, 2016), and alleviating depression (McPhie & Rawana, 2015). Accumulating evidence demonstrates that PA affects brain plasticity, influencing cognition and well-being (Fernandes, Arida, & Gomez-Pinilla, 2017). In fact, experimental and clinical studies have reported that PA induces structural and functional changes in the brain, determining important biological and psychological benefits (Mandolesi et al., 2018). Research has also shown that individuals who adhere to regular exercise programmes, compared to those who do not as much, experience greater improvements in fitness, physical function, quality of life, and disease-specific outcomes (Allen & Morey, 2010).

The Physical Activity Guidelines for Americans (Office of Disease Prevention and Health Promotion, 2008) state that adults need at least 150-minute moderate (or 75-minute vigorous) aerobic and muscle-strengthening activities on two or more days a week to achieve significant health benefits. Although nearly everyone in Western societies admits to being aware of the health benefits of exercise (Booth & Hawley, 2015), the rate of participation is extremely low (Zenko & Ekkekakis, 2015). In the United States, more than 80% of adults do not meet the guidelines for both aerobic and muscle-strengthening activities; similarly, more than 80% of adolescents do not perform enough aerobic activities and therefore do not meet the guidelines for the youth (Department of Health and Human Services, 2008). In addition, most of the exercisers drop out within the first year (Pate et al., 1995). To understand the reasons underlying low PA engagement, researchers have been investigating exercise behaviours for decades: What makes individuals choose to engage in a sedentary or exercise behaviour? If they choose to engage in exercise, then which modality, frequency, intensity, and duration would they prefer?

First of all, I want to establish the difference between PA and exercise; PA is "any bodily movement produced by skeletal muscles that results in energy expenditure above resting levels" (Caspersen et al., 1985). PA broadly encompasses exercise, sports, and physical activities done as part of daily living, occupation, leisure, and active transportation (Garber et al., 2011). While exercise is a behavioural subset of PA and is defined as "Physical activity that is planned, structured, and repetitive and has as a final or intermediate objective the improvement or maintenance of physical fitness" (Stults-Kolehmainen & Sinha, 2014). In this thesis, these two terms are sometimes used interchangeably.

Many approaches have been proposed to understand exercise behaviours. These approaches are either atheoretical, including descriptive data regarding motives and barriers through surveys, or theoretical, aiming to identify deeper underlying influences on PA engagement (Biddle & Nigg, 2000). Different theories have been proposed to explore exercise behaviours; well-known examples include the theories that focus on the cognitive antecedents of behavioural intentions, which are defined as the effort someone is prepared to invest in performing a target behaviour, such as the Reasoned Action (Fishbein & Ajzen, 1975) and Planned Behaviour theories (I Ajzen, 1985). Another example is the self-determination theory by Deci and Ryan (Deci & Ryan, 1985b), which describes the underlying reasons for the decision to be involved in activities, such as motivational factors that include intrinsic and extrinsic components. According to this theory, appearance, health, and weight are extrinsic motives, whereas enjoyment and social engagement are intrinsic motives (Egli, Bland, Melton, & Czech, 2011). Indeed, most exercise behaviour theories have one core attribute in common—that is, they all emphasize the importance of cognitively imagined end states (behaviours or goals), as well as behavioural control as an important factor for exercise behaviour (Brand & Cheval, 2019).

Loewenstein (1996) argued that decision-making approaches based on the influence of motivation do not take the impact of hedonic and visceral factors of exercise into consideration and that they are detached from emotional and visceral aspects of behaviours. *Visceral factors* are states such as hunger, thirst, sexual desire, drug cravings, physical pain, and emotion that influence how actions are valued. According to Loewenstein (1996), physical effort often produces an aversive sensation that is referred to as fatigue or—at higher levels—exhaustion, which is directly aversive, alters the desirability of different activities, and decreases the desirability of further increments of effort. Therefore, one possible explanation provided for high rates of inactivity is that individuals choose not to engage in behaviours they find aversive (Jung, Bourne, & Little, 2014). In this regard, Ekkekakis and Dafermos (Ekkekakis & Dafermos, 2012) suggested that affective responses to exercise play a role in shaping a certain perception or "marker" in the memory associated with the concept of exercise. Consequently, if both the cognitive evaluation of exercise (such as valuing long-term health benefits) and the experienced visceral perception were positive, this exercise would be evaluated as rewarding and the chances of exercise participation would increase. Generally, the evaluation of behaviour is linked to its rewarding properties (Loxton & Tipman, 2017); that is, to choose between different actions is necessary to maintain a representation of the predicted future reward associated with each action (O'Doherty, 2004). So, this raises a question: Does exercise have reward value for those who exercise?

1.1.Exercise reward

Reward is the positive value ascribed to an object, a behavioural act, or an internal physical state (Schultz, Tremblay, & Hollerman, 2000), through multiple neuropsychological components (Pool, Brosch, Delplanque, & Sander, 2016). Evidence suggests that rewards may influence behaviour even in the absence of being consciously aware of them (Kent C Berridge, Robinson, & Aldridge, 2009). Reward feeling is governed by the mesolimbic reward system that involves dopaminergic pathways (Blum et al., 2008); associations between these pathways and exercise behaviours have been found in both animal models (Setlow, Mendez, Mitchell, & Simon, 2009) and human beings (Lu et al., 2014) . PA is necessary for development and evolutionary survival and linked to rewarding outcomes (Cheval et al.,2017), for example, in ancient times, PA in the form of playing could be viewed as necessary means to achieve motor learning and development in children (Pellegrini & Smith, 1998), to find food or shelter, and to avoid predators (Cordain, Gotshall, & Eaton, 1998). However, human beings learned to minimize energy costs in order to obtain a specific reward (Skvortsova, Palminteri, & Pessiglione, 2014), as individuals who sustained PA for long periods were more likely to be rewarded by finding food or escaping dangers (Cheval et al., 2017).

In neurobiology literature, exercise is considered to be rewarding among individuals who regularly exercise (Boecker et al., 2008; Brené et al., 2007; Dietrich & McDaniel, 2004; Yau, Gil-Mohapel, Christie, & So, 2014). Chronic PA involves changes in adult neurogenesis, with possible impact on reward and cognitive behaviour (Dishman et al., 2006; Ernst, Olson, Pinel, Lam, & Christie, 2006; Yau et al., 2014). It is also believed that the mechanisms underlying the positive effects of exercise are through beneficial effects on reward functioning (Whitton, Treadway, & Pizzagalli, 2015). According to Wardle and colleagues (Wardle, Lopez-Gamundi, & LaVoy, 2018) , there are at least two major components of reward functioning: (1) motivational reward (i.e. exerting efforts to gain rewards), which is controlled by striatal dopaminergic circuits and (2) consummatory reward (i.e. pleasure when rewards are received), which is visceral and mediated by opioid “hotspots” in the striatum. Although these functions are unlikely to be completely independent, they do appear to have at least partially separable neural bases (Kent C Berridge et al., 2009). According to Cheval and colleagues (Cheval et al., 2018), due to the associations between exercise reward and cognitive evaluation, the behavioural tendency to minimize cost and lower energy expenditure can be most effectively counteracted by strengthening the individual’s cognitive resources and self-control capacity. Moreover, a recent approach that is used to investigate exercise decision-making involves the reinforcing or motivating values of different modes of exercise relative to that of sedentary alternatives (K. D. Flack, Johnson, & Roemmich, 2017a, 2017b). On the basis of this concept, the reinforcing value of exercise has been found to be a strong predictor of the choice to be active or sedentary (Leonard H Epstein & Roemmich, 2001). Behavioural reinforcement can be conceptualized as follows: (1) the motivational appetite to engage in a behaviour or (2) the operant responding that an individual is willing to engage in to obtain a reinforcer (Salamone & Correa, 2002); and it is controlled via the central dopamine system (Arias-Carrión et al., 2014).

Regarding the immediate visceral perception of exercise, several studies have shown that high intensities can be perceived as pleasant (Bartlett et al., 2011; Ekkekakis, Hall, & Petruzzello, 2005; Frazao et al., 2016) and that self-determined intensities are preferred over externally imposed ones (Focht, 2007; Rose & Parfitt, 2007; Williams & Raynor, 2013). On the contrary, individuals who are chronically sedentary or have low cardiorespiratory fitness are unlikely to rate exercise as pleasant (Zenko, Ekkekakis, & Ariely, 2016); as engaging in PA can be inconvenient, uncomfortable, and even embarrassing for beginners (Stults-

Kolehmainen & Sinha, 2014). Thus, exercise-promoting techniques should focus on improving the exercise experience through both cognitive interventions (Zenko et al., 2016) and improving cardiovascular fitness (Nabetani & Tokunaga, 2001), with an aim to overcome the negative “beginner” experience, thus making exercise experience more rewarding.

To summarize, the reward value of exercise was found to be associated with cognitive evaluation and self-control that are related to exercise delayed goals (Brand & Ekkekakis, 2018) and visceral feelings in addition to reinforcing value during a certain exercise workload (K. D. Flack et al., 2017a). Nevertheless, there is uncertainty about the role of each of these components in exercise reward valuation. However, there is a behavioural measure that is related to both aspects of exercise reward valuation, which is the discounting paradigm.

1.2. Discounting paradigm

The discounting paradigm combines research from economics, learning theory, behavioural and cognitive psychology, and neuroscience to understand how individuals decide to allocate their time, efforts, or resources among available alternatives (Leonard H Epstein, Salvy, Carr, Dearing, & Bickel, 2010). Delay (temporal) discounting (DD) is the process by which future events are subjectively devalued by the decision-maker (Tate, Tsai, Landes, Rettiganti, & Lefler, 2015); that is, individuals who discount at high rates do not place a high value on future events. For example, if an individual discount at a high rate, he/she would choose immediate rewards instead of waiting until a future date for a reward even if the reward is significantly larger and more valuable. Using monetary reward as an example, receiving £50 today is perceived to be valued more than the promise of receiving £75 in 30 days. Typically, as the time an individual has to wait for a reward increases, the subjective value of the future reward decreases (Odum, 2011b). Prior studies on intertemporal decision-making have identified brain regions that are activated at the time of choice associated with the discounting of subjective value, such as the ventromedial prefrontal cortex and ventral striatum (Fig. 1.1) (R. M. Carter, Meyer, & Huettel, 2010; Montague, King-Casas, & Cohen, 2006; Peters & Büchel, 2010). The process of DD reflects the relative balance of two neurobiological systems (MacKillop et al., 2012): (1) the executive system: specific prefrontal cortex regions associated with classes of self-directed behaviour aimed at changing one's future reinforcement (Bickel et al., 2007; Bickel & Yi, 2008; Prencipe et al., 2011; Weatherly & Ferraro, 2011) and (2) the impulsive system: limbic and paralimbic regions associated with actions that are prematurely exhibited, unnecessarily risky, and result in undesirable consequences (Bickel et al., 2007; Cardinal & Howes, 2005; Christakou, Brammer, & Rubia, 2011; Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013). This balancing process is referred to as the competing neurobehavioral decision systems hypothesis (Bickel, Quisenberry, & Snider, 2016; Snider, LaConte, & Bickel, 2016; Sofis, Carrillo, & Jarmolowicz, 2017; Sofis, Jarmolowicz, & Martin, 2014).

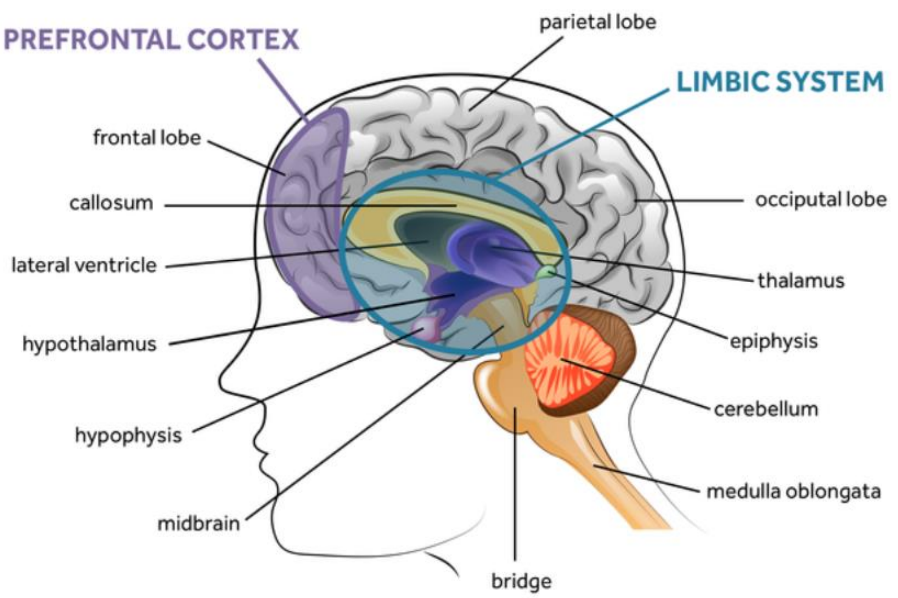

Figure 1.1. The competing brain regions, which are the frontal cortex and limbic system, are activated in decisions involving physical and mental effort/cost associated with an action. Source:(https://www.futurelearn.com)

Discounting rates can be influenced within the participants by the following factors: (1) The domain effect: it includes commodity type such as consumable like food (Rasmussen, Lawyer, & Reilly, 2010) and drugs of abuse (Carroll, Anker, Mach, Newman, & Perry, 2010) or non-consumable, such as money gains or losses, vacations, and health gains or losses (G. B. Chapman & Elstein, 1995; Johnson & Bickel, 2002; D. H. Smith & Gravelle, 2001). (2) The sign effect: it includes gains or losses (Baker, Johnson, & Bickel, 2003). (3) The magnitude effect: It includes the degree of effect like high or low (Odum, 2011a). Loewenstein and Thaler (1989) have manipulated three variables of interest: (1) the length of time to be waited, (2) the magnitude of the outcome, and (3) whether the outcome is a gain or loss. Three strong patterns emerged from the participants' responses: First, discounting rates declined sharply with the length of time to be waited. Second, discounting rates declined with the size of the reward: discounting rates for small amounts were very high, whereas those for large amounts were low. Third, discounting rates for gains were much higher than those for losses: the participants were required to be paid a lot to wait for a reward, but they were unwilling to pay much to delay a fine. In addition, DD was found to be associated with intrinsic motivation (linked to factors like enjoyment) on the basis of evidence that, compared to delayed rewards, immediate rewards increase intrinsic motivation by creating a perceptual fusion between the activity and its goal/reward (Woolley & Fishbach, 2018). In addition, as a behavioural measure, DD offers better insights compared to theory-based questionnaires, as these questionnaires may show some disadvantages as self-report measures; while in the case of DD, individuals appear to be fairly good at describing what they would choose in certain hypothetical situations without being directly asked to rate their own behaviours in these situations (Odum, 2011a).

1.3. Delay Discounting and Unhealthy Behaviour

Many researchers have found that high discounting rates underlie several unhealthy and risk behaviours in relation to addiction, obesity, and unsafe sex (Koffarnus et al., 2013). This tendency to discount delayed reward value can result in impulsive, short-sighted decisions that are not in one's best interests in the long term (Ainslie & George, 2001). DD has proved to be methodologically applicable and theoretically relevant to a variety of scientific and health interests and has resulted in an increasingly expanding scientific literature (Johnson & Bickel, 2008). The hyperbolic discounting utility function has been used to address various social behaviours relevant to health problems through demonstrating a relationship between laboratory measures of discounting and various behaviours and traits, such as obesity. In this regard, it was found that percent body fat was a significant and consistent predictor of discounting patterns for food (Rasmussen et al., 2010). Additionally, higher body mass was found to be strongly related to choosing a more immediate monetary reward using the Monetary Choice Questionnaire (MCQ);(Kirby & Maraković, 1996) (Jarmolowicz et al., 2014). Moreover, according to Chabris and colleagues (Chabris, Laibson, Morris, Schuldt, & Taubinsky, 2008), the discounting rate has at least as much predictive power as any variable in the field behaviours dataset (e.g. sex, age, and education). More recent studies on the relation between temporal perspective and healthy behaviours can be found in Sweeney and Culcea's meta-analysis (Sweeney & Culcea, 2017).

1.4. Delay Discounting and Exercise

Like many other health behaviours, regular PA is associated with a variety of favourable long-term outcomes (Warburton, Nicol, & Bredin, 2006). For example, those who engage in regular PA enjoy health benefits such as increased mobility later in life, lower blood pressure, and longer life expectancy compared to their sedentary counterparts (Leveille, Guralnik, Ferrucci, & Langlois, 1999). Moreover, those who exercise on a regular basis decrease their risk of developing cardiovascular disease, hypertension, and diabetes (Booth & Hawley, 2015).

Because exercise is a behaviour with prominent delayed effects, health promotion research has used DD to predict exercise participation. For example, Daugherty and Brase (Daugherty & Brase, 2010) used the MCQ as a measure for DD. In their study, two measures of time perspective—Consideration of Future Consequences Scale (Strathman, Gleicher, Boninger, & Edwards, 1994) and Zimbardo Time Perspective Inventory (Zimbardo (Zimbardo & Boyd, 2015) —were compared to each other and to self-reported health behaviours with 467 undergraduates. It was found that DD and time perspective significantly predicted exercise frequency among other behaviours investigated. Another study conducted by Garza and colleagues (Garza, Harris, & Bolding, 2013), with adults 50+ years of age and their spouses and partners, demonstrated a significant association between high money discounting rates and lower rates of healthful behaviours, including weekly vigorous PA level. They found that a high value of the future (lower money discounting rates) was associated with younger age, lower body mass index, more healthful diet, and increased PA. Evidence was also found that endurance runners demonstrate addictive-like behaviours (L. E. Martin et al., 2017). In their study, the researchers used the monetary DD paradigm to explore if the endurance runners preferred immediately available rewards by telling them if they chose the delayed reward, they would not be able to exercise during the delay period (2–12 weeks). The runners displayed an increased preference for immediately available compared to delayed rewards. However, most of the studies that investigated DD in relation to exercise were correlational, and the test was never assessing exercise as the modality to be discounted. Clearly, this raises many questions regarding DD for exercise reward as such and in relation to exercise-related parameters and body characteristics.

1.5. Altering Delay Discounting Rates

With DD involved in many health-related behaviours, researchers have sought to determine whether discount rate is a cause of—or simply a correlate or result of—unhealthy decision-making. Reports of treatments or manipulations that alter discount rate are increasingly appearing in the literature (Bickel, MacKillop, Madden, Odum, & Yi, 2015; Kaplan, Reed, & Jarmolowicz, 2016; Koffarnus et al., 2013; Radu, Yi, Bickel, Gross, & McClure, 2011; Rung & Madden, 2018; Rung, Peck, Hinnenkamp, Preston, & Madden, 2019) with a specific question to answer: is discount rate a result of the current environment or is it a relatively immutable pattern of behaviour?

There are many studies that investigated different DD manipulation techniques. Interventions that targeted the executive system involved enhancing the inhibitor control of the executive system over impulsive decisions, for example by: working memory training (Bickel, Yi, Landes, Hill, & Baxter, 2011), contingency management intervention (Weidberg et al., 2015; Yi et al., 2008), explicit-zero framing (Magen, Dweck, & Gross, 2008), explicit-date framing (LeBoeuf, 2006; Read, Frederick, Orsel, & Rahman, 2005), temporal priming (Zauberman, Kim, Malkoc, & Bettman, 2009), episodic future thought (Daniel, Said, Stanton, & Epstein, 2015; Kaplan et al., 2016; Peters & Büchel, 2010), and mindfulness (Morrison, Madden, Odum, Friedel, & Twohig, 2014). On the other hand , some studies have targeted the impulsive system to alter DD involved conditioning stimuli, priming, and cueing (Dixon & Holton, 2009; Dixon, Jacobs, & Sanders, 2006; M. Wilson & Daly, 2004). Psychological manipulation through evaluative conditioning (EC) has also been proven to be a successful approach for the purpose of altering individuals' exercise behaviour (Sheeran, Gollwitzer, & Bargh, 2013), automatic evaluation, and implicit attitudes towards exercise (Antoniewicz & Brand, 2016; Zerhouni, Bègue, Comiran, & Wiers, 2018), which is based on the notion that DD and EC share cognitive basis (Greville & Buehner, 2012). EC is a process that involves the repeated pairing of an attitude object (conditioned stimulus) with positively or negatively valenced stimuli (unconditioned stimulus) in an attempt to, respectively, create liking or disliking of the attitude object (De Houwer, Thomas, & Baeyens, 2001; Hofmann, De Houwer, Perugini, Baeyens, & Crombez, 2010). In animal models, Mazur (Mazur, 1997) found that the hyperbolic decay model, which is a mathematical expression of the relation between delay and reinforcer value *[V=A/(1+kD)]*, is an accurate method for quantifying the strength of a conditioned reinforcer in pigeons. Therefore, using EC approach could be a promising tool to alter DD because of the effects that emerge through the EC procedure, which include implicit and explicit attitudes (Greenwald et al., 2002), as explicit attitudes are more deliberative and propositional in nature (Gawronski & Bodenhausen, 2006), and implicit attitudes are more automatic and impulsive and are primarily based on associations in memory. More evidence about DD manipulation can be found in the reviews by Bickel and others (Bickel et al., 2015), (Bickel & Mueller, 2009), (Koffarnus et al., 2013), and (Odum et al., 2020).

Despite the promising results of these interventions, the existing interventions targeted either the executive system or the impulsive system, not both. PA as a behaviour may act to leverage both cognitive/executive and impulsive systems to decrease DD (Sofis et al., 2017). Sofis and colleagues were the only researchers who investigated the influence of PA in the form of brisk walking exercises on monetary DD tasks pre- and post-intervention. They found that individualized exercise at high and low efforts significantly reduced money discount rates and improved PA levels at follow-up. They also found that reductions in DD appeared to be sensitive to the relative improvement in physical fitness performance as measured by a change in pace of an individual session from the first to last exercise session. According to Sofis (2017), there are several proposed mechanisms to explain why exercise is a useful tool to alter DD, and they suggest that this could be accomplished through the effects of exercise on executive functions (P. J. Smith et al., 2010), including (1) increased blood and oxygen flow to the brain (Jorgensen, Nowak, Ide, & Secher, 2000); (2) increased levels of norepinephrine and endorphins, resulting in stress reduction and mood enhancement (Fleshner, 2000; Mikkelsen, Stojanovska, Polenakovic, Bosevski, & Apostolopoulos, 2017; Winter et al., 2007); and (3) increased growth factors that help create new nerve cells and support synaptic plasticity (Nie, Yang, Tang, Shen, & Li, 2016) thereby positively influencing temporal discounting (de Wit, Flory, Acheson, McCloskey, & Manuck, 2007; Henson, Carey, Carey, & Maisto, 2006; Kirby, Winston, & Santiesteban, 2005; Shamosh et al., 2008; Shamosh & Gray, 2008)

Although exercise behaviours have been investigated in research on DD, exercise p*er se* was not discounted before as a rewarding commodity as mentioned above. Presumably, exercise DD may play a role in exercise participation against other alternatives. However, it may show limited influence on exercise-related parameters in a specific participation as exercise intensity and duration might be valued differently, considering that their valuation might be based on immediate physical and muscular effort (Hartmann, Hager, Tobler, & Kaiser, 2013), therefore, could be assessed through effort discounting (ED) rather than DD. ED is based on the concept that reward value stands in inverse relation to the amount of effort required to obtain it (Kivetz, 2003; Phillips, Walton, & Jhou, 2007; Rudebeck, Walton, Smyth, Bannerman, & Rushworth, 2006). According to this basic principle, a reward carries a higher net value if it is easily obtained than if it is obtained only through great effort (Botvinick, Huffstetler, & McGuire, 2009). ED closely relates to DD, for which specific neural substrates have been identified (Roesch, Taylor, & Schoenbaum, 2006; Rudebeck et al., 2006). Given such findings, it seems plausible that the tight relationship between reward and effort that holds at the behavioural level may reflect the operation of the basic neural mechanism of reward valuation among active and sedentary individuals (Botvinick et al., 2009).

The difference between DD and ED is that DD tasks are used as a measure of impulsive decision-making, where response costs are varied by imposing a delay before the delivery of a larger reward versus acquiring an immediate, smaller reward. While in ED, response costs can be varied by increasing the effort required to receive a larger reward. In "effort-based" decision-making, the choice is between a small reward obtainable after a nominal amount of physical effort and a larger reward obtained after considerably more work, as energy expenditure is thought to be the ultimate currency evaluated by the participants during ED tasks (S. H. Mitchell, 2017). Therefore, exercise as a modality can be valued on the basis of its immediate and delayed outcomes, and as a physical effort, it can be valued on the basis of physical effort invested to achieve a desired subjective level of reward perception (Inzlicht, Shenhav, & Olivola, 2018). In short, a person either works harder or waits longer to obtain a larger subjective reward (Hartmann et al., 2013), thus, understanding the trade-offs between exercise costs, whether delay or physical efforts, and benefits must be measured in order to determine its discounting rates (Tate et al., 2015).

Summarized, under certain circumstances, if exercise as a modality and exercise-related physical strain can be valued as a reward, the concepts of DD and ED can be used to establish and investigate the exercise valuation as a reward against other alternatives and against its perceived costs. That is, if individuals do not perceive exercise as rewarding, they would only participate in exercise for its delayed outcomes (i.e. for better health and looks); in this case, any delay (travel time, etc.) would reduce their chances for participation, therefore, if the experience is rewarding, then the participation would be supported by both an immediate reward and a delayed outcome. However, the intensity question might be different, as in this case, high intensity exercise would be supported by delayed rewards, but its immediate reward value would be small due to poor pleasantness. Accordingly, intensity and delay would presumably have a separate influence on exercise participation. In this case, it would be important to dig deeper into exercise reward valuation among active and sedentary individuals to explore how exercise is valued.

1.6. Aims of Thesis

The general aim of this thesis was to investigate whether exercise is evaluated and perceived as a reward or not. More specifically, to investigate whether self-selected exercise experience is valued as a reward and discounted, such as established rewards of food and money. Additionally, what is the influence of PA levels, psychological measure, personality traits, and body characteristics on the subjective value and discounting rates of exercise. I also intended to conduct this investigation to a more generalized level, with the participants' own individualized exercise experience in exploring more parameters in relation to the discount rates of exercise (Chapter 4). Furthermore, I aimed to investigate how the reward evaluation of exercise can be manipulated via training and conditioning and how theses manipulations would influence exercise DD and selection of preferred exercise intensity (Chapters 2 and 3).

1.7. Research Questions

Chapter 2

- Is self-selected exercise experience valued and discounted as a reward? And could it be manipulated by high intensity training?

Chapter 3

- How are the potential reward properties of exercise balanced with its effortful components? And is it possible to manipulate these properties to influence the decision to choose a higher exercise intensity?

- Do alterations of visceral properties also affect the cognitive evaluation of exercise in connection to DD if their processing is linked?

Chapter 4

- Would participants from a wider population and with un-specific exercise experiences value and discount exercise experience similar to participants who self-selected exercise in a laboratory setting?

Chapter 2

Exercise as a Reward: Self-Paced Exercise Perception and Delay Discounting in Comparison with Food and Money

A published paper can be found on :

https://www.sciencedirect.com/science/article/pii/S0031938418305687

Chapter 3:

Influence of Evaluative Conditioning and Training on Self-Paced Exercise Intensity and Delay Discounting of Exercise Reward in Healthy Adults

3.1. Introduction

Exercise and physical activity are strongly associated with physical and mental wellbeing (J. J. Chapman, Fraser, Brown, & Burton, 2016; KESANIEMI et al., 2001; Sofi et al., 2011) , but only a small proportion of the population meets the required recommendations in physical activity (Brownson, Boehmer, & Luke, 2005; Farooq & Sazonov, 2017; Hallal et al., 2012). Additionally, exercise with higher intensities are found to be more beneficial for health protection than lower intensities (Swain & Franklin, 2006; van Waart et al., 2015). Certainly, an individual who decides to take part in exercise needs to make the decision based on the evaluation of the modality exercise versus other options, but also on the basis, when having decided to participate in an exercise, to what intensity and duration. Consequently, the decision making process entails at least two main steps, which may be influenced by different processes and factors. Besides many environmental and personal factors determining physical activity (Dishman, Sallis, & Orenstein, 1985), motivation with its intrinsic and extrinsic components are known to be critical for exercise participation (frequency) (Duncan, Badland, & Mummery, 2010). Extrinsic motives may be related, as an example, to delayed outcomes like health and looks (Egli et al., 2011; Ingledew et al., 2009); however, particularly, intrinsic motives can contain components, which are derived from pleasure and satisfaction of engaging in a behaviour (Deci & Ryan, 1985b). While pleasure and satisfaction of taking part in exercise could have numerous facets, like being competitive or enjoying social interaction, less is known about the rewarding properties of exercise in itself as a physical strain (Cheval et al., 2018) . Several studies have shown that high intensities can be perceived as pleasant (Bartlett et al., 2011; Ekkekakis et al., 2005; Frazao et al., 2016), and affective response to a bout of exercise could predict physical activity over 6 and 12 months (Williams et al., 2008); however, self-determined intensities are more preferred over externally controlled ones (Focht, 2007; Rose & Parfitt, 2007; Williams & Raynor, 2013). On the other hand, behavioural models of effort discounting, where a person needs to put effort into a task to gain an external reward, revealed that people try to maximize gain while effort is minimized (Kivetz, 2003; Phillips et al., 2007). Effort commonly carries a negative value or cost, which provides a reference against which rewards are evaluated; a reward is higher in subjective value if it is earned with easier than greater effort (Botvinick et al., 2009; Rudebeck, Saunders, Lundgren, & Murray, 2017). This concept is supported in human, as well as in animal studies (Botvinick et al., 2009; Hartmann et al., 2013; Klein-Flügge, Kennerley, Saraiva, Penny, & Bestmann, 2015; Salamone, Cousins, & Bucher, 1994; Stevens, Hallinan, & Hauser, 2005; Walton, Bannerman, & Rushworth, 2002); indeed, a concept which can only be applied to exercise as such, if I assume that exercise has an inherent rewarding property related to physical strain.

in my previous work, I have investigated the question of a potential reward value of exercise by investigating the DD of self-selected exercise on treadmill (Albelwi, Rogers, & Kubis, 2019). DD poses choice questions of immediate or delayed rewards with variable reward and delay magnitude (Kirby & Maraković, 1996; Tesch & Sanfey, 2008). Fast DD behaviour has been related to impulsive and risk behaviours like gambling and substance abuse (MacKillop et al., 2011; Myerson et al., 2003; Yi et al., 2010). The former study showed that self-selected exercise was discounted in time like other 'consumable' rewards (i.e. food) and that the velocity of DD was negatively associated with exercise motivation, as well as being reduced by training (Albelwi et al., 2019). Slower discounting has been assumed to be a sign of stronger involvement of cognitive elaborative processing over impulsive decision making (McClure et al., 2004). However, it was not clear whether subjects discounted exercise integrating delayed outcomes i.e. looks, health etc., or whether the exercise had a reward value based on its visceral qualities, which was acquired through training, and leading to DD changes and concomitant changes in speed preferences (Albelwi et al., 2019). According to Loewenstein (Loewenstein, 1996), the defining characteristic of a visceral factor is a direct hedonic impact and effect on desirability of goods and actions. If this applies to exercise, the behaviour itself is the desirable modality, unlike external rewards which are often used in behavioural paradigms. This certainly opens the questions, how the potential rewarding properties of exercise are balanced with its effortful components, and whether those properties can be manipulated to influence the decision to higher intensity? In addition, do alterations of visceral properties also affect cognitive evaluation of exercise in connection to delay discounting, if their processing is linked? To influence the visceral properties of exercise during self-selection of exercise intensity, I decided to use two different techniques; one is based on HIIT to alter physiological responses to exercise, and the other is associating a rewarding stimulus with increased physiological strain using a novel EC paradigm. EC can be defined as the procedure which changes the valence of a stimulus (conditioned stimulus – CS) that is induced by the pairing of that stimulus with another positive or negative stimulus (unconditioned stimulus – UCS) (De Houwer, 2007; De Houwer et al., 2001). EC concerns only evaluative responses to the conditional stimulus, therefore influencing only its liking rather than a change in type of response being expected from Pavlovian conditioning (De Houwer, 2007). Moreover, EC is known to produce stable effects in various paradigms using visual and appetitive stimuli as unconditional stimuli (Blechert, Testa, Georgii, Klimesch, & Wilhelm, 2016; Franken, Huijding, Nijs, & van Strien, 2011; Hofmann et al., 2010). In context of physical activity, only a few studies used EC with visual stimuli to induce effects with variable outcomes (Antoniewicz & Brand, 2016; L. Martin et al., 2015). Sweet rewards are often used in animal conditioning paradigms (Cantin et al., 2010; Huynh, Fam, Ahmed, & Clemens, 2017; Lenoir, Serre, Cantin, & Ahmed, 2007) but less in humans (Blechert et al., 2016; Franken et al., 2011; Prévost, Liljeholm, Tyszka, & O'Doherty, 2012). However, the rewarding nature of sweetness and its strength of it addictive potential is confirmed numerous times (Cantin et al., 2010; Lenoir et al., 2007; Madsen & Ahmed, 2015). Indeed, even non-caloric sweeteners have the potential to be used in conditioning paradigms (Lenoir et al., 2007; Nolan, Caudle, & Neubert, 2011) and were shown to have a similar reward response and value like sugars in humans (E. Green & Murphy, 2012; Griffioen-Roose et al., 2013), while non-caloric sweetener may activate the food reward pathways differently to sugars due to missing caloric stimuli (Veldhuizen et al., 2017; Q. Yang, 2010).

