Immune responses to next generation computer gaming

by

Francesca Pell

A thesis submitted in partial fulfilment for the requirements of the degree of MSc (by Research) at the University of Central Lancashire

March 2011

University of Central Lancashire

Student Declaration

Concurrent registration for two or more academic awards

Either *I declare that while registered as a candidate for the research degree, I have not been a registered candidate or enrolled student for another award of the University or other academic or professional institution

or ~~*I declare that while registered for the research degree, I was with the University's specific permission, a *registered candidate/*enrolled student for the following award:~~

_____

Material submitted for another award

Either *I declare that no material contained in the thesis has been used in any other submission for an academic award and is solely my own work

or ~~*I declare that the following material contained in the thesis formed part of a submission for the award of~~

_____

(state award and awarding body and list he material below):

* *delete as appropriate*

Collaboration

Where a candidate's research programme is part of a collaborative project, the thesis must indicate in addition clearly the candidate's individual contribution and the extent of the collaboration. Please state below:

Signature of Candidate _____

Type of Award MSc (By Research)

School School of Sport, Tourism + the Outdoors

Abstract

The purpose of this study was to investigate stress (as measured by cortisol) and immune response (s-IgA was used as a marker) to step aerobics on the Nintendo Wii between people with varying degrees of cardiorespiratory fitness (fair and good). Measures were taken at baseline and then after participants had attended three 30 minute sessions each week for four weeks. Following a washout period, measures were taken again. More specifically, before and after a four week control period (no Nintendo Wii exercise programme). A basic health screen (blood pressure, body composition and estimated $\dot{V}O_{2max}$) was also carried out and cardiorespiratory responses to exercise recorded. Results revealed that the exercise intervention was vigorous enough at the start to induce a significant ($p \leq .05$) increase in cortisol in the fair fitness group, but not at any other time for either fitness group. The exercise did not elicit any significant ($p > .05$) changes in s-IgA, regardless of fitness. Although there was a 26% reduction in s-IgA secretion rate following exercise in the fair fitness group. BP, estimated $\dot{V}O_{2max}$ and body composition were not significantly ($p > .05$) altered as a consequence of exercise in the fair fitness group. In contrast, SBP and estimated $\dot{V}O_{2max}$ were significantly ($p \leq .05$) improved in the good fitness group. METs, HR, relative $\dot{V}O_2$ and EE decreased in both groups, but only significantly ($p \leq .05$) for the fair fitness group. It was concluded that regular exercise on the Nintendo Wii does not improve immunosurviellence. If anything, it may even have the opposite effect in low conditioned individuals due to a temporary increase in stress hormones when first starting a structured exercise programme. Moreover, exercise on Wii step is sufficient enough in intensity to contribute to physical activity recommendations to elicit health benefits.

Table of Contents

List of Figures

List of Tables

Acknowledgements

Firstly I thank my supervisors; Dr Steve Atkins, Dr Stephanie Dillon and last but by no means least, Dr David John Fewtrell. Their expertise and continued support have been invaluable throughout this course. Thanks Matthew Quinn for your help with participant recruitment and data collection during the piloting phase. Next I thank Dr. Belinda Hornby for her advice and supervision during the analysis of the saliva samples. Special thanks to all the participants that made this project such a success with their continued commitment. Not forgetting Matthew Duckham and my family, thank you. This would not have been possible without you.

1. INTRODUCTION

Physical activity is imperative for good health (Blair, 2009; Maddison *et al*., 2007). Despite this, physical activity has decreased rapidly over the last hundred years (Booth *et al*., 2000) and is probably the primary risk to health nowadays (Blair, 2009). This is due to modern day lifestyles and environments, which promote sedentary behaviour (Dzewaltowski, 2008; Hillier, 2008; Maddison *et al.*, 2007). For example, children were recently reported as spending almost four hours engaged in screen-based (television, computer and video games) endeavours (Marshall *et al*., 2006). Such sedentary activities are said to be replacing what was once or would otherwise be healthy, physically active recreation (Pate, 2008; Vandewater *et al.*, 2004). This is apparent in Britain, where total screen time in excess of two hours each day is associated with reduced physical activity (Melkevik *et al.*, 2010). Innovative ways to increase physical activity among the children (Barkley & Penko, 2009) and adults (Baranowski *et al.*, 2008) of today is therefore warranted. The use of popular next generation active computer games is one potential way to revolutionise the way we exercise (Daley, 2009) and consequently improve health due to the well recognised benefits of regular physical activity (McArdle *et al.*, 2006).

1.1 Physical inactivity

Copious research indicates that physical inactivity is associated with a greater risk of cardiovascular disease, high blood pressure, stroke, type 2 diabetes, obesity, certain cancers and psychological disorders (ACSM, 2009). For example, Taylor *et al*., (1962) found that men working moderately active jobs were less likely to have coronary heart disease than those men with sedentary roles within the railroad industry. Moreover, Lee and Paffenbarger (2000) reported that vigorous activity was significantly ($p \leq .001$) and negatively related to mortality in 13,485 Harvard graduates.

Regardless, 61% of men and 71% of women in the UK do not meet current physical activity recommendations (Craig *et al*., 2009). This being an accumulation of at least 30 minutes of moderate intensity exercise on five days each week or 20 minutes of vigorous intensity exercise on three days every week (Haskell *et al*., 2007). Similarly, 68% of boys and 76% of girls in the UK fail to satisfy minimum physical activity guidelines (Craig *et al*., 2009), which for children is an hour's physical activity on five or more days per week (Hardman & Stensel, 2003). Evidently, recommendations that require significant lifestyle changes are still not being met generally (Hill, 2009) and therefore innovative ways to increase physical activity need to be explored (Barkley & Penko, 2009). New generation active computer games have been proposed as a possible way to do just that (Daley, 2009; Graves *et al.*, 2008a).

1.2 Physical inactivity and video games

In developed countries, children spend in excess of five and a half hours participating in screen-based activities on a daily basis (Hardman & Stensel, 2003). With 75% of children in the UK reportedly spending approximately two hours playing video games specifically, between three and seven days a week (Pratchett, 2005 cited in Graves *et al.*, 2008b). Video games in particular, are equally as popular among adults (Bausch *et al.*, 2008; Siegel *et al.*, 2009). Over one fifth of American adults for example, play video games on all or most days (Lenhart *et al*., 2008). The use of video games among both children and adults is anticipated to rise (Daley, 2009; Lanningham-Foster *et al.*, 2009). The popularity of video games is a growing concern due to their negative impact on health (Leon & Abbott, 2007 cited in Bausch *et al.*, 2008).

Video game use is inversely associated with physical activity (Janz & Mahoney, 1997 cited in Tremblay & Willms, 2003). However, Marshall *et al*., (2006) argue that video games (amongst other media-based inactivity) are being wrongly connected to the recent epidemic of inactivity, given that the amount of media use has not altered over the last five decades (Roberts *et al*., 1999 cited in Marshall *et al.*, 2006). Furthermore, there also seems to be a positive relationship between video games and childhood obesity (Brown, 2006; Hardman & Stensel, 2003; Stettler *et al.*, 2004; Vandewater *et al.*, 2004), although not conclusively (McMurray *et al*., 2000).

Stettler *et al*., (2004) reported that the risk of obesity was almost double with every daily hour spent playing electronic games. Opportunities are being provided within schools in an attempt to counteract inactivity (Jago & Baranowski, 2004 cited in Graves *et al.*, 2008b) and its associated health problems, such as obesity (Brown, 2006; Hardman & Stensel, 2003; Mohebati *et al.*, 2007; Stettler *et al.*, 2004). However, school-based interventions have had limited success (Baranowski *et al*., 2002). Daley (2009) and Graves *et al*., (2008b) both argued that in order to combat inactivity, every environment that children engage with needs to be addressed, including the home. Since video games are a fundamental part of modern day living (Daley, 2009), which are not simply going to disappear (Pate, 2008). It may be necessary in the fight against inactivity to unite with, as opposed to resist, such electronic entertainment (Daley, 2009). Thereby making technology part of the solution rather than the problem, as is has been so far (Hillier, 2008).

1.3 Rationale for video games and exercise ("Exergaming")

Given that millions of people play video games, it provides an obvious opportunity to improve fitness on a large scale (Siegel *et al*., 2009), simply by replacing what was once primarily sedentary video gaming (Barkley & Penko, 2009; Daley, 2009) with what is now active video gaming ("exergaming") (Fawkner *et al.*, 2010; Maddison *et al.*, 2007). This is perhaps a viable way of increasing physical activity, since people spend substantial amounts of time playing sedentary video games, which they are reluctant to give up (Faith *et al*., 2001 cited in Daley, 2009). New generation video games that are designed to promote movement are therefore being targeted as a contemporary way in which to encourage physical activity, not just among children (Daley, 2009; Graves *et al.*, 2008a), but the entire family (Lanningham-Foster *et al.*, 2009; Siegel *et al.*, 2009; Willems & Bond, 2009a; Willems & Bond, 2009b).

Video games have the potential to promote such positive behaviour change because they are enjoyable, captivate attention and appeal to a wide audience (Baranowski *et al*., 2008), which may help combat the current epidemic of overweight and obesity (Graves *et al.*, 2008a; Miyachi *et al.*, 2010). Additionally, it could be argued that unlike traditional forms of exercise, people are internally motivated to play video games because they are entertaining (Graf *et al*., 2009) and also have greater adherence rates (Mark *et al*., 2008). For example, Penko and Barkley (2010) and Barkley and Penko (2009) found that children and adults respectively, prefer playing Nintendo Wii boxing (despite being more physiologically demanding) rather than a more traditional form of physical activity (leisurely treadmill walking) and a sedentary video game. Although not all children are of this opinion, with some apparently finding active video games boring (Madsen *et al*., 2007, Chin *et al*., 2008 cited in Daley, 2009). Nevertheless, by

appealing to the interests and abilities of people through original forms of physical activity, there may be a greater promise of meeting recommendations (Bausch *et al*., 2008).

For instance, participation in a particular activity is governed by the extent to which a person likes that type of physical activity (Roemmich *et al*., 2008). Therefore, people may be more willing to engage in physical activity on the Nintendo Wii for example, rather than more traditional activities, which in comparison people like less (Barkley & Penko, 2009). Sell *et al*., (2005 cited in Sell *et al.*, 2008) also concluded that people who found a physically active video game (Eye Toy) more enjoyable, would be more willing to participate in this kind of activity, rather than a less enjoyable and more traditional mode of physical activity. Exergames therefore provide a greater promise for increased physical activity and also the maintenance of that health benefiting behaviour (Graves *et al*., 2010).

There is the worry however that promotion of active computer games may inadvertently reduce physical activity levels; in that they replace time spent engaged in authentic sports (Daley, 2009; Pate, 2008). Furthermore, playing active computer games pose a new risk of injury (Pasch *et al*., 2008). For example, a 16-year-old boy experienced a twisting injury, referred to as 'Wii knee', whilst playing a new generation active computer game (Robinson *et al*., 2008). More recently, a 'Wii fracture' was reported, as in the case of a 14-year-old girl who fractured her foot when she fell off her Nintendo Wii Fit balance board (Eley, 2010). Robinson *et al*., (2008) warns that injuries more commonly associated with athletic endeavour will ensue with the advancement of

activity promoting video games. However, Graf *et al*., (2009) highlighted that these injuries are also a risk related to all other forms of physical activity.

1.4 Nintendo Wii

The most recent activity-promoting video console is the Nintendo Wii (Graf *et al*., 2009), which is controlled by motion of a wireless handheld controller or force plate (Miyachi *et al*., 2010). The Nintendo Wii is highly popular (Graf *et al.*, 2009; Miyachi *et al.*, 2010; Pasch *et al.*, 2008; Willems & Bond, 2009a; Willems & Bond, 2009b), with sales in the UK exceeding six million since its release in December 2006, making it the fastest selling console in history (Nintendo, 2009). The Nintendo Wii Fit game specifically has sold almost three million (Wallop, 2009). No doubt because of its wide appeal, including both men and women (Wallop, 2009) as well as all ages, unlike previous consoles that were mostly limited to the 16 to 35 year old male gamer (Mintel, 2008).

The government previously frowned upon the use of video games, due to their sedentary nature and possible influence on the incidence of obesity (Wallop, 2009). However, the Nintendo Wii is attracting otherwise sedentary people to actually engage in fun and sociable exercise (Mintel, 2009). For this reason, the Department of Health has, for the first time, endorsed a video game (Dawar, 2009). Allowing Nintendo to advertise the NHS Change4Life programme, with the intention of increasing exercise (as well as healthy eating) (Wallop, 2009). Health benefits in doing so could be potentially widespread, given that nearly a quarter of homes in Britain own a Nintendo Wii (Wallop, 2009).

1.5 Exergaming and energy expenditure

A number of studies advocate the use of physically active video games to increase energy expenditure (EE) through body movements (Ridley & Olds, 2001 cited in Sell *et al.*, 2008). An early study by Graves *et al*., (2008a) established that children (15 ± 1 years) playing new generation active computer games expended significantly ($p \leq 0.001$) more energy when compared to sedentary computer games. Using the intelligent device for EE and activity system, predicted EE during Nintendo Wii Sports bowling, tennis and boxing was 190.6 ± 22.2, 202.5 ± 31.5 and 198.1 ± 33.9 $kj \cdot kg^{-1} \cdot min^{-1}$ respectively, versus 125.5 ± 13.7 $kj \cdot kg^{-1} \cdot min^{-1}$ during a sedentary game on the XBOX 360. Despite an increase in EE during active computer games, this was not adequate enough to contribute to daily physical activity recommendations (Graves *et al*., 2008a). Although, irrespective of whether physical activity guidelines are met, small increases in EE may improve health by protecting against obesity (Hill, 2009) and mortality (Manini *et al*., 2006).

Subsequently, Graves *et al*., (2008b) specifically measured upper limb and total body movement, guaranteeing more accurate results (Pasch *et al*., 2008), on EE in children (15 ± 1 years) during the same active and sedentary computer games. Using ActiGraph accelerometers, significantly ($p \leq 0.05$) greater movement in the upper limbs and total body were detected during the active Nintendo Wii games relative to the sedentary XBOX 360 game. Indirect calorimetry revealed unsurprisingly that the active computer games demanded significantly more EE (Graves *et al*., 2008b), thus corroborating their initial findings (Graves *et al*., 2008a). This more recent study however showed that in terms of metabolic equivalents (METs), boxing on Nintendo Wii Sports (3.2 METs) could be classified as moderate exercise (3-6 METs), within the intensity guidelines of

the ACSM (2009). Willems and Bond (2009a) have since supported that Nintendo Wii boxing can contribute to physical activity guidelines to elicit health benefits.

Likewise, Lanningham-Foster *et al*., (2009) studied EE and physical movement during an active Nintendo Wii game (Wii Sports Boxing) and a sedentary PlayStation 2 game (Disney's Extreme Skate Adventure) in both children (12 ± 2 years) and adults (34 ± 11 years). Movement during these activities was measured using accelerometers and was significantly ($p \leq 0.0001$) greater in all ages during the active computer game as opposed to the sedentary game. EE measured by indirect calorimetry was also significantly elevated during the active computer game compared to the sedentary game in both young and old ($p \leq .001$ and $p \leq .003$ respectively) and was comparable to more conventional types of physical activity (Daley, 2009). Therefore, even at the current use of video games, daily EE could be greatly improved (more than doubled) with the substitution of sedentary video games for active ones (Lanningham-Foster *et al*., 2009).

Subsequently, Miyachi *et al*., (2010) criticised Graves *et al*., (2008a; 2008b) and Lanningham-Foster *et al*., (2009) methods, speculating that EE may have been underestimated. Miyachi *et al*., (2010) therefore used a metabolic chamber to determine EE in adults (25 - 44 years) during all of the Nintendo Wii Sports and Wii Fit Plus activities. As predicted, METs were greater than those reported by Graves *et al*., (2008a). This may have been attributable to varying methods, but also possibly due to differences in participants' age (Zhang *et al*., 2004 cited in Miyachi *et al*., 2010). Nonetheless, Wii Sports bowling was still only considered as light intensity (2.7 METs), whereas tennis was promoted as moderately intense (3.0 METs), joining the same category as boxing (4.2 METs). Overall, a third of all Nintendo Wii Sports and Wii Fit

Plus activities were grouped as moderate intensity and can therefore contribute to daily physical activity recommendations (Miyachi *et al*., 2010).

Not only is there variation in the energy demands between games (Miyachi *et al*., 2010), as Böhm *et al*., (2008) explained, EE is also governed by the type of console used. Specifically, in this study Nintendo Wii Sports tennis required significantly ($p \leq .01$) less energy consumption than EyeToy Kinetic and was attributed to the gross muscle movements exclusive to the latter (Böhm *et al*., 2008). Consequently, Böhm *et al*., (2008) recommended a greater use of the legs to increase the metabolic demands of subsequent video games. This has been supported by Miyachi *et al*., (2010) research, whereby resistance and aerobic exercises (incorporating leg movements) within the Wii Fit Plus game required, on average, more EE than the games featured in its ancestor (Wii Fit Sports), which relies predominantly on smaller upper limb movements.

One such game that features in Nintendo Wii Fit Plus is free step. As recommended by Böhm *et al*., (2008), this game utilises gross musculature, maximising the metabolic demands. Accordingly, Miyachi *et al*., (2010) established that free step was 3.3 ± 0.6 METs and therefore is classified as moderate intensity exercise, in accordance with the intensity classifications outlined by the ACSM (2009). In agreement, Graves *et al*., (2010) reported that step aerobics on the Nintendo Wii was moderate intensity among adolescents, young adults and older adults (3.2 ± 0.7, 3.6 ± 0.8 and 3.2 ± 0.8 METs respectively). Although the findings of White *et al*., (2010) refute this. METs in their participants (n = 26) only averaged 2.43 ± .43 METs during Nintendo Wii step and it was therefore concluded that this activity promoting video game could not count as part of physical activity recommendations (White *et al*., 2010).

However, Quinn (2010) found that the energy costs of the free step activity could be exaggerated with the use of a riiser. The riiser being an unofficial Nintendo Wii balance board accessory, which elevates the height of the balance board to that of a conventional step (four inches) (ZooZen, 2009). Compared to Miyachi *et al*., (2010) and White *et al*., (2010) findings, Quinn (2010) reported higher METs for free step using the balance board alone (4.0 ± 0.4 METs), which was significantly less than when accompanying the balance board with a riiser (5.1 ± 0.7 METs). Further still, the height of the balance board was increased beyond the height of a traditional step with the inclusion of two riisers, making the step seven inches tall in total. This again led to a significant increase in METs (6.2 ± 0.5 METs) relative to both the balance board alone and the use of one riiser. Hence, free step with two riisers makes this Nintendo Wii Fit activity vigorous (> 6 METs) in intensity (ACSM, 2009). This is more comparable to the authentic version of step aerobics, which is also vigorous in intensity (8.5 METs) when using a step between six and eight inches in height (Ainsworth *et al*., 2000). Free step from Nintendo Wii Fit Plus was used to examine whether or not this moderate to vigorous exercise (Miyachi *et al*., 2010) could improve immunosurveillance.

1.6 Exergaming and heart rate

Increased heart rate (HR) is another physiological change associated with active but not sedentary video games (Mark & Rhodes, 2009). For example, HR was significantly higher during bowling, tennis and boxing (103 ± 17, 107 ± 15 and 137 ± 25 $b \cdot min^{-1}$ respectively) on Nintendo Wii Sports when referenced to the average HR of 85 ± 12 $b \cdot min^{-1}$ during a sedentary game on the XBOX 360 (Graves *et al.*, 2008b). Later, Willems and Bond (2009a) documented that HR response during 10 minutes of Nintendo Wii boxing (115 $b \cdot min^{-1}$) was similar to that recorded during treadmill

walking for the same amount of time. Given that walking at the speed (6.1 ± 0.6 km·h^{-1}) specified in Willems and Bonds (2009a) study is considered moderate intensity physical activity (Ainsworth *et al*., 2000), the non-significant difference between HR response during treadmill walking and Nintendo Wii boxing confirms that selected active video games are moderate exercise.