In the new EC paradigm, heart rate rise (cardiovascular strain) (= Conditioned Stimulus, CS) was paired with increased sweetness (based on sucralose) (= Unconditioned Stimulus, UCS) of a solution injected onto the tongue via a computerized double syringe system. In this way, the unconditioned primary reinforcer sweetness was coupled with the conditioned stimulus of increasing heart rate during high intensity interval training for three weeks (three sessions per week). A further training only group received a neutral saline solution with the same flow rate during training, similar to physiological saliva flow rate, and a control group received no training and no conditioning. Pre and post, as well as 4 weeks after training (follow up) subjects performed sessions for self-selected speed selection and DD of the selected exercise according to former work (Albelwi et al., 2019). Subjects selected intensity of exercise to adjust to maximize pleasantness (Feeling Scale) and also reported rate of perceived exertion/effort (RPE); in addition, heart rate, body characteristics and a battery of psychological questionnaires plus an assessment of DD rate of the self-selected exercise, favourite food and money was performed with a computer paradigm (Albelwi et al., 2019).

Hypotheses:

To investigate the assumption of a modifiable visceral reward of exercise in connection to physiological strain, I hypothesized that:

1. HIIT would lead to a transient increase of self-selected speed due to transient physiological adaptations and a decline at the follow-up; adaptations would lead to changes in physiological strain perceived as rewarding; consequently, leading to transient adjustments to higher speed maintaining subjective reward levels.
2. Training should reduce the DD of the self-selected exercise specifically due to integration of improved visceral experience into evaluation of exercise during discounting.

Secondly, using EC, where receipt of sweet solution as a reward was associated with elevation of heart rate during HIIT, I hypothesized that:

3. EC would increase self-selected speed with concomitant increase of heart rate and RPE levels after training and follow-up above the level induced by training only, assuming that the conditioned reward would be integrated in the exercise reward.
4. Elevation of reward value would induce a reduction of DD of exercise after training and follow up in the conditioning group due to magnitude effect (S. Frederick, Loewenstein, & O'donoghue, 2002).

3.2. Materials and Methods:

3.2.1. *Participants:*

After ethical approval by the ethics committee of the School of Sport, Health and Exercise Science, Bangor University (ethics number: P05-16/17). All the participants have read the information sheet beforehand (Appendix 16). 62 subjects (32 females) were recruited from students and general public in Bangor, UK, and 58 finished the study; two participants dropped out without stating reasons, two were excluded because of missing training sessions. Participants received £100 as a reimbursement for their time. Sample size was calculated on the basis of the study by Antoniewicz and Brand (Antoniewicz & Brand, 2016), who used EC with visual stimuli and observed an increase on exercise intensity selection. The power analysis, aimed to detect a significant difference in exercise intensities between groups using G*Power 3.1.9.2, ANOVA: Repeated Measures, within-between interactions at significance level of 5%; a sample size of 16 (8 in each group) would have 95% power to detect an effect based on a partial eta squared of 0.290 between groups. The sample size for the effect of exercise training on discounting rates, based on (Albelwi et al., 2019);, aimed to detect a significant difference between groups, ANOVA: Fixed effects, special, main effects and interactions at significance level of 5%; a sample size of 54 (divided into 2 group) would have 90% power to detect an effect size of 0.204 between groups.

Fifty-two participants were randomly assigned into two groups, a training group (TR) who received unflavoured electrolyte mouth rinse, and a conditioning plus training group with sweet mouth rinse group (COTR) during all HIIT sessions. A no training, no conditioning group (NTR) was recruited separately from the same population for testing of training effects on parameters (n=10).

3.2.2. Physical characteristics and physiological parameters

Weight and body composition (i.e. percent body fat) were assessed via bioelectrical impedance measurement using Tanita BC-418 MA system. Participants' height was measured using a standard stadiometer. Heart rate was measured during all exercise sessions (self-selected exercise sessions and HIIT sessions) using a Polar hear rate monitor in connection with bespoke computerized system for EC. Additionally, a standard sphygmomanometer was used to measure seated brachial arterial blood pressure for health screening before each exercise session.

3.2.3. Self-report measures

Participants were asked to fill out the following questionnaires during the first session:

1. Monetary Choice Questionnaire (MCQ)(Kirby et al., 1999), is a 27-item questionnaire which assesses DD of money using a set of choices between hypothetical monetary rewards of different magnitudes/values delivered at different delays; Cronbach's alpha (CRα): 0.98(Duckworth & Seligman, 2005) (Appendix 1).
2. Food Craving Questionnaire-Trait (FCQ-T) (Cepeda-Benito, Gleaves, Williams, et al., 2000) measures craving for foods, without confining them to certain categories, and covers behavioural, cognitive and physiological aspects of cravings with 39-items. The overall CRα for the FCQ-T is 0.98 and subscale alphas ranges from 0.71 to 0.95 (Cepeda-Benito, Gleaves, Williams, et al., 2000) (Appendix 2).
3. Exercise motivation Inventory (EMI-2) (Markland & Ingledew, 1997) assesses exercise participation motives applicable to both exercisers and non-exercisers. EMI-2 consists of 14 domains, which are Stress Management, Revitalization, Enjoyment, Challenge, Social Recognition, Affiliation, Competition, Health Pressures, Ill-Health Avoidance, Positive Health, Weight Management, Appearance, Strength and Endurance, and Nimbleness. Each subscale includes 3–4 questions, of which the

scores mean is calculated. The items challenge, affiliation, revitalization, and enjoyment were used as intrinsic factors (this study, Crα: 0.788), and appearance, weight management, positive health, health pressure, ill-health avoidance, and strength/endurance as extrinsic factors (this study, Crα: 0.713), according to Egli (Egli et al., 2011). Further motives (e.g., social recognition, stress management) are more difficult to classify along dichotomous categories and were included in the total exercise motivation score (this study, Crα: 0.883) (Appendix 3).

4. Barratt Impulsivity Scale (BIS II) (Patton et al., 1995) measures the personality/behavioural construct of impulsiveness based on scaling frequencies of common impulsive or non-impulsive behaviours and preferences. CRα was reported to be between 0.71 and 0.83 (Vasconcelos et al., 2012) (Appendix 4).
5. Physical Activity Readiness Questionnaire (PAR-Q)(Chisholm et al., 1975; Shephard, 1994) for assessment of potential health risks in association with physical activity participation (Appendix 5).
6. International Physical Activity Questionnaire (IPAQ)(Fogelholm et al., 2006) is a standardised self-report measure of habitual physical activity. Reliability was tested over 12 countries: Spearman's rho 0.81(C. L. Craig et al., 2003) (Appendix 6).
7. Reward Responsiveness (RR) scale: a subscale of the Behavioural activation system (BAS) scales (Carver & White, 1994). The RR scale measures the tendency to respond with heightened energy and positive affect when desired events are experienced or anticipated(Meyer, Johnson, & Winters, 2001). It includes 5-item, self-report measure that assesses reward sensitivity using a 4-point Likert scale (1=very true for me, 4=very false for me). Internal consistencies all BAS subscales were good (Cronbach's α ranged 0.68–0.79) (Markarian, Pickett, Deveson, & Kanona, 2013) (Appendix 7).

8. General Positive and Negative Affect Schedule PANAS-G (Mackinnon et al., 1999) to assess average mood state using two 10-item scales; CRα: 0.88 (Carvalho et al., 2013) (Appendix 8).

3.2.4. Procedure

Phase 1: Baseline measurements of self-selected exercise

Visit 1

Participants were informed to wear comfortable clothing that allows exercising on all visits. They were introduced to the protocol, consent was given, and asked to fill out self-report questionnaires (see self-reported measures), followed by measuring body characteristics. Then, participants were asked to walk for about 3 to 5 minutes on the treadmill to be familiarised with the exercise and manual settings of the treadmill for the further visits.

The goal for the exercise trials (1st and 2nd visits) was to establish the most pleasant/enjoyable exercise intensity possible for each participant to establish. This specific exercise experience would later serve as the exercise imagined during the DD task. The exercise intensity was set by repetitively self-adjusting the treadmill speed during the trials (see below). Social desirability and demand characteristics were minimized by emphasizing the aim to find the optimal exercise intensity for the participant's enjoyment using the same verbal protocol for all assessments and involving four different experimenters for reduction of bias and interpersonal contact.

All trials were performed using the same treadmill; during the exercise period, a nature soundtrack consisting of bird and forest sounds was played through speakers while the participants were facing a natural scenery through a wide window. This was performed to reduce possible negative effects of the technical environment on participants' perception. The heart rate (HR) was monitored throughout and after the end of the exercise sessions with a

HR monitor (Polar RS800CX). Exercise trials were terminated after 30 minutes or whenever the participant chose to end it earlier. The sessions were separated by at least 48 hours and maximally by one week. Before each exercise trial, each participant warmed-up on a cycler ergometer (Lode Excalibur) for 3 minutes before stepping on the treadmill.

For the first exercise trial, participants started walking on the treadmill at 3 km/h; display of speed and time was concealed from individuals in all trials. They were instructed to find the most pleasant exercise intensity they could adjust by modifying the speed of the treadmill using the control panel; it was emphasized that the experiment was not about fitness or performance. Participants were told that the exercise duration was up to 30 minutes maximally. After 2 minutes of exercise, participants were asked to rate the pleasantness of exercise using the 11-point Likert Feeling Scale (FS) that ranges from -5 to **5**; anchors are provided at zero ('Neutral') and at all odd integers, ranging from 'Very Good' (**5**) to 'Very Bad' (-5) (Hardy & Rejeski, 1989) (Appendix 12). For the rating, the participants were asked 'How do you rate the current exercise of being pleasant?'. Participants could modify the treadmill speed every two minutes to optimise pleasantness, e.g. increasing or decreasing the speed (selection could be made during the first 30 sec of the two minutes). Rating of current pleasantness was requested after the two-minute period elapsed; any set values were not visible for participants. After cooling-down, the participants were free to leave.

Visit 2

The second exercise trial had the goal to reconfirm the setting and experience of the self-selected exercise. After warming up, participants walked on the treadmill at 3 km/h and the speed was elevated gradually to the preferred speed selected in the first exercise trial by the experimenter and held for further 2 minutes. The researcher then manipulated the speed by increasing and decreasing it by 10 % of the preferred speed level, each period for 2 minutes, while pleasantness was rated every 2 minutes to confirm optimal setting of the preferred speed(Ekkekakis & Lind, 2006). Thereafter, a 5 minutes rest was given, and participants performed a further 5-10 minutes bout at the preferred speed to validate perception and to reinforce the feeling regarding this exercise bout.

Visit 3

The purpose of this exercise trial was to explore perception of perceived exertion/effort at preferred exercise speed. This measure was not introduced during the previous two trials to avoid any cross-over effects between the two perceptual modalities (pleasantness and effort). After the warm up, participants started walking on the treadmill and then the speed was gradually increased to the formerly self-selected preferred exercise speed by the experimenter; the speed as increased, as well as decreased, according to protocol of visit 2. Participants were asked to rate their perception of exertion/effort every 2 minutes using Rate of Perceived Exertion scale (Borg, 1970) which starts from 6 (no exertion at all) to 20 (maximal exertion) (Appendix 13).

After a resting period of about 5 minutes, participants were introduced to the DD task on the computer.

Delay discounting (DD) tasks

Tests were performed according to Albelwi (Albelwi et al., 2019); in brief, each participant was verbally introduced to the task, read the introductions and followed instructions on the computer screen. The DD tasks were generated using a specially designed computer programme based on the paradigm described by (Richards et al., 1999) via Inquisit™ program (developed by Milliseconds Software). The indifference points (IP) for each time delay of rewards for the tested commodities were obtained by randomization between delays and amount of rewards. The sooner, smaller hypothetical reward was offered ‘at the end of this session' as an immediate choice, and after 1, 7, 30, 60 and 180 days delay. The values of the three commodity rewards were adjusted between based on their monetary value (Charlton & Fantino, 2008; Rasmussen et al., 2010). The adjustment of the rewards was masked by randomization between delays and amount of rewards, and with the progression of the test, distractors were displayed to prevent the subject from predicting the questions and unmasking the underlying technique of the test as recommended by (Richards et al., 1999). The program terminated automatically and saved the experimental data after IP criteria had been achieved. Each computer task took about 4-6 minutes to be finished. For the monetary rewards, the hypothetical amounts offered were (£2-£7-£12-£17-£22-£27-£32-£37-£42-£47 and £50). The script for this task can be found in the supplementary file ( ). For the reward of food, the hypothetical amounts offered were 5, 10, 15, 20 and 30 bites (1 plate); 60 bites (2 plates), 90 bites (3 plates), 120 bites (4 plates), and 150 bites (5 plates) of food as the largest reward. The complete script can be found in the supplementary file ( ). For the exercise, the hypothetical exercises sessions offered were based on the formerly established treadmill exercise sessions (see above) and were fragmented into (5, 10, 15, 20, and 30 minutes (1 gym session), 60 minutes (2 gym sessions), 90 minutes (3 gym sessions), 120 minutes (4 gym sessions) and 150 minutes (5 gym sessions); assuming that 1 gym session = 30 minutes of exercise. The complete script is to be found in the supplementary file ( ).

The taste test was administered by the end of this phase for the COTR subjects.

Phase 2: HIIT Sessions with and without EC

EC Paradigm

Drinks Composition

For the EC process, following drink solution were used: SWEET SOLUTION: *Sqwincher Zero* Drink (Sqwincher, USA) with sucralose (MYPROTEIN.com) adjustment; the highest concentration of sweet solution (100% sweetness) = 0.877g *Sqwincher Zero* powder plus 20mg sucralose per 100ml.

NEUTRAL SOLUTION: The neutral solution was used for (0% sweetness) based on an electrolyte drink (bulkpowders.co.uk) dissolved according to manufacturer's protocol.

Both solutions were used for loading 60 ml syringes for syringe pumps (see below); solutions were freshly prepared and used at room temperature (15-17Cº).

Taste test

To ensure the optimized pleasantness of the sweet conditioning solution, COTR subjects conducted a taste test. Perceived pleasantness was recorded using stepwise dilutions of the 100% sweet solutions (20mg sucralose plus 0.877g *Squincher Zero* powder /100ml) in randomized order, for potential adjustment of the most pleasant concentration. A nine-point hedonic scale "1 = disliked extremely", "9 = liked extremely" (Peryam & Pilgrim, 1957) was used to rate the taste pleasantness for 5 sweet drink concentrations (100%, 75%, 50%, 25% and 12.5%) (Appendix 14). The participants were injected a volume of 5-ml for each concentration into the oral cavity with a syringe and asked to rate the taste pleasantness after rinsing mouth. Between the tested solutions, they took sips of water to flush out remaining tastants. The concentration with the highest pleasantness rating was used as the highest sweet reward (100%) during conditioning; however, all participants rated the original 100% solution as most pleasant. Therefore, no further adjustments were performed.

Syringe pump system

Two 60 ml syringes filled with either (2 x 60 ml NEUTRAL SOLUTION for the TR group, or 1 x 60ml NEUTRAL SOLUTION and 1 x 60ml 100% SWEET SOLUTION for the COTR group) were attached to two New Era programmable syringe pumps, Model: NE-4000. Combined flow rate was 2 ml/minute infused into a double tubing system and released through a double barrel mouthpiece onto the participant's tongue/oral cavity (Figure 3.1), (Figure 3.2). The selected flow rate of 2ml/min is in the range of normal stimulated saliva flow rate in adults which is 1-3 mL/minute (Dodds, Roland, Edgar, & Thornhill, 2015) to minimize swallowing during exercise. The TR group subjects received a constant NEUTRAL SOLUTION injection into the mouth during interval training, COTR subjects received NEUTRAL SOLUTION with SWEET SOLUTION admixture depending on heart rate. The admixture was controlled by a bespoke computer program using the heart rate measure for adjusting sweetness of mouth rinse solution of the COTR group. ≤ 85% of calculated heart rate max received 100% SWEET SOLUTION, while heart rate at individually self-selected speed (baseline) received 0% sweetness = NEUTRAL SOLUTION. While the total liquid rate kept constant (2ml/min), any increase in heart rate above baseline increased the sweetness admixture in a quadratic exponential manner achieving 100% sweetness at 85% heart rate max, see equation 1.

1) $$sweet\ solution\ rate = \frac{(\text{current HR}-\text{basline HR})2}{(85\%\ HRmax-baseline\ HR)2} * total\ liquid\ rate$$

The pairing between heart rate change (conditioned stimulus CS) and the sweet reward (unconditioned stimulus US) depended on exercise intensity increments during interval training. Six pairing periods were applied per training session; a total of 54 pairings over 9 conditioning sessions were applied during HIIT sessions over 3 weeks (Glautier et al., 1994). Pairings were induced during the HIIT sessions in the COTR groups, while TR group received the same HIIT with NEUTRAL SOLUTION injection. All participants attended all nine HIIT sessions over three weeks.

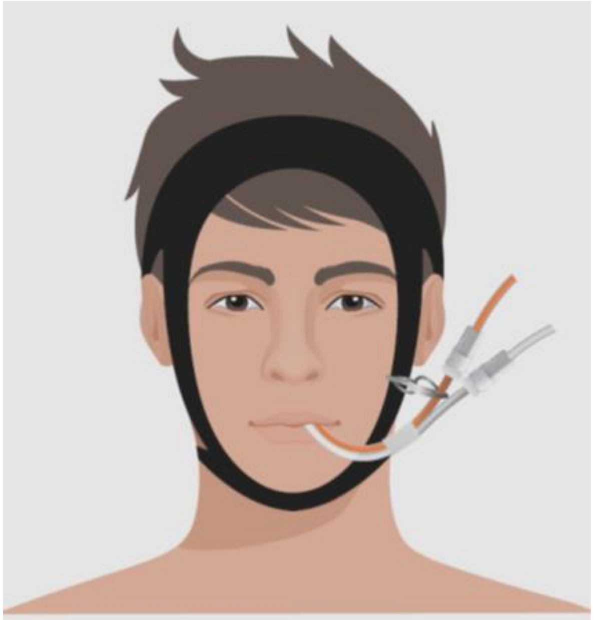

Figure 3.1. The drink tubes were attached to the head gear through a clip as a holder. The orange-coloured tube is for the sweet flavoured drink and the white-coloured tube for the unflavoured electrolyte drink. The drink mixing happened on the tongue.

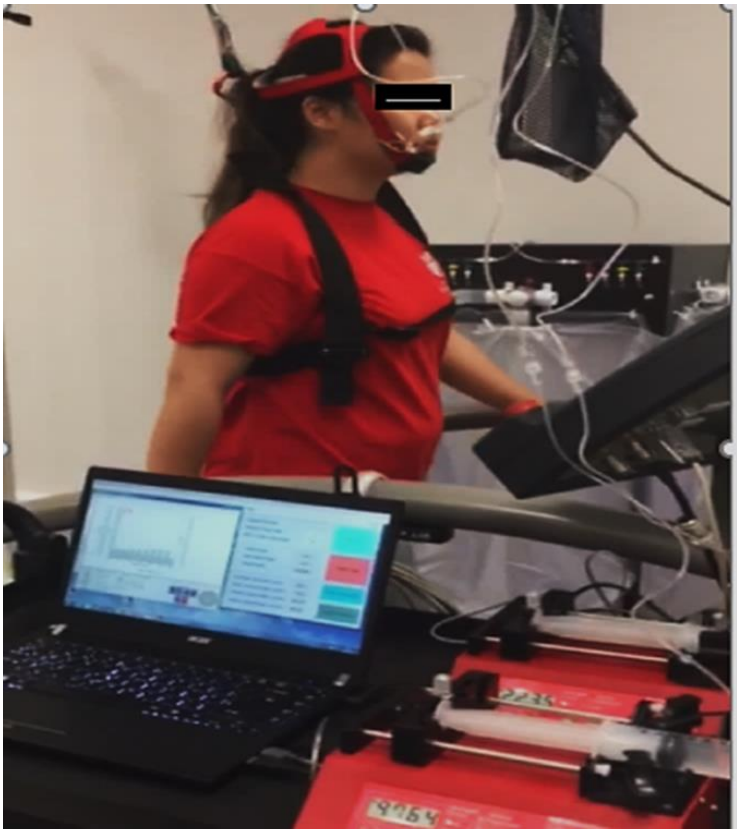

Figure 3.2. The experimental setting: the syringe pumps, the computer that controls the sweetness levels and the treadmill software that controls the exercise intervals protocol.

HIIT Sessions

The HIIT consisted of three sessions per week over three weeks for TR and COTR groups. The exercise training was performed using an HIIT protocol on treadmill consisting of progressive peak training intensities between 60-85% of HR_{max}. HR_{max} was calculated via 220 – age = HR_{max} which is suitable for the recruited age group (Tanaka et al., 2001). Target velocities for the treadmill were calculated by using heart rate / treadmill speed relationship from the assessment trials for self-selected speed. Speed was adjusted manually by the researcher if the target heart rate was not achieved. Subjects were verbally informed about oncoming increases or decreases in speed to avoid accidents (Figure 3.3). The training protocol was identical for TR and COTR groups.

Figure 3.3. The monitor screen during a typical training session (pilot): on the left is the h/p/cosmos treadmill software that monitors the HIIT with HR curve (in red). On the right: the drink sweetness control software that includes information about the subject's number, resting HR, 85% of estimated HR, the current HR, the average HR, the sweetness concentration at the moment, the syringe diameter in millimetres, the total output rate (ml/hr), sweet liquid rate (ml/hr) and the saline(electrolyte) liquid rate (ml/hr).

After a warm-up on a cycler ergometer (Lode Excalibur) for 3 minutes, subjects started exercising on a treadmill (computer-controlled treadmill, h/p-Cosmos) and gradually increased to participants' preferred speed (baseline). Subjects were blinded to all data of the treadmill settings. This was followed by intervals ramped from baseline to 60% HR_{max} over ~10 sec, then held for 2 minutes, followed by slowing down to baseline speed over ~10 sec; baseline speed was then held for further 1.5 minutes followed by the next cycle increasing intensity by 5% of HR_{max}. Six cycles were performed per training session (i.e. 60%, 65%, 70%, 75%, 80%, 85% of HR_{max}), total exercise time was about 30 minutes, followed by a cool-down at walking speed (Figure 3.3)

Phase 3: post-training assessments

It included 3 sessions, carried out during the following week after the exercise HIIT phase for TR and COTR groups, for the control group (NTR), three weeks after phase 1 (no training). All sessions and measurements were performed in the same order and ways as described for baseline measurements except omitting the taste test.

Phase 4: follow-up assessments

These were carried out 4 weeks after post-training assessments (phase 3) for TR and COTR groups. During this period participants were instructed not to engage in any physical training that was out of their usual former (before the intervention) daily routine. This phase included three sessions, using the same protocol as for phase 3. Subjects were reimbursed after this session and debriefed; participants were initially informed that the study was aimed to investigate the influence of oral cavity rinse to avoid dry mouth during exercise.

3.3. Analysis

All variables were tested on assumptions for parametric testing (i.e. mixed model ANOVA and ANCOVA, t-test); parameters, which were not normal distributed were transformed (by log: DD constants k, speed, heart rate; X^2: rate of perceived exertion (RPE)) to comply with ANOVA/ANCOVA test assumptions. ANOVA and ANCOVA were applied according to recommendations by Van Breukelen (Van Breukelen, 2006) with Bonferroni correction. Parameters, which could not be successfully transformed were analysed using non-parametric analysis e.g. Kruskal-Wallis followed by Mann & Whitney U-tests as indicated in the results section. Multiple regression analysis was performed using the backward stepwise elimination of selected parameters, as indicated in the results section. For model fitting of the hyperbolic effort discounting equation (Myerson & Green, 1995)on selected data, Microsoft Excel Solver programme using least square fit method was used to obtain effort discounting constant value k (k_{effort}). Fit of model parameters where tested using Wilcoxon sign test. In addition, DD constants k for money, food and exercise were calculated using Mazur's equation (Mazur, 1987) fitting participants indifference points (IP) data to hyperbolic functions using least square fit method with Microsoft Excel Solver programme. Data sets were removed if poor-fit in hyperbolic model ($R^2 <0.7$). Correlation analysis was performed using Spearman's and Pearson's correlation analysis. Data are displayed in mean and standard deviation, or median and 25 and 75 percentiles. Significance levels were reported if lower than $p<0.05$. Data were analysed using Statistical Package for the Social Science (IBM SPSS) version 25.

3.4. Results

3.4.1. Physiological and psychological characteristics

58 participants, out of 62 recruited, completed the study (32 females); two dropouts withdrawn without named reasons, and two were excluded by researchers because of missed training sessions. 48 participants concluded the randomized control trial, training group (TR) (n=24) and training plus conditioning group (COTR) (n=24); in the no-training group (NTR),

to control for time effects over the training period, ten participants completed (n=10). Body characteristics and psychological self-report parameters are shown in Table 3.1. Participants were young adults (24,3 (5.2) yrs.), with a wide range of BMI (BMI 18.5-40.5) but mostly eutrophic (53%), mainly reported moderate to high physical activity (86%), and more than medium exercise motivation (EMI-2). Psychological self-report questionnaires revealed that participants perceive moderate cravings (FCQ-T: 130.6 (31.2)), scored moderate levels in the impulsivity questionnaire (BIS II: 69.6 (16.9)) and monetary choice questionnaire (MCQ) resulted in a median k_{kirby}=0.01. The PANAS-PA and PANAS-NA reported more than medium scores for positive affect (38.0 (7.3)) and less than medium scores for negative affect (14.9 (4.7)). Participants reported a higher than medium rewards sensitivity (BASReward: 10.2 (3.7)). Comparison (Kruskal-Wallis test) of body characteristics and psychological self-report parameters reported no significant differences between groups, with exception of PANAS-PA (H:7.03, df:2, p=0.03), where follow-up tests (U-test) revealed significantly lower scores in the no-training group (NTR) compared with training (TR) and training plus conditioning groups (COTR), (U=64.5, p=0.035; U=50.0, p=0.008, respectively). Participants were not aware of the EC process; only 3 out of 24 participants of the COTR group reported contingency awareness of higher speed with sweetness after the intervention (debriefing). Concurrently, it was assumed that any conditioning effects were produced subconsciously.

Table 3.1. Body characteristics and psychometric self-reports

	No Training (NTR) (N=10)	Training (TR) (N=24)	Training plus conditioning (COTR) (N=24)
Sex	Female = 7; Male = 3	Female = 12; Male = 12	Female = 13; Male = 11

Age (yrs)	26.00 (5.12)	23.67 (4.19)	24.25 (6.05)
Weight (kg)	64.18 (8.69)	69.68 (15.92)	78.49 (19.36)
BMI (kg/m^2)	23.46 (3.24)	24.78 (4.61)	27.06 (5.40)
Percentage of body fat (%)	24.74 (8.85)	23.55 (9.33)	26.65 (9.66)
MCQ-k_{Kirby}	0.012 (0.019)	0.020 (0.027)	0.021 (0.035)
BIS II (Range of scores: 30-120)	61.90 (13.38)	74.92 (16.39)	67.54 (17.56)
FCQ-T (Range of scores: 39-234)	122.90 (27.21)	140.50 (33.81)	123.70 (28.39)
PANAS-G-PA (Range of scores: 10-50)	32.60 (6.60)	38.62 (6.86)	39.54 (7.24)
PANAS-G-NA (Range of scores: 10-50)	16.20 (4.37)	14.08 (4.03)	15.25 (5.38)
BASReward (Range: 5-20) High sensitivity = 5	9.90 (3.73)	10.79 (4.55)	9.75 (2.75)
IPAQ	h=6 ; m=3 ; l=1	h=5 ; m=15 ; l=4	h=10 ; m=11 ; l=3
EMI-2 (Range: 0-5)			
Extr. Ex. Mot.	3.60 (0.53)	3.28 (0.75)	3.30 (0.63)
Intr. Ex. Mot.	3.18 (1,15)	3.20 (0.89)	3.35 (0.38)
Intr. plus Extr. Mot.	2.84 (1.31)	2.42 (0.85)	2.62 (0.95)

3.4.2. *Effects of training and conditioning on reward discounting*

Computer based assessments of reward discounting of money, food, and exercise at baseline showed that the decay constant (k) for money (k_m) was significantly lower than k for food (k_{fo}) and exercise (k_{ex}) across groups (k-values were log-transformed due to skewed distribution; repeated measure ANOVA: F=69.96, df=2, p<0.0001, η^2=0.714; contrast k_m versus k_{ex}: F= 130.2, df=1, p<0.0001, η^2=0.696); no significant difference between k_{fo} and k_{ex} was found. Outcomes demonstrate that exercise was discounted faster than money, like a non-transferrable reward, similar to food (Table 3.2).

Table 3.2. DD constants (k) of money, exercise, and food

	Mean STD (±)	Median, (25^{th} | 75^{th} percentile)	R^2 mean STD (±)
No Treatment (NTR) (N=10)			
k_m - T_0	0.015 (0.025)	0.006 (0.003|0.014)	0.75 (0.15)
k_{ex} - T_0	0.076 (0.025)	0.079 (0.054|0.087)	0.79 (0.12)
k_{ex} – T_1	0.073 (0.026) #	0.082 (0.039|0.094)	0.75 (0.13)
k_{fo} – T_0	0.105 (0.085)	0.065 (0.043|0.155)	0.87 (0.09)
k_{fo} – T_1	0.122 (0.103)	0.086 (0.052|0.161)	0.86 (0.07)
Training (TR) (N=24)			
k_m - T_0	0.049 (0.064)	0.029 (0.011|0.048)	0.87 (0.08)
k_{ex} - T_0	0.307 (0.296)	0.194 (0.080|0.550)	0.82 (0.10)
k_{ex} – T_1	0.131 (0.144)	0.068 (0.033|0.163)	0.80 (0.11)
k_{ex} – T_2	0.238 (0.191)* #	0.159 (0.086|0.315)	0.88 (0.10)
k_{fo} - T_0	0.368 (0.404)	0.244 (0,095|0.456)	0.84 (0.10)
k_{fo} – T_1	0.359 (0.384)	0.226 (0.079|0.480)	0.85 (0.11)

$k_{fo} – T_2$	0.307 (0.354)	0.108 (0.088|0.481)	0.82 (0.10)
Training plus conditioning (COTR) (N=24)			
k_m - T_0	0.0421 (0.062)	0.013 (0.007|0.045)	0.83 (0.13)
k_{ex} - T_0	0.326 (0.291)	0.145 (0.092|0.579)	0.88 (0.08)
$k_{ex} – T_1$	0.144 (0.181)*	0.055 (0.030|0.195)	0.84 (0.08)
$k_{ex} – T_2$	0.263 (0.255)	0.179 (0.064|0.392)	0.85 (0.11)
k_{fo} - T_0	0.321 (0.257)	0.265 (0.147|0.459)	0.86 (0.10)
$k_{fo} – T_1$	0.260 (0.239)	0.202 (0.062|0.396)	0.84 (0.11)
$k_{fo} – T_2$	0.302 (0.246)	0.280 (0.085|0.465)	0.81 (0.08)

*Significant effect of training, p<0.05; #significant interaction of group x time (TR, COTR), p<0.05; †significant interaction of group x time (NTR, TR), p<0.05

To assess the hypothesized specific exercise training effect on discounting rates of exercise, ANOVAs of change between baseline and post training values were performed on the log-transformed decay constants of k_{ex} and k_{fo} using the data of NTR and TR groups. This method was preferred to a mixed model ANOVA due to significant lower levels of discounting rate constants in the NTR group compared with TR group at baseline (t-test: k_{ex}: t=3.02, df=31.39, p=0.0002; k_{fo}: t=2.68, df=25.52, p=0.013). Results revealed a significant difference between TR and NTR groups in change of k_{ex} from baseline to after training and no-training periods, respectively (Δk_{ex}: F=13.80, df=1, p=0.001); k_{ex} was significantly reduced after training while k_{ex} in the NTR group was unaltered (Table 3.2).

Moreover, this effect of HIIT was specific to k_{ex}; the changes in k_{fo} from baseline to after training/no-training period were not significantly different between groups and no change over time was reported within groups. Consequently, these results show that HIIT reduced discounting rates of exercise specifically; no effect on k_{fo}, and discounting of both, exercise and food rewards, were not affected by time (no change in NTR group).

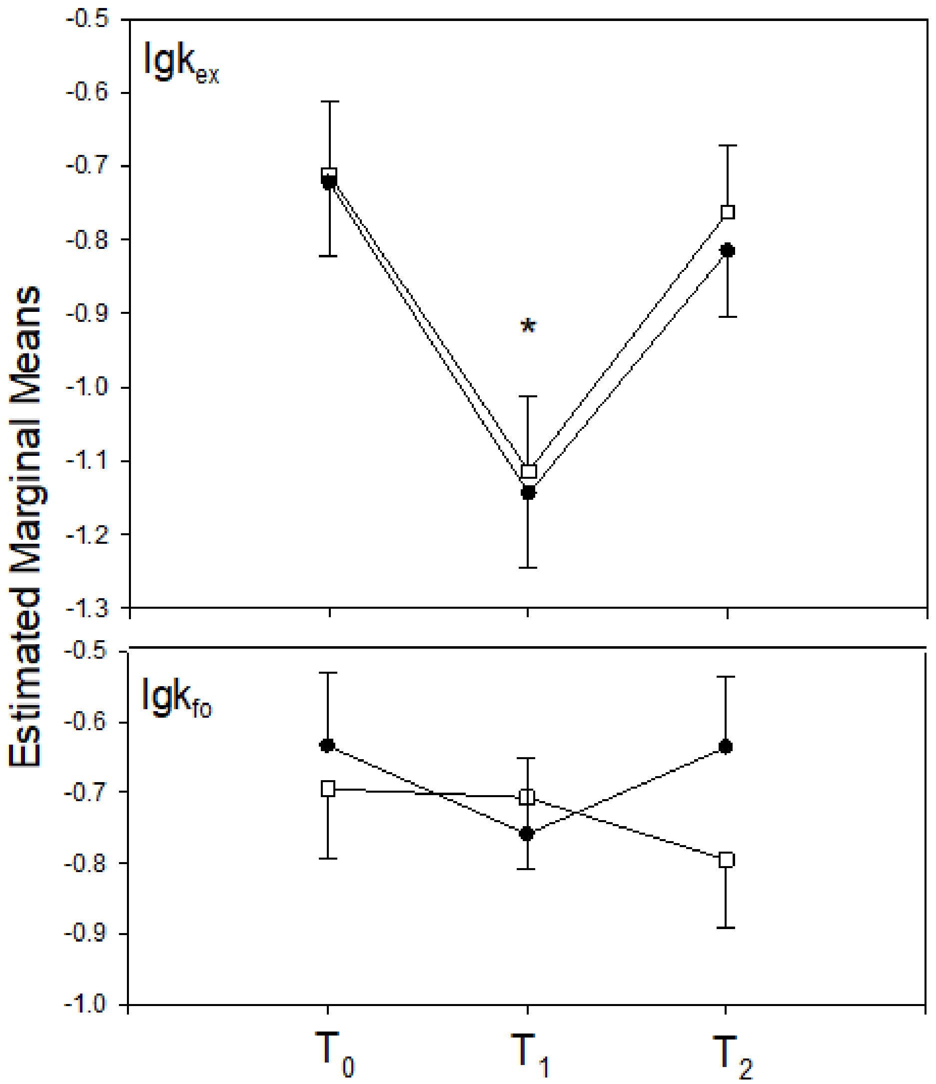

Figure 3.4. Log-transformed k_{ex} and k_{fo} changes over the three time points; baseline (T0), post-training (T1), and follow up (T2) for the training (TR) and conditioning plus training (COTR) groups. Open boxes COTR; closed boxes TR. *Significant effect of training, $p<0.05$; figure shows mean and SE.

For the hypothesis of an influence of EC on discounting rates of exercise, the data from the randomized control trial were used, TR and COTR groups. Groups revealed no significant difference of k_{ex} and k_{fo} at baseline and mixed model ANOVA of log-transformed data over three time points (baseline – T_0; post exercise –T_1; 4 weeks follow-up – T_2) was performed. Results (Table 3.2, Figure 3.4) showed a main effect of time ($F=24.56$, $df=2$, $p<0.0001$, $\eta^2=0.522$), where the post training k_{ex} values (T_1) were significantly reduced compared with baseline (T_0) (contrast T_1 versus T_0: $F=45.78$, $df=1$, $p<0.0001$, $\eta^2=0.499$). Moreover, contrasts revealed that k_{ex} values returned towards baseline levels in both groups at 4 weeks follow-up (T_2 versus T_1; $F= 27.94$, $df=1$, $p<0.0001$, $\eta^2=0.378$), with no significant differences between baseline and follow-up. Moreover, no significant effects of group and no interaction of group x time were found. In contrast, k_{fo} values were not affected by training or conditioning (Table 3.2, Figure 3.4), no significant effects of time, group, and interaction were reported, revealing stable levels of food reward discounting over time in both groups.

In summary, results show that discounting of exercise was affected specifically by the training context reducing exercise discounting rates. Training effects on exercise discounting were not sustained beyond the training period and returned to baseline levels after 4 weeks no-training period (follow-up, T_2, Figure 3.4). The effects were specific to exercise discounting and not detected for discounting of food rewards. Moreover, EC induced no alterations in discounting neither for exercise nor for food after training and follow-up.

3.4.3. *Effects of training and conditioning on self-selected speed, heart rate and RPE*

Training improved participants' cardiovascular exercise efficiency; heart rate per speed (HR/Speed) (table 3) was significantly reduced after training in both TR and COTR groups (mixed model ANOVA; main effect of time: $F=21.87$, $p<0.0001$, $\eta^2=0.504$; contrast baseline versus post training: $F=43.48$, $p<0.0001$, $\eta^2=0.497$; no significant interaction of group x time); no changes were detected in the NTR group.

Analysing the self-selected speed, heart rate and RPE data of the randomized control trial, results show that self-selected speed was selected on significant higher levels after training than at baseline in both, TR and COTR groups. A main effect of time was reported in the ANCOVA with baseline speed as a covariate ($F=6.65$, $df=2$, $p=0.003$, $\eta^2=0.236$), contrasts detected a significant increase in speed at post training (T_0 versus T_1: $F=9{,}64$, $df=1$, $p=0.003$, $\eta^2=0.180$). The self-selected speed was about 1 km/h faster after training than at baseline in both groups (see Table 3.3); no significant interaction of group x time was reported between baseline (T0) and post-training (T1). ANCOVA, however, reported a significant interaction of group x time ($F=7.70$, $df=2$, $p=0.001$, $\eta^2=0.264$), whereby contrasts revealed that the significant interaction was between after training (T_1) and 4 weeks follow-up (T_2), (T_2 versus T_1, $F=13.32$, $p=0.001$, $\eta^2=0.232$), (Figure 2). Pairwise comparison showed that the COTR group selected the speed significantly higher than the TR group at 4 weeks follow-up (T_2), ($t=-3.05$, $df=45$, $p=0.004$), (Table 3.3, Figure 3.5). Self-selected speed at T_2 was not different to baseline T_0 in the TR group.

Table 3.3. Exercise trials characteristics for No Training (NTR), Training (TR) and Conditioning Training (COTR) groups.

	Mean STD (±)	Median, (25th | 75th percentile)
No Training (NTR)		
Preferred Speed (km/h) - T_0 (N=10)	6.03 (2.34)	5.70 (4.70|6.25)
Preferred Speed (km/h) - T_1	6.06 (2.48) †	5.65 (4.73|6.33)
Average HR (bpm) - T_0 (N=10)	120.4 (20.5)	118.5 (102.5|134.5)
Average HR (bpm) - T_1	120.5 (20.6) †	117.5 (101.8|132.5)

HR/Speed (bpm/km*h^{-1}) – T_0	21.14 (4.00)	21.07 (19.40|22.65)
HR/Speed (bpm/km*h^{-1}) – T_1	21.11 (3.71)	21.61 (19.54|22.72)
RPE (range: 6-20) - T_0 (N=10)	10.30 (2.45)	10.50 (8.00|11.50)
RPE (range: 6-20) - T_1	10.50 (2.51)	10.00 (9.00|12.00)
Feeling Scale (Range: -5/0/5) - T_0 (N=10)	4.00 (1.16)	4.50 (3.00|5.00)
Feeling Scale (Range: -5/0/5) - T_1	3.90 (1.10)	4.00 (3.00|4.00)
Training (TR)		
Preferred Speed (km/h) - T_0 (N=23)	5.25 (1.27)	4.80 (4.30|5.90)
Preferred Speed (km/h) - T_1	6.29 (1.47)* †	5.80 (5.60|6.80)
Preferred Speed (km/h) – T_2	5.42 (1.02)#	5.27 (4.76|5.77)
Average HR (bpm) - T_0 (N=22)	118.7 (15.3)	118 (107.0|124.0)
Average HR (bpm) - T_1	127.3 (17.1)* †	125.5 (114.0|136.0)
Average HR (bpm) – T_2	119.0 (10.9) #	117.0 (111.5|125.5)
HR/Speed (bpm/km*h^{-1}) – T_0	23.21 (4.03)	23.98 (19.10|26.62)
HR/Speed (bpm/km*h^{-1}) – T_1	21.28 (3.05)*	21.58 (18.36|23.38)
HR/Speed (bpm/km*h^{-1}) – T_2	22.81 (3.25)	23.42 (20.47|25.04)
RPE (range: 6-20) - T_0 (N=24)	9.83 (1.98)	10.00 (8.25|11.00)
RPE (range: 6-20) - T_1	10.63 (1.76)* #	11.00 (9.00|12.00)
RPE (range: 6-20) – T_2	10.13 (1.78) #	10.00 (8.25|11.00)
Feeling Scale (Range: -5/0/5) - T_0 (N=24)	4.25 (0.99)	5.00 (3.00|5.00)
Feeling Scale (Range: -5/0/5) - T_1	4.25 (0.94)	5.00 (3.25|5.00)
Feeling Scale (Range: -5/0/5) – T_2	4.21 (0.83)	4.00 (3.25|5.00)
Training plus conditioning (COTR)		
Preferred Speed (km/h) - T_0	5.71 (1.22)	5.40 (4.93|6.40)

(N=24)		
Preferred Speed (km/h) - T_1	7.01 (1.56)*	6.45 (5.95|7.27)
Preferred Speed (km/h) – T_2	6.53 (1.47) #	6.33 (5.80|7.27)
Average HR (bpm) - T_0 (N=24)	123.1 (21.6)	117.5 (108.3|137.0)
Average HR (bpm) - T_1	135.5 (21.1)*	134.5 (115.5|154.3)
Average HR (bpm) – T_2	130.5 (20.2) #	131.0 (116.0|143.5)
HR/Speed (bpm/km*h^{-1}) – T_0	21.94 (3.44)	22.07 (18.79|24.31)
HR/Speed (bpm/km*h^{-1}) – T_1	19.69 (2.59)*	19.34 (17.84|21.74)
HR/Speed (bpm/km*h^{-1}) – T_2	20.41 (2.90)	20.07 (18.49|22.20)
RPE (range: 6-20) - T_0 (N=22)	9.82 (1.89)	10.00 (9.00|11.00)
RPE (range: 6-20) - T_1	11.46 (1.37) #	12.00 (11.00|12.00)
RPE (range: 6-20) – T_2	10.86 (1.61) #	11.00 (10.00|12.00)
Feeling Scale (Range: -5/0/5) - T_0 (N=24)	4.29 (0.96)	5.00 (3.25|5.00)
Feeling Scale (Range: -5/0/5) - T_1	4.42 (0.88)	5.00 (4.00|5.00)
Feeling Scale (Range: -5/0/5) – T_2	4.33 (0.82)	5.00 (4.00|5.00)

*Significant effect of training, p<0.05; #significant interaction of group x time (TR, COTR), p<0.05; †significant interaction of group x time (NTR, TR), p<0.05

Summarized, the results show that training led to an increase of self-selected speed, however, the effect did not last over the 4 weeks follow-up period and self-selected speed declined to baseline (TR group). Conditioning plus training led (COTR) to a matching training effect with increase in self-selected speed, while a specific conditioning effect was reported for the 4 weeks follow-up; the higher self-selected speed level detected after training was maintained over the post training follow-up period. This was not apparent in the TR group; therefore the elevated self-selected speed at follow-up was a specific effect of conditioning (COTR) (Figure 3.2).

Concomitant heart rate measurements at self-selected speeds showed that cardiovascular strain was selected on a higher levels after training (T1) compared with baseline (T0) (Figure 3.5, Table 3.3); ANCOVA with baseline heart rate as covariate reported a main effect of time (F=8.67, df=2, p=0.001, η^2=0.292), where contrasts revealed that the heart rate was a significant higher at post training compared with baseline (T1 versus T0: F=7.16, df=1, p=0.01, η^2=0.143) and with 4 weeks follow-up (T2 versus T1: F=6.42, df=1, η^2=0.130) in both groups. Moreover, a significant interaction of time x group was reported (F=5.43, df=2, p=0.008, η^2= 0.205), where the interaction was based on the difference in change of heart rate between T2 and T1 between groups (F=6.55, df=1, p=0.014, η^2=0.132), showing that COTR group maintained a higher cardiovascular strain at 4 weeks follow-up compared with TR, which is consistent with the conditioning effect in self-selected speed (COTR).

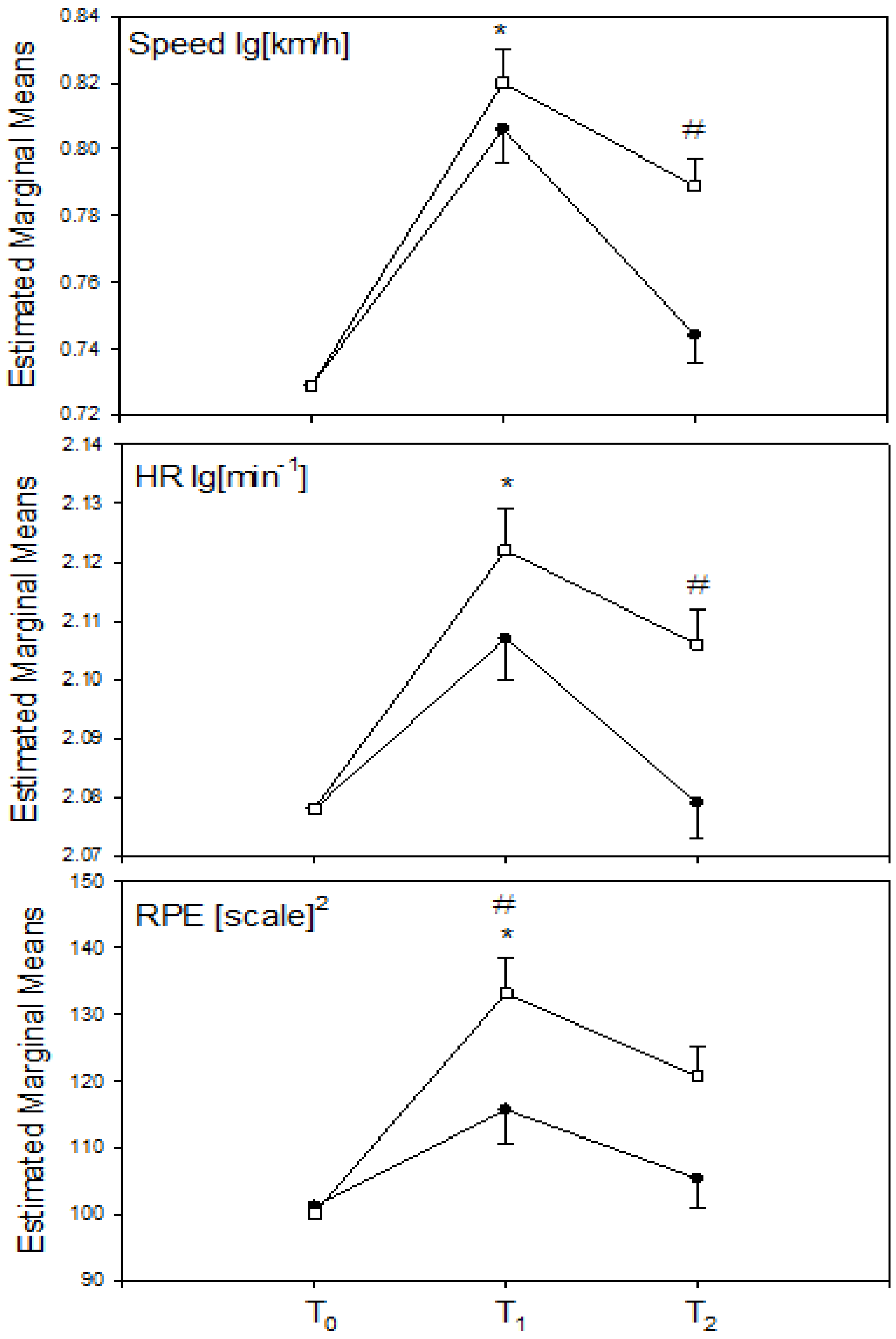

Figure 3.5. Log-transformed Speed, Heart Rate (HR), and Rate of Perceived Exertion (RPE) changes over the three time points; baseline (T_0)- post-training (T_1) and follow up (T_2) for Training (TR) and Conditioning Training (COTR) groups. Open boxes COTR; closed boxes TR. *Significant effect of training, $p<0.05$; #significant interaction of group x time; figure shows mean and SE.

Furthermore, ANCOVA with baseline as covariate showed, that RPE levels (Table 3.3, Figure 3.5) at self-selected speed were increased after training (main effect of time: F=17.58, df=2, p<0.0001, η^2=0.456; contrast T2 versus T1: F=33.10, df=1, p<0.0001, η^2=0.435), as expected from higher cardiovascular strain at higher speed. Moreover, a significant interaction of group x time was reported (F=3.78, df=2, p=0.031, η^2=0.153), where the interaction was significant between T1 and TO (F=5.38, df=1, p=0.025, η^2=0.111). The increase in RPE was stronger in the COTR group than TR group between baseline and post training. Pairwise comparison of RPE levels within groups showed that RPE levels between baseline and 4 weeks follow-up were not different in TR group, while 4 weeks follow-up RPE was significantly elevated compared with baseline in COTR group (t=-3.59, df=21, p=0.002); RPE was not returning to baseline at T2 in this group. To exclude any possible alteration in effort perception induced by training or conditioning I normalized RPE values on heart rate, assuming that cardiovascular strain would be the main driver of RPE during running at self-selected speed. Mixed model ANOVA reported no significant main effects of time or group, and no interaction of time x group (not shown), supporting the assumption of unaltered effort perception.

In summary, cardiovascular strain (heart rate) was selected on a higher level after the training intervention in both groups, while the heart rate at self-selected speed was reduced between post training and 4 weeks follow-up in the training group (TR). In the COTR group, heart rate remained on elevated levels, consistent with the higher self-selected speed in this group compared with TR group, confirming the conditioning effect seen on self-selected speed. Additionally, RPE levels at self-selected speed were reported on higher levels post training compared with baseline, however, stronger in the COTR group. RPE levels followed the general changes in speed and cardiovascular strain (Figure 3.5, Table 3.3).

3.4.4. *Multiple regression analysis*

To understand the contribution of psychological and physiological baseline parameters to the self-selected speed alterations seen after training and conditioning, I performed multiple regression analysis using hierarchical regression with the backward method. I added psychological self-report parameters, physiological characteristics, k-values, generated with the computer paradigm, as well as a group code into the model as predictor variables to explain variance of alterations of self-selected speed from baseline to post-training and from baseline to 4 weeks follow-up. The first model investigated the data within groups who took part in training (TR and COTR), (Table 3.4, model 1), and investigated the T_0 to T_1 period speed alterations. The model could explain about 67% of the variance of self-selected speed alterations within these groups, where the alteration in HR/speed, as a measure of training adaptation, explained most of the variance in speed change after training (beta= -0.613, p<0.0001) next to the alteration in RPE (beta=0.391, p=0.0002), and smaller contribution of impulsivity (BIS) and k_{ex}-T1 (Table 3.4). The group variable (TR and COTR) did not influence the regression model confirming that conditioning produced no effect on the altered speed selection over this period.

Table 3.4: Multiple regression analysis of self-selected speed changes

Model 1			
Speed Change T_0-T_1 (TR, COTR; n=44)			
R^2= 0.67	F=19.52	P<0.0001	
Variable	Beta	t	p
HR/Speed Change T_0-T_1	-0.613	-6.27	<0.0001
k_{ex}-T_1	0.253	2.58	0.014
BIS	-0.238	-2.46	0.018
RPE Change T_0-T_1	0.391	4.18	0.0002

Model 2			
Speed Change T_0-T_2 (TR, COTR; n=44)			
R^2= 0.80	F=38.65	P<0.0001	
Variable	Beta	t	p
Group	-0.417	-5.75	<0.0001
HR/Speed Change T_0-T_2	-0.559	-7.58	<0.0001
Age	0.344	4.96	<0.0001
RPE-T_0	0.252	3.50	0.001

For the explanation of the variance of self-selected speed alterations baseline to follow-up (T_0-T_2) in TR and COTR, the best model (T

able 3.4, model 2), explained about 80% of the variance. The model revealed that the strongest predictors were the EC (grouping variable: beta= -0.417, p<0.0001) and the alteration of HR/speed between baseline and follow-up (beta= -0.559, p<0.0001); additional predictors were age and RPE-T_0 (Table 3.4). Higher speed was selected with conditioning and better preservation of training effect (HR/Speed).

Summarized, changes in self-selected speed were strongly influenced by HR/Speed and effort perception; higher speed selection at follow up was mostly influenced by EC and changes in HR/Speed.

Self-selected speed changes over time were not correlated with k_{ex} alterations (not shown); indeed, to have a better understanding which of the measured parameters could explain the variance in k_{ex} changes, I performed multiple regression modelling using the same approach as mentioned above, however, included also speed changes as possible predictors. Within the training groups (TR and COTR), the variance of k_{ex} alterations (T_0-T_1) could be only explained by 22% (Table 3.5, model 1), and the only parameters with influence were the k_{ex} at baseline (beta=0.389, p=0.008) and HR/Speed changes between baseline and after training (beta=-0.273, p=0.059), showing that participants who had a higher baseline k_{ex} reduced the constant more than people who already had low k_{ex} values. However, exercise discounting changes from baseline to follow-up (T_0-T_2), groups TR plus COTR, were explained by 43% (table 5, model 2). Again, baseline k_{ex} levels were most influential for the prediction (beta=0.444, p=0.001). However, exercise motivation parameters (intrinsic and extrinsic) and BASreward scores contributed, as well to the model (Table 3.5, model 2) for discounting changes in exercise. No contribution of group variable was detected for the training and follow-up period regards the discounting changes of exercise.

Table 3.5: Multiple regression analysis of exercise discounting (k_{ex}) changes

Model 1			
k_{ex} T_0-T_1 (TR, COTR; n=48)			
R^2=0.22	F=5.56	P=0.007	
Variable	Beta	t	p
k_{ex}-T_0	0.389	2.78	0.008
HR/Speed Change T_0-T_1	-0.273	-1.95	0.059
Model 2			
k_{ex} T_0-T_2 (TR, COTR; n=48)			
R^2= 0.43	F=8.04	P<0.0001	
Variable	Beta	t	p
k_{ex}-T_0	0.444	3.62	0.001
BASreward	-0.279	-2.21	0.041
Intrinsic motivation	-0.455	-3.36	0.002
Extrinsic motivation	0.307	2.22	0.033

Summarized, k_{ex} alterations after training were influenced by baseline discounting of exercise and training adaptation, while exercise motivation and BASreward contributed for the follow-up period. No contribution of conditioning on exercise DD was detected.

3.4.5. *Effort model application*

Our multiple regression models (see above) showed that changes in HR/Speed and RPE explained majority of the variance of changes in self-selected speed from baseline to after training (T0 to T1) and baseline to follow up (T0 to T2). Consequently, in view of former effort discounting models (Botvinick et al. 2009; Kurniawan et al. 2010; Bialaszek et al. 2017), I suggested that participants pleasantness scores (Feeling Scale (FS), see table 3.3), recorded while selecting their self-selected speed, would be a measure of the subjective value (Vp) of the exercise. Moreover, it was hypothesized that the rate of perceived exertion (RPE) given at self-selected speed would be a measure of perceived costs (C) and the parameter HR/Speed a measure would determine the reward value (M) perceived during exercise. To test this hypothesis, a hyperbolic effort discounting model was used $\{Vp=M/(1+kC)\}$ (Myerson and Green, 1995) using the data from time point T0, T1, and T2, assuming, that if the model is valid for the combination of data, the Vp data from the least squares fit would be not significantly different to the measured FS values (Vp) data. In addition, it was expected that the k values of at T0 and T1 and T2 TR (training only group) would be on the same level, while the k value at T2 COTR of the conditioning group should be hugely affected by the added conditioned reward, which is not accounted for in the model. Because k_{effort} is connected to costs, an unaccounted reward value (conditioning) would need to reduce the cost term by reducing k to adjust to the subjective value measured. Firstly, fitting of the hyperbolic models to data at baseline (T0), after training (T1), and follow up (T2) produced

Vp values, which were not significantly different to the measured FS values (Table 3.6) (n= 48; T0: Z=-0.862, p=0.389; T1: Z=-1.005, p=0.315; T2: -1.005, p=0.315), suggesting an appropriate representation of the data by the model. Moreover, when groups were separately analysed at follow up point (T2), based on the significant effects of conditioning on speed and effort selection (see table 3.6), model fitting was improved (n= 24; 2-TR: Z= -0629, p= 0.530; T2-COTR: Z= -0.743, p=0.458). k values of the fitted models reveal that ks are consistent over the periods of baseline, after training and follow up (T2, TR only): k-T0= 0.204; k-T1= 0.204; k-T2 (TR)= 0.212; however, k-T2 (COTR)= 0.042, revealed that the k value in the conditioning group (COTR) was adjusted five times lower to accommodate for the unaccounted reward value from conditioning.