Despite the fact that the metabolic demands associated with playing active video games are encouraging (Daley, 2009), there is no parallel between the energy costs of playing active video games compared to participation in the sport itself (Graves *et al.*, 2008a; Graves *et al.*, 2008b; Miyachi *et al.*, 2010). For example, Graves *et al*., (2008b) and Miyachi *et al*., (2010) reported Nintendo Wii Sports boxing as 3.2 ± 1.4 and 4.2 ± 0.9 METs respectively, though actual boxing ranges from 6-12 METs (Ainsworth *et al*., 2000). Therefore, active video games cannot be a substitute for authentic sports (Daley, 2009). Although certain active video games are similar in intensity to some more traditional forms of physical activity, such as walking (Graf *et al*., 2009), skipping and jogging (Maddison *et al*., 2007). Regardless, video games may provide the only opportunity for activity in some cases (Barker, 2005 cited in Brown, 2006) and at least some lower intensity activity is better than none whatsoever (Daley, 2009).

Literature on next generation computer games remains limited (Mark & Rhodes, 2009). Of the studies that do exist, the focus tends to be predominantly on acute physiological responses to gameplay (Mark & Rhodes, 2009). Even though evidence to support that Nintendo Wii gameplay is more physiologically demanding than a sedentary counterpart is accumulating (Penko & Barkley, 2010), research to suggest that the physiological stress induced by exergaming is adequate enough to satisfy physical

activity recommendations remains scarce (Fawkner *et al*., 2010). Only a limited number of studies indicate that active computer games are moderate intensity exercise, depending on the specific exergame (Daley, 2009). Apparently no research has investigated the effect of this potentially new exercise mode on immune function. The purpose of this current research was therefore to address this contemporary research question.

1.7 Immune system

The immune system defends against foreign bodies by recognising, attacking and ultimately destroying them (Gleeson, 2006). In particular, the immune system protects the body from microorganisms that cause diseases (pathogens), including bacteria, protozoa, viruses and fungi (Gleeson, 2006). The immune system comprises of two parts; innate (natural or non-specific) and adaptive (acquired or specific) immunity (Gleeson, 2006). The innate immune system is the first line of defence against a pathogen (Mackinnon, 1999). This is achieved through physical barriers, namely the skin and mucosal membranes, which are responsible for preventing the pathogen from entering the body, chemical barriers, such as pH in the stomach that creates a hostile environment for microbes and finally phagocytic cells that destroy microorganisms (Mackinnon, 1999). Activation of the innate immune system usually initiates a subsequent response from the adaptive immune system (Gleeson, 2006). Both systems therefore interact to produce the optimum immune response (Mackinnon, 1999).

The adaptive immune system responds to specific antigens on a pathogen (Yaqoob & Calder, 2003). Furthermore, unlike the innate immune system, the adaptive immune system produces memory cells following the initial exposure to an antigen, making subsequent exposure to the same antigen quicker and more successful (Mackinnon,

1999). In this instance, the host will not experience any symptoms of illness (Gleeson, 2006). This is because there is no longer the delay of a few days that is evident during the primary immune response, whereby the pathogen is able to access and multiply within the body (Gleeson, 2006). The adaptive immune response is achieved via one of two ways; humoral immunity or immune cells (Mackinnon, 1999). The former is mediated by antibodies or in another word, immunoglobulins (Gleeson, 2006). The effectiveness of immune system can be both hindered and facilitated with exercise participation (Gleeson, 2007).

1.8 Immune function and exercise

Nieman (1994 cited in Bishop, 2006) proposed a J-shaped relationship between exercise intensity and infection risk (Figure 1). This suggests that while moderate exercise reduces the risk of infection below that of a sedentary person, high intensity exercise carries a greater risk of infection than a sedentary lifestyle (Bishop, 2006). Following anecdotal reports (Hardman, 2006), the relationship between heavy exercise and infection risk initially received the greatest attention (Nieman, 2000b). It is therefore well established that heavy exercise increases infection risk (Matthews *et al*., 2002). Since then, there has been more interest into the effect of moderate exercise on infection risk (Bishop, 2006), which has implications for public health (Nieman, 2000b). For example, upper respiratory tract infections (URTIs) are primarily responsible for doctors' visits and absence from work (Matthews *et al*., 2002). Therefore, a better understanding of the association between exercise and URTI is warranted for health promotion (Kostka *et al*., 2000).

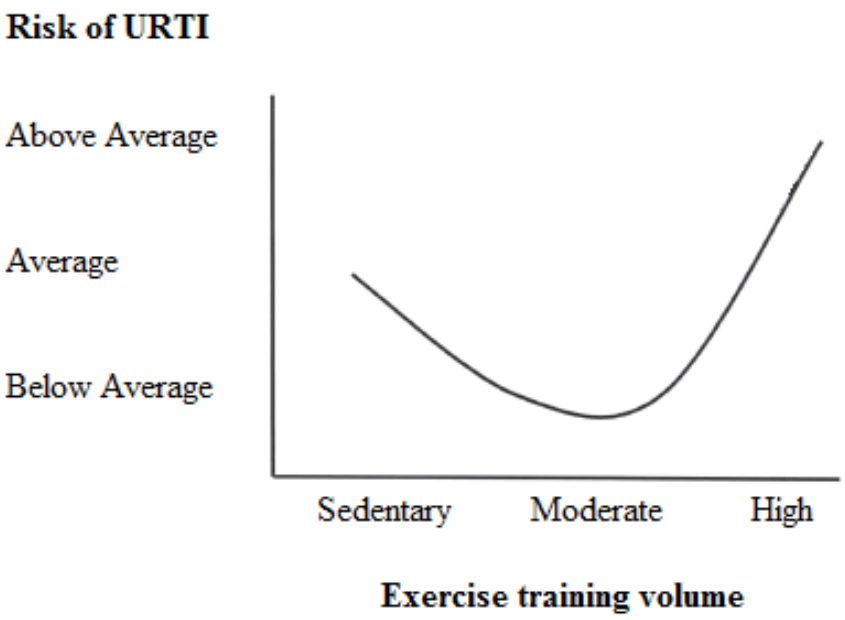


Figure 1. The J-shaped model of the relationship between upper respiratory tract infection (URTI) and exercise volume (Nieman, 1994 cited in Bishop, 2006)

1.9 Moderate exercise and immune function

Although there is still some confusion surrounding the optimal intensity of exercise for health (Lee & Paffenbarger, 2000), studies that corroborate the relationship between moderate exercise and infection risk include Shepard *et al*., (1995), who found that over three quarters of Masters athletes perceived themselves as less susceptible to viral illnesses than their age matched peers. Another more recent survey, reported that among a group of non-elite marathon runners (n = 170), 90% agreed that they seldom get sick (Nieman, 2000 cited in Bishop, 2006). This is because, unlike following prolonged endurance exercise (Nieman, 1997), the immune system is not suppressed as a consequence of moderate exercise (Nieman, 2000b).

Nieman *et al*., (1990 cited in Bishop, 2006) examined the effect of a 15 week exercise programme on illness symptoms in 36 sedentary and overweight females. Compared with a control group, the exercise group experienced fewer days with URTI symptoms

(10.8 ± 2.3 versus 5.1 ± 1.2 days respectively). Whilst this demonstrates that moderate exercise can alleviate the duration of URTIs, Matthews *et al*., (2002) acknowledged that the effect of moderate exercise on the number of URTIs is still vague.

Consequently, Matthews *et al*., (2002) measured the relationship between URTI in 547 healthy adults and their participation in moderate-to-vigorous activity over the course of a year. The results indicated a 20 to 30% reduction in the incidence in URTI with moderate levels of activity when compared to low levels of activity (Matthews *et al*., 2002). Similarly, Kostka *et al*., (2000) identified a significant ($p \leq .05$) negative association ($r = -0.29$) between the number of URTI and moderately intense physical activity among 61 healthy, active and elderly participants. Additionally, the duration of the URTI was significantly ($p \leq .05$) and inversely related ($r = -0.26$) to sports activity (Kostka *et al*., 2000). In contrast, a more recent study failed to recognise a difference in the occurrence of common cold between participants engaged in moderate leisure activity and those who were sedentary (Hemila *et al*., 2003).

Generally, these findings lend some support to the hypothesis that moderate exercise can improve immunity over a sedentary lifestyle (Moreira *et al*., 2009). This is thought to be explained by enhanced 'immunosurveillance', which improves the hosts ability to fight infections (Nieman, 2000b). This may be attributable to an increase in natural killer cell activity (NKCA), a type of lymphocyte that destroys cells infected by virus (Bishop, 2006). For example, Nieman *et al*., (1990 cited in Bishop, 2006) found a 57% increase in NKCA among participants after six weeks of a brisk walking programme (45 minutes, five times per week) compared to only a 3% increase among a control group, which possibly explained the fewer URTI symptom days experienced by the

exercising group. However, Nieman *et al*., (2000) later found that significantly higher NKCA among elite female rowers compared to non-athletes was not related to two month history of URTI. Alternatively, elevations in salivary immunoglobulin A (s-IgA) may account for the suggested lower risk of infection following moderate exercise (Bishop, 2006), as discussed in detail below. Although, more research is needed to better establish whether or not increases in NKCA or s-IgA, with moderate exercise, facilitate immune function (Bishop, 2006).

1.10 Immunogloulin A

Immunoglobulins are a type of glycoprotein that are synthesised by B lymphocytes (Rahimi *et al*., 2010). In particular, immunoglobulin A (IgA) is the primary antibody within mucosal secretions and is therefore largely responsible for pathogen protection at mucosal membranes (Bishop, 2006). IgA is responsible for preventing pathogens from entering the body by averting their attachment and multiplication (Nieman, 1997). An elevation in IgA concentration is therefore thought to aid protection from URTI (Klentrou *et al*., 2002).

Previous research has indicated that moderate exercise increases IgA, which consequently enhances immunity from infection (Mackinnon & Jenkins, 1993 cited in Cieslak *et al.*, 2003). Klentrou *et al*., (2002) for example, found that a 36.5% increase in resting salivary IgA (s-IgA) concentration, as a result of a 12 week moderate exercise program, was significantly related to a reduction in influenza symptoms (r = -0.70, $p \leq$ 0.01) and overall sick days (r = -0.64, $p \leq 0.05$). Likewise, an improvement in mucosal immune function was reported in 45 healthy and elderly participants following a

significant ($p \leq .05$) increase in s-IgA after a year of twice weekly moderate exercise training compared to baseline (33.8 ± 27.2 versus 24.7 ± 14.4 μg/ml respectively) (Akimoto *et al*., 2003).

In contrast, an earlier study by Mackinnon and Jenkins (1993 cited in Akimoto *et al*., 2003) revealed that eight weeks of exercise training did not result in an improvement in s-IgA levels. Some may therefore argue that moderate exercise does not influence s-IgA levels (Mackinnon, 1999). Whilst these discrepancies may be explained by varying methods used to measure IgA (Bishop, 2006), conflicting results certainly exist regarding the effect of exercise on s-IgA concentration (Rahimi *et al*., 2010). In addition, the association between exercise-induced changes in s-IgA and infection risk remains unclear (Rahimi *et al*., 2010), thus justifying the need for further studies to clarify this relationship (Bishop, 2006).

Even though previous research has used s-IgA as an indicator of mucosal immune function (Mackinnon, 1999), Nieman *et al*., (2000) argued that a solitary marker of immune function is unlikely to predict URTI risk in athletes, due to the complexity of the immune system. However, Gleeson *et al*., (1999) reported that pre-season s-IgA concentration, more specifically low s-IgA1 (one of the two subclasses of s-IgA) concentration was related to a greater incidence of URTI during the season in elite swimmers. This supports that s-IgA concentration can be used to predict infection risk in athletes (Gleeson *et al*., 1999), although future research is needed to confirm this (Nieman, 2000b).

1.11 Heavy exercise and immune function

In contrast, a reduction in s-IgA concentration is apparent during heavy exercise (Gleeson, 2000 cited in Gleeson, 2005), with the extent of the decrease dependent on exercise intensity (Mackinnon, 1999). It has not yet been established what mechanisms are accountable for the exercise-induced reduction in mucosal immunoglobulins (Mackinnon, 1999). One possible explanation is that elevated cortisol (described later), which is often associated with heavy exercise (Mackinnon, 1999), suppresses antibody synthesis (Ambrose, 1966 cited in Rahimi *et al.*, 2010), although Fleshner (2000 cited in Rahimi *et al.*, 2010) disagrees. Nevertheless, in this instance, the individual is more susceptible to infection, due to a reduction in the body's natural response (Klentrou *et al*., 2002).

This is a common view among athletes and their coaches, who believe they are more vulnerable to infection when participating in intense training (Fitzgerald, 1991 cited in Mackinnon, 1999). Several studies support that intense exercise performed at least every day is related to a reduction in s-IgA, which may explain the higher rate of URTI among athletes (Mackinnon, 1999). For instance, Mackinnon *et al*., (1993 cited in Nieman, 1997) reported low concentrations of IgA in elite hockey and squash players after exercise, leading to URTI.

In addition to a reduction in s-IgA, many other negative changes, such as a decrease in NKCA and T and B cell function following heavy exercise (Nieman, 1997) are assumed to be responsible for the increased incidence of URTI among athletes (Bishop, 2006). These changes in immunity may persist anywhere from three hours up to three days

post exercise, depending on the specific immune measure (Nieman, 2000a; Nieman, 2000b). During this time, often referred to as an 'open window', the suppression of host defence mechanisms allows an opportunity for viruses and bacteria to enter the body, thereby increasing the risk of infection (Hoffman-Goetz & Pedersen, 1994 cited in Nieman, 1997; Nieman, 2000b).

1.12 Cortisol

Cortisol is a steroid hormone secreted by the adrenal glands, a process that is controlled by the production of adrenocorticotrophic hormone from the pituitary gland in the brain (Frayn & Akanji, 2003). Cortisol is a marker for stress (Brenner *et al*., 1998 cited in Cieslak *et al.*, 2003) and has been associated with a reduction in immune function (Cieslak *et al*., 2003), possibly due to the significant link between elevated cortisol concentration and reduced s-IgA (Hucklebridge *et al*., 1998). For example, significant ($p = 0.03$) increases in cortisol levels following a swim test (five 400 meter laps at 85 ± 1.2 % of their personal best that season) was accompanied by a decline, although not significantly ($p = 0.06$), in IgA secretion rate (Dimitriou *et al*., 2002). However, Farzanaki *et al*., (2008) found that whilst routine training in young elite female gymnasts led to a significant increase in cortisol after two sessions, s-IgA was unchanged and did not correlate with cortisol concentration.

Typically, cortisol is only produced during rigorous exercise (Mackinnon, 1999). For example, Jacks *et al*., (2002) identified a significant ($p \leq .01$) increase in participants (n = 10) salivary cortisol concentration following intense (76.0 ± 6.0% $\dot{V}O_{2max}$) cycling comparative to rest, whilst the same exercise at low (44.5 ± 5.5% $\dot{V}O_{2max}$) and moderate

(62.3 ± 3.8% $\dot{V}O_{2max}$) intensities demonstrated no significant difference in salivary cortisol concentration. Therefore, in summary, given that cortisol is immunosuppressive (Cieslak *et al*., 2003) and that increased cortisol is only apparent during intense exercise (Jacks *et al*., 2002), it seems reasonable to suggest that this is one explanation as to why heavily exercising individuals are at more risk of infection than those who are moderately active, as illustrated by Nieman's (1994 cited in Bishop, 2006) J-shaped model of the relationship between URTI and exercise volume.

The purpose of this study was to investigate stress (measured by salivary cortisol) and immune response (assessed using s-IgA) to moderate exercise among participants with varying levels of cardiorespiratory fitness. Unlike any other previous research however, the mode of exercise was next generation active computer games. Furthermore, changes in physiological responses to regular participation in next generation active computer games were also investigated. It was hypothesised, based on previous literature, that the moderate exercise intervention would not affect cortisol concentration, but would enhance participants' immune function, as indicated by a significant increase in s-IgA. Furthermore, given that the extent to which exercise effects immune function is governed by fitness, with more sedentary individuals experiencing the greater benefit (Nehlsen-Cannarella *et al*., 1991 cited in Akimoto *et al.*, 2003), this was thought to be true among the lower fitness individuals relative to the higher fitness group in the current study.

2. METHOD

2.1 Participants

Thirteen females and four male participants were recruited via global e-mail, poster (Appendix 1) and word of mouth in the months of May and June 2010. Informed written consent (Appendix 2) was obtained from each participant after they had read an information sheet (Appendix 3). Estimated $\dot{V}O_{2max}$ was determined using the Åstrand-Ryhming (1954 cited in ACSM, 2009) cycle ergometer test (described below) and was used to separate participants into two groups, each with a minimum of seven participants, as recognised using Schoenfeld's (2010) power calculation (Appendix 4). Group one had an estimated $\dot{V}O_{2max}$ considered fair or below (referred to as the fair fitness group for convenience) and the second group had an estimated $\dot{V}O_{2max}$ deemed equal to or above good (labelled as the good fitness group hereafter), based on age and gender (ACSM, 2009). Participant characteristics are displayed in Table 1.

Table 1. Participant characteristics by estimated $\dot{V}O_{2max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$)

	Fair Fitness Group (n = 9)		**Good Fitness Group (n = 8)**	
	Mean	± SD	Mean	± SD
Age (yrs)	42	± 13	34	± 14
Mass (kg)	76	± 9	64*	± 5
Stature (cm)	164	± 9	163	± 5
Body Fat (%)	37	± 15	28	± 13
Body Mass Index ($kg \cdot m^2$)	28	± 5	24	± 2
Systolic Blood Pressure (mmHg)	126	± 12	119	± 11
Diastolic Blood Pressure (mmHg)	85	± 9	77	± 10
Estimated $\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	32	± 6	46*	± 6

* Significantly different ($p \leq .05$) from the fair fitness group (independent t-test) (Appendix 5)

An ethics form (Appendix 6) and risk assessment (Appendix 7) were submitted to the Ethics Committee of the school of Psychology at the university of Central Lancashire (UCLan), who provided ethical clearance.

2.2 Design

The study was a crossover design, whereby participants acted as their own controls. The order in which participants completed the exercise intervention (four-week Nintendo Wii programme) and the control condition was randomised according to participants' availability. A two-week washout period between the conditions was employed to allow all measures to return to baseline, thus preventing the effect of the previous condition confounding the results of the subsequent condition.

2.3 Procedure

Inclusion in the study depended on the outcome of a basic health screen. This involved satisfying a Physical Activity Readiness Questionnaire (Canadian Society for Exercise Physiology, 2002) or PAR-Q (Appendix 8). Eligibility was also subject to the absence of contraindicative blood pressure. Participants were excluded if their resting systolic blood pressure (SBP) was equal to or above 200 mmHg or diastolic blood pressure (DBP) was equal to or exceeding 115 mmHg (ACSM, 1995 cited in Howley & Franks, 1997). Blood pressure was assessed twice using a digital blood pressure machine (BoSo Medicus, Germany), following a minimum of five minutes seated rest, as advised by the National High Blood Pressure Education Program (2004).

2.3.1 Anthropometry and body composition

Stature (cm) was measured to within one millimetre using a free-standing stadiometer (Seca, Birmingham). Body mass was determined using integrated digital scales (accurate to 0.01 of a kilogram) contained in the BodPod air displacement plethysmography system. These scales were calibrated for accuracy using a series of

known masses. Fat and fat-free body mass were determined using the BodPod air displacement plethysmography system (Life Measurement, Inc, USA). In preparation for this test, participants were asked to wear either a swimming costume or other tight fitting clothing, remove all jewellery and wear a swim cap. Participants sat inside the calibrated BodPod and three tests, approximately 40 seconds in duration, were conducted. The BodPod measures body volume and uses body mass to calculate body density, which is then entered into the Siri equation to ultimately decipher body composition (Howley & Franks, 1997).

2.3.2 Aerobic Fitness

Aerobic fitness was assessed using the Åstrand-Ryhming (1954 cited in ACSM, 2009) cycle ergometer test. Participants used an appropriately adjusted Monark 834E cycle ergometer (Monark, Sweden). An individual and constant work rate was selected based on participants' fitness and age; the former being indicated by an International Physical Activity Questionnaire (IPAQ, 2002) (Appendix 9). Participants cycled at around 50 revolutions per minute for six minutes. In the 5th and final minute, an Onyx® 9500 fingertip pulse oximeter (Nonin Medical, Inc, USA) was used to record heart rate ($b \cdot min^{-1}$). Average heart rate was referred to a nomogram to estimate $\dot{V}O_{2max}$ (Astrand-Ryhming, 1954 cited in ACSM, 2009), which was adjusted for body mass (Adams, 2002) and corrected for age (Astrand, 1960 cited in Adams, 2002).

2.3.3 Saliva samples

Unstimulated, whole saliva samples were collected by passively drooling through a two inch straw into a 2mL safeseal polypropylene microtube (Sarstedt, Germany) for five

minutes, as instructed by Salimetrics (2009) (Appendix 10). To minimise sample contamination, participants were encouraged not to consume food or drink for a minimum of 30 minutes prior to collection and were also asked to rinse their mouth with distilled water (Chiappin *et al*., 2007). Each sample was dated and labelled with the time taken to collect the sample. The samples were immediately frozen at -25°C (Lec, UK). S-IgA concentration was measured using an enzyme immunoassay (Demeditec Diagnostics, Germany).

All saliva analysis was completed within the guidelines outlined in a CoSHH risk assessment (Appendix 11). Reagents and the plate were brought to room temperature. Saliva samples were thawed and centrifuged at 3000 rpm for five minutes using a MSE Micro Centaur (Sanyo, UK). Scales (Denver Instrument, Germany) were used to weigh the saliva samples to determine their volume (1ml of saliva = 0.9672g). This was then used to compute flow rate, since this influences s-IgA concentration (Kegler *et al*., 1992; Vining *et al*., 1983 cited in Salimetrics, 2009). Specifically, flow rate (ml/min) was calculated (Appendix 12) by dividing the volume (ml) of saliva by the time (minutes) taken to collect the sample (Mackinnon & Jenkins, 1993 cited in Akimoto *et al*., 2003).

With the aid of an automated work station (PerkinElmer Precisely, USA), 190 µl of red EIA buffer was pipetted into the wells corresponding to the unknown samples (Appendix 13). Ten µl of the unknown samples, which had been diluted with EIA buffer (10µl of saliva to 1ml of EIA buffer) were then added, whilst 100 µl of the calibrators and controls were pipetted into the appropriate wells. All samples were assayed in duplicate. The assay was incubated at 31°C for 1.5 hours. A plate washer

(BioTek, USA) washed the plate three times with washing solution concentrate that had been diluted (21 fold) with distilled water. Conjugate (100 µl) was added to every well and the plate was then incubated again at 31°C, but for 0.5 hours this time. The plate was washed five more times before 100 µl of substrate solution was dispensed. After a third and final incubation period of 0.25 hours at room temperature, 100 µl of stop solution was added. Optical density was then measured immediately at 450 nm using a multilabel plate reader (PerkinElmer Precisely, USA). Using WorkOut 2.5 software (Dazdaq, UK), the concentration of IgA in the unknown samples were interpolated from a standard curve (Figure 2). Before statistical analysis, these absolute concentrations were exported into Microsoft Office Excel 2007 and multiplied by saliva flow rate to provide IgA secretion rate ($\mu g \cdot min^{-1}$), a more reliable measure than just absolute s-IgA concentration (Mackinnon, 1999).

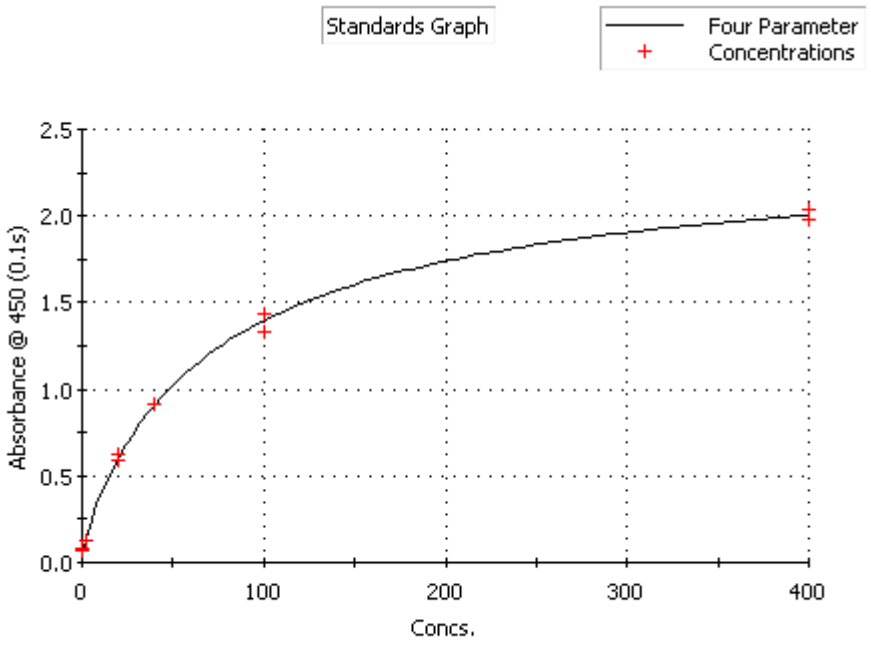


Figure 2. A typical example of an s-IgA standard curve

Participants were also required to provide six oral swabs (Sarstedt, Germany), one immediately before and after both the first and final session of the exercise intervention and pre and post the control condition. Where possible, samples were taken at the same time of day to control for diurnal variation in hormone concentration (Farzanaki *et al.*, 2008). Participants positioned the salivette under their tongue for one minute (Salimetrics, 2009). The salivette was subsequently labelled and frozen at -25°C, before being assayed in duplicate to measure cortisol concentration. Cortisol was measured using saliva samples as opposed to the traditional method of intravenous blood samples (Lumley *et al*., 1995 cited in Dimitriou *et al.*, 2002), since the anxiety associated with the latter can influence blood cortisol concentration (Vining *et al*., 1983 cited in Jacks *et al.*, 2002). Furthermore, compared to blood serum, saliva provides a more precise measure of biologically available (unbound) cortisol (Vining *et al*., 1983 cited in Rudolph & McAuley, 1998).

Samples were thawed and centrifuge at 6000 rpm for 10 minutes using a MSE Harrier 18/80 centrifuge (Sanyo, UK). Once the plate and reagents were to room temperature, 25 µl of standards, controls and unknowns were pipetted by an automated work station (PerkinElmer Precisely, USA) into the appropriate wells (Appendix 14). Next, 25 µl of assay diluent was added to the zero and NSB wells only. To each well, 200 µl of diluted conjugate (15 µl of conjugate and 24ml assay diluent) was then added. A microplate spectrophotometer (SPECTRAmax PLUS) was used to mix the plate, before being incubated for 55 minutes at room temperature. A plate washer (BioTek, USA) then washed the plate four times with wash buffer concentrate that had been diluted ten times with distilled water. TMB substrate solution (200 µl) was dispensed into each well and following mixing, the plate was then left to incubate for another 25 minutes at room

temperature. Finally, 50 µl of stop solution was added and the plate mixed before a plate reader (PerkinElmer Precisely, USA) at 450nm determined the optical density of individual wells. Cortisol concentration in the unknown samples were again interpolated from a standard curve (Figure 3) generated in WorkOut 2.5 (Dazdaq, UK) and data was then exported into Microsoft Office Excel 2007. It was not necessary to calculate saliva flow rate since this does not influence cortisol concentration (Riad-Fahmy *et al.*, 1983 cited in Rudolph & McAuley, 1998).

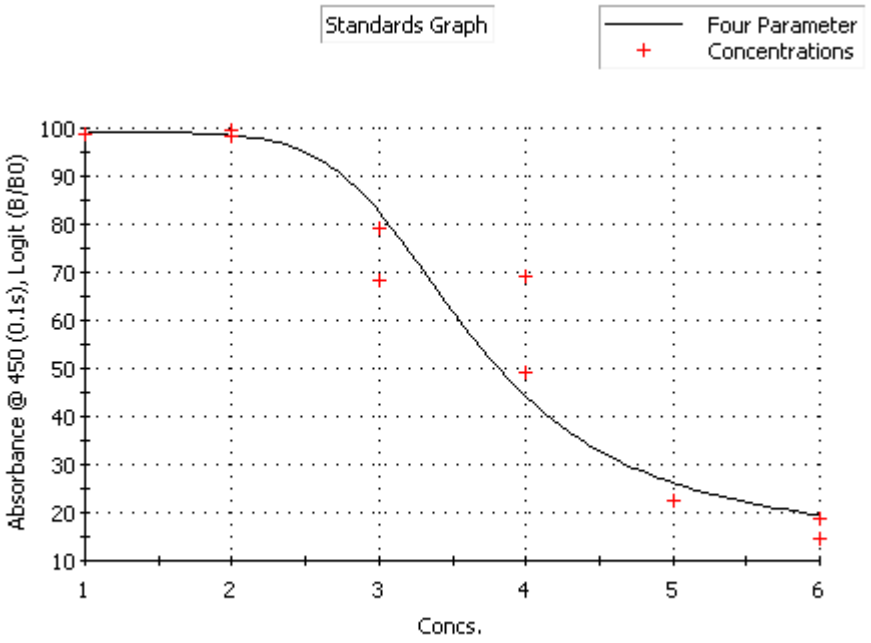


Figure 3. Typical example of a cortisol standard curve

2.3.4 Exercise intervention

The intervention was an exercise programme using the Nintendo Wii (Nintendo® Co, Ltd, Japan). Participants attended the physiology laboratory at UCLan for three sessions every week for four consecutive weeks. Only those participants with an 80% or above attendance rate (Appendix 15) were included in the analysis. Each session consisted of

30 minutes of free stepping on the Wii Fit Plus game, including a five minute warm-up and cool-down, concluding with optional stretches, as recommended by the ACSM (2009). The usually one inch Nintendo Wii Fit balance board was elevated a further six inches with the use of two Wii riisers (ZooZen Ltd, Hong Kong), thus exceeding the height of a conventional four inch step (ZooZen, 2009). Quinn (2010) established that compared to the balance board alone or the use of a single Wii riiser, using two Wii riisers significantly increases the energy costs of free step on Nintendo Wii Fit Plus (4.0 ± 0.4, 5.1 ± 0.7 and 6.2 ± 0.5 METs respectively). Measures of blood pressure, body composition, cardiorespiratory fitness and saliva were taken at the start of the exercise intervention and repeated once the exercise intervention was completed.

A two week washout period was imposed, before participants 'crossed over' from the exercise intervention into the control condition. This consisted of no Nintendo Wii exercise programme but the continuation of their normal physical activities. As with the exercise intervention, at the start and end of the four week control period, blood pressure, body composition, cardiorespiratory fitness and saliva were assessed.

2.3.5 Cardiorespiratory response during the exercise

During the first and last session of the exercise intervention, a MetaLyzer® 3B (CORTEX Biophysik, Germany) was used for breath-by-breath analysis of oxygen consumption ($\dot{V}O_2$) and other respiratory variables. Data was averaged over one minute epochs in the MetaSoft software and exported into Microsoft Office Excel 2007. EE ($J \cdot kg^{-1} \cdot min^{-1}$) was calculated from $\dot{V}O_2$ since 1L of oxygen is equivalent to 4.9 kcal and 1J is the same as 0.000239 kcal (McArdle *et al*., 1996 cited in White *et al.*, 2010). To

calibrate the MetaLyzer 3B, pressure from the laboratory barometer was manually entered. The gas sensors were calibrated with ambient air first and then a known concentration (5.09% CO_2 and 14.46% O_2) of calibration gas (Boc Limited, Germany). The pneumotach was calibrated using a three litre syringe (Hans Rudolf, Inc, USA). After successful calibration, participants were asked to wear an appropriately sized face mask (Hans Rudolf, Inc, USA) and accompanying head cap. A Polar transmitter (Polar, Finland) was placed inferiorly to the xiphosternal joint to detect HR. Conduction gel was used to aid recording. The complete exercise intervention equipment set-up is shown in Figure 4.

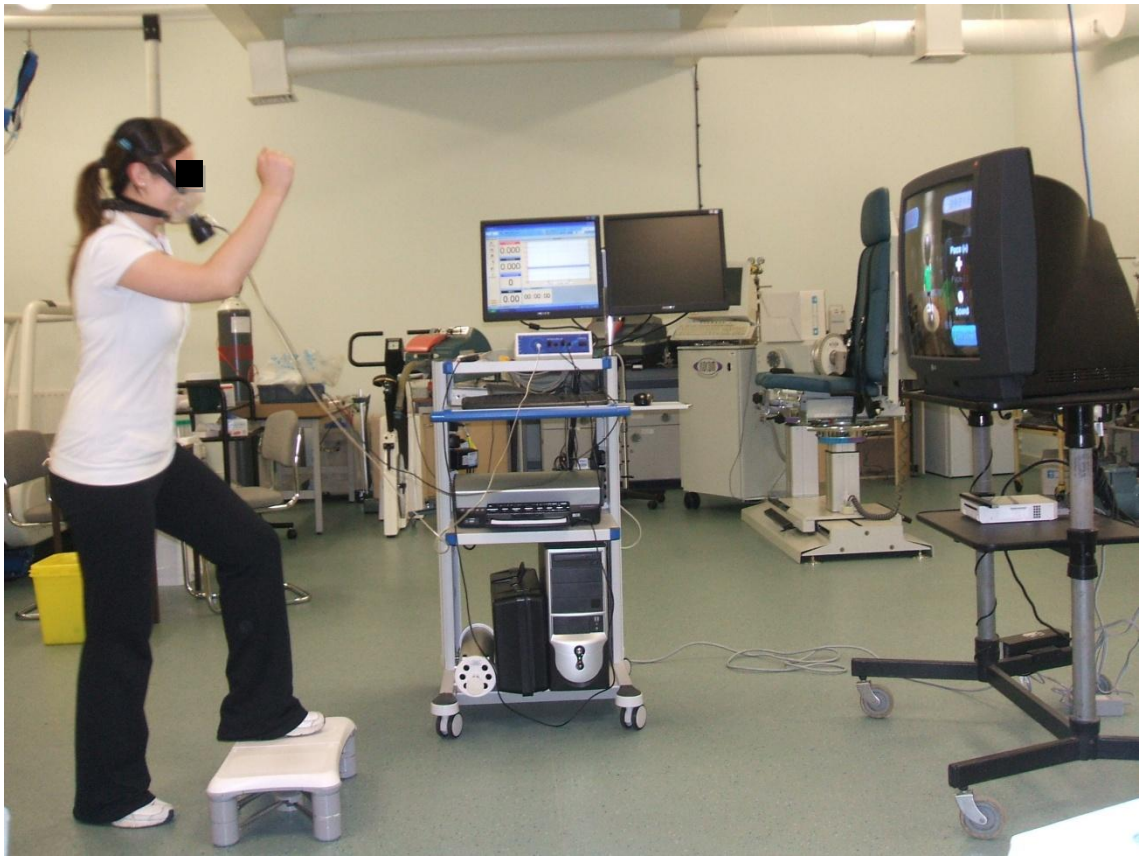


Figure 4. Example of a participant free stepping on the Nintendo Wii balance board and riisers, whilst wearing a face mask connected by a sample line to the MetaLyzer 3B.

2.4 Analysis

Results are presented as means and standard deviations. Kolmogrov-Smirnov tests were conducted to check if the data was normally distributed. Paired samples t-tests were then performed to test significant differences between pre and post both the exercise and control condition (Appendix 16) and also between baseline and post washout (Appendix 17) using PASW Statistics 18 (SPSS, UK). A priori t-tests were deemed appropriate as multiple post-hoc t-tests would be required anyway following an ANOVA, since there were only two means in each factor. Alpha level was set to $p \leq 0.05$. Effect size (Cohen's d) was also estimated (Kinnear & Gray, 2009) (Appendix 18). Where appropriate, an approximation of the magnitude of effect (Thomas & Nelson, 1996) was also calculated (Appendix 19).

3. RESULTS

The flow diagram in Figure 5 depicts participants compliance through all stages of the study, as recommended by the CONSORT Statement (Schulz *et al.*, 2010).

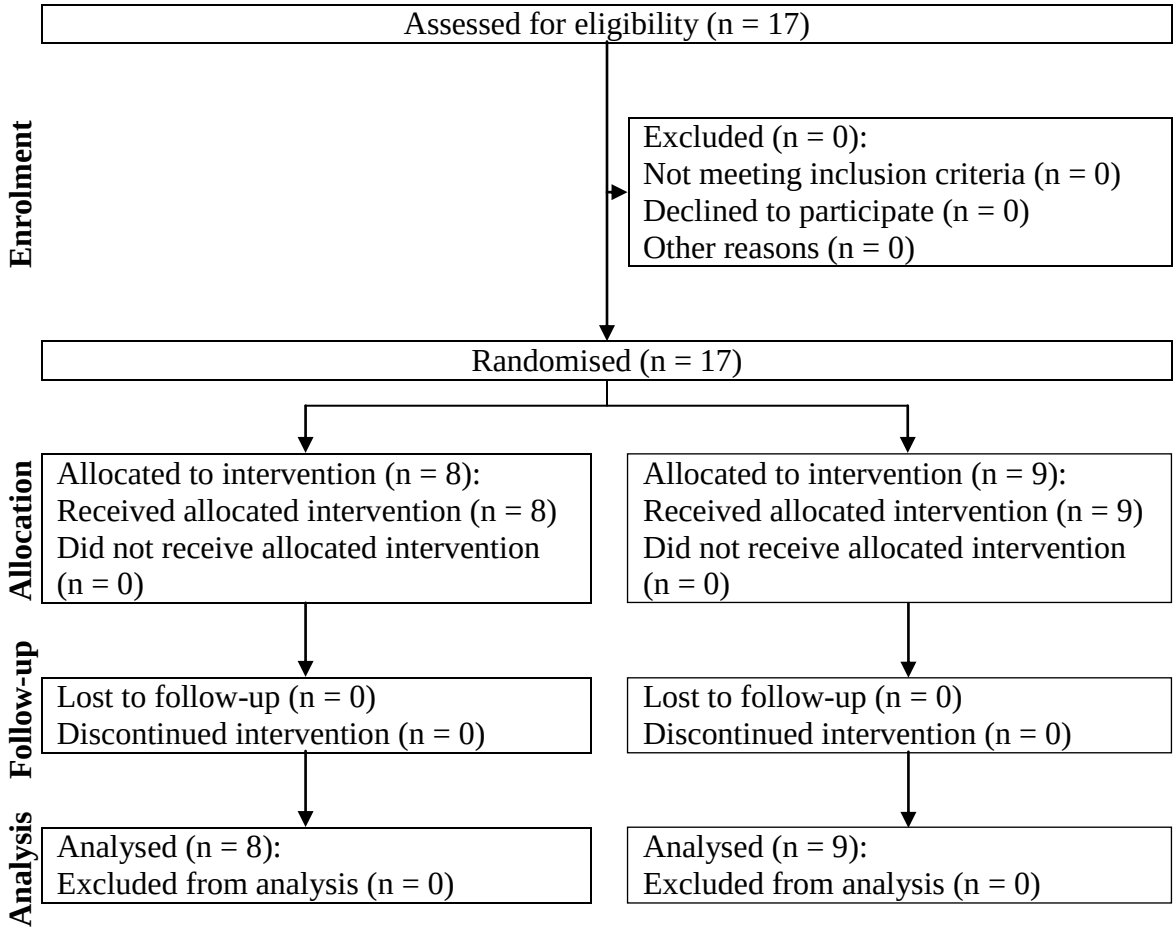
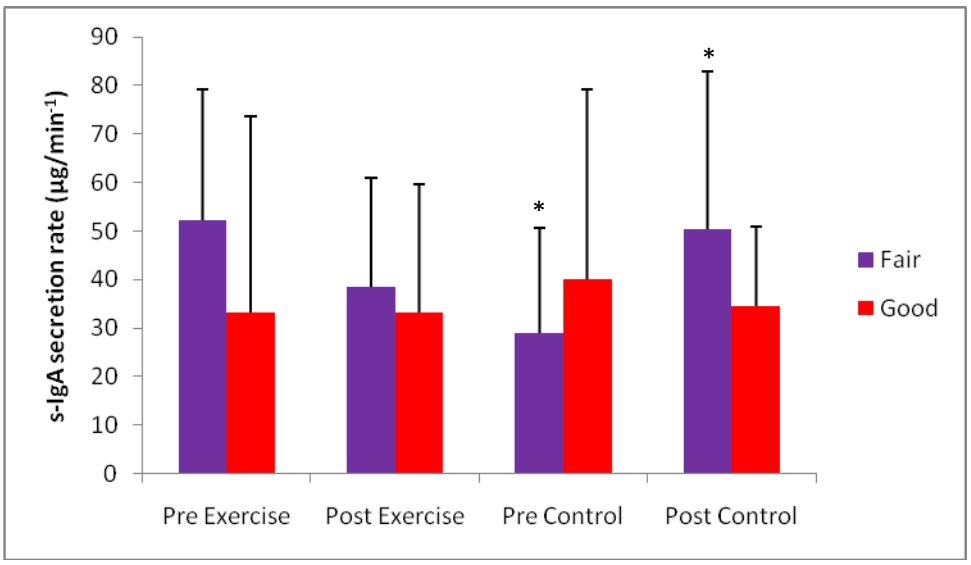


Figure 5. Flow diagram of the two fitness groups progressing through the phases of the parallel randomised trial (Schulz *et al.*, 2010)

3.1 Effect of the exercise intervention on resting s-IgA secretion rate

There was no significant ($t_{(8)} = 1.547$, $p = .161$, d = 0.5) difference in s-IgA secretion rate in the exercise condition for the fair fitness group (Figure 6). However, an approximation of the magnitude of the effect (Thomas & Nelson, 1996) revealed that there was a 26% reduction in s-IgA secretion rate (although not significant). In contrast, an increase in s-IgA secretion rate was significant ($t_{(7)} = -3.052$, $p \leq .05$, d = 1.1) in the control condition for the fair fitness group (Figure 6).