Table 3.6. Hyperbolic effort model fit

	mean	SD	Wilcoxon Sign test	k
V_p (norm. FS-T_0)	0.854	0.192		
V_p – T_0 model (n=48)	0.823	0.134	Z= -0.862; p=0.389	0.204
V_p (norm. FS-T_1)	0.867	0.181		
V_p – T_1 model (n=48)	0.848	0.119	Z= -1.005; p=0.315	0.204
V_p (norm. FS-T_2)	0.949	0.182		
V_p – T_2 model (n=48)	0.922	0.136	Z= -1.005; p=0.315	0.126
V_p (norm. FS-T_2)TR	0.936	0.183		
V_p – T_2 model TR (n=24)	0.908	0.120	Z= -0.625; p=0.530	0.212
V_p (norm. FS-T_2) COTR	0.963	0.180		
V_p – T_2 model COTR (n=24)	0.940	0.134	Z= -0.743; p=0.458	0.042

In summary, these outcomes support the hypothesis that HR/Speed determines the reward in the adjustment of self-selected speed and that EC led to an integration of the sweet reward into the perceived exercise reward for the adjustment of speed selection.

3.5. Discussion

3.5.1. *Alterations in self-selected speed: Effects of HIIT and EC*

It was hypothesized that HIIT would lead to a transient increase of self-selected speed due to transient physiological adaptations and a decline at the follow-up. The hypothesis was driven by the assumption that self-selected exercise intensity can be perceived as a reward at an individual cardiovascular strain during the exercise and that physiological adaptions would lead to transient adjustment to higher speed maintaining subjective reward level.

Indeed, self-selected speed was significantly increased after training (TR), no changes were detected in the control group (NTR) over time, showing that the training effect on self-selected speed was specific to training. To understand the influence of training on self-selected speed selection, multiple regression analysis was performed (table 3.4), showing that the changes in speed could be foremost attributed to changes in heart rate per speed (HR/Speed) and to RPE score changes, after training and at follow up (models explained 67% of speed variance after training and 80% of speed variance at follow up). Alterations in HR/Speed are connected to physiological adaptations to training enabling lower heart rate at a set speed after training (Vesterinen et al., 2013); however, the transient nature of those is seen at follow up four weeks after training where HR/Speed was not different to baseline. Adaptation to aerobic training and detraining in relation to heart rate changes are a commonly observed and an expected outcome (J. H. Green, Cable, & Elms, 1990); indeed, former work shows decline in training outcomes after training interruption for similar duration (Mujika &

Padilla, 2000). These effects are attributed to changes in plasma volume (Coyle, Hemmert, & Coggan, 1986; J. H. Green et al., 1990), autonomic nervous system balance (J. B. Carter, Banister, & Blaber, 2003; Hautala et al., 2003), and improved distribution of cardiac output to working muscles (Gliemann, Hansen, Rytter, & Hellsten, 2019), enabling changes in HR associated with increased cardiovascular fitness (Strath et al., 2000). The dimension of HR/Speed has been used in other context before; HR per running speed at submaximal levels has a linear association over a wide range of intensity and is used for monitoring training and as a predictor of endurance performance in connection with cardiovascular fitness (Boudet, Albuisson, Bedu, & Chamoux, 2004; Vesterinen et al., 2013). However, the specific causes for the changes are not important in the current context, besides the observation that changes in HR/Speed are a major determinant for the choice of self-selected speed to optimize pleasantness of exercise.

To understand the selection of a specific speed and why training led to an alteration in speed selection, it was assumed that the selection of exercise intensity would follow models generally suggested for choice decisions that include costs and rewards (Botvinick et al., 2009; L. Green & Myerson, 2004; Hartmann et al., 2013). Indeed, most behavioural models assume that the subjective value of a utility is a function of rewards and costs (Hartmann et al., 2013; Myerson & Green, 1995; Samuelson, 1937; Zipf, 1949). Distinct choice paradigms where subjects work for an external reward with varied imagined or received rewards (i.e. money) have shown that a reward value is discounted against effort or work, resulting in a subjective value for the rewarding utility (Białaszek, Marcowski, & Ostaszewski, 2017; Botvinick et al., 2009; Kurniawan et al., 2010). In confirmation, many animal studies showed that rewards and costs are discounted in behavioural choices in a similar manner as well (Botvinick et al., 2009; Salamone et al., 1994; Stevens et al., 2005; Walton et al., 2002). In this regard, various models are suggested from hyperbolic(Myerson & Green, 1995), sigmoidal (Klein-Flügge, Kennerley, Friston, & Bestmann, 2016) to parabolic (Hartmann et al., 2013); however, the principal rule applies that effort carries a negative value which is used as a reference against a reward is evaluated (Botvinick et al., 2009).

If I assume that adjustment of self-selected speed is a function of cost-reward, it is conceivable that training could have either reduced the perceived costs for a set speed or increased the perceived reward. Indeed, the higher the reduction of HR/Speed after training was for an individual, the higher the speed was selected, which could be an indication for perceived cost reduction. However, the concomitant increase in perception of effort (RPE scores) with increased speed selected, where RPE is undoubtedly a measure of costs, weakens this argument. Moreover, RPE score changes independently contributed for the variance explained of the self-selected speed changes (table 4), while HR/Speed and RPE were not significantly correlated at any time point measured (not shown). It is inconceivable, that changes in HR/Speed would solely generate a reduction in perceived costs, selecting a higher speed, when this choice is perceived at a significantly higher RPE score than at baseline. RPE is often associated with individuals' heart rate in aerobic exercise (Eston & Williams, 1988) and scales are partially attuned to heart rate levels i.e. scale 6-20(Borg, 1998). However, the integration of cardiovascular response (heart rate) into effort level perception does not exclude the possibility that heart rate per workload could determine the reward perceived at a certain workload and would therefore determine the intensity in selected speed. Indeed, heart rate is not always associated with effort perception, attention allocation influences the association, and at higher heart rates with increased workloads, the attention shifts more closely towards physiological sensation i.e. heart rate (Tenenbaum & Connolly, 2008). Accordingly, I proposed that HR/Speed, or more closely the cardiovascular strain per aerobic workload, might determine the intensity of workload individually selected, because it limits the intensity that can be perceived as rewarding. Former work on self-selected speed showed that low cost of movement is preferred in walking and running (Lussiana & Gindre, 2016; McNeill Alexander, 2002), and even metabolic efficiency might be perceived (Ekkekakis, Lind, & Vazou, 2010). Indeed, in this paradigm, subjects do not discount effort against an external reward but against a visceral reward made available by performing the behaviour at a distinct level of cardiovascular strain.

Additional support for this assumption of a modifiable visceral reward in exercise linked to cardiovascular strain, comes from this experiment using EC. I performed EC using the new paradigm, where receipt of sweet solution as a reward was associated with elevation of heart rate during HIIT. It was hypothesized that EC pairing sweet reward with higher cardiovascular strain during training would increase self-selected speed after training and follow-up, assuming that the conditioned reward would be integrated in the exercise reward followed by higher speed selection and concomitant increase in RPE. Indeed, the conditioning (COTR group) resulted in a significant increase in self-selected speed at follow-up compared with the training group (TR), while the former training effect on speed selection was not maintained over the follow-up period in the TR group. In the conditioning group (COTR) self-selected speed was preserved on a significant higher level (about 1km/hr higher than baseline); the higher self-selected speed in COTR was associated with significant higher heart rate and RPE than in TR group. However, EC effect was not significant at after training time point, which could be due to the strong training effect on speed selection at this time point.

In terms of conditioning process, there is no doubt about the rewarding nature of sweetness in humans (E. Green & Murphy, 2012; Griffioen-Roose et al., 2013), and the participants were tested in a taste test about the pleasantness of the tastant used. Moreover, the brain areas known to be activated and concerned with reward are heavily activated in response to sweetness (Stice, Burger, & Yokum, 2013), even with non-caloric sweeteners (E. Green &

Murphy, 2012; Griffioen-Roose et al., 2013). The selection of higher speed, cardiovascular strain (HR) and RPE in the conditioning group (COTR), shows that higher costs are chosen, which can only be explained by the integration of the sweet reward into the processes relevant for the speed selection. If exercise intensity would only be selected on the basis of minimizing costs of ‘travel’, the EC would be without effect due to the lack of principal integration of visceral rewards into the selection of speed. Concurrently, multiple regression analysis of self-selected speed change from baseline to follow up showed that the main contributors for explaining the variance of speed changes were the group variable (TR, COTR), HR/Speed change, and RPE scores; 80% of the variance was explained (table 4).

EC paradigms in humans usually used visual representations of an object or behaviour for the pairing with the unconditioned stimulus (De Houwer, 2007). In connection with exercise, there are only two studies who applied EC to exercise behaviour using visual stimuli for the exercise representation and the unconditioned stimulus (Antoniewicz & Brand, 2016; L. Martin et al., 2015); however, only the study by Antoniewicz and Brand (Antoniewicz & Brand, 2016) observed acute exercise intensity changes after the EC procedure. To my knowledge, this study is the first study which has used the pairing of a physiological parameter during performance of the behaviour with a primary reinforcer as UCS. Moreover, I associated the intensity of a tastant reward with the intensity of physical strain (heart rate), to direct the effect of the EC towards the selection of higher intensity in the self-selected exercise task. The use of primary reinforcers as unconditioned stimulus, tastants (rewarding and aversive), in connection with visual representations of food items and other objects, modifying food choices or implicit attitude towards selected food items, has been used before but only in a limited number of studies (Andreatta & Pauli, 2015; Hensels & Baines, 2016).

To integrate these findings of training and conditioning, I further explored the data using the hyperbolic effort discounting model to calculate effort discounting constant k_{effort} (Myerson

& Green, 1995). Outcomes revealed that using the feeling scale values as a measure of subjective value, the RPE values as costs, and the HR/Speed values as a determinant of reward, the model predicted the feeling scores successfully at all three study time points (table 6). Indeed, the fitting produced a consistent k_{effort} value for effort discounting at baseline, after training and at follow up for the TR group, while the k_{effort} value of the COTR deviated strongly at the follow up time point, where significant conditioning effects were detected for speed and RPE. Indeed, the five times smaller k_{effort} value for the COTR group at follow up could be explained by an additional reward which was not imputed in the equation, consistent with our assumption that EC added a reward apart from the one determined by HR/Speed values. Usually, paradigms in effort discounting use an external reward to be gained by various degrees of workload (Białaszek et al., 2017; Botvinick et al., 2009; Klein-Fluegge, 2014; Klein-Flügge et al., 2016; Klein-Flügge et al., 2015); and k_{effort} values within similar range of our data have been reported (Nishiyama, 2014; Klein-Fluegge et al. 2015). However, in our case the reward is the self-selected exercise itself, which is determined by the HR/Speed (e.g. cardiovascular fitness) of the individual or with addition of the conditioned reward; concurrently, the effort invested (RPE) is adjusted to the paradigm's demand of maximization of pleasantness (i.e. subjective value). In consequence, subjects do not adjust the speed to the lowest possible effort (RPE) because it is discounted against the visceral reward, determined by fitness, and the conditioned rewards. In support of this interpretation, a consistent k_{effort} value fitted for effort discounting can be seen at all time points in our study. In my opinion, this interpretation makes also evolutional sense if the idea of foraging and hunting was integrate into the interpretation; humans with elevated physical fitness would 'travel' larger distances, enabling them to increase probability of success in their foraging/hunting. Selection of speed or workload intensity would be selected as rewarding based on the specific capacity of an individual, apart from the exercise itself. The evaluation of exercise as a modality might be, however, more related to factors determining the DD of exercise.

3.5.2. *Alterations in delay discounting: Effects of HIIT and EC*

Based on former experiments (Albelwi et al., 2019) and former work by Sofis (Sofis et al., 2017), I hypothesized that training would reduce DD constant k of exercise specifically. It was assumed that the effect would be associated with training response seen in selected speed and that k values would increase at follow up, returning towards baseline levels. EC, which would increase the discounted reward value, would lead to a decrease k_{ex} specifically after training and follow up.

Our study shows that taking part in HIIT shifted the choice preference for exercise towards delayed option in the discounting paradigm; k_{ex} was significantly reduced in the training group (TR) but remained unaltered in the no-training group (NTR) after the three weeks intervention period. This effect was specific for exercise discounting; no alterations in food discounting were detected over time in both groups. Moreover, the effect on exercise discounting was not sustained after the four weeks follow-up period, where participants stopped training and returned to their habitual physical activity; k_{ex} returned to baseline at follow-up. Moreover, k_{ex} values have not been influenced by EC, no interaction of group and time was reported, while a reduction was expected due to a magnitude effect which would reduce k values (S. Frederick et al., 2002). However, there is a caveat for this expectation; the paradigm asked people to optimize the pleasantness, based on the feeling scale (optimizing subjective value), by adjusting the speed. Concurrently, participants perceived the same pleasantness, producing matching subjective values over time and groups. Therefore, the added reward by conditioning might not have revealed itself in the discounting paradigm, while it was apparent in the selection of speed at follow up time point. Moreover, propositions 2 and 5 by Loewenstein (Loewenstein, 1996) are referring to the problem of using past and likely future visceral factors for decision making. In general, visceral factors are underestimated in their capability for influencing behaviour if it comes to decision making regards cognitive evaluation and planning of future behaviour, as well as actual impact for a behaviour. In our study, the discounting of exercise shows that the additional reward from EC did not change k_{ex} values at follow up, where the effect of the conditioning on speed selection was apparent. It seems, that the information of a visceral change towards higher reward, which resulted in higher speed selection was not included in the processing of information for the DD of exercise. Indeed, if the visceral changes in exercise experience would be integrated, an association between k_{ex} changes and speed changes would be detect; however, the alterations in k_{ex} were not correlated with the speed changes (not shown). This again shows that processes for the actual selection of speed where not driven by the same factors as the DD of the exercise.

Multiple regression analysis within the groups which participated in the training (TR and COTR), showed that (k_{ex}-T_0) at baseline contributed the most to explain the variance of discounting alterations after training and after follow up (table 5); indeed, individuals who discounted exercise faster at baseline showed a stronger reduction in discounting over the training period than individuals who discounted slower. However, our model only explained a small proportion of variance of k_{ex} change (22%) after training, showing that other factors played a large role. At follow up, motivational factors (extrinsic and intrinsic motivation scores) and BASreward scores added to the contribution of k_{ex} baseline to explain about 43% of variance in k_{ex} changes (table 5). Indeed, the outcomes could formerly show that motivation towards delayed extrinsic goals, i.e. related to health and fitness, was associated with k_{ex} (Albelwi et al., 2019). However, context specific valuation could play a dominant role for the alteration of k_{ex} after training i.e. contextual relevance of delayed exercise training goals, which is also supported by the return to baseline k_{ex} levels at follow up, where the contextualization of delayed goals is expected to decline. In agreement with this interpretation, discounting was shown to be context sensitive in gamblers where k values where higher in a gambling environment than in a neutral environment (Dixon et al., 2006). Indeed, when a situation or state is not directly experienced any more, it turns to be more psychologically distant and would need more abstract cognitive representation (Trope & Liberman, 2003). The mental representation of delayed exercise training outcomes and goals might be more psychological distant and decontextualized with emerging time distance to the training period. Alterations in temporal discounting by manipulations of construal levels (concrete or abstract) and psychological distance has been shown experimentally (Kim, Schnall, & White, 2013). A further support for this interpretation, is that discounting alterations were specific for exercise and not seen in food discounting, revealing no generalized effect on discounting. Exercise training has been shown to improve executive function (Davis et al., 2011), which uses brain areas also engaged in attribution of delayed option in discounting i.e. lateral prefrontal cortex; a generalized effect of training on discounting would be therefore possible but is not been apparent in our data.

3.6. Conclusion:

In conclusion, our study suggests that exercise can be perceived as reward. However, intensity of exercise and exercise as a modality are differentially evaluated in context of delay and effort discounting. Self-selected intensity of exercise, which can be perceived as rewarding, seem to be determined by cardiovascular fitness and is discounted against effort following general effort discounting models i.e. hyperbolic. Consequently, intensity of exercise is not chosen based on minimizing the effort but to maximize subjective value of visceral experience of the exercise. Secondly, DD of the self-selected exercise as a modality seemed to be strongly influenced by contextual factors (here via training), exercise motivation and distinct personality traits (i.e. impulsivity). However, fitness is not a major determinant for DD of exercise, emphasizing that fitness is not a requirement to value and to participate in exercise.

Our study has limitations; particularly, our paradigm limits the generalization to other exercise types which might be connected to other rewarding stimuli (group exercises, competitions etc.). Moreover, self-selection of intensity might be limited in many team and competitive sports, therefore reducing the relevance of our findings those areas.

Chapter 4

Investigation of the Reward Value of Exercise in Comparison to Money and Food Using Delay Discounting Paradigm: An Online Survey

4.1. Introduction

Physical activity (PA) promotes mental and physical health (Penedo & Dahn, 2005); and regular PA is associated with a decreased cardiovascular risk in youth and adulthood and all-cause mortality (Singh, Uijtdewilligen, Twisk, Van Mechelen, & Chinapaw, 2012). A growing body of literature suggests that PA has several positive mental health outcomes, including health-related quality of life and improved mood states (Mikkelsen et al., 2017). In England, 67% of men and 55% of women self-reported meeting the recommended guidelines of at least 150 min of moderate-intensity or 75 min of vigorous-intensity activity per week(R. Craig, Fuller, & Mindell, 2015). However, when PA was measured objectively using accelerometers, only 6% of men and 4% of women met the guidelines (Centre, 2009). For children aged 5–15 years, only 33% of boys and 21% of girls met the recommended guidelines (≥1 hour per day of moderate-intensity PA)(Centre, 2009). Furthermore, studies have shown that physical inactivity and sedentary behaviour have various health outcomes, including all-cause mortality, cardiovascular diseases, adverse metabolic profile and obesity (Pearson & Biddle, 2011). First, it is important to distinguish between physical inactivity which represents the "non-achievement of recommended level of physical activity", and sedentary behaviours which represent "any waking behaviours characterized by an energy expenditure ≤ 1.5 METs, while in a sitting, reclining or lying posture" (Thivel et al 2018). PA and sedentary behaviours are not the opposite of each other; that is, although some individuals are considered active when they achieve age-recommended PA levels, but they also spend considerable time to sedentary behaviours; thus, they can be classified as active and sedentary at the same time (Genin et al., 2017). Therefore, leisure-time moderate-to-vigorous PA may not protect those who spend large amounts of time in sedentary behaviours (de Rezende, Lopes, Rey-Lopez, Matsudo, & do Carmo Luiz, 2014).

Similar to other unhealthy behaviours, sedentary behaviours can be viewed as a direct expression of personal choice. Thus, research has been directed towards establishing their psychological determinants (Conner & Norman, 2005). Deciding to engage either in PA or sedentary behaviours is implemented via overlapping networks of brain regions and pathways associated with reward (e.g., ventromedial prefrontal cortex, amygdala, ventral and dorsal striatum, mesocortical and mesolimbic) (McClure et al., 2004;Buckley, Cohen, Kramer, McAuley, & Mullen, 2014); the prefrontal cortex and limbic system activities also correlate with an individual’s assessment and selection of delayed rewards, immediate rewards and impulsivity, respectively (McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; McClure et al., 2004). Moreover, These brain regions are also activated in decisions involving physical and mental effort/cost associated with an action (Botvinick et al., 2009). Therefore, DD rates, defined as the decline in the present value of a reward with delay to its receipt (Odum, 2011a), may derive from the interplay between these brain regions (A. G. Wilson, Franck, Koffarnus, & Bickel, 2016).

In DD literature, PA engagement has been found to be associated money discounting rates (Daugherty & Brase, 2010; Garza et al., 2013; Sweeney & Culcea, 2017) . As the ability to anticipate the reward value of certain behaviour and use that information in developing and executing an efficient action plan is likely to determine PA behaviours (Buckley, Cohen, Kramer, McAuley, & Mullen, 2014). In our previous work (Albelwi et al., 2019) & unpublished results, chapter 3, the reward value of exercise using a DD paradigm was investigated. I found that self-selected exercise on a treadmill was discounted similarly to an established consumable reward (i.e. food) and faster than transferable rewards of money. This finding raises the question of whether DD of exercise includes only previously established-actively pursued exercise or is also influenced by general valuation of sport or exercise participation and via passive consumption through watching sports on screen. The passive consumption question is raised because previous literature suggested that watching Olympic Games may positively impact individuals' intention to participate in sports through changes in attitudes, perceived subjective norms and encouraged readiness for participation (Boardley, 2013). Therefore, the influence of sport-related screen time on exercise DD needs to be investigated, and whether increased sport-related screen hours is related to reduced exercise DD by enhancing motives and cognitive valuation of exercise, or it is related to increased exercise DD by reinforcing immediate exercise enjoyment like other sedentary behaviours (Baruth, Becofsky, Wilcox, & Goodrich, 2014). Screen-time (in the form of TV watching) has been previously investigated in DD literature as an example of smaller sooner rewards compared with exercising as larger later rewards (Simpson & Vuchinich, 2000), immediate gratification behaviours (Anokhin, Golosheykin, Grant, & Heath, 2011) and addictive behaviours (Ainslie, 2017). Moreover, sedentary behaviours' effect on health is delayed; thus, researchers hypothesise that an individual's tendency to make unhealthy choices is related to his/her DD rate (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; Grossman, 1972; Peter A Hall & Fong, 2007).

Based on our lab studies (Chapter 2 & 3) where subjects have been exposed to repeated exercise sessions to experience a specific exercise type and intensity which was then discounted in the discounting task, however, it is unclear whether exercise as such which is not formerly specified and freely selected for discounting would show similar discounting rates and associations with psychological and behavioural parameters. A large population with sedentary individuals and more generalised-unspecific forms of exercise have not been tested before. Investigating unspecific exercise experience as a discounted modality would allow a better interpretation of participants' exercise valuation and how this would influence exercise discounting rates. In our former study (Albelwi et al., 2019) I found that k_{ex} showed non-significant negative association with PA levels, but that association was borderline (p=0.076). therefore, the relationship between k_{ex} and PA levels in active and sedentary individuals need to be investigated in a large number of participants with more generalized level of former experience of exercise to explore if this association would be emphasized.

Motivations directed towards goals are normally associated with positive hedonic, i.e., pleasurable, processes (Esch 2010). Based on our former work (Albelwi, 2019), exercise motivation was found to be associated with exercise discount rates based on the cognitive aspects of DD, and that extrinsic motives, such as fitness, weight and health, are strongly associated with k_{ex} compared with other exercise motivations. These finding were interpreted based on the notion that individual's motivation to obtain rewards influences reward discount rates (Zhang et al., 2016). According to self-determination theory, exercise motivation is categorised into intrinsic motivation, extrinsic motivation and both (Egli et al., 2011). An individual who pursues an intrinsically captivating or leisure activity would display intrinsic motivation (Koestner & Losier, 2002). By contrast, extrinsic motivation refers to behaviours aimed at attaining activity-unrelated outcomes (Deci, 1971; C. M. Frederick & Ryan, 1993). An individual exhibits extrinsic motivation when he/she exercises to either fulfil an external demand or attain a reward (Ryan & Deci, 2000b) or because the outcomes of the behaviour are personally significant, though he/she may not enjoy the activity. One example is when an individual exercise because he/she values the health benefits of exercise (Edmunds, Ntoumanis, & Duda, 2006). However, it is important to investigate this further in a larger population with an un-specific exercise experience, and with a wider range of reported PA levels and body characteristics to find out if consistent associations between exercise motivation and exercise DD can still be found.

One of the aims of this thesis was an attempt to determine if and how rates of DD of exercise with different commodities might vary in their relationship. In our former work (Albelwi 2019, unpublished results of chapter 3), exercise has been established as a reward and its rewarding properties are related to its visceral qualities, which explains the similarity to food reward, with k_{fo} being quantitively higher. However, in that study, the preference of the rewards regarding its delays and amounts within the same commodity have been investigated but never explored across modalities. So, it would be important to find out if the exercise DD would still show the same association with food DD and whether this is a reflection of general preference for food over exercise. To address this question, it is important to understand the factors associated with exercise preference, such as the relative reinforcing value of exercise (RRV) (K. Flack, Pankey, Ufholz, Johnson, & Roemmich, 2019). The RRV of exercise relates to alternative behaviour, which is often a desired sedentary activity chosen in favour of PA. particularly knowing that the reinforcing value of a reward and its discount rates are closely related and often interact to predict a related outcome (A Carr, Oluyomi Daniel, Lin, & H Epstein, 2011). RRV was also found to be associated with PA engagement at a frequency, duration and intensity sufficient to meet PA guidelines (Flack et al., 2016). Reinforcers are usually not available in isolation unlike in a concurrent choice situation in which the person has to choose which behaviour to engage in (Legierski, 2008). RRV is always assessed by comparing preferences for at least two alternatives with varying magnitudes and behavioural costs; while DD is usually assessed by comparing an individual’s waiting time for the same alternative with different amounts and delays (Leonard H Epstein et al., 2010). Therefore, it would be important to explore the participants' immediate preference between exercise and food as the answers may reveal more about the factors that influence exercise DD rates.

Research Objectives

The current study aimed to investigate the reward value of exercise compared with that of food and money. An online survey was used to cover various ecological and psychological characteristics associated with unspecified exercise experience and create more generalised findings than our former laboratory studies. Additionally, this work aimed to investigate whether discounting necessarily applies to exercise activity evaluation *per se* or linked to passive consumption as well. Thus, passive sport consumption behaviours in the form of sport-related screen time are integrated into our exercise DD investigation as it was not explored in our former laboratory studies. This work also aimed to explore the differences in the reinforcing values of food and exercise and their relationship to their discount rates. Moreover, this work aimed to investigate association of PA and motivation with DD in a wider population sample.

Hypotheses

It was hypothesized that:

1. Un-specific exercise valuation based on an online survey is similar to the valuation and discounting of the specific validated exercise experience in laboratory settings; with similar associations with money and food discounting rates. It was also hypothesized that individual aerobic exercise would be the most frequently reported type of exercise imagined as preferred in the discounting task.
2. Exercise discounting rates and sport-related screen time are positively related, and that passive exercise consumption influences exercise valuation and discounting by enhancing immediate enjoyment and increasing exercise discount rates.

3. There is a negative association between exercise motivation and PA levels with exercise DD.
4. Participants who prefer exercises in the reward preference choice have low k_{ex} and high PA levels.

4.2. Methods

Ethical Approval

This study was ethically approved by the ethics committee of the School of Sport, Health and Exercise Science, Bangor University (ethics number: P06-18/19).

4.2.1 Participants

A total of 225 participants were recruited on Amazon's Mechanical Turk (MTurk; www.mturk.com), an online recruitment and data collection service where researchers can post "Human Intelligence Tasks" (HITs), which are tasks that can be completed on a computer (Paolacci & Chandler, 2014). As a platform for collecting data in research, MTurk provides several benefits compared to in-person laboratory studies, including that it is time-efficient and cost-effective. It also provides external link surveys which the participants used to access the Inquisit® discounting task. Recently, researchers have used MTurk as a way to recruit participants to complete computer-based tasks (McKerchar & Mazur, 2016; Mellis, Woodford, Stein, & Bickel, 2017; Meredith, Sweeney, Johnson, Johnson, & Griffiths, 2016; Reed, Becirevic, Atchley, Kaplan, & Liese, 2016). Qualifications for the present HITs were that the MTurk worker have a HIT approval rating of at least 90%. The number of MTurk workers who completed the task successfully were 115 participants and were compensated $8 for their efforts. First, a short introduction about the study information and recruitment inclusion criteria was displayed. The introduction included an external link to a detailed participant information sheet (Appendix 17). Participants who accepted to participate clicked "I consent" as a part of the informed consent process and to go ahead with the questionnaire. Only responses of participants aged 18 to 69 years were included; therefore, participants who reported having poor health conditions and/or were older or younger than the required age range were neither included nor compensated.

For this study, the sample size calculation was based on data from our former study (Albelwi et al., 2019), which reported significant associations between exercise discounting rates with money discounting rates, exercise motivation, and self-selected preferred speed. Based on these data, a sample size was calculated for the lowest reported significant correlation which was between k_{ex} and the "EMI intrinsic plus extrinsic" (*rho*=–261*, *p*=0.045, *n*=59), using an online calculator for sample size calculation based on correlation analysis (https://www.sample-size.net/correlation-sample-size/; (Hulley, Cummings, Newman, Browner, & Grady, 2013); the total sample size needed to reveal significant correlations between k_{ex} and reported parameters was =113.

4.2.2. Measurements

Demographic and Body Characteristics

Participants were asked to enter their sex, age, weight, and height (to calculate body mass index—BMI) and whether they consider themselves healthy or unhealthy.

Questionnaires

1. International Physical Activity Questionnaire-Short Form (IPAQ-SF). It is a standardised self-report measure of habitual physical activity. It comprises a set of four generic items used to provide a standardised global surveillance and comparison of physical activity levels. The reliability and validity of this questionnaire have been reported (C. L. Craig et al., 2003), demonstrating that the

IPAQ is an acceptable measure for use in both regional and national physical-activity-monitoring studies across diverse populations of age (Grimm, Swartz, Hart, Miller, & Strath, 2012) (Appendix 18).

2. Exercise motivation inventory—EMI-2 (Markland & Hardy, 1993). This assesses exercise participation motives applicable to both exercisers and non-exercisers. The EMI-2 is a 51-item self-report questionnaire capable of measuring a broad range of exercise motives in adult males and females. It has 14 subscales: stress management, revitalisation, enjoyment, challenge, social recognition, affiliation, competition, health pressures, ill-health avoidance, positive health, weight management, appearance, strength and endurance, and nimbleness. The subscales were calculated by summing the numerical equivalents for each item related to the subscale and then dividing by the number of items that make up each subscale. The responses for each question were made on a 6-point Likert-type scale ranging from 0 (not at all true for me) to 5 (very true for me). The EMI-2 has satisfactory psychometric properties with support for the scale's internal consistency with alpha coefficients ranging from .68 to .95 (Markland & Ingledew, 1997). Confirmatory factor analysis has indicated the EMI-2 was able to discriminate between men and women with respect to their exercise motives (Markland & Ingledew, 1997). The items of challenge, affiliation, revitalisation, and enjoyment were used as intrinsic factors (this study, Crα: 0.886) and appearance, weight management, positive health, health pressure, ill-health avoidance, and strength/endurance as extrinsic factors (this study, Crα: 0.851), according to Egli and colleagues (Egli et al., 2011). Further motives (e.g., social recognition, stress management) are more difficult to classify alongside dichotomous categories and were included in the total exercise motivation score (this study, Crα: 0.713). The three EMI-2 sub-categories' Crα is 0.831.