* Significantly ($p \leq .05$) different

Figure 6. S-IgA secretion rate (µg/min^{-1}) of the fair (n = 9) and good (n = 8) fitness groups pre and post both the exercise and control condition

S-IgA secretion rate did not alter in the exercise condition and was therefore not significantly ($t_{(7)} = .008$, $p = .994$, d = 0.0) different for people with a good level of fitness (Figure 6). Whilst there was a 14% reduction in s-IgA secretion rate in the control condition (Figure 6) for the good fitness group, this was not significant ($t_{(7)} = .486$, $p = .642$, d = 0.2).

3.2 Effect of the exercise intervention on resting cortisol concentration

Resting cortisol concentration did not change significantly in either the exercise ($t_{(6)} = -1.408$, $p = .209$, d = 0.5) or control ($t_{(6)} = -2.024$, $p = .089$, d = 0.8) condition for the fair fitness group (Figure 7), despite an increase of 15% and 10% respectively.

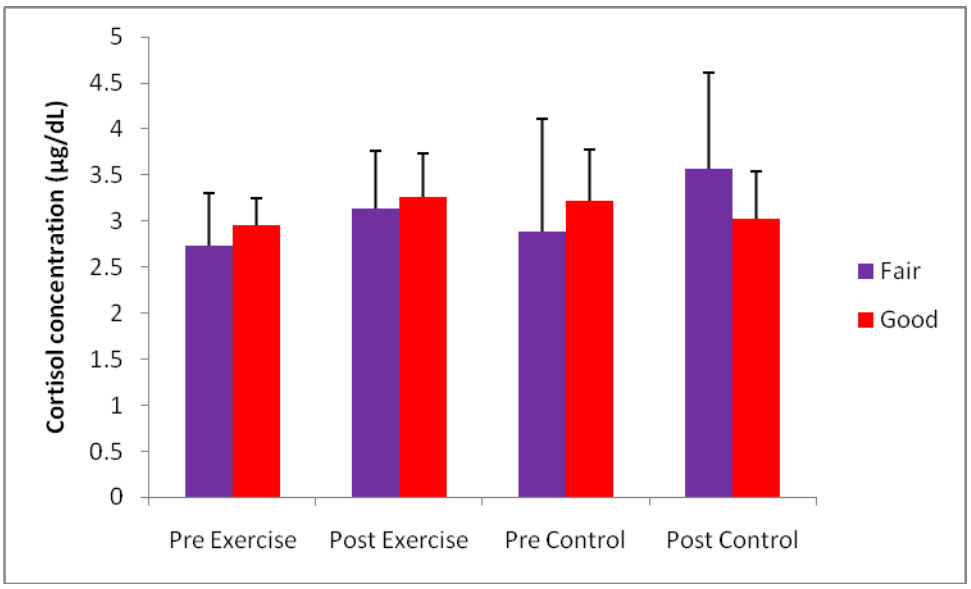


Figure 7. Cortisol concentration (µg/dL) of the fair (n = 9) and good (n = 8) fitness groups pre and post both the exercise and control condition

The good fitness group experienced a 10% increase in resting cortisol concentration in the exercise condition and a 6% decrease in the control condition (Figure 7). Even so, these changes were not significant ($t_{(6)} = -2.404$, $p = .053$, $d = 0.9$ and $t_{(6)} = .938$, $p = .385$, $d = 0.4$ correspondingly).

3.3 Effect of an acute bout of exercise on cortisol concentration

In the initial exercise session, the fair group had a significant ($t_{(6)} = -2.440$, $p \leq .05$, $d = 0.9$) increase in cortisol concentration from the start (2.73 ± .57 µg/dL) to the end (3.20 ± .41 µg/dL). Contrary, during their final exercise session, cortisol concentration reduced by 11% from the start (3.32 ± .60 µg/dL) compared to after (2.94 ± .51 µg/dL), but this was not a significant ($t_{(5)} = 1.980$, $p = .105$, $d = 0.8$) difference.

For the good fitness group, cortisol concentration increased by 4% from before (2.96 ± .28 µg/dL) compared to after (3.07 ± .19 µg/dL) their first exercise bout, which was not significantly ($t_{(6)} = -.979$, $p = .365$,

d = 0.4) different. Likewise, a negligible 1% decrease in cortisol concentration before (3.26 ± .48 µg/dL) and after (3.23 ± .36 µg/dL) their last exercise session was not significant ($t_{(6)} = .275$, $p = .792$, d = 0.1).

3.4 Health screen

There were no significant changes in any of the parameters measured as part of the health screen in either the exercise or control condition for the fair fitness group (Table 2). Though a 6% decrease in fat % ($t_{(7)} = 2.241$, $p = .06$, d = 0.8) and a 3% increase in fat free % ($t_{(7)} = -2.241$, $p = .06$, d = 0.8) were almost significant. As well as a 17% increase in estimated $\dot{V}O_2$ in the exercise condition ($t_{(8)} = -2.173$, $p = .06$, d = 0.7).

Table 2. Health screen for the fair fitness group (n = 9)

	Exercise		**Control**	
	Pre	**Post**	**Pre**	**Post**
SBP (mmHg)	126 ± 11	123 ± 13	124 ± 12	126 ± 11
DBP (mmHg)	85 ± 8	86 ± 10	85 ± 11	86 ± 6
Fat (%)	35 ± 15	33 ± 14	33 ± 16	34 ± 16
Fat Free (%)	65 ± 15	67 ± 14	67 ± 16	63 ± 18
Mass (kg)	76 ± 9	77 ± 9	76 ± 10	76 ± 9
Estimated $\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	29 ± 6	34 ± 10	42 ± 17	36 ± 10
IPAQ	1 ± .05	2 ± .78	2 ± .71	2 ± .60

Note: SBP = systolic blood pressure, DBP = diastolic blood pressure and IPAQ = international physical activity questionnaire (1, Low; 2, Moderate; 3, High physical activity)

In contrast, the good fitness group had a significant decrease in SBP in both the exercise ($t_{(7)} = 2.681$, $p \leq .05$, d = 0.9) and control ($t_{(7)} = 2.521$, $p \leq .05$, d = 0.9) condition (Table 3). They also had a significant ($t_{(7)} = 2.785$, $p \leq .05$, d = 1.0) reduction in DBP in the control condition. Furthermore, estimated $\dot{V}O_{2max}$ was significantly ($t_{(7)} = -2.549$, $p \leq .05$, d = 0.9) improved as a consequence of exercise. There were no significant differences in any of the other measures.

Table 3. Health screen for the good fitness group (n = 8)

	Exercise		Control	
	Pre	**Post**	**Pre**	**Post**
SBP (mmHg)	119 ± 11	109 ± 7*	119 ± 8	112 ± 8#
DBP (mmHg)	77 ± 10	72 ± 5	82 ± 4	74 ± 9#
Fat (%)	28 ± 13	28 ± 11	27 ± 12	27 ± 12
Fat Free (%)	72 ± 13	72 ± 11	73 ± 12	73 ± 12
Mass (kg)	64 ± 6	64 ± 6	63 ± 6	63 ± 6
Estimated $\dot{V}O_{2max}$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	43 ± 6	57 ± 15*	50 ± 9	56 ± 12
IPAQ	3 ± .53	2 ± .52	2 ± .35	2 ± .89

Note: SBP = systolic blood pressure, DBP = diastolic blood pressure and IPAQ = international physical activity questionnaire (1, Low; 2, Moderate; 3, High physical activity)
*, # Significantly different ($p \leq .05$) from pre exercise and pre control respectively

3.5 Cardiorespiratory responses to exercise

There were no significant differences in METs, HR, relative $\dot{V}O_2$ or EE at rest for either the fair (Table 4) or good (Table 5) fitness group. In the exercise condition however, METs, HR, relative $\dot{V}O_2$ and EE did significantly ($t_{(8)} = 3.622$, $p \leq .01$, d = 1.2; $t_{(8)} = 3.420$, $p \leq .01$, d = 1.1; $t_{(8)} = 3.511$, $p \leq .01$, d = 1.2 and $t_{(8)} = 3.653$, $p \leq .01$, d = 1.2 respectively) decrease in the fair fitness group.

Table 4. Mean (± SD) metabolic equivalents (METs), heart rate (HR), relative oxygen consumption (relative $\dot{V}O_2$) and energy expenditure (EE) at rest and during exercise at the start and end the exercise intervention for the fair fitness group (n = 9)

	Rest		Exercise	
	Pre	**Post**	**Pre**	**Post**
METs	0.79 ± 0.42	0.97 ± 0.84	4.82 ± 0.74	3.94 ± 0.64*
HR ($b \cdot min^{-1}$)	75 ± 9	68 ± 6	126 ± 12	114 ± 15*
Relative $\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	2.6 ± 1.7	2.2 ± 0.9	16.8 ± 2.7	13.8 ± 2.3*
EE ($J \cdot kg^{-1} \cdot min^{-1}$)	56 ± 30	49 ± 14	336 ± 41	276 ± 33*

*Significantly different ($p \leq .05$) from pre exercise

The effects of exercise on METs, HR, relative $\dot{V}O_2$ and EE were not significantly different in the good fitness group (Table 5). However, both METs and relative $\dot{V}O_2$ were approaching significance ($t_{(7)} = 2.075$, $p = .077$, d = 0.7 and $t_{(7)} = 2.254$, $p = .059$, d = 0.8 respectively).

Table 5. Mean (± SD) metabolic equivalents (METs), heart rate (HR), relative oxygen consumption (relative $\dot{V}O_2$) and energy expenditure (EE) at rest and during exercise at the start and end the exercise intervention for the good fitness group (n = 8)

	Rest		Exercise	
	Pre	**Post**	**Pre**	**Post**
METs	1.28 ± 0.77	0.93 ± 0.16	5.04 ± 1.11	4.32 ± 1.04
HR ($b \cdot min^{-1}$)	76 ± 12	71 ± 5	117 ± 16	110 ± 9
Relative $\dot{V}O_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	4.4 ± 2.6	3.4 ± 1.2	17.8 ± 3.8	15.1 ± 3.7
EE ($J \cdot kg^{-1} \cdot min^{-1}$)	93 ± 55	66 ± 34	361 ± 77	316 ± 76

There was no significant difference in measures taken at baseline compared to at the end of the washout period, irrespective of the order in which the conditions were completed, with the exception of estimated $\dot{V}O_2$ when the exercise condition was completed prior to the control condition (Table 6).

Table 6. Paired samples t-tests between participants pre-exercise and post-washout measures by order of conditions (those that did the exercise then control condition and vice versa)

	Exercise Condition 1st	**Control Condition 1st**
S-IgA secretion rate (µg/min^{-1})	$t_{(7)} = 1.28$, $p = .24$	$t_{(7)} = .25$, $p = .81$
Cortisol concentration (µg/dL)	$t_{(4)} = -1.26$, $p = .28$	$t_{(6)} = .20$, $p = .85$
SBP (mmHg)	$t_{(8)} = 1.23$, $p = .26$	$t_{(7)} = -.49$, $p = .64$
DBP (mmHg)	$t_{(8)} = 1.17$, $p = .28$	$t_{(7)} = -1.28$, $p = .24$
Fat (%)	$t_{(6)} = 1.03$, $p = .34$	$t_{(5)} = .42$, $p = .69$
Fat Free (%)	$t_{(6)} = -1.03$, $p = .34$	$t_{(5)} = -.39$, $p = .71$
Mass (kg)	$t_{(7)} = .70$, $p = .51$	$t_{(5)} = 1.81$, $p = .13$
Estimated $\dot{V}O_{2max}$ (ml·kg^{-1}·min^{-1})	$t_{(7)} = -3.65$, $p \leq .01$*	$t_{(7)} = -.95$, $p = .37$
IPAQ	$t_{(7)} = -.36$, $p = .73$	$t_{(7)} = 1.00$, $p = .35$

Note: s-IgA = salivary immunoglobulin A, SBP = systolic blood pressure, DBP = diastolic blood pressure and IPAQ = international physical activity questionnaire

*Significantly different ($p \leq .01$) from pre-exercise to post-washout

4. DISCUSSION

The primary purpose of this study was to investigate stress and immune response to a four week Nintendo Wii step aerobics programme. The hypothesis that the Wii exercise sessions would not alter cortisol concentration was rejected, although measures of resting cortisol concentration would support this. S-IgA was expected to increase significantly in the exercise condition, consequently indicating an improvement in immune function. This was thought to be more pronounced in the fair fitness group relative to those with a good level of fitness. The hypothesis was again rejected, as the Nintendo Wii exercise programme did not significantly increase s-IgA in either fitness group. In fact, exercise had the opposite effect for the fair fitness group (s-IgA declined), although this was not significant statistically, whilst s-IgA remained unchanged in the good fitness group.

4.1 Resting s-IgA

Since there were no significant changes in s-IgA in either fitness group following the exercise intervention, this contradicts the findings of previous research. For example, Akimoto *et al*., (2003) found that s-IgA significantly increased after exercise twice a week for four and 12 months (33.8 ± 27.2 µg/min^{-1} and 46.5 ± 35.1 µg/min^{-1} respectively) compared to baseline (29.5 ± 26.0 µg/min^{-1}). Furthermore, Klentrou *et al*., (2002) witnessed a significant increase in s-IgA from 237.3 ± 61.2 ml·l^{-1} to 373.5 ± 81.1 ml·l^{-1} following 12 weeks of moderate exercise, which was accompanied by significantly less influenza symptoms.

The results do however agree with McDowell *et al*., (1991 cited in Rahimi *et al.*, 2010) and Nehlsen-Cannarella *et al*., (2000 cited in Rahimi *et al.*, 2010). Likewise,

Mackinnon and Jenkins (1993 cited in Akimoto *et al.*, 2003) also reported no significant difference in s-IgA following two months of interval training. Akimoto *et al*., (2003) later suggested that the duration of Mackinnon and Jenkins (1993 cited in Akimoto *et al.*, 2003) study may not have been adequate enough to significantly alter s-IgA. This may also explain why s-IgA was not significantly changed in the current study, whereby only a four week exercise intervention was employed, though further research would be needed to confirm this. Whilst moderate exercise is proposed to improve immunosurviellence (Nieman, 2000b), these results may support that moderate exercise rarely influences immune function (Bishop, 2006). However, exercise in the fair fitness group did cause a 26% reduction in s-IgA concentration, albeit non-significantly. This unexpected finding may be explained when the results for cortisol are considered (see below).

In the control condition, there was an unpredicted significant increase in s-IgA in the participants with a fair level of fitness. The IPAQ scores during the control condition indicated that the fair fitness group were still moderately active in spite of no Nintendo Wii exercise. In this instance, the significant increase in s-IgA would agree with the effect of moderate exercise in previous studies (Akimoto *et al.*, 2003; Klentrou *et al.*, 2002) and would conform to Nieman's (1994 cited in Bishop, 2006) J-shaped model, whereby moderate activity is related to improved immune function.

Contrary to the fair fitness group, the good fitness group had a non-significant 14% reduction in s-IgA during the control period. Reference to Nieman's (1994 cited in Bishop, 2006) model may also help to explain this. Specifically, during the exercise period, the addition of the Nintendo Wii exercise programme to their regular physical

activity may have resulted in them exercising at the optimum level with regard to immune function, which may explain why s-IgA remained unchanged in the exercise condition. Contrary, once they were no longer participating in the Nintendo Wii exercise programme (i.e. the control condition) they were more sedentary and therefore subjected to a negative effect on immune function (decreased s-IgA), as depicted by Niemans (1994 cited in Bishop, 2006) J-shaped model.

4.2 Cortisol

In response to the first exercise session, the fair fitness group had a significant increase in cortisol concentration, which is usually only associated with rigorous exercise (Mackinnon, 1999). For instance, cortisol significantly increased following 2.5 hours of intensive running among a group of marathoners (Nieman *et al*., 1995 cited in Nieman, 1997). Whilst METs (4.82 ± 0.74 METs) would suggest that the exercise was only moderate intensity, maximum heart rate (HR_{max}) minus resting heart rate (HR) was computed to give heart rate reserve (HRR) (Cole *et al.*, 1999). This established that exercise was initially performed at 85% of HRR in the fair fitness group and that the exercise intensity was arguably more than vigorous (HHS, 1996 cited in ACSM, 2009). Based on METs, Quinn's (2010) research would further reinforce that exercise on Wii step using two riisers is vigorous. This may explain why s-IgA unexpectedly decreased as a result of the 'moderate' exercise, since elevated cortisol is correlated with a reduction in s-IgA (Hucklebridge *et al.*, 1998). In contrast, there was no significant exercise-induced change in cortisol concentration during their final exercise session for the fair fitness group. Possibly because exercise training causes a reduction in the cortisol response at a given exercise intensity (Mackinnon, 1999).