3. Barratt Impulsivity Scale—BIS II (Patton et al., 1995) . This measures the personality/behavioural construct of impulsiveness based on scaling frequencies of common impulsive or non-impulsive behaviours and preferences. This questionnaire is composed of 30 items grouped into three impulsivity subscales. Each item comprises four Likert-type answer options: rarely/never, occasionally, often, and almost always/always. The total score is the sum of all the items. The scores range is 30 to 120.
4. Exercise behaviour/liking. To record the passive exercise consumption "sports-related screen time" behaviour in terms of type and frequency, participants were asked two questions: "What is your favourite sport to watch?" and "How often do you watch sports or sports-related shows on TV/online (for at least half an hour)?" The multiple answers ranged from (1) On a daily basis to (6) Never.
5. To record the active participation details such as type of sport/exercise and the frequency of participation, the participants were asked the next questions: "What is the sport that you are currently practicing?" Then, they were asked closed questions, which were, "When was your last exercise practice?" The multiple answers ranged from (1) Less than 2 hours ago, to (7) More than a week ago. Next, the participants were asked about the intensity of their last exercise practice (if applicable): "How intense was your exercise session?" The three answers were (1) Mild, (2) Moderate, and (3) Vigorous.
6. Food Liking and Eating Behaviour-Related Questions

The participants were asked two questions to control for difference in satiety state and possible variance in k_{fo} due to differences in the food imagined during discounting. Participants were asked the following direct questions with open answers: “What is your favourite food?” and “How long since you had your last meal?”. Satiety level was rated by using the Hunger and Satiety Scale (Flint, Raben, Blundell, & Astrup, 2000). The participants rated their hunger and satiety levels by using a Likert scale ranging from −10 = “extremely hungry” to 10 = “extremely satiated”.

7. Reward Preference

Preference of reward (food vs. exercise) was established to examine the relationship between discounting utility immediate preference and its discounting rates by asking the participants the following question: “Please choose one: at this moment, what do you prefer: (1) 30 minutes participating in your favourite sport, or (2) Eating 30 bites of your favourite meal?” The dichotomous choice between the two commodities allowed for categorisation by preference, as their choice would indicate a stronger preference towards either exercise or food (Sze, Slaven, Bickel, & Epstein, 2017).

Discounting task

To rate the participants’ DD, they were guided to click an external link to access an Inquisit® discounting task. The task is a specially designed computer programme based on the paradigm described by Richards (Richards et al., 1999) . The Inquisit™ programme (developed by Milliseconds Software) was especially designed for this research to obtain the IPs for each time delay for three commodities: money, food, and exercise. The delays in days were 1, 7, 30, 60, and 180. The amounts of the rewards were roughly equated between the three commodities (Charlton & Fantino, 2008; Rasmussen et al., 2010). For the money as a reward, the hypothetical rewards offered were (£2, £7, £12, £17, £22, £27, £32, £37, £42,

£47, and £50 as the largest delayed reward). The task was proceeded by the following guide text:

> "The purpose of this experiment is to see how you make decisions concerning amounts of money and delays. Two combinations of amounts of imaginary money and time delays will appear on the monitor; your task is to choose which of the two combinations of hypothetical money and delays is most appealing to you. All tasks are in randomised order and unrelated; please do not attempt to plan your answers ahead. Just judge each amount of money with its time delay based on what is most appealing to you. The test consists of a number of questions, such as the following: Would you rather have (A) £50 after one week or (B) £5 immediately after the test? You will not actually receive any of the amounts that you choose, but we want you to make your decisions as though you were really going to get the amount of money you choose".

For food as a reward, the hypothetical rewards were (5 bites–10 bites-15 bites-20 bites- 30 bites (1 plate)- 60 bites (2 plates)- 90 bites (3 plates)- 120 bites (4 plates) and 150 bites (5 plates) of food as the largest delayed reward—assuming that one plate of food approximately equals 30 bites of food. For the food task, the guiding text was as follows:

> "In the task that follows, you will have the opportunity to choose between combinations of food amounts with different delays. The type of food that will be imaginary in this task is your favourite food of today—you have answered a question to define your favourite food already. The food amounts combined with time delays will be given in number of bites. A full plate of your favourite food will consist of 30 bites. Two combinations of amounts of food and time delays will appear on the monitor. Please choose the combination which is currently most appealing to you. It is

> important to imagine that the quality of your favourite food will not suffer with time delays and you are certainly not be forced to eat it all in one go. The test consists of a number of questions, such as the following: Would you rather eat (A) 10 bites of your favourite food available now, or (B) 5 plates (1 plate=30 bites) available in one week? You will not actually receive any of the food that you choose, but we want you to make your decisions as though you were really going to get the food of your choice"

For exercise reward, the offered exercise sessions were 5 minutes, 10 minutes, 15 minutes, 20 minutes, 30 minutes (1 gym session), 60 minutes (2 gym sessions), 90 minutes (3 gym sessions), 120 minutes (4 gym sessions), and 150 minutes (5 gym sessions), assuming that 1 gym session equals 30 minutes of exercising. The guiding text to the exercise computer task was as follows:

> "In the following task, you will be asked to choose between two combinations of durations of your favourite exercise session and time delays; the questions will be displayed on the monitor. The exercise session will be exactly what you have enjoyed most being established in the previous exercise trials. If you choose the delayed option, the imaginary exercise sessions will be available to you, but imagine that you don't have to perform the offered sessions in one go, and you have to imagine that other exercises will not affect the enjoyment of the offered favourite exercise session. The test consists of a number of questions, such as the following: Would you rather have (A) 5 of your favourite exercise sessions after 30 days or (B) 10 minutes of the exercise session immediately after this test? You will not actually receive any of the offers of exercise sessions that you choose, but we want you to make your decisions as though you were really going to receive the exercise sessions"

For all the tasks, the choices were shown in the monitor with two letters (A and B) under each question to choose from by placing the cursor on the chosen option letter and clicking on it. Rewards and delays were adjusted to obtain the IPs; the adjustment of the rewards was masked by randomisation between delays and the amount of rewards, and with the progression of the test, distractors were displayed to prevent the subject from predicting the questions and unmasking the underlying technique of the test. (See the full description for the computer task programme in Richards et al., 1999.)

Post Discounting Questions

After submitting their computerised discounting task, the participants were transferred back to the Qualtrics page and were asked the following questions: "Which kind of exercise did you imagine when completing the exercise discounting task?" and "What kind of food did you imagine when completing the food discounting task?". The purpose of these questions was to obtain information about the imagined rewards while performing the discounting task.

4.3. Analysis

The Qualtrics survey data were saved under the researchers' Qualtrics account (https://bangorsport.eu.qualtrics.com/Q/MyProjectsSection). Likewise, the Inquisit discounting task data were saved under the researchers' account (https://www.millisecond.com/myaccount/).

The discounting rate *k* was calculated from the successive IPs yielded from the computer-discounting task. There are numerous ways for calculating the discounting rate; the most used discount function in behavioural models is the hyperbolic function (Critchfield & Kollins, 2001), as it was found to have the best representation to k levels by providing superior fit for data compared to an exponential equation (Odum, 2011a); therefore, it can predict indifference points (IPs) for subjects' choices for different time delays. This hyperbolic function as proposed by Mazur (Mazur, 1987) is as follows:

$$V=A/(1+kD)$$

Here, V represents the current subjective value, A represents the amount, and D represents delay of the reward, respectively, and k is a fitted parameter whose value can be interpreted as an index of sensitivity to delay. Mazur's equation was used as a model to fit participants' IP data to hyperbolic functions using the least square fit method with the Microsoft Excel Solver programme to obtain an individual representation for k values for each commodity.

Because some of the outcome variables were not normally distributed based on Levene's test of normality, a successful log-10 transformation of k-values was performed for k_m, k_{fo}, k_{ex}, exercise motivation scores, age, and BMI for further data analysis. Data are displayed in median, 25th and 75th percentiles plus mean and standard deviation for parameters which were not normally distributed. To examine group differences in log-transformed k-values, a one-way analysis of variance (ANOVA) and Bonferroni post-hoc tests were used for follow-up analyses. Correlation analysis was performed using Pearson correlation analysis; a correlation coefficient >0.5 was considered large, between 0.49 to 0.30 was considered moderate, and <0.29 was considered small (Cohen, 1988). Multiple linear regression and logistic regression were employed to investigate possible influence of psychological and body characteristics and choice-relate parameters measured by various instruments. Additionally, moderation analysis using PROCESS 3.0 (Hayes, 2013) with SPSS was conducted. Moderation analysis is a sequential regression analysis to test a potential association between two variables, which may be caused by a third variable (moderator). Dummy coding was created for categorical variables to be used as predictors in regression analysis. Data were analysed using Statistical Package for the Social Science (IBM SPSS) version 25.

4.4. Results

4.4.1 Body Characteristics and Physical Data

Two hundred participants took part in the survey and 115 completed all the survey sections and provided valid answers (72 males and 43 females). Body characteristics and psychological self-report data are presented in (Table 4.1); based on the independent-samples t-test, log-transformed weight showed a significant effect of gender with females being lighter [t(113)=5.14, *p*(2-tailed)=0.000] but with no significant difference of log-transformed BMI [t(113)=1.743, *p*(2-tailed)=0.08]. Participants were mostly young adults (mean=33.94 years, STD= 9.95) were overweight as classified by BMI (mean=25.97 kg/m^2, STD= 5.26), and the majority reported moderate to high physical activity in the IPAQ: high (42), moderate (52), and low (21). Participants scored moderate-low levels of the impulsivity questionnaire (BIS II).

Table 4.1. Body characteristics and psychometric self-reports

N=115 (43 Females)	Mean	STD (±)	Median	25th percentile	75th percentile
Age (Yrs.)	33.94	(9.95)	31.00	27.00	38.00
Weight (Kg)	79.41	(20.64)	77.00	65.00	90.00
BMI (Kg/M^2)	25.97	(5.26)	22.60	24.93	28.1
					Range of scores
BIS II	58.3	(11.43)			30–120
IPAQ	high=42	mod=52	low=21		
EMI-2 (0–5)	Mean (0-5)	STD	Median (0-5)	25th percentile	75th percentile
Intrinsic	2.69	(1.02)	2.63	2.20	3.64

Extrinsic	3.24	(0.79)	2.23	2.71	3.98
Intrinsic Plus Extrinsic	2.61	(1.04)	2.71	1.88	3.54
Total Exercise Motivation	2.95	(0.79)	2.97	2.47	3.74

4.4.2. Delay Discounting of money, food and exercise, and choice behaviour.

The computer-based DD tasks generated indifference points for the tested modalities of money, exercise and food. Twenty participants' data out of 115 were removed due to poor fit of hyperbolic model (R^2 <0.6).; n-numbers for the specific sets of variables are given in the table (Table 4.2). Analysis of variance (ANOVA) was conducted for the three commodities' k values followed by post hoc analysis that revealed significant differences between log-transformed k values [$F(2,315) = 116.016$, $p = 0.000$]. Bonferroni post hoc multiple comparisons revealed that k_m was significantly smaller than k_{ex} and k_{fo} (p=0.000), but the difference was marginal between k_{ex} and k_{fo} (p=0.05), with k_{fo} being higher than k_{ex} and the highest of the three commodities (Table 4.2).

Table 4.2. DD constants (k) of money, exercise, and food

	Mean	STD (±)	Median	25th percentile	75th percentile	R^2 mean	STD (±)
k_m (n=103)	0.0323	(0.028)	0.022	0.0110	0.0410	0.855	(0.100)
k_{ex} (n=104)	0.172	(0.168)	0.102	0.045	0.2184	0.856	(0.102)
k_{fo} (n=104)	0.238	(0.199)	0.102	0.104	0.385	0.875	(0.109)

4.4.3. *Correlation analysis of associations between Discounting rates' and different self-report parameters*

The Pearson correlation analysis reported significant positive correlation between k_{ex} and k_{fo} (*rho*=0.408, p=0.000, n=104) and k_m with k_{ex} (*rho*=0.234, p=0.022, n=95). k_{ex} was found to show a significant negative association with extrinsic motivation (*rho*=–0.288, p=0.003, n=107) but not intrinsic motivation, meaning that participants with higher extrinsic motivation had lower discount rates of exercise. Moreover, k_{ex} was found to have a small negative significant correlation with IPAQ activity level (*rho*=–0.212, p=0.029, n=107; Table 4.3). In addition, a small negative partial correlation was found between sports screen time and k_{ex} after controlling for IPAQ activity level (*rho*=–0.198, p=0.042, n=104), as IPAQ activity levels were found to have a moderate negative association with sports screen time frequency (*rho*=–0.344, p=0.000, n=115). Note that the screen time scale is reversed- see methods section page (116)- which means that participants who discount exercise slower (integrating delayed outcomes in their valuation of exercise) watch less sports on screen, if controlled for the influence of PA.

To explore which kind of reward (food or exercise) participants would prefer in the absence of the delay (time) factor, the following question was asked: “Please choose one: at this moment, what do you prefer: (1) 30 minutes participating in your favourite sport, or (2) eating 30 bites of your favourite meal?” Forty (34.8%) of the participants preferred an exercise reward over a food reward, and 75 (65.2%) of the participants preferred a food reward over an exercise reward, while there was no significant association between food choice with Hunger and Satiety state, meaning that their answers were not confounded by their hunger state. Exercise reward preference was found to be associated with the number of participants who reported not practicing any type of exercise (*rho*=0.314, p=0.001, n=115), as the more frequently the participants reported not practicing any type of exercise, the more frequently those participants chose food over exercise in the reward preference question.

Barratt impulsiveness scores were found to correlate positively with k_m (*rho*=0.496, p=0.000, n=103) and k_{ex} (*rho*=0.265, p=0.006, n=107). Moreover, participants’ age had significant negative associations with k_m (*rho*=–0.285, p=0.003, n=103) and k_{fo} (*rho*=-0.211, p=0.028, n=108) but not with k_{ex} (*rho*=–0.111, p=0.257, n=107).

Baseline EMI-2 scores showed generally moderate exercise motivation (Table 4.1). Integrating the domains into intrinsic, extrinsic, and "extrinsic plus intrinsic" factors, as mentioned in the methods section, showed significant positive correlation between the intrinsic and extrinsic (*rho*=0.545, p=0.000, n=115), intrinsic and total EMI-2 score (*rho*=0.865, p=0.000, n=115), and finally, extrinsic with total EMI-2 score (*rho*=0.800, p=0.000, n=115) (not shown). These factors were also found to have different associations with various measures; extrinsic factors were found to be negatively correlated with k_{ex} as mentioned above as well as k_{fo} (*rh*o=–0.290, p=0.002, n=108). Similarly, age had negative associations with intrinsic motivation (*rho*=–0.210, p=0.024, n=115) but not with extrinsic motivation (*rho*=0.018, p=0.848, n=115). Additionally, positive associations between IPAQ PA level with total EMI-2 scores (*rho*=0.373, p=0.000, n=115), intrinsic (*rho*=0.497, p=0.000, n=115), and both extrinsic plus intrinsic exercise motivation (*rho*=0.336, p=0.000, n=115) were detected, but not with extrinsic motivation (Table 4.3).

In summary, exercise is discounted as an established reward, but looking at k medians (Table 4.2), the exercise decay rates of k_{ex} and k_{fo} are similar, and both are higher than k_m , with k_{fo} as the highest mean of decay rate. Also, k_{ex} showed associations with other discounted commodities; these associations were found to be higher with k_{fo} compared to k_m. Participants with higher k_{ex} had lower extrinsic exercise motivation scores as well as lower PA levels. Exercise motivation components -except for extrinsic- showed a positive association with PA levels. Moreover, longer sports screen time was also found to be associated with higher k_{ex} after controlling for PA levels. The participants' stated choice between food and exercise rewards revealed a significantly higher preference of food over exercise for that moment. In addition, participants with higher BIS scores had higher k_{ex} and

k_m—as they are all considered measures of impulsivity. Older people had lower k_{fo} and k_m and had lower intrinsic exercise motivation scores. Finally, participants who reported higher PA status had higher exercise motivation scores in general.

4.4.4. Exercise activity level based on last exercise practice

Participants' practice levels were categorised based on their answers to the direct last exercise practice question into three categories: high practice, moderate practice, and low practice. The participants who chose one of the first three options: "less than 2 hours ago", "earlier today", or "yesterday" were classified under "high practice". Those who chose one of the middle three options: "2 days ago", "3 days ago", or "less than a week ago" were classified under "moderate practice". Finally, participants who chose one of the last two options: "more than a week ago" and "never" were classified under "low practice" (Table 4.5).

The Pearson correlation analysis was used to investigate the associations between these three categories with exercise, personality, and choice decision behaviours. It was found that there is a highly significant large positive association between practice activity level and IPAQ activity levels (*rho*=0.567, p=0.000, n=115), and significant moderate positive association between practice activity level and intrinsic motivation (*rho*=0.354, p=0.003, n=115). This association means that practice-based activity level is highly consistent with IPAQ activity measure and that increased practice activity levels are associated with higher intrinsic exercise motivations. Otherwise, no significant associations were detected (Table 4.5).

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Table 4.3: Pearson Correlation coefficients among k values, IPAQ: Ipaq physical activity questionnaire, BIS: Barratt Impulsivity Scale, Age and EMI-2: exercise motivation inventory.

	lgk_m	lgk_{ex}	lgk_{fo}	IPAQ Activity Levels	BIS	lgAge
lgk_{ex}	0.234* 0.022 95		0.408** 0.000 104	–0.212* 0.029 107		
BIS	0.496** 0.000 103	0.265** 0.006 107	0.089 0.359 108	–0.092 0.329 115		
lgAge	–0.285** 0.003 103	–0.111 0.257 107	–0.211* 0.028 108	–0.170 0.069 115	–0.157 0.093 115	
Lg EMI Intrinsic	0.017 0.865 103	0.033 0.732 107	0.085 0.381 108	0.497** 0.000 115	0.139 0140 115	–0.210* 0.024 115
Lg EMI Extrinsic	–0.099 0.319 103	–0.288** 0.003 107	–0.290** 0.002 108	0.154 0.099 115	0.034 0.720 115	0.018 0.848 115
EMI Intrinsic Plus Extrinsic	0.031 0.756 103	0.050 0.612 107	0.016 0.870 108	0. 336** 0.000 115	0.205* 0.028 115	–0.222* 0.017 115
EMI Mean Score	–0.028 0.779 103	–0.081 0.404 107	–0.090 0.355 108	0.373** 0.000 115	0.141 0.134 115	–0.149 0.111 115

Numbers in boxes: Spearman's rho over p-value over n-number; * significant p<0.05

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 4.4. Exercise-behaviour related data, the table shows the number of the participants that chose each answer to each specified question.

<table>
<tr><td colspan="8">1. “What is Favorite sport to watch”</td></tr>
<tr><td colspan="2">Team sport (%)</td><td colspan="2">Individual aerobic (%)</td><td colspan="2">Resistance (%)</td><td colspan="2">None (%)</td></tr>
<tr><td colspan="2">99 (86)</td><td colspan="2">8 (6.9)</td><td colspan="2">2 (1.7)</td><td colspan="2">6 (5.2)</td></tr>
<tr><td colspan="8">2. “How often do you watch sports or sport-related shows on TV/online (for at least half an hour)?”</td></tr>
<tr><td>Daily (%)</td><td colspan="2">4-5 times a week (%)</td><td>2-3 times a week (%)</td><td colspan="2">Once a week (%)</td><td>Less than once a week (%)</td><td>Never (%)</td></tr>
<tr><td>11 (9.5)</td><td colspan="2">11(9.5)</td><td>21 (18)</td><td colspan="2">23 (21)</td><td>28 (24)</td><td>21 (18)</td></tr>
<tr><td colspan="8">3. “What is the sport/exercise that you are currently practicing?”</td></tr>
<tr><td colspan="2">Team sport (%)</td><td colspan="2">Individual aerobic (%)</td><td colspan="2">Resistance (%)</td><td colspan="2">None (%)</td></tr>
<tr><td colspan="2">32 (27.8)</td><td colspan="2">21 (18)</td><td colspan="2">3 (2.6)</td><td colspan="2">59 (51.3)</td></tr>
<tr><td colspan="8">4. “When was your Last sport/exercise practice?”</td></tr>
<tr><td><2 Hours (%)</td><td>Earlier today (%)</td><td>Yesterday (%)</td><td>2 days ago (%)</td><td>3 days ago (%)</td><td><a week (%)</td><td>>a week (%)</td><td>None (%)</td></tr>
<tr><td>1 (0.9)</td><td>8 (7)</td><td>18 (15.7)</td><td>13 (11.3)</td><td>6 (5)</td><td>5 (4.3)</td><td>5 (4.3)</td><td>59 (51.3)</td></tr>
<tr><td colspan="8">5. “What kind of sports/exercise did you imagine while answering discounting task?”</td></tr>
<tr><td colspan="2">Team sports (%)</td><td colspan="2">Individual aerobic (%)</td><td colspan="4">Resistance exercise (%)</td></tr>
<tr><td colspan="2">9 (8)</td><td colspan="2">88 (76.5)</td><td colspan="4">18 (15.6)</td></tr>
</table>

Exercise behaviour and sport-related data extracted from the direct questions revealed that most of the sample (99 out of 115) preferred to watch team sports when they were asked about their favourite sport to watch. Next, when they were asked about their watching frequency, their answers ranged from “on a daily basis” to “never”. The highest frequency chosen was “less than once a week” =28 (Table 4.4). When they were asked about their favourite exercise/sport to practice, most of the participants had no favourite sport/exercise practice (59 responses/51.2%) followed by (32 responses/ 27.8%) those who preferred team sports, then individual aerobic practice (21 responses/18.3%); the least was (3 responses/2.6%) those who chose resistance exercises. However, when they were asked to imagine their favourite exercise to use it when they performed the discounting task, the majority of them chose individual aerobics (88 responses/76.5%) over the other two options (team sport and resistance exercise). All exercise behaviours and sports watching (passive exercise consumption) data are listed in (Table 4.4).

Summarized, most of the participants preferred team sports to watch, with more than half of them reporting not practicing any type of exercise, while the majority of then preferred individual aerobic exercise to imagine during the discounting task.

Table 4.5. Pearson's correlation coefficients between exercise discount rate and IPAQ activity levels with the practice levels extracted from the participants' answers to the direct questions about their sport practice and exercising behaviour. The exercise practice categories columns show the correlation between each variable on the left with the number of positive answers in each category.

		Exercise Practice Categories		
	Exercise practice levels	Low practice	Moderate practice	High practice
Lg k_{ex}	–0.025 0.798 107	0.199* 0.039 107	–0.008 0.933 107	–0.151 0.121 107
IPAQ	0.567** 0.000 115	–0.554** 0.000 115	0.197* 0.034 115	0.460** 0.000 115
Lg EMI Intrinsic	–0.289** 0.002 115	–0.359** 0.000 115	–0.106 0.259 115	0.398** 0.000 115
Lg EMI Extrinsic	0.119 0.205 115	–0.155 0.098 115	0.039 0.682 115	0.084 0.369 115
EMI Intrinsic Plus Extrinsic	0.214* 0.022 115	–0.290** 0.002 115	–0.063 0.506 115	0.297** 0.001 115

EMI mean Score	0.300** 0.001 115	–0.295** 0.001 115	–0.100 0.285 115	0.341** 0.000 115

Numbers in boxes: Pearson's rho over p-value over n-number; * significant p<0.05

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed)

4.4.5. Multivariate prediction of exercise delay discounting rates.

To understand the contribution of psychological and physiological parameters of k_{ex}, I performed a multiple regression analysis using hierarchical regression with the backward method. Psychological self-report parameter (BIS and exercise motivation) were added. physiological characteristics (BMI, gender), discounting and choice parameters (k-values, reward preference, and imagined exercise), and physical activity practice-related parameters (IPAQ, exercise practice based on direct questions and sports screen time frequency) (Fig. 4.1). Tests to check if the data met the assumption of collinearity indicated that multicollinearity was not a concern. The resulting model could explain about 37% of k_{ex} variance [F(8,95)=6.991, p=0.000. R^2=0.371], where the k_{fo} was the highest parameter to explain the variance in k_{ex} (beta=0.298, p=0.001). The next highest contributions were BIS (beta=0.243, p=0.004), extrinsic motivation (beta=–0.232, p=0.010), imagined exercise (individual resistance; beta=0.250, p=0.004), then IPAQ activity level (low; beta=0.220, p=0.044). Practice activity levels based on the direct questions as well as IPAQ moderate activity levels have contributed to the model, but their p values were not significant (Table 4.5). These results mean that high k_{fo} rate, high impulsiveness score, low extrinsic motivation, preference for resistance exercise as imagined exercise reward, and falling in the IPAQ low active group would predict a higher exercise discount rate up to 37%.

Table 4.2: Multiple regression analysis for exercise discounting (k_{ex}) as a predicted outcome. Lgk_{fo} is food discount rate; BIS is Barratt Impulsivity Scale; IPAQ is activity levels from the international physical activity questionnaire.

Model 1					
k_{ex}					
R^2=0.371	F=6.99	P=0.000		Collinearity Statistics	
Variable	Beta	*t*	*p*	*Tolerance*	*VIF*
Lg k_{fo}	0.298	3.431	0.001	0.876	1.142
BIS	0.243	2.959	0.004	0.984	1.016
Lg extrinsic motivation	–0.232	–2.628	0.010	0.849	1.178
Imagined exercise-individual resistance	0.211	2.526	0.013	0.948	1.054
IPAQ (Low)	0.220	2.037	0.044	0.568	1.762
IPAQ (Moderate)	0.161	1.594	0.114	0.648	1.544
Practice Level "low active "	–0.174	–1.408	0.162	0.436	2.292
Practice Level "moderately active"	–0.169	–1.585	0.116	0.579	1.727

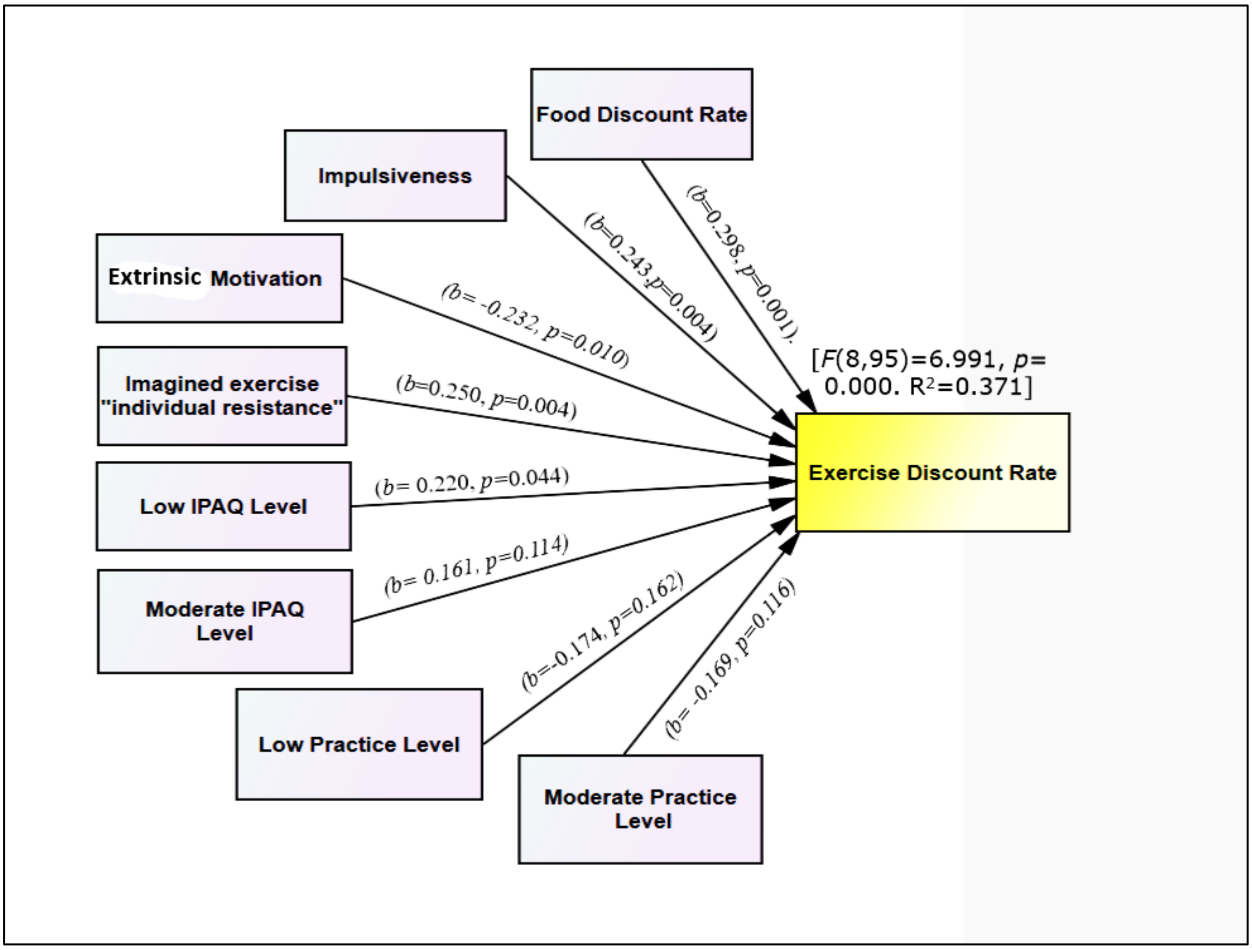

Figure 4.1. Multiple regression analysis for exercise discounting (k_{ex}) as a predicted outcome. Lgk_{fo} is food discount rate; BIS is Barratt Impulsivity Scale; IPAQ is activity levels from the international physical activity questionnaire. Beta values *b*, *F*, *p*, and R^2 depict the significant of the whole model. * p<0.05; ns, not significant.

4.4.6. Logistic regression for IPAQ PA level prediction.

To understand the contribution of psychological and physiological baseline parameters of IPAQ physical activity levels, multiple regression analysis was performed using hierarchical regression with the backward method. Psychological self-report parameters, physiological characteristics were added, and k-values generated with the computer paradigm as predictor variables to explain IPAQ variance. IPAQ levels were dummy coded (low/moderate/high) along with the outcomes. The k_{ex}, extrinsic motivation, BMI, intrinsic motivation, imagined exercise, sports screen time, reward preference, and age resulted as predictors (Table 4.6). The “high” activity level category was chosen as a reference category because the researchers were interested in the factors that contribute to and predict a higher PA participation. This model was significant [$\chi^2(14)=60.17$, $p<0.000$]. Pearson's chi-square test [$\chi^2(198)=167.1$, $p=0.946$] and deviance chi-square test [$\chi2(198)=163.423$, $p=0.965$] both indicated a good fit with the data. The results indicated that intrinsic motivation was the most significant predictor in the model for both sections of the analysis: "low" vs. "high" (b=–13.05, s.e.=3.1, $p<0.001$) and "moderate" vs. "high" (b=–9.45, s.e.=2.63, $p<0.001$). This negative relationship means that participants scoring higher on intrinsic motivation were less likely to have low and moderate activity levels; however, these odds are less in the "low" compared to "moderate" categories. The second most significant predictor is exercise discount rate; again, this relationship is larger in "low" vs. "high" (b=3.31, s.e=1.07, $p=0.002$) than in "moderate" vs. "high" (b=1.63, s.e.=0.78, $p=0.036$). This positive relationship means that as participants scored higher in k_{ex}, they are more likely to have low and moderate levels of activity. Similarly, this relation is more prominent in the low activity group compared to the moderate activity group. The third most significant predictor was the extrinsic motivation. Unlike the intrinsic motivation, it has a positive association with the activity level categories. As the participants scored high in extrinsic motivation, they were more likely to fall in the "low" vs. "high" category (b=10.35, s.e=4.81, $p=0.031$), which is not true for the "moderate" vs. "high" comparison (Table 4.6). As indicated in Table 4.3, the classification statistics used to determine which group memberships were best predicted by the model suggest that the highly active participants were correctly predicted by the model 69% of the time. Moderately active participants were correctly predicted 57.8% of the time, and finally, only 40% of the time for low active participants. The overall percentage of correct prediction for all the categories was 58.9%. In summary, the participants' k_{ex}, BMI, intrinsic and extrinsic motivation, reward

Table 4.6. Logistic regression analysis with IPAQ activity level as an outcome with body mass index (BMI), intrinsic motivation, exercise discount rate (k_{ex}), screen time frequency, imagined exercise, reward preference, and extrinsic motivation.

	"Low" vs. "High" log odds				*"Moderate" vs. "High" log odds*			
Predictor variable	Coefficient estimate (standard error)	Wald	95% Confidence interval	*p*-value	Coefficient estimate (standard error)	Wald	95% Confidence interval	*p*-value
Lg BMI	–4.52 (4.63)	0.95	1.25E-6; 95.34	0.329	3.80 (3.07)	1.53	0.108; 18373.01	0.217
Lg intrinsic motivation	–13.05 (3.10)	17.69	4.90E-9; .001	0.000	–9.45 (2.63)	13.06	4.416E-7; .013	0.000
Lg k_{ex}	3.31 (1.07)	9.63	3.39; 222.84	0.002	1.63 (0.78)	4.4	1.113; 23.537	0.036
Screen time	0.51 (0.25)	3.99	1.01; 2.72	0.046	0.29 (0.19)	2.35	0.923; 1.924	0.125
Imagined exercise	–1.17 (0.81)	2.1	0.06; 1.51	0.148	–0.41 (0.53)	0.60	0.236; 1.871	0.440
Reward preference	1.17 (0.83)	2.01	0.64; 16.38	0.156	0.70 (0.53)	1.73	0.709; 5.740	0.188
Lg extrinsic motivation	10.35 (4.81)	4.636	2.531; 386027366.07	0.031	5.27 (3.22)	2.68	0.354; 107310.72	0.102

preference choice, and the type of exercise imagined in the discounting task were able to moderately predict the low and moderate IPAQ activity levels to different extents when compared to high IPAQ activity levels.

4.4.7. Moderation Analysis

Based on correlation and regression analysis results, a thorough analysis was conducted to investigate a possible moderation and/or mediation relation between k_{ex} and IPAQ PA levels with other measured parameters. Multiple moderation/mediation analyses models were integrated to investigate how much k_{ex} and activity levels could be indirectly predicted by personality parameters, psychological measures, and body characteristics and how the different parameters may interact, but no significant models were found. However, based on the significant positive correlation previously detected between extrinsic exercise motivation with intrinsic exercise motivation, while no direct significant association was found between k_{ex} and intrinsic exercise motivation, a moderation analysis using PROCESS was conducted using regression with bootstrapping (5000 samples) in which k_{ex} was entered as the outcome variable, intrinsic motivation as predictor variable, and extrinsic motivation as the moderator (Fig. 4.2). The analysis revealed a small significant k_{ex} prediction by intrinsic motivation as an indirect predictor, (b=2.3612, SE=1.1094, 95% LLCI: 0.1611, UPCI: 4.5614). However, intrinsic motivation was not found to be a significant predictor of k_{ex} on its own (b=–.7349, SE=0.4686, 95% LLCI: –1.6643, UPCI: 0.1945) while extrinsic motivation was found to be a significant predictor of k_{ex} (b=–2.1915, SE=.5866, 95% LLCI: –3.3550, ULCI: –1.0281), suggesting an interaction effect of extrinsic motivation as a full moderator. Hence, the moderation model was significant at $F(3,103)=5.437$, $p<.01$, $R^2=.13$ (Fig. 4.2).

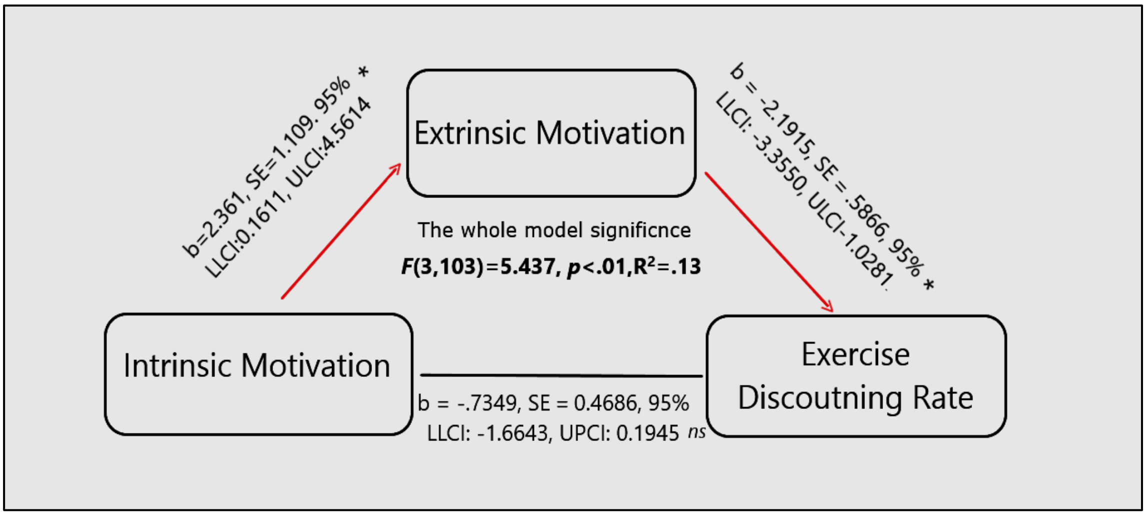

Figure 4.2: Moderation analysis for the effect of intrinsic motivation on k_{ex} with extrinsic motivation as moderator. Beta values (b), standard errors (SE), and confidence intervals (CI) from regression analysis next to solid lines between variables shown inboxes; values in the middle (F, p, and R2) depict the significant of the whole model. * p<0.05; ns, not significant.

These results reveal that the effect of intrinsic motivation on exercise discount rate was fully moderated by extrinsic motivation. However, the conditional effects of the focal predictor at values of the moderator show that the intrinsic motivation prediction of k_{ex} was significant with high extrinsic motivation scores, borderline with medium extrinsic motivation scores, and not significant with low extrinsic motivation scores (Fig. 4.3) These results identify extrinsic motivation as a moderator of the relationship between intrinsic motivation and exercise discounting rate.

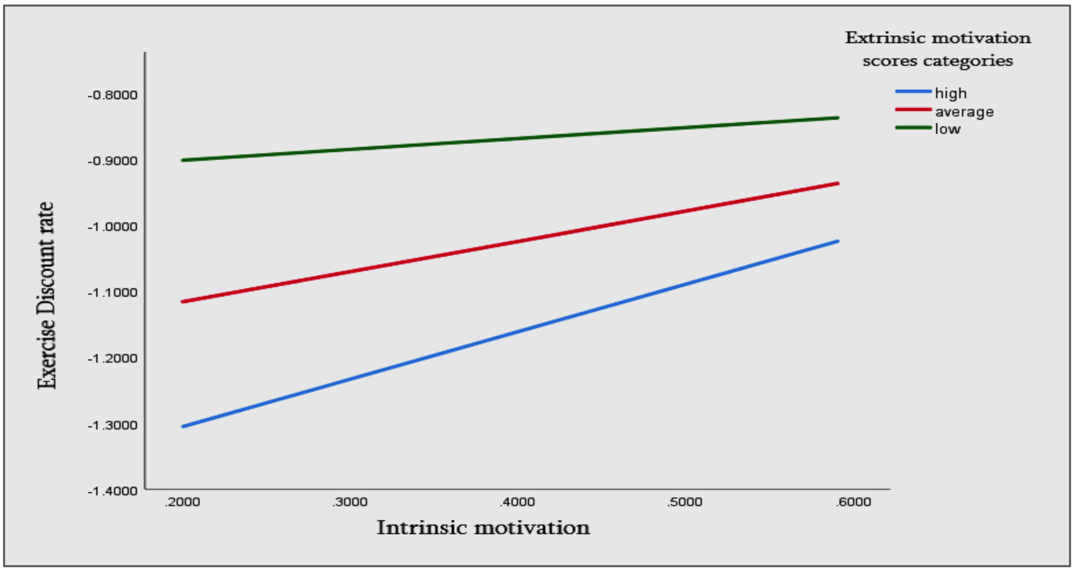

Figure 4.3: The conditional effects of the focal predictor of values of the moderator show that the intrinsic motivation prediction of the exercise discount rate was significant with high extrinsic motivation scores, borderline with medium scores, and not significant with low extrinsic motivation scores. * Extrinsic motivation values in conditional tables used to produce the graph are the 16th (low), 50th (average), and 84th (high) percentiles.

4.5. Discussion

There is little known about the perceived reward value of exercise, how exercise is discounted, and what the influencing and/or confounding factors that may play a role in its variability. The objectives of the current study were to investigate the reward value and discounting rates of un-specific exercise experience in comparison with food and money using an online survey to enable a wider spectrum of ecological and psychological characteristics for better generalisation of findings than our former laboratory studies. Additionally, aspects of passive sports consumption—in the form of sport-related screen time —were integrated to investigate its potential influence on exercise discounting rates.

Our main findings were that k_{ex} was discounted as an established reward and is positively correlated with k_m, k_{fo}, and impulsiveness scores. k_{ex} was also found to have a negative correlation with physical activity levels and the hours spent on screen watching sports. Moreover, k_{ex} was found to be moderately predicted by several parameters related to personality, psychological and activity levels. k_{ex} was also found to be one of the parameters that can moderately predict the levels of physical activity alongside exercise motivation, BMI, sports screen time, reward preference, and the type of the exercise imagined during the exercise discounting task, which is all discussed below.

k_{ex} was found to be discounted as an established reward consistent with our first hypothesis which supports the resemblance of exercise and food discounting rates, both being non-transferrable consumable rewards in consistency with our previous results (Albelwi et al., 2019), but in a wider range of population and with individualised exercise experiences. In addition, monetary rewards were found to be discounted less steeply than food and exercise rewards, with the food showing the highest discounting rates. These results replicate the findings that consumable rewards (i.e., food, alcohol, drugs) are discounted more steeply than non-consumable rewards such as money (Charlton & Fantino, 2008; Estle et al., 2007; Odum, Baumann, & Rimington, 2006; Odum & Rainaud, 2003). Delayed consumable rewards in general are thought to be evaluated differently than delayed monetary rewards, which are exchangeable for consumable rewards but are not themselves directly consumable (Estle et al., 2007). However, food rewards are also thought to be discounted differently from exercise rewards as exercise is either “received”, “practised”, or “performed” rather than “consumed” as in food (Albelwi et al., 2019). It was also suggested in our previous study (Albelwi, 2019) and unpublished results; chapter 3, that the k_{ex} is discounted differently as an outcome of the HIIT performed aiming to reduce k_{ex}, as k_{fo} remained at the same level of baseline measure. Additionally, 75 (65%) out of 115 answered that they preferred food over exercise in response to reward preference question to explore if these rewards are different in their the immediate visceral valuation. These findings about the k_{fo} being the most steep and most preferred reward is consistent with previous research, which suggested that food is more reinforcing than a variety of other outcomes (e.g., money, books, music; Charlton & Fantino, 2008; Odum, Baumann, & Rimington, 2006), and people tend to discount rewards that they desire and enjoy more (Tsukayama & Duckworth, 2010). Additionally, based on the k values and the reward preference question, our findings emphasised the strong visceral quality of food over exercise. As visceral factors, which include drive states such as hunger, thirst and sexual desire, moods and emotions, physical pain, and craving for a drug one is addicted to, they are more likely to affect intertemporal choice as well as other aspects of decision-making, leading to steeper food discounting rates (Loewenstein, 1996).

In the current study, k_{ex} was found to be positively associated with k_{fo} and k_m; these findings are consistent with prior studies that involved a variety of rewards (e.g., (Charlton & Fantino, 2008; Johnson et al., 2010; Jones & Rachlin, 2009; Tsukayama & Duckworth, 2010), and exercise, specifically (Albelwi, 2019; Albelwi experimental research, chapter 2). These positive associations between k values across the tested commodities support the notion that there is a domain-general aspect of delay discounting, including k_{ex}. This means that if an individual has a steep discounting rate in a specific domain, he will also have relatively steep discounting rates in other compared domains. This concept was first proposed by Zimbardo and Boyd (Zimbardo & Boyd, 2015) as “Time perspective is one factor that influences decisions about the present and future; present oriented people might have steeper discount rates in general than those with a predominant future time perspective” (Tsukayama & Duckworth, 2010). These associations across k values can also be influenced by the suggestion that people make domain-general decision rules (e.g., if the delay for any reward is less than a month, choose the larger reward; otherwise, choose the immediate reward), which could lead to similar discounting across domains (Tsukayama & Duckworth, 2010). Another cause for these associations might be the working memory, which is defined as “the ability to maintain active representations of goal-relevant information despite interference from competing or irrelevant information" (Cowan, 2008), as individuals with a low working memory capacity may be less proficient at evaluating delayed options, and thus, may default to immediate options for all commodities (Bickel et al., 2011; Shamosh et al., 2008; Wesley & Bickel, 2014).

In addition, k_{fo} was not associated with the Satiety and Hunger Scale; the lack of association is explicable for a visceral reward as the food discounting task was completely theoretical and did not entail real food cues provided to the participants before the task as, for example, in Rasmussen's paper (Rasmussen et al., 2010). Indeed, earlier comparative studies have demonstrated the role of both the appetizing/palatable properties of food-related stimuli and state motivation levels (e.g., hunger) in activating the neural circuits, underlying food selection, and intake decisions (Bassareo & Di Chiara, 1999; K. C. Berridge, 1996; Kelley & Berridge, 2002; Saper, Chou, & Elmquist, 2002). Further, the relative reinforcing value of food is thought to involve substantial individual differences (Leonard H. Epstein, Leddy, Temple, & Faith, 2007), which means that food-related decisions could be confounded by the absence of food real stimuli, and individual differences in rating the relative reinforcing value of food.

Exercise Discount Rate and Physical Activity Levels

In the current study, k_{ex} had a weak negative association with the level of physical activity measured by both IPAQ and direct exercise participation questions; meaning that higher exercise discounting rates are associated with lower activity levels. The relation between k_{ex} and activity levels is consistent with previous research but with different kinds of rewards, mainly monetary (Sweeney & Culcea, 2017). It was found that exercisers tended to view long-term healthy rewards as being more important while non-exercisers were more likely to choose immediate gains and score higher discounting rates (Tate et al., 2015). Studies have also shown that people with a greater future time perspective are more likely to engage in various health-promoting behaviours, including engaging in regular physical activity (Bickel et al., 2012; Peter A. Hall et al., 2012; Henson et al., 2006). Moreover, unhealthy behaviour-including sedentary behaviour- has a delayed effect on health, leading researchers to hypothesise that an individual's tendency to make unhealthy choices is related to their discounting rate, the rate at which they devalue delayed outcomes (Bickel et al., 2012; Grossman, 1972). These observations combine to suggest that discounting can be viewed as a concurrent marker of the extent of unhealthy behaviour, rather than exclusively as an anteceding risk factor (Story et al., 2014). On the other hand, in our former study (Albelwi et al., 2019), the association between IPAQ activity level and k_{ex} was non-significantly negative although the correlation coefficient is higher than the current study, but the significance was borderline, bearing in mind that the sample size of that study was considerably less than the current study. Meanwhile, in the current study, the significant association found between k_{ex} and IPAQ activity levels may be emphasised by the higher sample size and the variance of the population involved, as well as the generality of the exercise/sport type that was imagined during the discounting task.

In the current study, no relations were found between k_m and k_{fo} with physical activity levels, this outcome is inconsistent with previous research which revealed small associations between discount rates and physical activity behaviours (Adams & White, 2009; Peter A. Hall et al., 2012; Henson et al., 2006). The absence of this association might be affected by that notion that discounting can be influenced by contextual framing (Koffarnus et al., 2013); when implemented in the current findings; participants might have been affected by the purpose of the study and the exercise/sport related questions in a way that led them to focus more on the exercise discounting task. This effect is thought to be influenced by the tolerance of delay that could be altered to match the state environmental and motivational conditions of the survey (Lahav, Benzion, & Shavit, 2011) as discount rates can have both state (immediate) and trait components (Story et al., 2014). To assess the activity levels IPAQ-SF was used; although this tool has been recommended as a cost-effective method to assess PA, the current findings failed to reveal significant associations between IPAQ activity levels and discounting rates of money and food, as well as the weak relation detected between activity levels and k_{ex}. This might be attributed to the controversy about the validity of self-report physical activity measures; it has been frequently argued that it is difficult to obtain a good measure of low and moderate PA using self-administered questionnaires (Washburn, Heath, & Jackson, 2000; Welk, 2002) because these activities are being accumulated throughout the day and the number and diversity of these activities is enormous, resulting in a poor recall. In contrast, high-intensity PA are much more structured and stable over time and are much easier to recall, which explains the larger predictability for vigorous-intensity PA compared with moderate-intensity and low-intensity PA. Second, it has been reported that people tend to overestimate time spent in high-intensity activities and under-report time spent in light and moderate-intensity activities compared to an objective device (Hagströmer, Oja, & Sjöström, 2006; Lee, Macfarlane, Lam, & Stewart, 2011), which leads to overestimated PA levels. Additionally, k_{ex} was found to have a significant positive correlation with sports-related screen time, the longer screen hours' association with higher k_{ex} can be explained as watching sports may increase the immediate enjoyment, moreover, spending a long screen time is also associated with a less active lifestyle and higher discounting rates (Regis et al., 2016).

Exercise discounting rates and exercise motivation

Consistent with the previous study (Albelwi et al., 2019), k_{ex} was found to have a moderate negative association with extrinsic motives implying that participants who were more motivated by extrinsic motives (like appearance, weight, and health) discounted exercise less steeply than people who were less motivated by those; this could be understood as these domains represent the delayed outcomes (rewards) of exercise (Albelwi, 2019). The relation between k_{ex} and exercise extrinsic motivation can be attributed to the differences between intrinsic and extrinsic exercise motivation components. According to the Cognitive Evaluation Theory (Deci & Rayan,1993), outcome-oriented individuals adopt a more extrinsic motivational orientation in competitive sports (C. M. Frederick & Ryan, 1993), which might explain why participants who scored more in extrinsic motivation domains had lower exercise discount rates. However, extrinsic goals are also mostly delayed, therefore people who integrate more delayed goals into their exercise evaluation will inadvertently reduce their discounting due to preferred time perspective for the rewards set as goals.

In the previous literature, it was found that intrinsic motives related to enjoyment, competence, and social interaction were stronger than extrinsic motives like appearance, health, and weight in people who had a high exercise participation (C. M. Frederick & Ryan, 1993). This is clearly illustrated in this study by the positive association between intrinsic motivation with higher activity levels, unlike extrinsic motivation. In addition, no direct associations were found between k_{ex} with the other motivation components of "intrinsic", "total EMI-2 score", and "both intrinsic plus extrinsic", unlike the results in the previous study (Albelwi et al., 2019), which could be explained as the population's mean age is relatively higher in the current study while extrinsic motivators to exercise were found to be the most significant determinants of physical activity participation in the older population (Dacey, Baltzell, & Zaichkowsky, 2008)—especially that the intrinsic motivation mean score is considerably lower in the current study (2.69/5) versus the former studies :the experimental (3.24/5) and cross-sectional (3.33/5; Albelwi, 2019). Also compared to the former study (Albelwi, 2019), the highly active group participants were higher in number than the moderate and low activity groups, unlike the current study where the moderately active group had the highest number of participants. Thus, it is entirely expected to have a lower intrinsic motivation score in the current sample based on the notion that intrinsic motives were found to be stronger than extrinsic motives in people who had a high exercise participation (C. M. Frederick & Ryan, 1993).

Regarding the type of imagined exercise, regression analysis revealed that the number of the participants who imagined individual aerobic exercise as preferred during discount task performance was found to be a predictor of a higher k_{ex} in the following manner: The more frequently the participants chose individual aerobic of exercise as imagined, the higher the k_{ex} would get. This relation between the type of preferred imagined exercise and k_{ex} could be linked to the suggestion that individual sports participation seems to focus upon aspects of the task itself as a reason for participation, which is characteristic of an intrinsically motivated orientation (C. M. Frederick & Ryan, 1993) ;and that intrinsic motivation is also linked to enjoyment of the behaviour which leads to immediate reward choice and higher k_{ex}. This finding may also explain the reason why significant direct relation could not be found between intrinsic motivation and k_{ex}, unlike extrinsic motivation. However, a possibility of an indirect association was investigated based on the significant association between intrinsic and extrinsic motivation on one hand, and on intrinsic motivation and activity levels on the other hand, which both have a direct significant association with k_{ex}. As expected, a small significant indirect relation was found between k_{ex} and intrinsic motivation mediated by high extrinsic motivation. This means that if a participant scored high in extrinsic motivation, intrinsic motivation could significantly predict exercise discounting, which might be in extension of to the positive associations between all exercise motivation components, and that EMI-2—as a self-report measure—taps into different aspects of exercise motivation, leading to the possibility that some components are captured by the delay-discounting task, while others are not (Mobini, Grant, Kass, & Yeomans, 2007).

Exercise Discount Rates and Self-report Parameters

In the current study, multiple regression analysis revealed that the variance of k_{ex} was found to be moderately predicted by several parameters (R^2=0.371). I have categorised the predictor parameters into choice-related, personality trait-related, exercise activity level, and motivation-related for thorough interpretation. First: choice-related (k_{fo} and the type of imagined exercise during the discounting task) can be explained by the domain-general aspect of DD as time perspective influences decisions (Zimbardo & Boyd, 2015).

Second, personality related (BIS) impulsiveness is a personality construct which can be defined as an inability to wait, insensitivity to consequences, the tendency to act without forethought, an inability to inhibit inappropriate behaviours, and deficient tolerance of delay of gratification (Ainslie, 1975; Eysenck, 1993; Logue, 1995; McCown & DeSimone, 1993). Impulsivity was found to be closely related to discount rates in several studies (J. M. Mitchell, Fields, D'Esposito, & Boettiger, 2005; Mobini et al., 2007; Weafer, Mitchell, & de Wit, 2014). In fact, some authors consider DD as an impulsivity measure (L. Green, Myerson, & Ostaszewski, 1999; Kirby, 2009); thus, it is expected that higher impulsivity scores can predict higher k_{ex} which is also true for k_m in the current findings. This finding seems to be consistent with Gray's model (J. A. Gray, 1987) suggesting that individuals with high impulsivity generally show higher sensitivity to rewards delivered immediately. The relation between DD and impulsiveness has been researched previously, and it was suggested that DD task performance activates two different brain systems: one that mediates impulsivity and reward, mainly seeking localised limbic and paralimbic areas, and the other that mediates abstract reasoning that underlie future orientation localised mainly in lateral prefrontal cortical areas (Bickel et al., 2012; McClure et al., 2004) . The competition between these two systems leads to the actual preference between sooner smaller or delayed larger rewards (Steinberg et al., 2009). Therefore, high impulsivity scores would lead to preference of sooner rewards, hence, higher discount rates, which is consistent with the current findings.

Third, exercise behaviour-related (activity levels), the relation between discount rates and healthy behaviour including physical activity levels, has been well investigated as discussed earlier. Relative to people who are present-oriented, studies have shown people with a greater future perspective are more likely to engage in various health-promoting behaviours, including eating a healthy diet, engaging in regular PA, and maintaining a lower body mass index (Adams & White, 2009; Peter A. Hall et al., 2012; Henson et al., 2006). Based on previous research, an individual's physical activity level is closely related, in several ways, to delay discounting. However, the low ability for regression analysis to reveal a highly significant prediction model might be affected by the individual's cognitive differences in performing the computerised discounting tasks, as discounting tasks are thought to involve cognitive costs, and such effort costs are highly subjective and may vary greatly across individuals and populations (Westbrook et al., 2013). In addition, individuals' tendency to think about and value future outcomes varies between individuals (Sweeney & Culcea, 2017), which might have influenced—to some extent—the participants' outcomes in discounting tasks. Additionally, discounting rates could be affected by the level of the motivation to perform the computerised tasks, as the motivation to overcome effortful cognitive costs in pursuit of rewards is fundamental (Chong et al., 2018). If so, then it is not clear whether cognitive differences or motivation levels have had the upper hand in the choice of decision between delays and amounts of exercise rewards. Therefore, it is essential to consider measuring general motivation on top of exercise motivation to explore the factors that underlie the exercise preferences and exercise DD choices.

For better understanding of how exercise is discounted, it is also essential to know that the computation of the integrated value of a reward with its associated cost in the brain (subjective value) is critical in guiding choice behaviour (Kable & Glimcher, 2009; Rangel, Camerer, & Montague, 2008). The effort involved in obtaining the exercise reward can be considered as a cost that may influence preference when compared to other rewards, even with the absence of time (delay) factor “i.e. effort discounting” (Botvinick et al., 2009). According to Epstein (Leonard H Epstein et al., 2010), choice may, in part, be a function of cost of something in terms of the cost forgone by not choosing the other alternative. For example, many people may prefer to have a healthy body rather than eat a tasty snack; however, that snack, although worth less after all, is available right now with little effort, whereas the healthy body requires time and exertion (Odum, 2011b). in this regard, behavioural studies have shown that rewards that entail higher effort are chosen less often compared to those requiring little effort (Treadway, Buckholtz, Schwartzman, Lambert, & Zald, 2009), and their values are discounted accordingly (Kool & Botvinick, 2014; Westbrook, Kester, & Braver, 2013). This supports the finding regarding k_{fo} being the highest among tested commodities and reward preference choice as discussed above. Likewise, k_{ex} can also be influenced by cost invested in order to enjoy the reward (unpublished results, Chapter 3). Thus, the cost to perform exercise might contribute to exercise-specific discount rates as it has a unique effort investment compared to other types of rewards. it is also well-known that exercise benefits depend on how much effort you invest represented by exercise intensity, time, and/or distance (Rankin, Rankin, MacIntyre, & Hillis, 2012). According to the previous literature, exercise cost can be represented by perceived effort during exercise performance and measured by the RPE scale, as RPE was found to influence the delayed memory score (J. J. Chapman et al., 2016), and discounting rates (Sofis et al., 2017). However, exercise cost can also be attributed to travel cost and gym membership fees; and because the current study did not involve an actual effort/cost investment in exercise, the uncertainty toward which cost the participants have integrated when discounting exercise can be considered a confounding situation because some might have discounted high intensity training, and others might have discounted team play or travel cost, depending on their own perceptions and thoughts about exercise.

Limitations

This study is not without limitations. First, the sample was recruited from Amazon's MTurk (AMT), which may not reflect the general population. However, research has shown AMT to be a viable research method and suggests crowdsourced samples may be more representative of the general population (Strickland & Stoops, 2019). Also, the use of self-report in an online survey is a conservative approach to establish an overweight/obese status because of people's tendency to underestimate their weights and overestimate their heights (Engstrom, Paterson, Doherty, Trabulsi, & Speer, 2003); and PA levels were rated by self-report instead of using more direct measures which may have decreased the accuracy of the activity level of the participant. Also, this study did not consider the difference in exercise and sports participation if it is for fitness goals or competitive goals, and what kind of effort and cost (if any) was discounted. Finally, socioeconomic status, culture, and race data were not included in the current study, therefore, the impact they may have had on participants' behavioural decisions is not known.

4.5.4. Practical insights

Some effective strategies to change exercise-related behaviour can be drawn from the current findings to improve physical activity participation; one is the improvement in the work environment as this might be effective in nudging individuals towards increasing physical activity. One practical way is to provide neighbourhood amenities and improve the quality of such amenities so that the costs of engaging in physical activity will be reduced and the benefits of utilising such amenities will increase (Fan & Jin, 2014). The literature includes significant research supporting a strong association between access to neighbourhood amenities (e.g., playgrounds, parks, cycling, and footpaths) and increased outdoor physical activity (Bedimo-Rung, Mowen, & Cohen, 2005; Roemmich et al., 2006). Furthermore, changing social norms of physical activity (Sallis et al., 2015) and promoting a culture of healthy activity habits during childhood (Zimmerman, 2009) can have sustainable and broad impacts on health status.

Additionally, major organizations can contribute to improve their employees' physical and mental health and reduce sitting time for better productivity, more profitability, and less job stress (Chen et al., 2015; Puig-Ribera et al., 2015); this can be achieved by, for example, providing some incentives for regular exercisers.

5.5. Conclusion

In summary, the current study offers a better understanding of decision-making and time-preferences regarding exercise behaviours in order to promote physically active lifestyles. Exercise was found to be discounted as established rewards compared to money and food in a wider and more diverse population, with subjective imagined rewards which are not specific to a certain type of sport/physical activity. The exercise discount rate was found to have close relation with some factors that can moderately predict its variability; these factors include behavioural-, motivational-, and personality-related elements as originally expected.

However, future research is recommended to investigate exercise discounting rates in a wider range of population, including athletes, compared to inactive controls in order to explore, in-depth, the influence of different motivation components, whether physical or cognitive motivation, and fitness levels on decision-making process that underlie exercise DD rate.

Chapter 5

General discussion

5.1. Summary

The objective of this thesis was to investigate the reward value of exercise using a DD paradigm as a promising tool for exploring people's perceptions toward exercising and for understanding how different psychological and physiological parameters may influence exercise discounting rates and physical activity levels (Chapters 2 and 4). Additionally, this work aimed to manipulate the participants' self-selected intensity and exercise discounting rates through HIIT (Chapter 2) as well as through an EC technique using cardiovascular strain as a conditioned stimulus and a sweet- tasting drink as an unconditioned stimulus during HITT (Chapter 3). This chapter discusses and integrates the main findings presented in this thesis.