If indeed the exercise was more vigorous at the start of the exercise intervention, the cortisol results for the fair fitness group would support the findings of Jacks *et al*., (2002). Specifically, there was a significant ($p \leq .01$) increase in salivary cortisol concentration following intense cycling, whereas at low and moderate intensities there were no significant differences (Jacks *et al.*, 2002). Likewise, Farzanaki *et al*., (2008) found that significant increases in cortisol were only evident during days of increased training volume in a cohort of young female gymnasts and not when training was reduced. Despite the increase in cortsiol on heavier training days there was no significant change in s-IgA (Farzanaki *et al.*, 2008), similarly to the current study.

The good fitness group on the other hand had no significant alteration in cortisol concentration after exercise at either the start or end of the exercise intervention. This difference compared to the fair fitness group may be explained by the fact that increased cortisol is dependent on exercise intensity in relation to exercise capacity (Mackinnon, 1999). These results support that exercise has to be performed at high intensity and for one hour or more in order for cortisol to significantly increase (Jacks *et al.*, 2002). Furthermore, these results illustrate that cortisol response after exercise is less pronounced in fit people compared with those who are untrained (Luger *et al*., 1987 cited in Rudolph & McAuley, 1998). Likewise, Marthur *et al*., (1986 cited in Rudolph & McAuley, 1998) reported a 36% increase in cortisol among fit runners, compared to a 161% increase in unfit runners following maximal exercise.

The moderate exercise intervention did not alter resting cortisol concentration in either fitness group. This mimics the findings of O'Connor *et al*., (1989), who also found that an increase in exercise training did not alter resting cortisol concentration among a

group of swimmers. As was expected, there were also no significant changes in cortisol concentration during the control period, again for people with either classification of fitness.

4.3 Health screen

4.3.1 Body composition

Regular active video gaming was not adequate enough to alter overall body mass. It may not be surprising that both fitness groups maintained their body mass since they were completing approximately 2000 steps in each session, which is equivalent to burning approximately 100 kilocalories (kcal) and has been known to prevent weight gain (Hill *et al*., 2003 cited in Hill, 2009). An extra 2000 daily steps has even resulted in a reduction in body mass index (Toole *et al*., 2007 cited in Hill, 2009). However, actual weight loss is usually dependant on a combination of both increased EE and a reduction in energy intake (ACSM, 2009). Consequently, weight loss in the current study may have been limited by the fact that energy intake was not modified and was presumably relatively stable throughout the study. Irrespective of whether or not they lost weight though, participation in regular physical activity is still advisable for the health of the participant (Blair, 2009). For example, a study by Church *et al*., (Church *et al.*, 2005) showed a significantly greater risk of mortality from cardiovascular disease in normal weight men who had low cardiorespiratory fitness compared to overweight or obese men that were moderately or highly fit.

Sell *et al*., (2008) suggested that future research on active video games should look at changes in actual body composition. Under this advice, this study revealed that whilst

there was not a reduction in body mass, there was a shift in the ratio of fat mass to fat free mass in the fair fitness group. Their percentage body fat in particular reduced by 6% so that it was approaching the optimal range for health (10% to 22% for males and 20% to 32% for females) (Lohman, 1982 cited in ACSM, 2009). Interestingly, the positive change in the fat to fat free mass ratio induced by the Nintendo Wii exercise was reversed during the control condition. It may be concluded therefore that participation in active video games not only maintains but actually improves body composition in people who are less fit and overweight according to their BMI (ACSM, 2009).

4.3.2 Blood pressure

One of the ways in which exercise prevents premature death is through a reduction in blood pressure (Lee & Paffenbarger, 2000). However, the Nintendo Wii exercise programme did not alter blood pressure in the fair fitness group. Whilst a reduction in SBP of 3 mmHg was not statistically significant, realistically this is significant given that even a 2 mmHg reduction in SBP is related to a 14% less chance of stroke and a 9% decrease in coronary artery disease risk (Pescatello *et al*., 2004 cited in Warburton *et al.*, 2007). There was a significant reduction in SBP in the exercise condition in the good fitness group, although a reduction in both SBP and DBP was also observed in the control condition for the participants with good fitness. Since a reduction in blood pressure is a classic effect of exercise (Whelton *et al.*, 2002), it may be proposed that the good fitness group were actually engaged in more physical activity during the control period relative to during the Nintendo Wii exercise condition, with the amount of physical activity during this time being underreported via the IPAQ.

4.3.3 Estimated $\dot{V}O_{2max}$

Exercise improved estimated $\dot{V}O_{2max}$ in both fitness groups. This is the result of an increase in both maximal cardiac output and oxygen extraction (Bouchard *et al.*, 2006). Only the good fitness groups increase from 43 ± 6 $ml \cdot kg^{-1} \cdot min^{-1}$ to 57 ± 15 $ml \cdot kg^{-1} \cdot min^{-1}$ was significant. Despite a typical improvement in aerobic fitness being 8-20% following aerobic training (Warburton *et al*., 2004 cited in Warburton *et al.*, 2007), the 17% improvement in fair fitness group from 29 ± 6 $ml \cdot kg^{-1} \cdot min^{-1}$ to 34 ± 10 $ml \cdot kg^{-1} \cdot min^{-1}$ was not quite significant (p = .06). Nevertheless, these improvements are particularly encouraging since low cardiorespiratory fitness has been identified as the leading cause of all deaths, ahead of obesity, diabetes, smoking and either high blood pressure or cholesterol (Blair, 2009). What is more, the fair fitness groups estimated $\dot{V}O_{2max}$ declined during the control period in the absence of the Nintendo Wii exercise programme. In contrast, the good fitness group continued to experience an improvement in $\dot{V}O_{2max}$, although this was not significant. However, the results for estimated $\dot{V}O_{2max}$ during the control condition may be dubious since estimated $\dot{V}O_{2max}$ was still significantly elevated at the start of the control period compared to baseline, despite a two-week washout period. It should also be acknowledged that $\dot{V}O_{2max}$ was only estimated from a cycle ergometer test and therefore the results are not as accurate than if actual $\dot{V}O_{2max}$ had been measured (ACSM, 2009).

4.4 Cardiorespiratory responses to exercise

Previous research has tended to investigate only the acute physiological responses to a single bout of active video gaming, whilst long-term benefits of active video games on fitness has been overlooked (Mark & Rhodes, 2009). The following findings may help address this shortage of knowledge.

4.4.1 Heart rate

In the fair fitness group, HR at baseline was 126 ± 12 b·min^{-1}. This is comparable to the HR reported in a group of children (122 ± 18 b·min^{-1}) during the same active video game (White *et al.*, 2010), although higher than those witnessed by Graves *et al*., (2010) among adolescents (102 ± 18 b·min^{-1}), young adults (95 ± 10 b·min^{-1}) and older adults (95 ± 11 b·min^{-1}). Comparisons between studies have to be made with caution though as many factors such as competiveness and the enthusiasm of the movement can affect the metabolic demands of active video games (Willems & Bond, 2009a). Following the exercise intervention, the fair fitness groups HR reduced significantly to 114 ± 15 b·min^{-1}. A reduction in HR at a given work load is a classic benefit associated with regular exercise (ACSM, 2009). This suggests that active video games on the Nintendo Wii, particularly Wii step, can elicit the same benefits as more conventional modes of exercise. Whilst the good fitness groups HR did reduce from 117 ± 16 b·min^{-1} to 110 ± 9 b·min^{-1} following the exercise intervention, unlike the fair fitness group, this reduction was non-significant. This indicates that people with lower fitness and therefore a greater exercising heart rate at the same work rate have a greater potential to reduce HR from this type of exercise.

In order to retain or improve cardiorespiratory fitness, adults must work at an exercise intensity of at least 60% HR_{max} (Pollock *et al.*, 1998 cited in Graves *et al.*, 2010). Participants HR_{max} was estimated using the Karvonen formula (Jackson, 2007) and their percentage HR_{max} was derived from their average exercising HR. Since the fair fitness group were exercising at 70% HR_{max} and the good fitness group at 64% HR_{max}, step aerobics on the Nintendo Wii can benefit cardiorespiratory fitness. This corroborates the findings of White *et al*., (2010), whereby HR during Wii step was 62% of participants

(n = 26) HR_{peak}. In contrast, Graves *et al*., (2010) reported that Wii aerobics (including step) was not sufficient enough to elicit positive changes in cardiorespiratory fitness.

4.4.2 Energy expenditure

Irrespective of fitness, the METs achieved during the Nintendo Wii step (between 4 and 5 METs) contribute to existing research, in that Wii step aerobics is moderate to vigorous in intensity (>3 METs) (Graves *et al.*, 2010; Quinn, 2010). This demonstrates that certain active video games such as Wii step and others like it, for example Wii boxing (Graves *et al.*, 2008b; Miyachi *et al.*, 2010; White *et al.*, 2010; Willems & Bond, 2009a), are a novel way to contribute to daily physical activity recommendations (Haskell *et al.*, 2007). That said, care must be taken when advocating the use of active video games, as not all are adequate enough in intensity to satisfy physical activity recommendations (Miyachi *et al.*, 2010).

Furthermore, Wii step has not consistently been reported as moderately intense. Specifically, White *et al*., (2010) findings contradict the results of the current study and others like it (Graves *et al.*, 2010; Quinn, 2010), since they argued that Wii step is only light in terms of intensity (2.43 ± .43 METs). Methodological differences may account for the difference in EE (Zhang *et al*., 2004 cited in Miyachi *et al.*, 2010). For example, both the current study and Quinn (2010) used riisers to elevate the height of the Wii balance board, as well as the energy costs of Wii step (Quinn, 2010). Whereas it would appear that White *et al*., (2010) used the balance board at its stand alone height, which may account for the discrepancies between their findings and those in the current study. However, Graves *et al*., (2010) did not increase the height of the balance board and yet

they reported similar results to the current study. Hence, when the balance board is elevated, the intensity of Wii step is adequate enough to contribute to physical activity recommendations, although when the Wii balance board is not elevated it may (Graves *et al.*, 2010) or may not (White *et al.*, 2010) be a suitable exercise to contribute to physical activity recommendations. Even so, whilst light intensity exercise may fall short of physical activity recommendations, small increases in EE are easily attained and sustained and may therefore still help with weight management (Hill, 2009). Additionally, some exercise, be it light, is better than none at all (Daley, 2009).

Graves *et al*., (2010) highlighted the absence of longitudinal studies that investigate how experience of the Nintendo Wii affects EE. This study showed that EE reduced in the fair fitness group and whilst this was true among the good fitness group, the latter was not significant. In particular, EE went from 336 ± 41 $J \cdot kg^{-1} \cdot min^{-1}$ at the beginning of the exercise programme to 276 ± 33 $J \cdot kg^{-1} \cdot min^{-1}$ at the end in the fair fitness group. Likewise, the good fitness group initially had an EE of 361 ± 77 $J \cdot kg^{-1} \cdot min^{-1}$, which declined to 316 ± 76 $J \cdot kg^{-1} \cdot min^{-1}$ following the exercise intervention. In contrast, Sell *et al*., (2008) found that EE increased with experience. However, this was using another type of active computer game (dance dance revolution), which has three difficulty levels that participants were allowed to self-select (Sell *et al.*, 2008), even though the energy requirements vary depending on the level (Fawkner *et al.*, 2010) and not necessarily with experience.

EE was comparable to a similar study by Graves *et al*., (2010), whereby EE was 348 ± 45 $J \cdot kg^{-1} \cdot min^{-1}$ among adolescents (16 ± 1 years) and 345 ± 60 $J \cdot kg^{-1} \cdot min^{-1}$ among young adults (28 ± 5 years). EE in older adults (58 ± 7 years) was significantly lower

(252.2 ± 84 $J \cdot kg^{-1} \cdot min^{-1}$) however, compared with the younger participants. Likewise, Lanningham-Foster *et al*., (2009) also noticed that EE was significantly greater in children (5.14 ± 1.7 $kcal \cdot kg^{-1} \cdot hr^{-1}$) relative to adults (2.67 ± 0.95 $kcal \cdot kg^{-1} \cdot hr^{-1}$) when playing active computer games on the Nintendo Wii. These studies illustrated that the degree of EE is dependent on the age of the participants (Zhang *et al*., 2004 cited in Miyachi *et al.*, 2010). Consequently, children may receive a greater benefit in terms of EE compared to the adults tested in this study when participating in Nintendo Wii step.

Moderate intensity physical activity that requires a daily EE of around 200 calories is enough to elicit health benefits (Pate *et al.*, 1995). Whilst the energy expended by both the fair (pre; 122 ± 11 kcal, post; 101 ± 18 kcal) and good (pre; 108 ± 16 kcal, post; 95 ± 19 kcal) fitness groups did not satisfy this recommendation, if they were to complete the Nintendo Wii step sessions twice a day (40 minutes in total), generally they would expend sufficient calories (approximately 200) for positive health outcomes. This seems feasible since the majority of children in the UK spend approximately two hours playing video games up to seven days a week (Pratchett, 2005 cited in Graves *et al.*, 2008b) and video game use in all ages is set to rise (Lanningham-Foster *et al.*, 2009). Better still, Lee and Skerrett (2001 cited in Warburton *et al.*, 2006) suggested that even a weekly energy expenditure of 500 kcal may be adequate enough for health benefits. In this case, at the bare minimum, performing Wii step for 20 minutes each day for five days a week could elicit health benefits. Although greater benefits are obtained with increasing EE (Warburton *et al.*, 2006).

Nintendo Wii step is similar in terms of EE to activities including; volleyball, doubles tennis, skateboarding and gymnastics (Ainsworth *et al.*, 2000). Whilst this is

encouraging when comparing active video games with sedentary ones (Mark *et al.*, 2008), this study also illustrated that active computer games are not comparable to the actual activity, in this instance step aerobics, since this is much more vigorous in intensity (Ainsworth *et al.*, 2000). This corroborates that the Nintendo Wii is no substitute for authentic sports, as reported in several previous studies (Daley, 2009; Graves *et al.*, 2008a; Graves *et al.*, 2008b; Miyachi *et al.*, 2010).

4.4.3 Relative oxygen consumption

At baseline, relative $\dot{V}O_2$ for both the fair and good fitness group (16.8 ± 2.7 and 17.8 ± 3.8 $ml \cdot kg^{-1} \cdot min^{-1}$ respectively) was similar to that reported by White *et al.*, (2010) (17.0 ± 4.9 $ml \cdot kg^{-1} \cdot min^{-1}$). Relative $\dot{V}O_2$ was then reduced as a result of the Wii exercise programme. This was a significant reduction for the fair fitness group (13.8 ± 2.3 $ml \cdot kg^{-1} \cdot min^{-1}$), although not for the good fitness group (15.1 ± 3.7 $ml \cdot kg^{-1} \cdot min^{-1}$). This demonstrated that both fitness groups, but the fair fitness group more so, were both consuming less oxygen relative to the same workload after the four week exercise intervention. A reduction in myocardial oxygen cost being an advantage of regular exercise (ACSM, 2009).

In summary, cardiorespiratory responses to the Nintendo Wii were enhanced in both fitness groups as a result of the Nintendo Wii exercise programme, although the reductions in METs, HR, EE and relative $\dot{V}O_2$ were only significant in the fair fitness group. This conforms to the dose-response curve, which estimates the association between physical activity and health benefits (Pate *et al.*, 1995). Specifically, it illustrates how lower active individuals have more to gain in health benefits compared

to more active individuals (Pate *et al.*, 1995). However, further studies are needed to better established the potential health benefits of active video games (Miyachi *et al.*, 2010).

4.5 Limitations

Willems and Bond (2009a) identified a small sample size (n = 10) as a limitation in their study and the same applies here, whereby only 17 participants were recruited. Though this sample size was adequately powered to indentify significant effects, generalising these results to the wider population is restricted since the sample size is so low. Another criticism that has been appreciated by several other authors (Lanningham-Foster *et al.*, 2009; Mark *et al.*, 2008; Pasch *et al.*, 2008) was that the study was conducted in a laboratory, which is not ecologically valid since active video games are usually played in the comfort of your own home. On the other hand, this could be considered as an advantage as it enabled participants' compliance with the exercise programme to be monitored.

Additionally, there are a number of factors which influence immune function. These include for example, diet, obesity and genetics (Gleeson, 2006). However, these factors were not controlled for in the current study. Consequently, any changes in immune function, as indicated by an alteration in s-IgA, may not be entirely attributable to the Wii exercise intervention. Furthermore, whilst every effort was made to take saliva samples at the same time of day, since both s-IgA and cortisol exhibit diurnal variation (Hucklebridge *et al.*, 1998), this was not always feasible due to participants availability and the saliva results may have been wrongly influenced as a result. The final flaw was

that a measure of the incidence of URTIs was not taken. Therefore it is not known whether or not any of the changes in s-IgA transpired into any clinically relevant changes in the number or duration of URTI experienced by the participants.

4.6 Practical implications

There was a zero dropout rate in the current study. This is particularly surprising since dropout rates in structured exercise programmes have been known to range from 9% to 87% (Marcus *et al.*, 2006). This may be a result of the novel exercise mode, as previous studies have identified a greater adherence to active video games when compared to traditional exercise (Annessi & Mazas, 1997; Rhodes *et al*., 2008 cited in Mark & Rhodes, 2009; Warburton *et al.*, 2007). This is probably because both adults (Barkley & Penko, 2009; Sell *et al.*, 2008) and children (Penko & Barkley, 2010) alike prefer active video games over more conventional modes of exercise. Active computer games may therefore provide a greater promise of maintaining physical activity participation (Graves *et al.*, 2010) and consequently enhance the number of people meeting physical activity recommendations. Active video games may also lead to participation in others types of physical activity (Maddison *et al.*, 2007). However, other potential barriers to long-term engagement in exergaming include the cost of active video games, limited space, type of game and the players age (Dixon *et al.*, 2010). These factors therefore need further consideration if exergames are going to be a successful tool for maintaining recommended physical activity levels (Dixon *et al.*, 2010).

To conclude, regular exercise on the Nintendo Wii does not improve immunosurviellence. If anything, it may even have the opposite effect in low

conditioned individuals due to a temporary increase in stress hormones when first starting a structured exercise programme. The exercise intensity was sufficient enough to improve measures of cardiorespiratory fitness, with the lower fitness group receiving the greatest benefit overall. These results, coupled with the high adherence rates, confirm that active gaming can be an innovative way to contribute to daily physical activity recommendations to elicit health benefits.

5. REFERENCES

ACSM (2009) *ACSM's Guidelines for Exercise Testing and Prescription*. Philadelphia: Lippincott Williams & Wilkins.

Adams, G.M. (2002) *Exercise Physiology Laboratory Manual*. New York: McGraw-Hill.

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., Irwin, M.L., Swartz, A.M., Strath, S.J., O'Brien, W.L., Bassett, D.R., Jr., Schmitz, K.H., Emplaincourt, P.O., Jacobs, D.R., Jr., & Leon, A.S. (2000) Compendium of physical activities: an update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise*. **32:** S498-S504.

Akimoto, T., Kumai, Y., Akama, T., Hayashi, E., Murakami, H., Soma, R., Kuno, S., & Kono, I. (2003) Effects of 12 months of exercise training on salivary secretory IgA levels in elderly subjects. *British Journal of Sports Medicine*. **37:** 76-79.

Baranowski, T., Buday, R., Thompson, D.I., & Baranowski, J. (2008) Playing for real: video games and stories for health-related behavior change. *American Journal of Preventive Medicine*. **34:** 74-82.

Baranowski, T., Cullen, K.W., Nicklas, T., Thompson, D., & Baranowski, J. (2002) School-based obesity prevention: a blueprint for taming the epidemic. *American Journal Health Behavior*. **26:** 486-493.

Barkley, J. E. and Penko, A (2009) Physiologic Responses, Perceived Exertion, and Hedonics of Playing a Physical Interactive Video Game Relative to a Sedentary Alternative and Treadmill Walking in Adults. *Journal of Exercise Physiology*. **12:** 12-32.

Bausch, L, Beran, J, Cahanes, S, and Krug, L (2008) Physiological responses while playing Nintendo Wii sports. *Journal of Undergraduate Kinesiology Research*. **3:** 19-25.