5.2. General findings

Chapter 2

This chapter aimed to investigate whether the participants evaluated exercise as a reward similar to established rewards such as food and money. Using a DD approach, possible relations between exercise DD traits and general DD traits were explored as well as the factors that play a role in the variance of exercise discounting rates. In the first study, self-selected exercise experience was found to be discounted like a consumable, non-transferrable reward, with the subjective value of the transferrable reward (i.e. money) revealing slower decay in time. While k_{ex} was not significantly different from k_{fo}, both were significantly larger than k_m. Based on these findings, the quantitative resemblances between k_{ex} and k_{fo} decay rates might suggest that exercise may have visceral qualities which are evaluated during discounting. the first study results concluded that physical activity behaviour can be rewarding at a specific level of exercise intensity (cardiovascular strain), and this is consistent with studies that have reported a preference for self-selected speed on the treadmill over imposed speed (Dias et al., 2014; Williams & Raynor, 2013). These findings also support Dishman's suggestions (Dishman et al., 1985) that the affective response of pleasure/displeasure to exercise has motivational significance to engage in physical activity (PA). In the second study, as hypothesized, HIIT was found to be able to increase the participants' self-selection to a higher exercise intensity as their preferred workload after the training due to increased positive exercise valuation. In both studies, the self-selected intensity average reached only 62% of the estimated HR_{max} based on the group's average age. This falls in the mid-range of the physical activity level recommended by the American College of Sports Medicine (ACSM), which states that moderate intensity exercise should achieve 50%–70% of estimated HR_{max}. Therefore, it is clearly important to increase the level of "pleasant" cardiovascular strain for individuals to initiate and maintain their PA engagement at the recommended intensity in order to gain the desired physiological and mental effects, which was the rationale for conducting the second study of this chapter as well as the next chapter's randomised control trial. The results also revealed a significant negative association between k_{ex} and exercise motivation, predominantly with extrinsic motives and with self-selected speed, and showed that participants who were more physically active selected a higher speed and discounted the exercise more slowly. Moreover, consistent with the hypotheses, the three-week-long, HIIT successfully altered k_{ex} specifically by decreasing its rates; hence, the next experimental study was designed to further investigate the effect of HIIT on exercise discounting rates and self-selected speed.

Chapter 3

Based on chapter 2 findings, exercise was discounted as a reward at a specific level of cardiovascular strain, and that HIIT successfully reduced k_{ex} and increased self-selected speed. However, it was not clear whether subjects discounted exercise by integrating delayed outcomes, i.e. appearance, health, etc., or whether the exercise had a reward value based on its visceral qualities, acquired through training and leading to k_{ex} changes and concomitant changes in speed preferences. Thus, I was interested to investigate if altering the subjective value of exercise, represented by both self-selected speed and k_{ex}, is possible through a three-week-long HIIT. The training intervention involved two groups: one group received HIIT only, while the other received the same training protocol but with the integration of a sweet-tasting reward with exercise at higher intensities using the EC technique. I also intended to add further evidence of the influential physiological and psychological parameters that were found to be related to exercise discounting rates in Chapter 2. On this basis, I conducted a randomised controlled trial to explore the influence of HIIT compared to controls, assuming that self-selected exercise intensity can be perceived as a reward at an individual level of cardiovascular strain during exercise and that physiological adaptions would lead to a transient adjustment to higher speeds while maintaining a subjective reward level. It was found that self-selected speed significantly increased after training, and the increase occurred only after training and there was no apparent effect of EC. However, while the effect of the training on speed selection was not maintained in the follow-up period in the TR group, it was preserved at a significant level in the COTR group. Additionally, the higher self-selected speed in the COTR was associated with a significantly higher heart rate and RPE than in the TR group. The improvement in cardiovascular strain with reference to the recommended exercise intensity in the three groups was as follows: for the NTR group, the cardiovascular strain of selected speed was at 62% of the estimated HR_{max} in both measurements; for TR group, the cardiovascular strain improved from 60% pre-training to 65% post-training and then lowered to 60% in the follow-up. Interestingly, in the COTR group, the cardiovascular strain was at 63% pre-training and 69% post-training, and then lowered to 66% in the follow-up. These alterations in speed are presumably caused by physiological adaptation to exercise; however, these trials were different from any previous fitness test because the researchers made sure that 1) the participants were assured many times that the speed selection should be about pure enjoyment and pleasantness, not performance, and 2) the treadmill monitor was concealed so the participants relied only on their visceral perception when rating and adjusting the speed, which eliminated any cognitive input when they adjusted the speed. This suggests that self-selected exercise intensity was rewarding, consistent with the results reported in Chapter 2. Moreover, following ED models, it was concluded that the sweet-tasting conditioning reward was integrated with the higher speed selection, which was found to follow a different process than the exercise DD valuation process; as discussed earlier, DD is related to immediate/delayed rewards, while ED is about less/more workload. The DD of the self-selected exercise as a modality is strongly influenced by psychological closeness to exercise, emphasising long-term outcomes through training; it is also affected by general personality traits. On the other hand, EC intervention had no influence on exercise DD rates, but it had an apparent effect on the self-selected speed detected four weeks after the training ended. This suggests that the visceral reward valuation of exercise has increased, leading to the preservation of the subjective reward value of exercise perceived at higher cardiovascular strain, which is not directly related to the cognitive process that underlies the DD process. This might have occurred because visceral factors can influence behaviour without conscious cognitive mediation (Bolles, 1975; Loewenstein, 1996).

In summary, subjective reward valuation for exercise can be assessed by DD for previously experienced self-selected, treadmill exercise reward, and visceral and cognitive evaluation can be altered by HIIT and the integration of external rewards for exercise.

Chapter 4

In Chapters 2 and 3, exercise was found to be evaluated and discounted as a reward in a laboratory setting with relatively young, active university students. However, my interest was to investigate this finding in a larger sample with a more diverse range of age, activity level, exercise interests/experiences and exercise-related habits in a non-laboratory setting to explore whether exercise was discounted in a similar way. In addition, I was interested in exploring the impact of sports-related screen hours on the participants' valuation of exercise as it offers a great deal of immediate enjoyment and whether sports-related screen time has an influence on exercise discounting rates and participants' PA levels. I also wanted to investigate participants' preferences between exercise and food (Sze et al., 2017) as they both share visceral reward qualities. To explore these aspects, an online survey was used to enable a wider spectrum of ecological and psychological characteristics and better generalization of findings than the previous laboratory studies. The participants were recruited through Amazon's Mechanical Turk (MTurk), allowing a large number of participants with a wide range of exercise interests to participate in the study. Regarding exercise discounting rates, the findings were consistent with those of Chapter 2, showing that exercise was discounted as a reward and had a positive association with money and food discount rates. Also, the results revealed a significant negative association with extrinsic motivation, emphasizing the role of the effect of delayed outcome on exercise valuation. Moreover, it was found that participants who had high physical activity levels discounted exercise less steeply. Although the association was small, it is acceptable looking at the questionable validity of subjective physical activity self-report measures. An objective tool for physical activity measure within a large-scale field research would be necessary to gain better insight.

Interestingly, the findings revealed that the vast majority of the participants (77%) imagined individual aerobic exercise in their exercise discounting tasks, yet only 18% gave the same answer when they were asked about their actual exercise practice. Thus, the majority of the non-exercisers, when asked to imagine their preferred exercise, chose individual aerobics as the most pleasant modality. This is understandable as aerobic exercises include everyday activity and mostly do not require a specific location or equipment, for instance, active travel (cycling or walking), heavy household work, gardening, occupational activity, or exercise such as brisk walking, hiking, and jogging (Wang et al., 2017). Longer sports-related screen time was found to be associated with higher exercise discounting rates and lower physical activity levels, suggesting that this behaviour is either associated with high k_{ex} by enhancing the immediate rewarding perception as other sedentary behaviours. This finding is not different from previous research that revealed that viewing sports games did not generate any enduring increase in sport participation (Coalter, 2004; Girginov & Hills, 2008).

5.3. Strengths and weaknesses:

Novelty

The main objectives of this thesis were to investigate the reward value of exercise and the determinants of this value. Previous exercise behaviour research has focused on the cognitive valuation of exercise in terms of autonomy, goals, motives and perceived benefits (Z. Yang & Petrini, 2018), which are considered external factors (Magnus, Kowalski, & McHugh, 2010). However, it was not clear whether exercise is perceived as a reward per se in comparison with established rewards like food (a visceral reward) and money (an abstract reward). According to previous research, exercise in itself is less rewarding for the individual than food intake and watching television (K. D. Flack et al., 2017a), and this is one of the reasons for low exercise participation rates. On the other hand, less is known about the reward properties of exercise in itself as a physical strain (Cheval et al., 2018), and whether subjects discounted exercise by integrating delayed outcomes, i.e. appearance, health, etc., or whether exercise had a reward value based on its visceral qualities. In this thesis, it was found that specific self-selected exercise experience was perceived as a reward, regardless of any external incentives or rewards, and this reward was based on the exerciser's visceral perception, which made the exerciser adjust the intensity to a subjective reward level through a process that does not follow "minimizing energy" theories. Instead, the intensity selection was controlled based on a visceral-hedonic decision related to the individual's fitness, not necessarily lower in terms of effort, but rather higher as a reward.

In the previous literature, DD was thought to be a general trait rather than specific to one behaviour (Odum, 2011a). In this thesis, I found that DD can be specific to exercise and is modifiable through visceral feeling modification. It was not known if the visceral reward perception of exercise can be purely manipulated by improving fitness or if there is another technique that can be utilized to improve the exercise experience. Therefore, in this thesis, I used two different techniques to influence the visceral properties of exercise during self-selection of exercise intensity; one is based on HIIT to alter physiological responses to exercise, and the other is associating a reward stimulus with increased physiological strain using a novel EC paradigm. As a result, alteration of visceral properties through exercise was found to indirectly influence exercise DD through its impact on the cognitive evaluation of exercise, which is presumably related to exercise decision-making as a modality, not as intensity. On the other hand, the perception of exercise with regard to the intensity chosen to optimize pleasantness depends on fitness, but this visceral element is not transferred to cognitive evaluation directly. In addition, the manipulation via EC and HIIT shows that exercise is viscerally perceived as a reward and discounted against the effort invested and does not result in minimizing the effort made. These findings are novel and interesting because as they suggest that a health behaviour like exercise is balanced in intensity via the ED process.

On a technical level, this thesis investigated the reward value of exercise using a discounting paradigm. The discounting approach has been frequently used to explore people's behaviour in relation to many perceived rewards, such as food (Rasmussen et al., 2010), drugs and gambling (Reynolds, 2006), alcohol and money (Odum & Rainaud, 2003), sex (Herrmann, Johnson, & Johnson, 2015), and TV watching (Acheson, Reynolds, Richards, & De Wit, 2006). To the best of our knowledge, this study is the first of its kind to investigate DD rates using exercise as a reward, and a computerized exercise DD task was designed and used for the first time. This thesis should be influential in this field for the following reasons: first, the preferred self-selected speed optimized to the highest subjective pleasantness has proven to be a useful tool in assessing how exercisers would value cardiovascular strain against perceived effort on a treadmill; second, the exercise discounting task could successfully produce indifference points which could fit hyperbolic curves, matching other investigated rewards in the literature. This thesis is important as it also demonstrates a novel EC with sweet reward approach to increase visceral rewarding value of exercise, based on these findings, a promising intervention technique can be developed and used on an individual level and in different exercise settings to enhance positive training effects, improve performance and overcome the physical effort of strenuous training, particularly among athletes. In fact, a portable mini rucksack of a similar design is already under development in the laboratory by the team leader for further research.

Limitations:

Physical activity level was rated by self-report instead of using more direct measures, which may have decreased the accuracy of the activity level identified by participants. Also, the use of self-reports is a conservative approach to establishing overweight/obese status because of people's tendency to underestimate their weight and overestimate their height (Engstrom et al., 2003). Psychological and personality self-report measures are also a limitation because such measures may be biased (Odum, 2011b).

For Chapter 4, I intended to recruit a larger number of participants, but only half of the responses were valid; recruiting a larger sample would allow more robust findings. Moreover, socioeconomic status, culture and race data were not included in the current study; therefore, the impact they may have had on participants' behavioral decisions was not clear. Another limitation is the fact that I had to remove data sets for cases with a very poor hyperbolic fit of DD indifference points; this might indicate that DD is a highly demanding cognitive task for some participants (Hirsh, Morisano, & Peterson, 2008). In some cases, in the Chapter 2 and 3 studies, I had to ask participants to repeat the task due to poor performance.

In Chapters 2 and 3, a limitation is the lack of generalizability of the findings to different populations, as most of the participants who joined the study were relatively young, active and highly motivated to engage in exercise training. Further, the paradigm limits generalization to other exercise types which might be connected to other rewarding stimuli (group exercises, competitions, etc.). Moreover, the opportunity to self-select exercise intensity is limited in many team and competitive sports, therefore reducing the relevance of the findings in these areas.

In Chapter 4, the sample was recruited from Amazon MTurk (AMT) and thus may not reflect the general population. However, research has shown AMT to be a viable research method and suggests crowdsourced samples may be representative of the general population (Strickland & Stoops, 2019).

Practical insights:

The findings of this thesis demonstrate how the reward value of exercise is an important factor in exercise participation. Since most people do not achieve the recommended PA engagement for better health, it is essential to find effective techniques based on people's perceptions and preferences to enhance exercise reward value. In this thesis, I suggested that exercise valuation shows visceral aspects, and reward valuation is affected greatly by the visceral state, whether hot or cold (Loewenstein, 1996); people in a "hot" state evaluate visceral behaviour more favourably than people in a cold state (Nordgren, van der Pligt, & van Harreveld, 2007). In an exercise context, the physical proximity of a suitable exercise practice location (e.g. a gym) would be beneficial for a person who is in a "hot" state to lead them start exercising immediately; if exercise is postponed for an hour, the person moves into a "cold" state. Therefore, participation in physical activity can be increased if accessibility to exercise is improved (e.g. implementation in workplaces) and food accessibility is reduced (no sales of unhealthy foods on or close to school grounds and workplaces). Additionally, major organizations such as companies can contribute to improving their employees' physical and mental health and reducing sitting time for better productivity and profitability and less job stress (Chen, Fang, & Fang, 2015; Puig-Ribera et al., 2015). This can be achieved, for example, by providing incentives for regular exercise or by setting up a small gym in the workplace to overcome travelling time and effort and to enhance the environment effect. Additionally, the current data also suggest the important contribution of delayed extrinsic motives for discounting of exercise in the tested population; therefore, providing information about the positive effects of exercise may still be a valuable strategy to promote more physical activity as well as the adoption of a healthy lifestyle.

Furthermore, changing social norms related to physical activity (Sallis et al., 2015) and the promotion of a positive and supportive culture of physical activity habits can have sustainable and broad impacts on health status. For example, in Saudi Arabia, according to a review in *Al-Hazzaa* (Al-Hazzaa, 2018), studies have indicated that the mean physical inactivity prevalence ranged from 50% to 85% among males and from 73% to 91% among females. According to the review, barriers that were reported included weather conditions, the reduced tendency to walk or use bikes for transportation or leisure due to urbanization, lack of social support (especially for women), lack of time and resources and low self-efficacy. Therefore, I recommend initiating a notional scheme in Saudi Arabia to promote more rewarding physical activity targeting schools, universities, local primary care units and public locations like shopping malls and neighbourhood clubs. Also, self-selected exercise is essential to exercise adherence and workload, and this can be improved within the population by emphasizing the satisfaction and reward derived from exercise and improving participation by means of self-paced training sessions,

Future research directions

This thesis adds important findings to the body of literature that has investigated DD in relation to exercise as a healthy behaviour. However, a similar design that includes a probability discounting measure would be important in terms of explaining exercise discounting changes in different parameters. Future research that include an objective means for physical activity monitoring, such as *Fitbit* or an accelerometer might show better results. Also, collection of social and economic data and education levels is recommended as they were reported to influence discount rates in some cases (Lempert, Steinglass, Pinto, Kable, & Simpson, 2019). Additionally, exercise discounting rates and EC could be assessed in athletes in different settings and with various types of exercise to explore their influence on performance. Also, fMRI research might be recommended to investigate the impact of exercise training on exercise discounting–related areas of the brain.

In addition, no research has been conducted yet to understand whether the preference or tolerance for exercise intensity can be increased with repeated exposures to exercise for longer periods of time (e.g. months/years). Understanding the factors that influence exercise discounting would yield valuable information that could be used to design exercise programs that improve aerobic fitness while concurrently increasing rewarding experience and long-term adherence to PA recommendations.

Furthermore, to understand the valuation process of physical activity choice, an investigation should include not only the choice of behaviour *per se* but also how that choice interacts with other real-world options consisting of different rewarding commodities (Bickel et al, 2011). Thus, it is possible to investigate exercise DD using a cross-commodities design such as exercise vs. money/food. Outside of the laboratory, the choice is almost never whether to engage in a behaviour now or later, but rather whether to eat junk food now or to engage in an alternative behaviour, e.g. exercise, now and reduce the risk of disease later (Leonard H Epstein et al., 2010).

My interest as a physiotherapist is to initiate similar research involving clinical populations with physical health issues, such as neurological disorders and chronic pain. Previous literature has demonstrated the influence of physical lesions on money discounting rates from a physiological and psychological point of view. However, it would be interesting to explore the influence of physical issues on exercise discounting rates, specifically on the delivery of therapeutic exercise treatment in a physiotherapy and rehabilitation setting and how this would affect treatment outcomes.

5.4. Conclusion:

This doctoral thesis shows, for the first time, that self-selected exercise intensity has a visceral reward value and is discounted in the same way as established rewards. Increasing the reward value of exercise should shift choice towards physically active behaviors, increase exercise participation and result in more people meeting PA guidelines. This can be accomplished through HIIT alone and with EC by increasing exercise motivation and making ecological adjustments. Furthermore, this thesis demonstrated that the intensity of exercise is not chosen based on effort perception as such but on how much the individual is willing to tolerate extra effort to reach a level of perceived reward value. The balance between exercise reward preference and tolerance for the costs/efforts of exercise may increase the physical activity needed to meet PA guidelines. The valuation of exercise could be driven by two systems—one visceral, which evaluates based on perceptual responses to exercise intensity and duration—and the other cognitive, which integrates values of delayed outcomes into exercise valuation. Finally, the direct result of valuation is choice; therefore, to know how exercise is valued is to open a wide window into understanding choice behaviours related to physical activity.

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Appendices:

Appendix 1: Monetary choice questionnaire

Name: ....

Monetary-Choice Questionnaire (MCQ)

For each of the next 27 choices, please indicate which reward you would prefer: the smaller reward today or the larger reward in the specified number of days.

1. Would you prefer $54 today or $55 in 117 days?

[ ] smaller reward today
[ ] larger reward in the specified number of days

2. Would you prefer $55 today, or $75 in 61 days?

[ ] smaller reward today
[ ] larger reward in the specified number of days

3. Would you prefer $19 today, or $25 in 53 days?

[ ] smaller reward today
[ ] larger reward in the specified number of days

4. Would you prefer $31 today, or $85 in 7 days?

[ ] smaller reward today
[ ] larger reward in the specified number of days

5. Would you prefer $14 today, or $25 in 19 days?

[ ] smaller reward today
[ ]larger reward in the specified number of days

6. Would you prefer $47 today, or $50 in 160 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

7. Would you prefer $15 today, or $35 in 13 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days.

8. Would you prefer $25 today, or $60 in 14 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days.

9. Would you prefer $78 today, or $80 in 162 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

10. Would you prefer $40 today, or $55 in 62 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

11. Would you prefer $11 today, or $30 in 7 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

12. Would you prefer $67 today, or $75 in 119 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

13. Would you prefer $34 today, or $35 in 186 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

14. Would you prefer $27 today, or $50 in 21 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

15. Would you prefer $69 today, or $85 in 91 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

16. Would you prefer $49 today, or $60 in 89 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

17. Would you prefer $80 today, or $85 in 157 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

18. Would you prefer $24 today, or $35 in 29 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

19. Would you prefer $33 today, or $80 in 14 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

20. Would you prefer $28 today, or $30 in 179 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

21. Would you prefer $34 today, or $50 in 30 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

22. Would you prefer $25 today, or $30 in 80 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

23. Would you prefer $41 today, or $75 in 20 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

24. Would you prefer $54 today, or $60 in 111 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

25. Would you prefer $54 today, or $80 in 30 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

26. Would you prefer $22 today, or $25 in 136 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

27. Would you prefer $20 today, or $55 in 7 days?

[ ]smaller reward today
[ ]larger reward in the specified number of days

End of Questions

Thank you

Appendix 2: Trait Food Craving Questionnaire

APPETITE TOWARDS SPECIFIC FOOD CHOICES

Name: .... Date: ....

Trait Food Craving Questionnaire FCQ-T

How frequently each statement "would be true for you in general" using a 6-point scale that ranged from 1 (*never*) to 6 (*always*);

		1	2	3	4	5	6
1	Being with someone who is eating often makes me hungry						
2	When I crave something, I know I won't be able to stop eating once I start						
3	If I eat what I am craving, I often lose control and eat too much						
4	I hate it when I give in to cravings						
5	Food cravings invariably make me think of ways to get what I want to eat						
6	I feel like I have food on my mind all the time						
7	I often feel guilty for craving certain foods						
8	I find myself preoccupied with food						
9	I eat to feel better						
10	Sometimes, eating makes things seem just perfect						
11	Thinking about my favourite foods makes my mouth water						
12	I crave foods when my stomach is empty						
13	I feel as if my body asks me for certain foods						
14	I get so hungry that my stomach seems like a bottomless pit						
15	Eating what I crave makes me feel better						
16	When I satisfy a craving I feel less depressed						
17	When I eat what I am craving I feel guilty about myself						
18	Whenever I have cravings, I find myself making plans to eat						
19	Eating calms me down						

APPETITE TOWARDS SPECIFIC FOOD CHOICES

20	I crave foods when I feel bored, angry, or sad						
21	I feel less anxious after I eat						
22	If I get what I am craving I cannot stop myself from eating it						
23	When I crave certain foods, I usually try to eat them as soon as I can						
24	When I eat what I crave I feel great						
25	I have no will power to resist my food crave						
26	Once I start eating, I have trouble stopping						
27	I can't stop thinking about eating no matter how hard I try						
28	I spend a lot of time thinking about whatever it is I will eat next						
29	If I give in to a food craving, all control is lost						
30	When I'm stressed out, I crave food						
31	I daydream about food						
32	Whenever I have a food craving, I keep on thinking about eating until I actually eat the food						
33	If I am craving something, thoughts of eating it consume me						
34	My emotions often make me want to eat						
35	Whenever I go to a buffet I end up eating more than what I needed						
36	It is hard for me to resist the temptation to eat appetizing foods that are in my reach						
37	When I am with someone who is overeating, I usually overeat too						
38	When I eat food, I feel comforted						
39	I crave foods when I'm upset						

Appendix 3: Exercise Motivation Inventory-2

The Exercise Motivations Inventory - 2 (EMI-2)

On the following pages are a number of statements concerning the reasons people often give when asked why they exercise. *Whether you currently exercise regularly or not,* please read each statement carefully and indicate, by circling the appropriate number, whether or not each statement *is true* for you personally, *or would be true* for you personally if you did exercise. If you do not consider a statement to be true for you at all, circle the '0'. If you think that a statement is very true for you indeed, circle the '5'. If you think that a statement is partly true for you, then circle the '1', '2', '3' or '4', according to how strongly you feel that it reflects why you exercise or might exercise.

Remember, we want to know why *you personally* choose to exercise or might choose to exercise, not whether you think the statements are good reasons for *anybody* to exercise.

It helps us to have basic personal information about those who complete this questionnaire. We would be grateful for the following information:

Your age .... **years** **Your gender** ...... **male/female**

		Not at all true for me					Very true for me
Personally, I exercise (or might exercise) …							
1	To stay slim	0	1	2	3	4	5
2	To avoid ill-health	0	1	2	3	4	5
3	Because it makes me feel good	0	1	2	3	4	5
4	To help me look younger	0	1	2	3	4	5
5	To show my worth to others	0	1	2	3	4	5
6	To give me space to think	0	1	2	3	4	5

Personally, I exercise (or might exercise) …	Not at all true for me					Very true for me
7 To have a healthy body	0	1	2	3	4	5
8 To build up my strength	0	1	2	3	4	5
9 Because I enjoy the feeling of exerting myself	0	1	2	3	4	5
10 To spend time with friends	0	1	2	3	4	5
11 Because my doctor advised me to exercise	0	1	2	3	4	5
12 Because I like trying to win in physical activities	0	1	2	3	4	5
13 To stay/become more agile	0	1	2	3	4	5
14 To give me goals to work towards	0	1	2	3	4	5
15 To lose weight	0	1	2	3	4	5
16 To prevent health problems	0	1	2	3	4	5
17 Because I find exercise invigorating	0	1	2	3	4	5
18 To have a good body	0	1	2	3	4	5
19 To compare my abilities with other peoples'	0	1	2	3	4	5
20 Because it helps to reduce tension	0	1	2	3	4	5
21 Because I want to maintain good health	0	1	2	3	4	5
22 To increase my endurance	0	1	2	3	4	5
23 Because I find exercising satisfying in and of itself	0	1	2	3	4	5

Personally, I exercise (or might exercise) …	Not at all true for me					Very true for me
24 To enjoy the social aspects of exercising	0	1	2	3	4	5
25 To help prevent an illness that runs in my family	0	1	2	3	4	5
26 Because I enjoy competing	0	1	2	3	4	5
27 To maintain flexibility	0	1	2	3	4	5
28 To give me personal challenges to face	0	1	2	3	4	5
29 To help control my weight	0	1	2	3	4	5
30 To avoid heart disease	0	1	2	3	4	5
31 To recharge my batteries	0	1	2	3	4	5
32 To improve my appearance	0	1	2	3	4	5
33 To gain recognition for my accomplishments	0	1	2	3	4	5
34 To help manage stress	0	1	2	3	4	5
35 To feel more healthy	0	1	2	3	4	5
36 To get stronger	0	1	2	3	4	5
37 For enjoyment of the experience of exercising	0	1	2	3	4	5
38 To have fun being active with other people	0	1	2	3	4	5

Please Turn Over

	Not at all true for me					Very true for me
Personally, I exercise (or might exercise) …						
39 To help recover from an illness/injury	0	1	2	3	4	5
40 Because I enjoy physical competition	0	1	2	3	4	5
41 To stay/become flexible	0	1	2	3	4	5
42 To develop personal skills	0	1	2	3	4	5
43 Because exercise helps me to burn calories	0	1	2	3	4	5
44 To look more attractive	0	1	2	3	4	5
45 To accomplish things that others are incapable of	0	1	2	3	4	5
46 To release tension	0	1	2	3	4	5
47 To develop my muscles	0	1	2	3	4	5
48 Because I feel at my best when exercising	0	1	2	3	4	5
49 To make new friends	0	1	2	3	4	5
50 Because I find physical activities fun, especially when competition is involved	0	1	2	3	4	5
51 To measure myself against personal standards	0	1	2	3	4	5

Thank you for completing this questionnaire

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January 1997

Appendix 4: Barratt Impulsiveness Scale

Barratt Impulsiveness Scale (BIS II)

Name:......................

DIRECTIONS: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and put an X on the appropriate circle on the right side of this page. Do not spend too much time on any statement. Answer quickly and honestly.

① Rarely/Never ② Occasionally ③ Often ④ Almost Always/Always

1	I plan tasks carefully.	①	②	③	④
2	I do things without thinking.	①	②	③	④
3	I make-up my mind quickly.	①	②	③	④
4	I am happy-go-lucky.	①	②	③	④
5	I don't "pay attention."	①	②	③	④
6	I have "racing" thoughts.	①	②	③	④
7	I plan trips well ahead of time.	①	②	③	④
8	I am self controlled.	①	②	③	④
9	I concentrate easily.	①	②	③	④
10	I save regularly.	①	②	③	④
11	I "squirm" at plays or lectures.	①	②	③	④
12	I am a careful thinker.	①	②	③	④
13	I plan for job security.	①	②	③	④
14	I say things without thinking.	①	②	③	④
15	I like to think about complex problems.	①	②	③	④
16	I change jobs.	①	②	③	④
17	I act "on impulse."	①	②	③	④
18	I get easily bored when solving thought problems.	①	②	③	④
19	I act on the spur of the moment.	①	②	③	④
20	I am a steady thinker.	①	②	③	④
21	I change residences.	①	②	③	④
22	I buy things on impulse.	①	②	③	④
23	I can only think about one thing at a time.	①	②	③	④
24	I change hobbies.	①	②	③	④
25	I spend or charge more than I earn.	①	②	③	④
26	I often have extraneous thoughts when thinking.	①	②	③	④
27	I am more interested in the present than the future.	①	②	③	④
28	I am restless at the theater or lectures.	①	②	③	④
29	I like puzzles.	①	②	③	④
30	I am future oriented.	①	②	③	④

Patton, Stanford, Barratt (1995). *J Clin Psy*, vol. 51, pp. 768-774

Appendix 5: Physical Activity Readiness Questionnaire

Name ………………………..

PAR-Q FORM

	YES	NO
- Has your doctor ever said that you have a heart condition and recommended only medically supervised physical activity?	____	____
- Do you frequently have pains in your chest when you perform physical activity?	____	____
-Have you had chest pain when you were not doing physical activity?	____	____
- Do you lose your balance due to dizziness or do you ever lose consciousness?	____	____
- Do you have a bone, joint or any other health problem that causes you pain or limitations that must be addressed when developing an exercise program (i.e. diabetes, osteoporosis, high blood pressure, high cholesterol, arthritis, anorexia, bulimia, anemia, epilepsy, respiratory ailments, back problems, etc.)?	____	____
- Are you pregnant now or have given birth within the last 6 months?	____	____
- Have you had a recent surgery?	____	____

If you answered NO honestly to all PAR-Q questions you can be reasonably sure that you can become more physically active and take part in a fitness appraisal/training.

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

If you 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

If you answered YES to one or more questions You will need to complete the Medical authorization Form BEFORE you meet with a trainer or become more physically active. Tell your doctor about the PAR-Q and which questions you answered YES to.

NOTE: 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 which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.

If you have marked YES to any of the above, please elaborate below:

____

____

____

Do you take any medications, either prescription or non-prescription, on a regular basis? Yes/No

What is the medication and it's use? ____

How does this medication affect your ability to exercise or achieve your fitness goals?

____

____

Please check any of the following injuries you have had and specify which bone, muscle, joint, etc., and the year the injury occurred:

Broken bones ____________________ Muscles strain/sprain___________________

Ligament, tendon, cartilage injury__________________ Joint injury or chronic pain_____________

Back injury or chronic pain__________________ Other___________________________________

Are you currently being treated for any of the above injuries? Please specify type of treatment.

____

At this present time, do you have any health conditions or injuries that would affect or limit your training?

____

Appendix 6: International Physical Activity Questionnaire

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (October 2002)

LONG LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ
The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information
More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective.* Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place ➡ ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard ➡ ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard ➡ ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**
_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.

Appendix 7: Behavioural Avoidance/Inhibition Scales

Name: .... Date: .... Visit: ....

Behavioural avoidance/inhibition (BIS/BAS) scales

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very true for me
2 = somewhat true for me
3 = somewhat false for me
4 = very false for me

	1	**2**	**3**	**4**
1. A person's family is the most important thing in life.				
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.				
3. I go out of my way to get things I want.				
4. When I'm doing well at something I love to keep at it.				
5. I'm always willing to try something new if I think it will be fun.				
6. How I dress is important to me.				
7. When I get something I want, I feel excited and energized.				
8. Criticism or scolding hurts me quite a bit.				
9. When I want something I usually go all-out to get it.				
10. I will often do things for no other reason than that they might be fun.				
11. It's hard for me to find the time to do things such as get a haircut.				
12. If I see a chance to get something I want I move on it right away.				
13. I feel pretty worried or upset when I think or know somebody is angry at me.				
14. When I see an opportunity for something I like I get excited right away.				

15. I often act on the spur of the moment.				
16. If I think something unpleasant is going to happen I usually get pretty "worked up."				
17. I often wonder why people act the way they do.				
18. When good things happen to me, it affects me strongly.				
19. I feel worried when I think I have done poorly at something important.				
20. I crave excitement and new sensations.				
21. When I go after something I use a "no holds barred" approach.				
22. I have very few fears compared to my friends.				
23. It would excite me to win a contest.				
24. I worry about making mistakes.				

Appendix 8: Positive and Negative Affect Schedule

Name.................................

Positive and Negative Affect Schedule (PANAS) - **General**

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer . Indicate to what extent you generally feel this way, that is, how you feel on the average . Use the following scale to record your answer.

Indicate how much do you feel:		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 2	Distressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 3	Excited	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 4	Upset	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 5	Strong	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 6	Guilty	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 7	Scared	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 8	Hostile	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 9	Enthusiastic	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 10	Proud	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 11	Irritable	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 12	Alert	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 13	Ashamed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 14	Inspired	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 15	Nervous	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 16	Determined	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 17	Attentive	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 18	Jittery	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 19	Active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 20	Afraid	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Appendix 9: Lark or Owl Questionnaire

psychology
WORKS TAURANGA

hope / motivate / heal

Lark or Owl Questionnaire

- Make sure that you read each question carefully before answering.
- Although each question has a selection of answers, choose one only.
- Answer every question.
- Trust your initial response and answer honestly.
- There is no right or wrong answer; it is your personal experience that counts.
- When you have finished, add up your score to determine your 'best time' performance.

1. Taking into account only your own 'feeling best' rhythm, at what time would you get up if you were entirely free to choose?

Before 6 am	5
6 -7 am	4
7 – 9 am	3
9 – 10 am	2
After 10 am	1

2. Taking into account only your own 'feeling best' rhythm, at what time would you go to bed if you were entirely free to choose?

Before 9 pm	5
9 – 10 pm	4
10 pm – 12 am	3
12 – 1 am	2
After 1 am	1

3. If there is a particular time by which you must get up in the morning, to what extent do you rely on being woken up by an alarm of some kind?

Not at all dependent	4
Somewhat dependent	3
Fairly dependent	2
Completely dependent	1

4. After a usual night's sleep, do you find it easy to get up in the mornings?

Not at all easy	4
Not very easy	3
Fairly easy	2
Very easy	1

5. Within 30 minutes of getting up in the morning, how alert do you feel?

Not at all easy	4
Not very easy	3
Fairly easy	2
Very easy	1

6. Within 30 minutes of getting up in the morning, how stimulated is your appetite?

Not at all easy	4
Not very easy	3
Fairly easy	2
Very easy	1

Permission to use this questionnaire was kindly provided by author Fiona Johnson at www.shiftwork.co.nz.

7. Within 30 minutes of getting up in the morning, how tired or otherwise do you feel?

Very tired	4
Fairly tired	3
Fairly refreshed	2
Very refreshed	1

8. If you have no special plans the next day, at what time would you go to bed compared with your normal routine?

Seldom or never later	4
Less than 1 hour later	3
1-2 hours later	2
More than 2 hours later	1

9. You and a friend commit to doing some regular exercise together for 1 hour twice a week, and it suits your friend to do it between 7 and 8 am. Taking into account only your own 'feeling best' rhythm, would you…?

Be in good form	4
Be in reasonable form	3
Find it difficult	2
Find it very difficult	1

10. You have given an undertaken to do 2 continuous hours of hard physical work, but you can choose any time at all to do it. Taking into account your own 'feeling best' time, which one of the following slots would you choose?

8-10 am	4
11 am – 1 pm	3
3-5 pm	2
7-9 am	1

11. At home in the evening, at what time would you feel tired and make preparations for bed?

Before 9 pm	5
9-10 pm	4
10 pm – 12 am	3
12-1 am	2
After 1 am	1

12. You have got a 2-hour, mentally exhausting test coming up. Taking into account your 'feeling best' time, which of the following time slots would you choose to do the test in?

8-10 am	4
11 am – 1 pm	3
3-5 pm	2
7-9 pm	1

13. Would you be tired if you went to bed at 11 pm?

Not at all	4
A little	3
Fairly	2
Very	1

14. If you have gone to bed several hours later than usual but are free to do whatever you like the following morning, will you…?

Wake up at the usual time and not fall asleep again	4
Wake up at the usual time and then doze for a while	3
Wake up at the usual time and then go back to sleep	2
Not wake up until later than usual	1

15. You're involved in a night-watch exercise, which means you have to stay awake between 4 and 6 am. Assuming no commitments the following day, which one of the following options would best suit you?

Don't go to bed until the watch is over	4
Take a nap before and sleep properly afterwards	3
Take a good sleep before and nap afterwards	2
Go to bed in time to have a full sleep before the watch	1

16. You and a friend commit to doing some regular exercise together for 1 hour twice a week and it suits your friend to do it between 10 and 11 pm. Taking into account only your own 'feeling best' rhythm, would you?

Be in good form	4
Be in reasonable form	3
Find it difficult	2
Find it very difficult	1

17. You were offered a really interesting job that paid by results and involved working for 5 consecutive hours each day, which 5-hour time slot would you choose?

4-9 am	5
7 am – 12 pm	4
10 am – 3 pm	3
4-9 pm	2
9 pm – 2 am	1

18. On any given day, at what time would you achieve your 'feeling best' peak?

5-7 am	5
8-9 am	4
10 am – 4 pm	3
5-9 pm	2
10 pm – 4 am	1

19. If you had to describe yourself as a morning or evening type of person, which one of the following would come closet?

Absolutely a morning type	4
Tend more towards a morning type then an evening type	3
Probably more an evening type than a morning type	2
Absolutely an evening type	1

Scoring

Extreme morning type	70-86
Moderately morning type	59-69
Neutral type	42-58
Moderately evening type	31-41
Extreme evening type	16-30

- If the test score indicates that you are a moderately morning type, a neutral type of a moderately evening type, the chances are that you will be able to adapt to changes in your sleep pattern.
- Extreme morning types or larks are likely to experience considerable difficulty adjusting to shiftwork.
- Extreme evening types or owls adjust to changing time schedules more easily than most people.

Appendix 10: Physiology Informed Consent and Medical Questionnire

FORM 4 - Physiology Informed Consent and Medical Questionnaire (Revised 09/03/11)

Bangor University
SCHOOL OF SPORT, HEALTH AND EXERCISE SCIENCES

Name of Participant ....

Age ....

Are you in good health? ☐ YES ☐ NO

If no, please explain

How would you describe your present level of activity?
Tick intensity level and indicate approximate duration.

Vigorous		Moderate		Low intensity	

Duration (minutes)...

How often?

< Once per month		2-3 times per week	
Once per month		4-5 times per week	
Once per week		> 5 times per week	

Have you suffered from a serious illness or accident? ☐ YES ☐ NO

If yes, please give particulars:

Do you suffer from allergies? ☐ YES ☐ NO

If yes, please give particulars:

Do you suffer, or have you ever suffered from:

	YES	NO		YES	NO
Asthma			Epilepsy		
Diabetes			High blood pressure		
Bronchitis					

Are you currently taking medication? ☐ YES ☐ NO

If yes, please give particulars:

Are you currently attending your GP for any condition or have you consulted your doctor in the last three months? ☐ YES ☐ NO

If yes, please give particulars:

Have you, or are you presently taking part in any other laboratory experiment? ☐ YES ☐ NO

PLEASE READ THE FOLLOWING CAREFULLY

Persons will be considered unfit to do the experimental exercise task if they:

- have a fever, cough or cold, or suffer from fainting spells or dizziness;
- have suspended training due to a joint or muscle injury;
- have a known history of medical disorders, i.e. high blood pressure, heart or lung disease;
- have had hyper/hypothermia, heat exhaustion, or any other heat or cold disorder;
- have anaphylactic shock symptoms to needles, probes or other medical-type equipment;
- have chronic or acute symptoms of gastrointestinal bacterial infections (e.g. Dysentery, Salmonella);
- have a history of infectious diseases (e.g. HIV, Hepatitis B); and if appropriate to the study design, have a known history of rectal bleeding, anal fissures, haemorrhoids, or any other condition of the rectum.

PLEASE COMPLETE AND SIGN THE DECLARATION BELOW

DECLARATION

I agree that I have none of the above conditions and I hereby volunteer to be a participant in experiments/investigations during the period of …………………20……

My replies to the above questions are correct to the best of my belief and I understand that they will be treated with the strictest confidence. The experimenter has explained to my satisfaction the purpose of the experiment and possible risks involved.

I understand that I may withdraw from the experiment at any time and that I am under no obligation to give reasons for withdrawal or to attend again for experimentation.

Furthermore, if I am a student, I am aware that taking part or not taking part in this experiment, will neither be detrimental to, or further, my position as a student.

I undertake to obey the laboratory/study regulations and the instructions of the experimenter regarding safety, subject only to my right to withdraw declared above.

Signature *(participant)* ………………………………….. Date …………………..

Print name ……………………………………………………………………………..

Signature *(experimenter)* ………………………………. Date …………………..

Print name ……………………………………………………………………..…...

Appendix 11: State Food Craving Questionnare

APPETITE TOWARDS SPECIFIC FOOD CHOICES

Name: .... Date: .... Visit: ....

State Food Craving Questionnaire (FCQ-S)

Indicate the extent to which you agreed with each statement "right now, at this very moment" using a 5-point scale that ranged from 1 (*strongly agree*) to 5 (*strongly disagree*).

	1	2	3	4	5
I have an intense desire to eat something tasty					
I'm craving (one or more specific foods)					
I have an urge for (one or more specific foods)					
Eating (one or more specific foods) would make things just perfect					
If I were to eat what I'm craving, I am sure my mood would improve					
Eating (one or more specific foods) would feel wonderful					
If I ate something, I wouldn't feel so sluggish and lethargic					
Satisfying my craving would make me feel less grouchy and irritable					
I would feel more alert if I could satisfy my craving					
If I had (one or more specific foods), I could not stop eating it					
My desire to eat (one or more specific foods) seems overpowering					
I know I'm going to keep on thinking about (one or more specific foods) until I actually have it					
I am hungry					
If I ate right now, my stomach wouldn't feel as empty					
I feel weak because of not eating					

Appendix 12: Feeling Scale

Feeling Scale (FS)
(Hardy & Rejeski, 1989)

While participating in exercise, it is common to experience changes in mood. Some individuals find exercise pleasurable, whereas others find it to be unpleasant. Additionally, feeling may fluctuate across time. That is, one might feel good and bad a number of times during exercise. Scientists have developed this scale to measure such responses.

+5 Very good

+4

+3 Good

+2

+1 Fairly good

0 Neutral

-1 Fairly bad

-2

-3 Bad

-4

-5 Very bad

Appendix 13: Rate of Perceived Exertion Sheet

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Table 1. The Borg Rating of Perceived Exertion Scale

Appendix 14: 9-Point Hedonic Scale

9-Point Hedonic Scale	
9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

Appendix 15: Study 1- Chapter 2- Participant Information Sheet

BANGOR UNIVERSITY

SCHOOL OF SPORT, HEALTH AND EXERCISE SCINCES

A PhD project

An Investigation on the Reward Value of Exercise

1. Study Title

An investigation of the reward value of exercise.

2. Invitation paragraph

You are being invited to take part in a research study to investigate the reward value of exercise using a discounting paradigm at the School of Sport, Health, and Exercise Sciences (SSHES), Bangor University. Before you agree to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. If you wish, discuss it with friends and relatives. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part, or not.

3. What is the background of the study?

The promotion of physical activity in the population is an important public health aim as it has been shown to improve quality of life and to reduce all-cause mortality and the incidence of many diseases and disabilities (Warburton et al., 2010). However, dropout rates are high especially when participants are left to exercise on their own after the end of exercise interventions (Williams et al., 2007). In order to address this issue, it is important to understand people's perception of exercise more in detail and in comparison with other stimuli, like food and money; this might help to find reasons for low exercise adherence rates. Time preferences studies are widely used to study people's behaviours regarding various stimuli representing potential rewards, one of them is the discounting paradigm. This paradigm was used before with various stimuli like money and food among other commodities (Da Matta et al., 2012), but not to study exercise perception. In this investigation, we are going to study people's time preferences and decision making regarding exercise compared with established rewards of food and money.

The aim of this study: To investigate the perception of exercise compared with money and food stimuli using a discounting paradigm.

4. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form.

5. What are my rights?

You may decide to stop being a part of the research study at any time without explanation. You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome; such questions will be answered after completion of the study). If you have any questions as a result of reading this information sheet, you should ask the researcher before the study begins.

6. What will happen to me if I take part?

If you initially agree to take a part in this study, you will be invited to 4 visits to the school of Sport, Health and Exercise Science to participate in our study.

On the first visit: You will be asked to sign a consent form, and then fill out the following questionnaires:

- General Health questionnaire (Bangor University).
- Physical Activity Readiness Questionnaire (PAR-Q).
- Your personal characteristics (height, weight, age, body composition)
- Mood [Positive and Negative Affect Schedule (PANAS-General) (Mackinnon et al., 1999)],
- Perception of food [Trait Food Craving Questionnaire (FCQ-T) (Cepeda-Benito et al. 2000)],
- Exercise habit [International Physical Activity Questionnaire (IPAQ)],
- Motivation [Exercise Motivations Inventory (EMI) (Markland and Hardy,1993)],
- Impulsiveness [Barrat Impulsivity Scale (BIS-11) (Patton et al. 1995),
- Sleep pattern [Lark or Owl Questionnaire for morningness-eveningness (Smith, Reilly, & Midkiff, 1989)].
- Delay discounting [Monetary Choice Questionnaire (Kirby et al., 1999)].

Some baseline measures such as weight, height and body composition will be taken. Weight and body composition will be measured by Bio Impedance Assessment, a scale like device, which sends very tiny, not tangible electrical currents through the body for measuring your body composition. Then you will familiarize yourself with walking or running on a treadmill to make sure that you know what will follow during the next visits. Please wear clothing and shoes that are suitable for exercising. If you do not feel confident to walk or run on a treadmill, you can be given a harness to wear for safety (whole visit approximately 60).

On the second visit: You are again asked to fill out questionnaires about your acute state of mood [Positive and Negative Affect Schedule (PANAS-Moment) (Mackinnon et al., 1999)] and appetite [State Food Craving Questionnaire and (FCQ-S) (Cepeda-Benito et al. 2000)]. After a short warm up on a cycle ergometer, you will then start an exercise session on the treadmill, where we try to establish the exercise intensity (walking or running) and duration, which you might enjoy most. You will be asked questions about your perception of enjoyment during the exercise. This session will be approximately 30 minutes. Your heart rate will be monitored during the exercise sessions with a heart rate monitor. (Whole visit about 45 minutes).

On the third visit: You are asked to fill out the questionnaires about your acute state of mood again [Positive and Negative Affect Schedule (PANAS-Moment) (Mackinnon et al., 1999)] and appetite [State Food Craving Questionnaire and (FCQ-S) (Cepeda-Benito et al. 2000)] again. Then you will do a short warm up exercise on the cycle ergometer followed by exercise on the treadmill at approximately the established intensity and for the duration, you enjoyed most in the last visit. We will modify the speed slightly (increase and decrease) to make sure that we have optimized the exercise for your enjoyment. You will be asked questions about your acute perception of the exercise during the session. After a resting period for 5 minutes, where you can drink water, you will be asked to step on the treadmill again to exercise at the established speed for further 10 minutes for making sure that there is no doubt regarding the settings of the exercise for you, again the rating scale for feeling of enjoyment/pleasantness will be shown to you. The exercise session will be about 30 minutes depending on you former exercise session. Your heart rate will be monitored during the exercise sessions with a heart rate monitor. After this, you will start a computer session to perform the delay discounting experiment with questions about your preference of acute or delayed receive of money (as a reward), food, and your established exercise bout. The computer will generate these questions in a repetitive manner using the various commodities with varied sizes and delays. (Whole visit about 75 minutes)

On the fourth and last visit: You will be asked again to fill out questionnaires about your acute state of mood [Positive and Negative Affect Schedule (PANAS-Moment) (Mackinnon et al., 1999)] and appetite [State Food Craving Questionnaire and (FCQ-S) (Cepeda-Benito et al. 2000)]. After this, , you will do a short warm up on the cycle ergometer followed by exercise on the treadmill with the established protocol for your enjoyment. During this session, you will be asked questions regarding your perception of effort using the Rate of Perceived Exertion (RPE) (Borg, 1970). Your heart rate will be monitored during the exercise sessions with a heart rate monitor. After a short rest, the second discounting computer task about money as a cost will be started just like the previous session, after finishing you are free to leave. (Whole session 90 minutes)

Total time commitment: 4-5 hours over 2 weeks depending on your availability.

7. What do I have to do?

You are supposed to attend all the sessions including answering the questionnaires, exercising and answering the computer task session.

8. What are the possible disadvantages and risks of taking part?

If you agree to participate, there are no other risks than the usual doing exercise on a treadmill at the self-selected intensity. The risk of falls should be minimal because you are not asked to exhaust yourself and you have the option to wear a harness if you choose to.

9. What are the possible benefits of taking part?

You will contribute to research to establish ways to improve exercise participation. Additionally, you can receive general guidance and recommendations according to your body composition measures and appetite questionnaire scores. Moreover, you will receive a £20 food vouchers for reimbursement of you effort.

10. Cost, Reimbursement and Compensation

Your participation in this study is voluntary. Participants will receive a £20 food vouchers when participation has been completed. Participants also gain portfolio credits if needed.

11. Confidentiality

All information that is collected about you during the course of the research will be kept strictly confidential. Any information that leaves the School will have your name and address removed so that you cannot be recognized. It will not be possible to identify you in any report or publication of the study.

12. Who has reviewed the study?

This study has been approved by the School of Sport, Health and Exercise Sciences, as well as School of Psychology Ethics Committee.

For Further Information

Dr. Hans-Peter Kubis and Prof Robert Rogers, the supervisor and co-supervisor of this study (h.kubis@bangor.ac.uk; r.rogers@bangor.ac.uk) and Tamam Albelwi, PhD student (pep607@bangor.ac.uk /07482021342) will be glad to answer your questions about this study at any time.

If you would like to find out about the final results of this study, please contact one of the researchers.

School of Sport, Health and Exercise Sciences

School of Psychology

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BANGOR UNIVERSITY

SCHOOL OF SPORT, HEALTH AND EXERCISE SCINCES

A PhD project

An Investigation on the Reward Value of Exercise

Researcher:

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Appendix 16: Study 2-Chapter 3- Participant Information Sheet

BANGOR UNIVERSITY

SCHOOL OF SPORT, HEALTH AND EXERCISE SCINCES

A PhD project

An Investigation on the Reward Value of Exercise

1. Study Title

An investigation of the effect of interval training accompanied with soft drink mouth rinse on the reward value of exercise.

2. Invitation paragraph

You are being invited to take part in a research study to investigate the effect of interval training on your perception towards exercise at the School of Sport, Health, and Exercise Sciences (SSHES), Bangor University. Before you agree to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. If you wish, discuss it with friends and relatives. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part, or not.

3. What is the background of the study?

The promotion of physical activity in the population is an important public health aim as it has been shown to improve quality of life and to reduce all-cause mortality and the incidence of many diseases and disabilities (Warburton et al., 2010). However, dropout rates are high especially when participants are left to exercise on their own after the end of supervised exercise interventions (Williams et al., 2007). In order to address this issue, It is important to better understand people's perception of exercise, and to compare with other stimuli, like food and money; this might help to find reasons for low exercise adherence rates. We will use a combination of questionnaires and computer based choice tasks to investigate the perception of exercise, after establishing the most preferred intensity and duration on a treadmill. This will be followed by a training intervention to understand how training influences peoples' exercise perception. Pre and post the training period measures of body characteristics and questionnaires/computer tasks will be performed.

The aim of this study: In this research, we have two main objectives: the first is to investigate people's perception towards exercise compared with established rewards of food and money.

The second is to explore the effect of 3 weeks interval training accompanied with soft drink mouth rinse on your preferred exercise intensity.

4. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form.

5. What are my rights?

You may decide to stop being a part of the research study at any time without explanation. You have the right to have your questions about the procedures answered (unless answering these questions would interfere with the study's outcome; such questions will be answered after completion of the study). If you have any questions as a result of reading this information sheet, you should ask the researcher before the study begins.

6. What will happen to me if I take part?

If you initially agree to take a part in this study, you will be invited to the school of Sport, Health and Exercise Science to participate in our study. The experiment will include 3 phases. The study phases are described below:

Phase 1:Pre-Training Phase: includes 3 sessions over 6 days:

Session 1 You will be asked to sign a consent form, and then fill out a number of questionnaires about your health, physical activity level, exercise habits, your food appetite and psychological status. Some baseline measures such as weight, height and body composition will be taken. Weight and body composition will be measured by Bio Impedance Assessment, a scale like device, which sends an electrical current, which you will not feel, through your body. This method estimates how much water you have in your body and from that predicts your fat mass (% body fat) . Then you will familiarize yourself with walking or running on a treadmill to make sure that you know what will follow during the next visits. If you do not feel confident to walk or run on a treadmill, you can be given a harness to wear for safety (Total time in the laboratory is 60 minutes). For all the sessions, you are expected to wear clothing and shoes that are suitable for exercising. After a short warm up on a cycle ergometer, you will then start an exercise session on the treadmill, where we try to establish the exercise intensity (walking or running) and duration, which you might enjoy most. You will be asked questions about your perception of enjoyment during the exercise. This session will be approximately 30 minutes. Your heart rate will be monitored during the exercise sessions with a heart rate monitor. (Total time is about 90 minutes).

Session 3 You will carry out a short warm up exercise on the cycle ergometer followed by exercise on the treadmill at approximately the established intensity and for the duration you enjoyed most in the last visit. We will modify the speed slightly (increase and decrease) to make sure that we have optimized the exercise for your enjoyment. You will be asked questions about your acute perception of the exercise during the session. The exercise session will be about 30 minutes depending on you former exercise session. Your heart rate will be monitored during the exercise sessions with a heart rate monitor. After this, you will start a computer session to perform the delay discounting experiment with questions about your preference of acute or delayed receive of money (as a reward), food, and your established exercise bout. The computer will generate these questions in a repetitive manner using the various commodities with varied sizes and delays. (Total time is about 70 minutes).

Session 4: You will do a short warm up on the cycle ergometer followed by exercise on the treadmill with the established protocol for your enjoyment. During this session, you will be asked questions regarding your perception of effort using the Rate of Perceived Exertion (RPE) (Borg, 1970). Your heart rate will be monitored during the exercise sessions with a heart rate monitor. After a short rest, the second discounting computer task about money will be started just like the previous session, after finishing you are free to leave (Total time is about 100 minutes).

Total time commitment for phase 1: 4-5 hours.

Phase 2: Interval Training:

- You will undergo an interval training on the treadmill 3 times a week over 3 weeks (9 sessions in total, 30 min each). This phase will involve moderate and fairly hard exercise.

- Training sessions will be in the form of interval training with training peaks .The baseline training intensity will be on the level of the phase 1 preferred speed. After a warm-up for 3 minutes, speed will be increased to baseline (preferred speed). Intervals will be ramped from baseline towards higher exercise intensities within your physical tolerance. This will go on for 6 cycles in each session, followed by a cool-down at walking speed. You will wear a harness to protect you from falls.
- During the training session, small amounts of energy drink will be delivered to your mouth through a mouthpiece & tubes connected to the pumping system controlled by a computer program to enhance your performance.
- Total time commitment for phase 2 is about **6** hours over 3 weeks.

Phase 3: Post-Training Phase:

•Includes 2 sessions over 1 week (each is 1 hour):

Session (1 hour): the first exercise trial will be repeated as in phase 1 to determine post-training preferred speed, exercise and food discounting rate using a discounting computer task + filling out food craving questionnaire.

Phase 4: follow-up test:

This will be carried out after 4 weeks of the last session. And will be similar to phase 3.

The total engagement in the project will include 16 sessions (~15 hours total)

7. What do I have to do?

You will be asked to complete all the exercise sessions, questionnaires and computer tasks detailed above.

8. What are the possible disadvantages and risks of taking part?

If you agree to participate, it is expected that you will experience some tiredness related to the interval training on a treadmill. You will undergo a health screening and exercise participation risk stratification in the pre-training phase so the exhaustion caused by exercise load increments should be bearable and within your physical tolerance. The risk of falls should be small but you will wear a harness during training sessions to prevent falling.

9. What are the possible benefits of taking part?

You will contribute to research to establish ways to improve exercise participation. Additionally, you can receive general guidance and recommendations according to your body composition measures and appetite questionnaire scores. Moreover, **you will receive £100** upon completion of the study for your time and effort.

10. Cost, Reimbursement and Compensation

Your participation in this study is voluntary. Participants will receive £100 when participation has been completed. SSHES student participants also gain portfolio credits if needed.

11. Confidentiality

All information that is collected about you during the course of the research will be kept strictly confidential. Any information that leaves the School will have your name and address removed so that you cannot be recognized. It will not be possible to identify you in any report or publication of the study.

12. Who has reviewed the study?

This study has been approved by the School of Sport, Health and Exercise Sciences ethical committee.

For Further Information

Dr. Hans-Peter Kubis and Prof Robert Rogers, the supervisor and co-supervisor of this study (h.kubis@bangor.ac.uk; r.rogers@bangor.ac.uk), Tamam Albelwi, PhD student (pep607@bangor.ac.uk /07482021342) & Ben Price (b.price@bangor.ac.uk) will be glad to answer your questions about this study at any time.

If you would like to find out about the results of this study, please contact one of the researchers at: School of Sport, Health and Exercise Sciences

Bangor University

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BANGOR UNIVERSITY

SCHOOL OF SPORT, HEALTH AND EXERCISE SCINCES

A PhD project

An investigation on the Reward Value of Exercise- an online survey

1. Study Title

An investigation on the Reward Value of Exercise- an online survey

2. Invitation paragraph

If you are an active or sedentary, healthy males or female aged above 18, you are being invited to take part in a research study to investigate the reward value of exercise using a delay-discounting paradigm online designed at the School of Sport, Health, and Exercise Sciences (SSHES), Bangor University, UK.

This study has been approved by the ethics committee of the School of Sport, Health and Exercise Sciences, Bangor University and it is conform to GDPR requirements. Before you agree to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. If you wish, discuss it with friends and relatives. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part, or not.

3. What is the background of the study?

The promotion of physical activity in the population is an important public health aim as it has been shown to improve quality of life and to reduce all-cause mortality and the incidence of many diseases and disabilities (Warburton et al., 2010). However, dropout rates are high especially when participants are left to exercise on their own after the end of exercise interventions (Williams et al., 2007). In order to address this issue, it is important to understand people's perception of exercise more in detail and in comparison with other stimuli, like food and money; this might help to find reasons for low exercise adherence rates. Time preferences studies are widely used to study people's behaviours regarding various stimuli representing potential rewards, one of them is the delay discounting paradigm. This paradigm was used before with various stimuli like money and food among other commodities (Da Matta et al., 2012), but not to study exercise perception. In this investigation, we are going to study people's time preferences and decision making regarding exercise compared with established rewards of food and money.

The aim of this study: To investigate the perception of exercise compared with money and food stimuli using a delay-discounting paradigm.

4. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will read the information sheet and then be asked to click on "I consent"

5. What is required of me if I take part?

All parts of this research will be performed online via this webpage. If you agree to take a part in this study, you are asked to confirm consent on the page by clicking the box for it. Then you are asked to fill out a number of questionnaires about your personal characteristics, physical activity level, impulsivity, and exercise motivations. Additionally, there are some questions about your active and passive sport and exercise participation to be answered.

After this, you will start a program via a web-link where the delay-discounting questions will be asked about your preference of acute or delayed hypothetical rewards of money (as a reward), food, and your favorite exercise. The computer will generate these questions in a repetitive manner with varied sizes and delays. (Like: 'Do you want £20 now or £50 in 14 days?'). This will be performed with money, food, and exercise. Choice preferences will be stored and used to calculate your response to delaying an outcome (money, food, and exercise).

Total time commitment: 20-25 minutes

6. What do I have to do?

You are supposed to answer the questionnaires and the choice questions during the delay-discounting task. You can skip any question you wish to without explaining the reasons.

7. What are the possible disadvantages and risks of taking part?

No risks are expected upon participating.

8. What are the possible benefits of taking part?

You will contribute to research to establish ways to improve exercise participation. Additionally, you can enter a draw for a £50 prize as a 'Thank you' for your participation. There will be ten prize draws (each £50) for the people who finished the survey.

9. Confidentiality

This study is administered through an online questionnaire software (Qualtrics). The online questionnaire is very secure. Qualtrics servers are protected by high-end firewall systems, and vulnerability scans which are performed regularly. Qualtrics uses security encryption for all transmitted data. They also protect surveys with passwords and HTTP referrer checking. Any information that leaves the School will have your name and address removed so that you cannot be recognized. It will not be possible to identify you in any report or publication of the study. Data collected will be stored securely by the university for 5 years.

10. Who is organizing or funding the research? (if applicable)

Bangor University, UK, and Ministry of Health, Saudi Arabia is funding the research.

11. Who has reviewed the study?

This study has been approved by the School of Sport, Health and Exercise Sciences, Bangor University, Bangor, UK

12. Feedback on Conduct of Research

SSHES is always keen to hear the views of research participants about their experience. If you would like to feedback, please ask your researcher to provide you with Form 6 – Participant Feedback Form – from the Ethics Guidelines Handbook. Completion of this form is optional. That form, or any concerns or complaints about this study, or the conduct of individuals conducting this study, should be referred to:

College Manager, College Manager, School of Psychology, Bangor University, Bangor, Gwynedd LL57 2AS; or, e-mail: huw.ellis@bangor.ac.uk.

Appendix 18: International Physical activity Questionnaire-Short Form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities ➡ ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities ➡ ***Skip to question 5***

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.