Bishop, N. C. Exercise and infection risk. *In:* M. Gleeson, ed. (2006) *Immune Function in Sport and Exercise.* Philadelphia: Churchill Livingstone Elsevier.

Blair, S.N. (2009) Physical inactivity: the biggest public health problem of the 21st century. *British Journal of Sports Medicine*. **43:** 1-2.

Böhm, H., Hartmann, M., & Böhm, B. (2008) Predictors of metabolic energy expenditure from body acceleration and mechanical energies in new generation active computer games. *In: Computer Science in Sport - Mission and Methods.* Germany: Schloss Dagstuhl - Leibniz Center for Informatics.

Booth, F.W., Gordon, S.E., Carlson, C.J., & Hamilton, M.T. (2000) Waging war on modern chronic diseases: primary prevention through exercise biology. *Journal of Applied Physiology*. **88:** 774-787.

Bouchard, C., Blair, S.N., & Haskell, W.L. (2006) *Physical Activity and Health*. Champaign: Human Kinetics.

Brown, D. (2006) Playing to win: video games and the fight against obesity. *Journal of the American Dietetic Association*. **106:** 188-189.

Canadian Society for Exercise Physiology (2002) *PAR-Q & YOU* [online] Available at: <http://www.csep.ca/CMFiles/publications/parq/par-q.pdf> [Accessed on 5-11-2010].

Chiappin, S., Antonelli, G., Gatti, R., & De Palo, E.F. (2007) Saliva specimen: a new laboratory tool for diagnostic and basic investigation. *Clinica Chimica Acta*. **383:** 30-40.

Church, T.S., Lamonte, M.J., Barlow, C.E., & Blair, S.N. (2005) Cardiorespiratory fitness and body mass index as predictors of cardiovascular disease mortality among men with diabetes. *Archives of Internal Medicine*. **165:** 2114-2120.

Cieslak, T.J., Frost, G., & Klentrou, P. (2003) Effects of physical activity, body fat, and salivary cortisol on mucosal immunity in children. *Journal of Applied Physiology*. **95:** 2315-2320.

Cole, C.R., Blackstone, E.H., Pashkow, F.J., Snader, C.E., & Lauer, M.S. (1999) Heart-rate recovery immediately after exercise as a predictor of mortality. *New England Journal of Medicine*. **341:** 1351-1357.

Craig, R., Mindell, J., and Hirani, V. (2009) *Health Survey for England 2008* [online] Available at: <http://www.ic.nhs.uk/webfiles/publications/HSE/HSE08/Volume_1_Physical_activity_and_fitness_revised.pdf> [Accessed on 27-9-2010].

Daley, A.J. (2009) Can exergaming contribute to improving physical activity levels and health outcomes in children? *Pediatrics*. **124:** 763-771.

Dawar, A (2009) *NHS Change4Life Campaign endorses video game exercises* [online] Available at: <http://www.timesonline.co.uk/tol/life_and_style/health/article6890221.ece> [Accessed on 31-1-2010].

Dimitriou, L., Sharp, N.C., & Doherty, M. (2002) Circadian effects on the acute responses of salivary cortisol and IgA in well trained swimmers. *British Journal of Sports Medicine*. **36:** 260-264.

Dixon, R., Maddison, R., Ni, M.C., Jull, A., Meagher-Lundberg, P., & Widdowson, D. (2010) Parents' and children's perceptions of active video games: a focus group study. *Journal of Child Health Care*. **14:** 189-199.

Dzewaltowski, D.A. (2008) Emerging technology, physical activity, and sedentary behavior. *Exercise and Sport Sciences Reviews*. **36:** 171-172.

Eley, K.A. (2010) A Wii fracture. *The New England Journal of Medicine*. **362:** 473-474.

Farzanaki, P, Azarbayjani, M. A, Rasaee, M. J., Jourkesh, M, Ostojic, S. M, and Stannard, S (2008) Salivary immunoglobulin A and cortisol response to training in young elite female gymnasts. *Brazilian Journal of Biomotricity*. **2:** 252-258.

Fawkner, S.G., Niven, A., Thin, A.G., Macdonald, M.J., & Oakes, J.R. (2010) Adolescent girls' energy expenditure during dance simulation active computer gaming. *Journal of Sports Sciences*. **28:** 61-65.

Frayn, K. N. & Akanji, A. O. Integration of Metabolism 3: Macronutrients. *In:* M. J. Gibney, I. A. Macdonald, & H. M. Roche, eds. (2003) *Nutrition & Metabolism.* Oxford: Blackwell Publishing.

Gleeson, M (2005) Immune Function and Exercise. *European Journal of Sport Science*. **4:** 52-66.

Gleeson, M. Introduction to the immune system. *In:* M. Gleeson, ed. (2006) *Immune Function in Sports and Exercise.* Philadelphia: Churchill Livingstone Elsevier.

Gleeson, M. (2007) Immune function in sport and exercise. *Journal of Applied Physiology*. **103:** 693-699.

Gleeson, M., Hall, S.T., McDonald, W.A., Flanagan, A.J., & Clancy, R.L. (1999) Salivary IgA subclasses and infection risk in elite swimmers. *Immunology and Cell Biology*. **77:** 351-355.

Graf, D.L., Pratt, L.V., Hester, C.N., & Short, K.R. (2009) Playing active video games increases energy expenditure in children. *Pediatrics*. **124:** 534-540.

Graves, L., Stratton, G., Ridgers, N.D., & Cable, N.T. (2008a) Energy expenditure in adolescents playing new generation computer games. *British Journal of Sports Medicine*. **42:** 592-594.

Graves, L.E., Ridgers, N.D., & Stratton, G. (2008b) The contribution of upper limb and total body movement to adolescents' energy expenditure whilst playing Nintendo Wii. *European Journal of Applied Physiology*. **104:** 617-623.

Graves, L.E., Ridgers, N.D., Williams, K., Stratton, G., Atkinson, G., & Cable, N.T. (2010) The physiological cost and enjoyment of Wii Fit in adolescents, young adults, and older adults. *Journal of Physical Activity and Health*. **7:** 393-401.

Hardman, A. E. Acute Responses to Physical Activity and Exercise. *In:* C. Bouchard, S. N. Blair, & W. L. Haskell, eds. (2006) *Physical Activity and Health.* Champaign: Human Kinetics.

Hardman, A.E. & Stensel, D.J. (2003) *Physical Activity and Health: The evidence explained*. London: Routledge.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., Macera, C.A., Heath, G.W., Thompson, P.D., & Bauman, A. (2007) Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Medicine and Science in Sports and Exercise*. **39:** 1423-1434.

Hemila, H., Virtamo, J., Albanes, D., & Kaprio, J. (2003) Physical activity and the common cold in men administered vitamin E and beta-carotene. *Medicine and Science in Sports and Exercise*. **35:** 1815-1820.

Hill, J. O (2009) Can a small-changes approach help address the obesity epidemic? A report of the Joint Task Force of the American Society for Nutrition, Institue of Food Technologists, and International Food Information Council. *American Journal of Clinical Nutrition*. **89:** 477-484.

Hillier, A. (2008) Childhood overweight and the built environment: Making technology part of the solution rather than part of the problem. *Annals of the American Academy of Political and Social Science*. **615:** 56-82.

Howley, E.T. & Franks, B.D. (1997) *Health Fitness Instructor's Handbook*. Champaign: Human Kinetics.

Hucklebridge, F., Clow, A., & Evans, P. (1998) The relationship between salivary secretory immunoglobulin A and cortisol: neuroendocrine response to awakening and the diurnal cycle. *International Journal of Psychophysiology*. **31:** 69-76.

IPAQ (2002) *Downloadable Questionnaires* [online] Available at: <http://www.ipaq.ki.se/downloads.htm> [Accessed on 14-4-2010].

Jacks, D.E., Sowash, J., Anning, J., McGloughlin, T., & Andres, F. (2002) Effect of exercise at three exercise intensities on salivary cortisol. *The Journal of Strength & Conditioning Research*. **16:** 286-289.

Jackson, A.S. (2007) Estimating maximum heart rate from age: is it a linear relationship? *Medicine and Science in Sports and Exercise*. **39:** 821.

Kinnear, P.R. & Gray, C.D. (2009) *SPSS 16 made simple*. Sussex: Psychology Press.

Klentrou, P., Cieslak, T., MacNeil, M., Vintinner, A., & Plyley, M. (2002) Effect of moderate exercise on salivary immunoglobulin A and infection risk in humans. *European Journal of Applied Physiology*. **87:** 153-158.

Kostka, T., Berthouze, S.E., Lacour, J., & Bonnefoy, M. (2000) The symptomatology of upper respiratory tract infections and exercise in elderly people. *Medicine & Science in Sports & Exercise*. **32:** 46-51.

Lanningham-Foster, L., Foster, R.C., McCrady, S.K., Jensen, T.B., Mitre, N., & Levine, J.A. (2009) Activity-promoting video games and increased energy expenditure. *Journal of Pediatrics*. **154:** 819-823.

Lee, I.M. & Paffenbarger, R.S. (2000) Associations of light, moderate, and vigorous intensity physical activity with longevity. The Harvard Alumni Health Study. *American Journal of Epidemiology*. **151:** 293-299.

Lenhart, A, Jones, S., and Macgill, A. R. (2008) *Adults and video games* [online] Available at: <http://www.pewinternet.org/~/media//Files/Reports/2008/PIP_Adult_gaming_memo.pdf.pdf> [Accessed on 6-10-2010].

Mackinnon, L.T. (1999) *Advances in Exercise Immunology*. Champaign: Human Kinetics.

Maddison, R., Mhurchu, C.N., Jull, A., Jiang, Y., Prapavessis, H., & Rodgers, A. (2007) Energy expended playing video console games: an opportunity to increase children's physical activity? *Pediatric Exercise Science*. **19:** 334-343.

Manini, T.M., Everhart, J.E., Patel, K.V., Schoeller, D.A., Colbert, L.H., Visser, M., Tylavsky, F., Bauer, D.C., Goodpaster, B.H., & Harris, T.B. (2006) Daily activity

energy expenditure and mortality among older adults. *Journal of the American Medical Association*. **296:** 171-179.

Marcus, B.H., Williams, D.M., Dubbert, P.M., Sallis, J.F., King, A.C., Yancey, A.K., Franklin, B.A., Buchner, D., Daniels, S.R., & Claytor, R.P. (2006) Physical activity intervention studies: what we know and what we need to know: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity); Council on Cardiovascular Disease in the Young; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. *Circulation*. **114:** 2739-2752.

Mark, R and Rhodes, R. E (2009) Active Video Games: A Good Way to Exercise? *WellSpring*. **20**.

Mark, R, Rhodes, R. E, Warburton, D. E. R, and Bredin, S. S. D (2008) Interactive Video Games and Physical Activity: A Review of the Literature and Future Directions. *Health & Fitness Journal of Canada*. **1:** 14-24.

Marshall, S.J., Gorely, T., & Biddle, S.J. (2006) A descriptive epidemiology of screen-based media use in youth: a review and critique. *Journal of Adolescence*. **29:** 333-349.

Matthews, C.E., Ockene, I.S., Freedson, P.S., Rosal, M.C., Merriam, P.A., & Hebert, J.R. (2002) Moderate to vigorous physical activity and risk of upper-respiratory tract infection. *Medicine & Science in Sports & Exercise*. **34:** 1242-1248.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2006) *Exercise Physiology: Energy, Nutrition and Human Performance*. Philadelphia: Lippincott Williams & Wilkins.

McMurray, R.G., Harrell, J.S., Deng, S., Bradley, C.B., Cox, L.M., & Bangdiwala, S.I. (2000) The influence of physical activity, socioeconomic status, and ethnicity on the weight status of adolescents. *Obesity Research*. **8:** 130-139.

Melkevik, O., Torsheim, T., Iannotti, R.J., & Wold, B. (2010) Is spending time in screen-based sedentary behaviors associated with less physical activity: a cross national investigation. *International Journal of Behavioral Nutrition and Physical Activity*. **7:** 46.

Mintel (2008) *Video and Computer Games - UK - August 2008* [online] Available at: <http://academic.mintel.com/sinatra/oxygen_academic/search_results/show&/display/id=280418> [Accessed on 13-10-2010].

Mintel (2009) *Fitness in the Home - UK* [online] Available at: <http://oxygen.mintel.com/sinatra/oxygen/display/id=394699> [Accessed on 29-1-2010].

Miyachi, M., Yamamoto, K., Ohkawara, K., & Tanaka, S. (2010) METs in adults while playing active video games: a metabolic chamber study. *Medicine & Science in Sports & Exercise*. **42:** 1149-1153.

Mohebati, L., Lobstein, T., Millstone, E., & Jacobs, M. (2007) Policy options for responding to the growing challenge from obesity in the United Kingdom. *Obesity Reviews*. **8:** 109-115.

Moreira, A., Delgado, L., Moreira, P., & Haahtela, T. (2009) Does exercise increase the risk of upper respiratory tract infections? *British Medical Bulletin*. **90:** 111-131.

National High Blood Pressure Education Program (2004) *The Seventh Report of the Joint National Comittee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure* [online] Available at: <http://www.nhlbi.nih.gov/guidelines/hypertension/jnc7full.pdf> [Accessed on 5-11-2010].

Nieman, D.C. (1997) Immune response to heavy exertion. *Journal of Applied Physiology*. **82:** 1385-1394.

Nieman, D.C. (2000a) Exercise effects on systemic immunity. *Immunology and Cell Biology*. **78:** 496-501.

Nieman, D.C. (2000b) Is infection risk linked to exercise workload? *Medicine & Science in Sports & Exercise*. **32:** S406-S411.

Nieman, D.C., Nehlsen-Cannarella, S.L., Fagoaga, O.R., Henson, D.A., Shannon, M., Hjertman, J.M., Schmitt, R.L., Bolton, M.R., Austin, M.D., Schilling, B.K., & Thorpe, R. (2000) Immune function in female elite rowers and non-athletes. *British Journal of Sports Medicine*. **34:** 181-187.

Nintendo (2009) *Wii sales in UK top six million in less than three years* [online] Available at: <http://www.nintendo.co.uk/NOE/en_GB/news/2009/wii_sales_in_uk_top_six_million_in_less_than_three_years_15296.html> [Accessed on 8-10-2010].

O'Connor, P.J., Morgan, W.P., Raglin, J.S., Barksdale, C.M., & Kalin, N.H. (1989) Mood state and salivary cortisol levels following overtraining in female swimmers. *Psychoneuroendocrinology*. **14:** 303-310.

Pasch, M., Berthouze, N., van Dijk, B., & Nijholt, A. (2008) Motivations, Strategies, and Movement Patterns of Video Gamers Playing Nintendo Wii Boxing. *In: Facial and bodily expressions for control and adaptation of games (ECAG 2008).* pp. 27-33.

Pate, R.R. (2008) Physically active video gaming: an effective strategy for obesity prevention? *Archives of Pediatrics and Adolescent Medicine*. **162:** 895-896.

Pate, R.R., Pratt, M., Blair, S.N., Haskell, W.L., Macera, C.A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G.W., King, A.C., & . (1995) Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *The Journal of the American Medical Association*. **273:** 402-407.

Penko, A.L. & Barkley, J.E. (2010) Motivation and physiologic responses of playing a physically interactive video game relative to a sedentary alternative in children. *Annals of Behavioral Medicine*. **39:** 162-169.

Quinn, M. 2010. *The effect of three riiser heights on energy expenditure during Nintendo Wii Fit step aerobics.* Unpublished dissertation. UCLan.

Rahimi, R., Ghader, M, Mirzaei, B, Ghaeni, S, Faraji, H, Vatani, D. S, and Rahmani-Nia, F (2010) Effects of very short rest periods on immunoglobulin A and cortisol

responses to resistance exercise in men. *Journal of Human Sport & Exercise*. **5:** 146-157.

Robinson, R.J., Barron, D.A., Grainger, A.J., & Venkatesh, R. (2008) Wii knee. *Emergency Radiology*. **15:** 255-257.

Roemmich, J.N., Barkley, J.E., Lobarinas, C.L., Foster, J.H., White, T.M., & Epstein, L.H. (2008) Association of liking and reinforcing value with children's physical activity. *Physiology and Behavior*. **93:** 1011-1018.

Rudolph, D.L. & McAuley, E. (1998) Cortisol and affective responses to exercise. *Journal of Sports Sciences*. **16:** 121-128.

Salimetrics (2009) *Saliva Collection and Handling Advice* [online] Available at: <http://www.salimetrics.com/assets/documents/collection-supplies/Saliva-Collection-and-Handling-Advice-large-format-4-7-09.pdf> [Accessed on 31-8-0010].

Schoenfeld, D (2010) *Statistical considerations for a cross-over study where the outcome is a measurement* [online] Available at: <http://hedwig.mgh.harvard.edu/sample_size/js/js_crossover_quant.html> [Accessed on 26-6-2010].

Schulz, K.F., Altman, D.G., & Moher, D. (2010) CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. *Trials*. **11:** 32.

Sell, K., Lillie, T., & Taylor, J. (2008) Energy expenditure during physically interactive video game playing in male college students with different playing experience. *The Journal of American College Health*. **56:** 505-511.

Shephard, R.J., Kavanagh, T., Mertens, D.J., Qureshi, S., & Clark, M. (1995) Personal Health Benefits of Masters Athletics Competition. *British Journal of Sports Medicine*. **29:** 35-40.

Siegel, S.R., Haddock, L., Dubois, A.M., & Wilkin, L.D. (2009) Active Video/Arcade Games (Exergaming) and Energy Expenditure in College Students. *International Journal of Exercise Science*. **2:** 165-174.

Stettler, N., Signer, T.M., & Suter, P.M. (2004) Electronic games and environmental factors associated with childhood obesity in Switzerland. *Obesity Research*. **12:** 896-903.

Taylor, H.D., Klepetar, E., Keys, A., Parlin, W., Blackburn, H., & Puchner, T. (1962) Death rates among physically active and sedentary employees of the railroad industry. *American Journal of Public Health and the Nations Health*. **52:** 1697-1707.

Thomas, J.R. & Nelson, J.K. (1996) *Research Methods in Research Activity*. Champaign, IL: Human Kinetics.

Tremblay, M.S. & Willms, J.D. (2003) Is the Canadian childhood obesity epidemic related to physical inactivity? *International Journal of Obesity and Related Metabolic Disorders*. **27:** 1100-1105.

Vandewater, E.A., Shim, M.S., & Caplovitz, A.G. (2004) Linking obesity and activity level with children's television and video game use. *Journal of Adolescence*. **27:** 71-85.

Wallop, H (2009) *NHS endorses Nintendo Wii Fit video game* [online] Available at: <http://www.telegraph.co.uk/technology/nintendo/6430935/NHS-endorses-Nintendo-Wii-Fit-video-game.html> [Accessed on 31-1-2010].

Warburton, D.E., Bredin, S.S., Horita, L.T., Zbogar, D., Scott, J.M., Esch, B.T., & Rhodes, R.E. (2007) The health benefits of interactive video game exercise. *Applied Physiololgy, Nutrition and Metabolism*. **32:** 655-663.

Warburton, D.E., Nicol, C.W., & Bredin, S.S. (2006) Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*. **174:** 801-809.

Whelton, S.P., Chin, A., Xin, X., & He, J. (2002) Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. *Annals of Internal Medicine*. **136:** 493-503.

White, K., Schofield, G., & Kilding, A.E. (2010) Energy expended by boys playing active video games. *Journal of Science and Medicine in Sport*.

Willems, M.E.T. & Bond, T.S. (2009a) Comparison of Physiological and Metabolic Responses to Playing Nintendo Wii Sports and Brisk Treadmill Walking. *Journal of Human Kinetics*. **22:** 43-49.

Willems, M. E. T. and Bond, T. S. (2009b) Metabolic equivalent of brisk walking and playing new generation active computer games in young-adults. *Medicina Sportiva*. **13:** 95-98.

Yaqoob, P. & Calder, P. C. The Immune and Inflammatory Systems. *In:* M. J. Gibney, I. A. Macdonald, & H. M. Roche, eds. (2003) *Nutrition & Metabolism.* Oxford: Blackwell Publishing.

ZooZen (2009) *Real workout with your Wii balance board* [online] Available at: <http://www.zoozen.com/cgi-bin/zoozen2/engine.pl?function=viewid&id=RKS00021> [Accessed on 12-10-2010].

6. SELF REFLECTION

What a year, probably one of the worst of my life! I never envisaged that this Msc would be as difficult as it turned out to be. I am shocked that I am here actually writing a self reflection and putting together all of the finishing touches to my thesis. On numerous occasions over the last 12 months, I severely questioned whether or not I would make it this far. Credit to my willpower (or rather stubbornness), that I have survived right through to the end.

As you may have guessed, this project has not been by any means easy for me. This is primarily attributable to the repeated set-backs that I encountered along the way. For example, it was several months after I had initially put in an order for my saliva kits before they were actually purchased. In retrospect, I should have used my support network (supervisors) sooner rather than later, since that is what they were there for. As well as be a bit more proactive about the situation myself, although at the time, I thought I was doing everything within my power to get it resolved. Had I done this, things may have been sorted quicker and may not have had such a negative impact on my progress.

What have I learned? Possibly that I am not cut out for postgraduate study or at least I am not prepared to sacrifice my life for any further study. That is not to say that you have to sacrifice your life if undertaking postgraduate study, only I seemed to struggle to get the balance right between work and play. Mainly all work and no play! This is not very healthy for anyone. This is all despite attending workshops to help with time and project management. I do not know why I struggled so much with this, since I coped better at undergraduate when I had exams, lectures and assignments to juggle, in addition to my dissertation. The worse thing I ever did was probably not allowing

myself an official holiday, whereby I could completely switch off from work and recover for the next stage. I suppose this knowledge would lend itself well to if I ever did decide (god forbid) to do a PhD.

I have identified that I am seriously lacking in confidence. For instance, when questioned about my methods by a member of staff I literally went to pieces, despite knowing that I could justify what it was that I was being queried about. I do not think this is directly related to my belief in my academic ability but circumstances in my personal life. Whilst this does not exactly fill me with joy when anticipating my viva, this experience has been invaluable in terms of teaching me to believe in myself and my own expertise more. Though I think this will take time. Who knows, if I cope well in my viva that may just help me on my way.

I managed to generate a reference list and even make use of the in-text citations function on Reference Manager and would therefore say that this is a skill I have gained through this Msc project. I have never used a bibliographic database before and was quite intimidated by the prospect of doing so, as I do not consider myself adept with computers. Since I paid for the privilege, I thought I better use it, and in doing so I can now appreciate how a package like Reference Manager can be an invaluable tool and time-saver on a project of this scale. I would definitely use it again, especially since I found it relatively easy to use once I knew how. For future reference, I should maybe allow myself to invest more time in getting to grips with software like Reference Manager, so that I can experience the benefit in the long run.

I must admit that I am finding it difficult to identify skills that I have developed by virtue of this MSc. I imagine my skill development has been extensive in many areas, although usually I need feedback and reassurance from others in order to acknowledge the things I am good at. Again, this is probably a confidence thing. One thing in particular that I remember my supervisor mentioning was my writing skills. They said that I was undoubtedly writing at the correct level (i.e. postgraduate). I feel this was aided by a technical/scientific writing course, which I was especially receptive to because of the way in which it was delivered.

Another skill, which I myself would like to highlight, is my organisational skills. Coordinating 17 people to come in three times a week for four weeks, in addition to four separate testing sessions over the course of a 10 week period and orchestrating that around their family and work commitments, as well as my own, was a mammoth task. I felt I excelled in organising this through effective communication and cooperation from the participants. Most people might find this stressful, but I seem to thrive in situations like this. My brain seems to be very ordered and logical in the way in which I approach and complete tasks and this may explain why I did not handle things well when situations that were out of my control did not go to plan.

Even though I have found this last year extremely challenging, indeed overwhelming at times, I do not regret embarking upon this project, as it has been equally as rewarding. I am very fortunate and grateful to have had this opportunity with the help of the Gilbertson Excellence Scholarship. Overall, I can honestly say that I have tried my best, and as my mum always tells me, that is all you can do.

7. APPENDICES

APPENDIX 1

Do you want to get Wii Fit™?

Do you fancy a change to conventional exercise methods? As part of our MSc project, we are offering a FREE health screen and a four week step aerobics programme using the Nintendo Wii. Perfect if you are keen to improve your health, fitness and overall well-being.

Interested? Please contact either Francesca or Matt on:

Francesca: 07878929049
Matt: 07898853727

FPell@uclan.ac.uk
MPDuckham@uclan.ac.uk

APPENDIX 2

University of Central Lancashire

School of Psychology

CONSENT FORM

Title of Project: The effect of step aerobics using Nintendo Wii Fit on immune function and blood lipids

Name of Researcher(s): Matthew Duckham & Francesca Pell (MSc students)

Name of Supervisor(s): Steve Atkins, Stephanie Dillon, & David Fewtrell

Please Tick box

I confirm that I have read and understand the participant information sheet for this study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.	☐
I agree to take part in this study.	☐

Name of Participant	Date	Signature

I confirm that I have explained to the above individual the nature, purpose and possible risk associated with the participation in this research study, and have answered any questions that have been raised.

Researcher(s)	Date	Signature

APPENDIX 3

Participant Information Sheet

We (Francesca Pell and Matthew Duckham) are currently masters (MSc) students undertaking a masters research project. The following information will indicate why we are conducting this research and what participation will entail. Please read the following information carefully. You may ask any questions if you are not clear on anything or if you would like more information.

Study title

The effect of a four week Nintendo Wii Fit training programme on blood lipids and immune function.

What is the purpose of the study?

To investigate the effect of a four week Nintendo Wii programme (step aerobics) on blood lipids (e.g. cholesterol) and immune function.

Why have I been chosen?

You have kindly volunteered to take part in this study.

Do I have to take part?

Taking part in this study is entirely voluntary. You may withdraw at any time (see contact details at the bottom of the page) before completing your final testing session, at which point your data will be anonymised (for the purpose of analysis) and therefore we cannot trace your results back to you personally after this time.

What do I have to do?

Participants are invited to attend the sports physiology lab at the University of Central Lancashire. Participants will be asked to give both a blood and two saliva samples, along with some basic data (height, weight etc). After four weeks have passed, these measures will be repeated and participants will begin their four week step aerobics programme, using the Nintendo Wii. Each training session will be about 20 minutes long and it is hoped participants will attend three sessions per week for the entire four week training programme. When the four week training has been completed, a third and final measure of blood, saliva and the body (height, weight etc) will be taken. In addition, participants will be asked to wear a metalyser (meta-max) during the first and last training session of the Nintendo Wii programme. This involves placing a face mask

over the mouth and nose, whilst wearing a device that rests on the shoulders, this allows measures of heart rate, oxygen consumption and other gas analyses to be obtained. Blood samples will be taken using a lancet to make a small puncture (finger prick) at the end of a finger of choice (index or middle finger), whilst the blood is collected. In addition, a saliva sample will be taken by passively dribbling through a straw.

What are the possible risks of taking part?

The study will include some moderate-to-vigorous physical activity and as such, a questionnaire (PAR-Q) is used to assess participants' suitability. In subsequent exercise sessions, you will be asked if your health has changed so that you now answer 'YES' to any of the questions on the PAR-Q. Participation will be dependent on this response. Moreover, a comprehensive risk assessment has been undertaken to identify and control any potential risks, in order to help ensure the safety of all participants.

What are the possible benefits of taking part?

You may enjoy this exciting new way in which to exercise on the Nintendo Wii, not to mention the health benefits that are commonly associated with participation in physical activity. You will receive a free health screen (e.g. blood pressure and physical fitness test) and will also be taking part in an innovative study, which can contribute to the limited research in this area.

Will the results be confidential?

The results of the study will be anonymous in that no results can be linked the participants' name. This will be achieved by identifying participants by a unique number rather than their name, a record of which will be stored separate from any of the participants' results. In no instance will individual data be presented, only group averages.

What will happen to the results of the research study?

The data will be saved on a password protected laptop and then incorporated into a written report and presentation, which will be assessed by internal and external staff at UCLAN. Thereafter, it is possible that the results may be published in an academic journal.

Student Contact Details

For further information or if you wish to withdraw, please do not hesitate to contact:

Matthew Duckham (BSc Hons)
MSc Research Student
MPDuckham@uclan.ac.uk

Francesca Pell (BSc Hons)
MSc Research Student
FPell@uclan.ac.uk

Supervisory Contact Details

Dr Stephanie Dillon
Course Leader for BSc (Hons) Human Nutrition
Disability Contact & Extenuating Circumstances Officer [ECs] for CASES,
School of Psychology
University of Central Lancashire
Preston
PR1 2HE
Tel: 01772 893516
SDillon@uclan.ac.uk

Dr David Fewtrell
Senior Lecturer
Sports Biomechanics
Centre for Applied Sport & Exercise Sciences
University of Central Lancashire
Preston
Lancashire
PR1 2HE
01772 893329
djfewtrell@uclan.ac.uk

Dr Steve Atkins
Principal Lecturer
Centre for Applied Sport & Exercise
University of Central Lancashire
Preston
Lancashire
PR1 2HE
Tel: 01772 893523
SAtkins@uclan.ac.uk

Further Information

Please let us know if we can be of assistance in directing you to any further information sources relating to health and fitness.

APPENDIX 4

Statistical considerations for a cross-over study where the outcome is a measurement

Request

0.05 Significance Level (%) — 2 sided *(default is 0.05, two-sided)*

6.3 ◉ Within patient standard deviation *(if known)*, or ○ Standard deviation of the difference between the two value for the same patient *(if known)*

Enter two of the following three values and the remaining value will be calculated

1. [ ] Total number of patients
2. 0.8 Power (usually 0.8 or 0.9)
3. 12.2 Minimal detectable difference in means

Calculate

Response

Calculation performed at: 14 December 2010 18:22:56

The provided parameters were: significance level (adjusted for sidedness) = 0.025, standard deviation within patients = 6.3, standard deviation of the difference = undefined, number of patients = undefined, power = 0.8, difference in means = 12.2.

The variable calculated was the total number of patients.

A total of 7 patients will enter this two-treatment crossover study. The probability is 85 percent that the study will detect a treatment difference at a two-sided 0.05 significance level, if the true difference between treatments is 12.200 units. This is based on the assumption that the within-patient standard deviation of the response variable is 6.3.

APPENDIX 5

T-Test

[DataSet22] C:\Users\Matt\Documents\MSc Thesis\Blood Pressure_1.sav

Group Statistics

	Poor_or_Good	N	Mean	Std. Deviation	Std. Error Mean
Age_yrs	1.00	9	40.0000	13.28533	4.42844
	2.00	8	33.8750	14.05538	4.96933
BMI	1.00	9	27.8993	5.08324	1.69441
	2.00	8	24.0938	2.11112	.74639
Mass_kg	1.00	9	76.3778	8.65141	2.88380
	2.00	8	63.7500	6.58461	2.32801
Height_cm	1.00	9	166.3889	8.75992	2.91997
	2.00	8	162.6250	4.86056	1.71847
SBP_mmHg	1.00	9	126.0556	11.06923	3.68974
	2.00	8	118.6250	10.70297	3.78407
DBP_mmHg	1.00	9	85.2778	8.84276	2.94759
	2.00	8	77.2500	9.67323	3.42000
BF_Percent	1.00	8	34.5625	14.71908	5.20398
	2.00	7	27.6286	12.79163	4.83478
Estimated_VO2max_mL_kg_min	1.00	9	29.2267	5.98010	1.99337
	2.00	8	43.3900	6.29571	2.22587

Independent Samples Test

		Levene's Test for Equality of Variances	
		F	Sig.
Age_yrs	Equal variances assumed	.208	.655
	Equal variances not assumed		
BMI	Equal variances assumed	2.787	.116
	Equal variances not assumed		
Mass_kg	Equal variances assumed	1.663	.217
	Equal variances not assumed		
Height_cm	Equal variances assumed	1.969	.181
	Equal variances not assumed		
SBP_mmHg	Equal variances assumed	.081	.780
	Equal variances not assumed		
DBP_mmHg	Equal variances assumed	.000	.989
	Equal variances not assumed		
BF_Percent	Equal variances assumed	.450	.514
	Equal variances not assumed		
Estimated_VO2max_mL_kg_min	Equal variances assumed	.135	.718
	Equal variances not assumed		

Independent Samples Test

		t-test for Equality of Means		
		t	df	Sig. (2-tailed)
Age_yrs	Equal variances assumed	.923	15	.370
	Equal variances not assumed	.920	14.520	.373
BMI	Equal variances assumed	1.967	15	.068
	Equal variances not assumed	2.055	10.935	.065
Mass_kg	Equal variances assumed	3.351	15	.004
	Equal variances not assumed	3.407	14.693	.004
Height_cm	Equal variances assumed	1.075	15	.299
	Equal variances not assumed	1.111	12.753	.287
SBP_mmHg	Equal variances assumed	1.403	15	.181
	Equal variances not assumed	1.406	14.874	.180
DBP_mmHg	Equal variances assumed	1.788	15	.094
	Equal variances not assumed	1.778	14.339	.097
BF_Percent	Equal variances assumed	.966	13	.351
	Equal variances not assumed	.976	13.000	.347
Estimated_VO2max_mL_kg_min	Equal variances assumed	-4.755	15	.000
	Equal variances not assumed	-4.740	14.545	.000

Independent Samples Test

		t-test for Equality of Means	
		Mean Difference	Std. Error Difference
Age_yrs	Equal variances assumed	6.12500	6.63275
	Equal variances not assumed	6.12500	6.65622
BMI	Equal variances assumed	3.80554	1.93518
	Equal variances not assumed	3.80554	1.85152
Mass_kg	Equal variances assumed	12.62778	3.76862
	Equal variances not assumed	12.62778	3.70621
Height_cm	Equal variances assumed	3.76389	3.50231
	Equal variances not assumed	3.76389	3.38812
SBP_mmHg	Equal variances assumed	7.43056	5.29637
	Equal variances not assumed	7.43056	5.28521
DBP_mmHg	Equal variances assumed	8.02778	4.48964
	Equal variances not assumed	8.02778	4.51494
BF_Percent	Equal variances assumed	6.93393	7.17469
	Equal variances not assumed	6.93393	7.10327
Estimated_VO2max_mL_kg_min	Equal variances assumed	-14.16333	2.97836
	Equal variances not assumed	-14.16333	2.98798

Independent Samples Test

		t-test for Equality of Means	
		95% Confidence Interval of the Difference	
		Lower	Upper
Age_yrs	Equal variances assumed	-8.01238	20.26238
	Equal variances not assumed	-8.10335	20.35335
BMI	Equal variances assumed	-.31920	7.93027
	Equal variances not assumed	-.27258	7.88365
Mass_kg	Equal variances assumed	4.59516	20.66040
	Equal variances not assumed	4.71379	20.54177
Height_cm	Equal variances assumed	-3.70111	11.22889
	Equal variances not assumed	-3.57014	11.09792
SBP_mmHg	Equal variances assumed	-3.85839	18.71950
	Equal variances not assumed	-3.84292	18.70403
DBP_mmHg	Equal variances assumed	-1.54167	17.59723
	Equal variances not assumed	-1.63438	17.68993
BF_Percent	Equal variances assumed	-8.56605	22.43391
	Equal variances not assumed	-8.41178	22.27964
Estimated_VO2max_mL_kg_min	Equal variances assumed	-20.51155	-7.81512
	Equal variances not assumed	-20.54947	-7.77720

```
DATASET ACTIVATE DataSet19.
DATASET CLOSE DataSet22.
DATASET ACTIVATE DataSet19.
DATASET CLOSE DataSet21.
DATASET ACTIVATE DataSet19.
DATASET CLOSE DataSet20.
```

APPENDIX 6

SCHOOL OF PSYCHOLOGY ETHICS COMMITTEE
ETHICS FORM FOR
STAFF, MPhil/PhD & MSc RESEARCH PROJECTS

Before completing this form you should read the UCLAN *Code of Conduct* and the British Psychological Society *Code of Conduct* (both online at *www.uclan.ac.uk/scitech/psychology/research/ethics.php).* In addition, for questions 4-22, please see the attached guidance notes. PhD & MSc students should discuss the completion of this form with their supervisor.

All researchers MUST obtain ethical approval BEFORE collecting any data.

Research Team
Researcher name(s) & email

Francesca Louise Pell: FPell@uclan.ac.uk

Researcher type: MSc Student

Supervisor name(s) & email (if applicable)

Stephen Atkins: SAtkins@uclan.ac.uk
Stephanie Dillion: SDillon@uclan.ac.uk
David John Fewtrell: DJFewtrell@uclan.ac.uk

Project details (please see attached guidance notes)
What is the project title?

Effect of step aerobics using Nintendo Wii Fit on immune function

What is the likely duration of project?

One year

Please provide a brief summary of the project aims (Max 250 words)

This current research is intended to investigate the effect of moderate/vigorous exercise on immune function, but more specifically and unlike any other previous research, it will utilise active games on the Nintendo Wii console as the mode of exercise. Concentrations of salivary immunoglobulin A (S-IgA) and cortisol will be utilised to assess whether this type and intensity of exercise has an immunosuppressive effect or alternatively an advantageous effect on immune function, as depicted by Nieman's (1994 cited in Gleeson, 2005) J-shaped model of the relationship between infection risk and exercise volume. Furthermore, the purpose of this study is to determine whether or not it is plausible for the Nintendo Wii to act as a vehicle in which to encourage moderate/vigorous intensity exercise, resulting in other potential health benfits, by contributing to exercise recommendations outlined by the ACSM (2009).

Please provide a brief summary of the project methods (Max 250 words)

Twenty participants will be invited to take part in this single subject design study. Baseline measures of immune function will be taken initially and repeated again after

one month (control condition). They will then participate in a four week training programme (experimental condition) on the Nintendo Wii. This will consist of moderate/vigorous exercise sessions (step aeorobics), 20 minutes in duration on three separate occasions for each of the four weeks. Subsquently, measures of immune function will be taken in order to examine whether the intervention influences immune function in comparison to the control condition. Markers of immune function will be assessed via a saliva sample, these will include S-IgA and cortisol. In order to obtain a salvia sample, participants will be asked to passively drool through a straw into a cryovial. This sample will be stored appropriately (frozen) until it is analysed using enzyme-linked immunosorbant assay (ELISA) to determine the concentration of both S-IgA and cortisol.

Does the research involve contact with any other organisation or group (e.g. schools, companies, charities, hospitals, sports clubs)? If **yes**, please give details.

No

Is the research to be funded externally? If **yes**, please give details.

No

Will ethical approval for the proposed research be sought from any other body (e.g. collaborating departments, Home Office, health authority, education authority)? If **yes**, please give details.

No

Has a Risk Assessment form been completed?

Yes (see attached)

Has permission been obtained to use any copyright materials (e.g. personality tests)? Please also indicate whether particular qualifications or training are needed to administer the tests, and if so, whether the researcher is appropriately qualified.

The 'Save a life' Basic First Aid course and a defibrillator course have been completed to allow unsupervised testing and data collection to take place.

Participants (Please see attached guidance notes. Projects without participants may leave this section blank and proceed to Q. 22.)
Who do you propose to use as participants and do they belong to a group unable to provide **informed** consent?

The healthy adults with a sedentary lifestyle recruited for this study will all be able to provide written informed consent.

Please indicate exactly how participants will be recruited for the project.

Advertisments (see attached) in the form of posters and also electronic advertisements (e-mail and screen saver adverts) will be accessible by both staff and students at UCLAN

How exactly will consent be given (e.g., verbal or written)?

Written (see consent form attached)

What information will be provided at recruitment and briefing to ensure that consent is **informed**?

Participants will be provided with a comprehensive information sheet (see attached)

Please indicate what information will be provided to participants at debrief.

None, as all necessary information will be provided within the information sheet, which participants will recieve (and retain) at briefing

Please give details of any proposed rewards or incentives to be offered to encourage participation.

None

Is any deception involved? (If **yes**, please give details and explain why deception is necessary.)

No

Does the procedure involve **any** possible distress, discomfort or harm to participants? If so, what measures are in place to reduce it?

Participants will be invited to provide a saliva sample, wherby they will be asked to passively drool through a straw into a cryovial. This activity may be somewhat embarrassing for some participants. However, each participant will be fully aware of this procedure (via the information sheet) and may therefore chose not to participate in the study. Even after consent is provided, the participant may still withdraw from the study if (s)he wishes.

What mechanism is there for participants to withdraw from the investigation and how is this communicated to participants?

Participants can withdraw from the study at any time prior to data analysis (at which point the data is anonymised and therefore cannot be traced back to the participant). This will be communicated to participants through the information sheet and participants will also be verbally reminded throughout the testing period that they may withdraw.

How are confidentiality and/or anonymity to be maintained?

Each participant will be assigned a number, a record of which will be saved on a password secured computer, only accessible by the researchers. This number will then be used to identify participants results, in order to ensure that their results remain anonymous. Individual data will not feature in the written dissertation or viva, only group averages, which will be veiwed by all the necessary professionals. There is potential for this data to be puplished, but again only anonymised group data will be presented and therefore cannot be linked to any individual participant.

Additional information
Please give details of any other ethical issues that have been considered.

N/A

Submission checklist:
Please attach any risk assessments, questionnaires, interview schedules, experimental protocols, other relevant research materials, advertisements, introductory letters, letters of approval, consent forms, participant briefing/debriefing materials, etc.
Please do NOT submit unnecessary material (for example, multiple copies of the same questionnaires, risk assessment notes or ethics guidance notes, etc.). Staff and Mphil/PhD students should submit the ethics form and attachments to **Susan Ross** (DB120). MSc students should submit the forms to their project supervisor.
Dates of Ethics Committee meetings and submission deadlines are available at: www.uclan.ac.uk/scitech/psychology/research/ethics.php

Would you like to attend the ethics meeting to discuss your proposal (staff, PhD researchers and MSc *supervisors*, not normally MSc students, are welcome to attend that part of the meeting at which their research is to be discussed)? No

(If you indicate 'yes', please make sure you are available 1-3 pm on the day of the meeting and include a contact number we can reach you on when your proposal is about to be considered. Please leave your office extension number and, if you wish, a mobile number here:)

Please print and sign – remember to print from page 4 onwards only.

Signed ……..……...……...…

(Signing this form certifies that you agree to carry out your research in the manner specified. If you want to deviate from the approved method at any time, you should seek further ethical approval for the change.)

Date …….

Supervisor signature (MSc projects only)……

(**Note to supervisors:** Signing this form certifies that, in your opinion, the project specified here is ethical under Departmental and BPS guidelines. Do not sign if you are unsure, or if the student has not attached final versions of the research materials they are planning to use.)

APPENDIX 7

School of Psychology RISK ASSESSMENT FORM (Medium & High Risk, Student Version)

Use this form to risk-assess:
Off-campus student activities (research, fieldwork, educational visits etc) in medium/high risk environments such as factories, farms, prisons, remote areas or participants' homes.
All student activities involving medium/high risk procedures or use of specialist equipment.
For low risk locations and activities, use the appropriate low risk form.

This form should be completed by the staff member responsible for the activity (e.g. the project supervisor), in consultation with the student and a qualified or otherwise competent person (normally a technician or Faculty HSE officer). Completed forms must be countersigned by the Head of School or the Chair of the School Health & Safety Committee.

Students:	**Assessment Undertaken By: (Staff member)**	**Assessment Verified By: (Technician or other competent person)**
Names: Francesca Pell Matthew Duckham	Name:	Name:
Signed:	Signed:	Signed:
Date: 22/03/10	Date:	Date*:
Note: Risk Assessment is valid for **one year from the date given above. Risk Assessments for activities lasting longer than one year should be reviewed annually.*		
Countersigned by Head of School or Chair of H&S Committee:		
Date:		

Risk Assessment For:
Activity: Four week step aerobics programme using the Nintendo Wii Fit. Blood and saliva sampling
Location of Activity: *University of Central Lancashire* *Darwin Room 026 (Physiology Laboratory)* *Preston* *Lancashire* *PR1 2HE*

List significant hazards here:	List groups of people who are at risk:	List existing controls, or refer to safety procedures etc:	For risks which are not adequately controlled, list the action needed:	Remaining level of risk (high, medium or low):
Obstacles	Participants, Investigators,	Check area before and throughout testing		Low
Injury	Participants	Qualified First Aider present, equipped with First Aid Kit and defibrillator.	Phones available	Med
Slippery/wet surfaces	Participants, Investigators,	Warning signs	Assess prior to testing and re-assess throughout testing	Med
Equipment	Participants, Investigators	Equipment regularly checked and maintained	Test before use	Med
Inappropriate footwear and/or clothing	Participants	Participants advised to come wearing the correct clothing and footwear for physical activity	Check clothing/footwear and exclude participants from the study if it is inappropriate	Low
Trails not appropriate for the	Participants	Screening (PAR-Q)	Inability to satisfy a health questionnaire will	High

health of the participant			result in exclusion from testing	
Fire	Participants, Investigators	Alarms, knowledge of fire exits and drills		High
Electrical Items	Participants, Investigators	Cover/tape any trailing cables, check that it is well maintained	Check before use and use in accordance with instructions	Med
Jewellery	Participants, Investigators	Advise participants to remove or cover any jewellery prior to the testing		Low
Untied long hair	Participants	Provide bobbles so participants can tie back hair		Low
Blood Collection	Participants, Investigators	Investigator will be familiar with the appropriate procedure (see below). Latex gloves and a plastic bib will be worn. The finger will be sterilised using alcohol		High

		wipes. New gloves and lancets will be used for each participant.		
Saliva Collection	Participants, Investigators	Investigator will be familiar with the appropriate procedure (see below). Latex gloves and a plastic bib will be worn. Each participant will be provided with an individual straw and cryovial for their saliva sample.		Med
Bodily Waste Products		Sharps will be disposed of appropriately in a sharp bin, whilst contaminated tissues/gloves etc will be disposed of in a clinical waste bag	Subsequently, these will be collected by the appropriate professionals and disposed of in accordance with relevant guidelines	High
Sample Storage		Samples will be labelled and appropriately		Low

		stored (frozen) in preparation for analysis		

Continue on another sheet if necessary.

APPENDIX 8

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

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

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

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

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

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

If you answered

YES to one or more questions

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

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

NO to all questions

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

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

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

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

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

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

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

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Supported by: Health Canada Santé Canada

continued on other side...

APPENDIX 9

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

Think about *only* those physical activities that you did for at least 10 minutes at a time.

_____ **days per week** ⇨

or

☐ **none**

1b. How much time in total did you usually spend on one of those days doing vigorous physical activities?

_____ **hours** _____ **minutes**

2a. Again, think *only* about 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, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week** ⇨

or

☐ **none**

2b. How much time in total did you usually spend on one of those days doing moderate physical activities?

_____ **hours** _____ **minutes**

3a. During the last 7 days, on how many days did you **walk** for at least 10 minutes at a time? This includes walking at work and at home, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure.

_____ **days per week** ⇨

or

☐ **none**

3b. How much time in total did you usually spend walking on one of those days?

_____ **hours** _____ **minutes**

The last question is about the time you spent sitting on weekdays while at work, at home, while doing course work and during leisure time. This includes time spent sitting at a desk, visiting friends, reading traveling on a bus or sitting or lying down to watch television.

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

____ **hours** _____ **minutes**

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

This is the final SHORT LAST 7 DAYS SELF-ADMINISTERED version of IPAQ from the 2000/01 Reliability and Validity Study. Completed May 2001.

APPENDIX 10

SALIMETRICS®
101 Innovation Boulevard, Suite 302, State College, PA 16803 • USA
Tel 814.234.7748 • Fax 814.234.1608 • www.salimetrics.com

COLLECTING UNSTIMULATED WHOLE SALIVA SAMPLES BY PASSIVE DROOL FROM HUMAN SUBJECTS (ages 5+)

Things to avoid:

1. Brushing teeth within 1 hour prior to collection.
2. Using salivary stimulants: chewing gum, lemon drops, granulated sugar, drink crystals.
3. Consuming a major meal within 1 hour prior to collection.
4. Consuming alcohol 12 hours prior to collection.
5. Consuming acidic or high sugar foods within 20 minutes prior to collection.

Suggested protocol:

1. Rinse mouth with water 10 minutes prior to sample collection
2. Document prescription and over-the-counter medications taken.
3. Record time of day sample is collected.

Materials required:

- Plastic drinking straws
- Scissors
- Cryovials: polypropylene – 2mL capacity
- Labels

Salimetrics Item No.	Description
5002.01	2 mL cryovial

***Note**: Collections for multiple hormones may require larger vials (information available upon request). It is advisable to use a vial with at least twice the capacity of the necessary sample volume because some saliva foaming will occur.*

Prior to Saliva Collection:

1. Cut plastic drinking straws into 2-inch (5 cm) pieces.
2. Give each subject one (1) straw piece and one (1) cryovial.
3. Have subjects rinse their mouth with water 10 minutes prior to collection.

Collecting saliva:

1. Instruct subject to imagine eating their favorite food and allow saliva to pool in the mouth.
2. With head tilted forward, subject should drool down the straw and collect saliva in the cryovial. (It is normal for saliva to foam.)
3. Repeat as often as necessary until sufficient sample is collected. (1 mL - excluding foam - is adequate for most tests).
4. If subject's mouth is dry, instruct them to gently chew on the end of the straw. This will stimulate saliva production.
5. Keep samples cold after collection (4ºC) and freeze (-20º to -80ºC) as soon as possible.*

** Secretory IgA and DHEA-S testing requires calculation of saliva flow rates. Do this before freezing samples. Contact Salimetrics for details.*

Rev. 12-05-08 mjc

APPENDIX 11

CoSHH RISK ASSESSMENT FORM. (*Page 1 of 2)*

Faculty/Department	**Assessors Name(s)**	**Job Title/Position**	☎
Psychology	Belinda Hornby	Senior Technician	3737

Briefly describe the task/process. (description, use, users)

Enzyme linked immuno-sorbent assay (ELISA) of saliva samples to measure cortisol and other hormones.
The saliva samples have been collected outside of the laboratory by Francesca Pell under the attached risk assessmentprocedure.
Once in the laboratory they are stored frozen.
Prior to analysis salivettes are placed in the class 2 cabinets to thaw, transferred to centrifuge vessels and then centrifuged (6000rpm for 10 minutes), any handling of the salivettes is done wearing gloves and lab coat.

Decontamination procedure: the manual testing Class 2 cabinet is $0.72m^2$ and therefore the base should be sprayed with 216mls of 1% Virkon and the sides with 660mls.
The virkon should be left on for 10 minutes before washing off. The centrifuge is should be sprayed liberally with 150mls of 1% Virkon as left on for 10 minutes prior to cleaning off , likewise the benches in the lab sprayed with 650mls 1% virkon. The robotic cabinet should be decontaminated with 900ml of 1% Virkon per long panel and 432ml 1% Virkon per short panel. The base should be with 900ml of 1% Virkon following the same protocol as for the manual assay cabinet above.

On analysis the ELISA kit is removed from the 4 °C storage, the reagents are placed in the class II cabinet to reach room temperature, the operator wears PPE to include gloves and a lab coat.
The salivettes (saliva samples) are also placed in the class II and allowed to thaw out.
On reaching room temperature the cotton swabs are discarded into a pot within cabinet that contains 1% Virkon.
Opening of all salivettes takes place in the class II lids/tops facing away from the operator to prevent the operator inhaling any aerosol generated by the opening of the samples
The assay then proceeds in the class II cabinet:

The robot will discard the plate and its contents via the hazardous waste jar with the red lid in the class II cabinet, if the assay is to be automated, otherwise manually discard the plates and tips into A hazardous/clinical waste container
If there is a spillage then virkon is used to decontaminate
Gloves etc. are placed in the 1% Virkon biohazards container which is inside the cabinet.

Substances (used or produced as by-products or wastes)	**Quantity**	**Hazard Class**	**WEL**	**Exposure Route(s)**	**Frequency and Duration of Exposure**	**Known Health Effects:**
Saliva from salivettes	50µL/well approx 80 wells per assay, from 40 different samples	Class 2 (unless donor is found to be infected after saliva has been collected or the saliva sample visibly contains blood (salivette will be discoloured) and then saliva sample (salivette) is disposed of via autoclave and clinical waste route). Operator protection containment is sufficient for most potential pathogens of low titre in saliva. However, according to the HSE document working with viruses, regarding swine flu (see attached p3 bottom para 6) then if it is the predominant circulating strain at the time of doing diagnostic testing then Class II and a vaccination for the operator is sufficient protection. With regards to other pathogens which are transmitted via respiratory liquids (saliva) e.g. Hepatitis, meningitis tuberculosis, salmonella types, class II is considered sufficient as participants in studies are only taken from the healthy normal population and for those who may be asymptomatic and so the titre of virus is likely to be low and so is classed as class II (see Part 3B p40 -45 of Biological Agents: managing the risks in laboratories and healthcare premises).		Inhalation From aerosol droplets created when salivette is opened.	40 times	infection
Antibody coated wells	96 wells per plate	n/a	n/a	n/a	n/a	n/a
Bromo-nitro-dioxan (Conjugate)	0.015%	Harmful, irritant	Not listed	Inhaled, splashed on skin, ingestion.	During one stage of assay, pipetting 200µL into every well of 96 well	corrosive

					plate.	
N-Methylisothiaziazolon hydrochloride (conjugate)	0.01%	Not known	Not known	Inhaled, splashed on skin, ingestion.	During one stage of assay, pipetting 200µL into every well of 96 well plate.	Not known
Human inactivated serum (standards) containing **proclin**	100%	Biological Class 2, - (treat as patient specimens as recommended by manufacturer). Toxic, corrosive. Biohazard.	N/A	Inhaled, splashed on skin, ingestion.	Pipetting 50µL into 10 wells	May be highly toxic, corrosive (from MSDS). Biohazard.
Thiomersal (standards)	0.02%	Toxic by inhalation, skin contact or if swallowed Cumulative effects.	N/A	Inhalation, skin contact, ingestion.	Pipetting 50µL into 10 wells	Nausea, vomiting, acidosis, ataxia. Chronic exposure risks nerves, kidneys, carcinogen/ tumorigenic, fatal on inhalation.
Hydrogen peroxide (colour reagent)	0.015%	Harmful on inhalation, causes severe burns	OEL 1.4mg/m3	Inhalation, skin contact, eyes, ingestion	Pipetting 100µL into 10 wells	Burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, and Vomiting. Inhalation may result in spasm, inflammation and edema of the larynx and bronchi, chemical pneumonitis, and pulmonary oedema. Extremely destructive to tissue of the mucous Membranes and upper respiratory tract, eyes, and skin.
3.3'.5.5'-tetramethylbenzidine (colour reagent)	0.03%	Possible mutagen, irritant, harmful if swallowed	Not established	Skin, lungs, eyes, mucous membranes, ingestion.	Pipetting 100µL into 10 wells	The results of exposure have not been thoroughly investigated
Dimethylsulphoxide (colour reagent)	<5%	Irritant	Not established	Skin, lungs, eyes, mucous membranes, ingestion.	Pipetting 100µL into 10 wells	Not hazardous after acute exposure, after prolonged exposure possible mutagen and irritant
Sulphuric acid 0.5M (stop solution)	0.5M	Causes severe burns		Skin, lungs, eyes, mucous membranes, ingestion	Pipetting 100µL into 10 wells	Toxicological properties have not been thoroughly investigated. Known symptoms include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea, and vomiting. Inhalation may result in spasm, inflammation and edema of the larynx and bronchi, chemical pneumonitis, and pulmonary oedema. Material is extremely destructive to tissue of the mucous

						Membranes and upper respiratory tract, eyes, and skin.

Results of Relevant Health Surveillance	Results of Exposure Monitoring

Control Measures				
☐ Elimination	☐ Substitution	√Reduction	☐ Isolation	√ Eng. Control
Details	*Details*	*Details* **Hand washing, personal hygiene is of paramount importance, training in personal and laboratory hygiene, waste disposal and safe and good laboratory practice is mandatory for all conducting this procedure and working in this laboratory. Access to the laboratory is restricted to those who have been trained and are wearing appropriate PPE e.g. a lab coat. Any cuts must be covered with a water proof plaster.**	*Details (glovebox)*	*Details(LEV, fumehood)* **All work should be conducted in an operator protection safety cabinet,** especially opening of salivettes and standards which is likely to generate aerosols and pipetting of solutions which is also likely to generate aerosols.

Further Details (if required)

All assays are conducted with PPE and under class 2 containment levels employing good laboratory practice procedures. All staff and students are trained in GLP and health and safety issues including personal hygiene (hand washing, hair tied back, no eating or drinking in a laboratory environment, all surfaces are decontaminated before and after experimentation) before they are allowed to take part in saliva collection or analysis. They are further trained to a high level in laboratory techniques and saliva collection too.

For the biological risks to staff or students doing prolonged amounts of this work, which it is recognised may not be apparent in donors of saliva (e.g. if they are asymptomatic) vaccinations are recommended where there is one available; for example, a Hepatitis B vaccine course is recommended and available via either experimenters own GP or the university health centre (by prior arrangement with HR). Likewise, when the H1N1 influenza vaccination becomes available, this will also be recommended. Those doing this type of work are also subject to health surveillance annually and any signs of respiratory difficulty, although the risks are minimal, from things such as TB will hopefully be detected. Training includes emphasis on personal hygiene with hand washing and cleansing of hands with alcohol gel being stressed as of paramount importance. All surfaces likely to come into contact with saliva and biological fluids are regularly swabbed down with virkon solution 1% at a rate of 300ml/ m^2 from a spray container, which although not tested specifically on H1N1 it is specific against influenza type A viruses.

With regards to the chemicals which are hazardous, apart from the TMB and 0.5M sulphuric acid, these are present in extremely low concentrations so as to be of minimal risk.

Regarding the TMB and acid, all of the procedures are done with full PPE (gloves and lab coat) and in an operator protection containment cabinet.

The Class II cabinet is decontaminated with formalin, KI tested, serviced, and the HEPA filter is changed if necessary, every 6 months.

Personal Protective Equipment

√ Gloves	√ Eye protection	√ Coverall/lab coat	☐ Foot protection	☐ Respiratory protection
Details: use the nitrile gloves provided and not latex gloves.	*Details:* Only for work outside the fume cupboard, spinning down the saliva in case of burst salivettes in the centrifuge	*Details:* lab coat	*Details*	*Details:*

√ Health Surveillance required: Doing lots of immunoassays over a prolonged period of time. E.g. everyday for a few weeks or months	√ Exposure monitoring required: as previously

Emergency Arrangements

First Aid:	
Eyes	Wash with sterile water (lab wash bottles) for at least 15 minutes. Call physician
Skin	Wash with sterile water (lab wash bottles) for at least 15 minutes. Remove any contaminated clothing. Call physician.
Ingestion	Rinse mouth with copious amounts of water, and call a physician.
Inhalation	Remove individual to fresh air. If breathing is difficult give oxygen and call a physician

Fire: Extinguisher Type			
☐Water	√ Foam	√ Powder	√ CO_2

Spillage/release:

Mop up any spills using the spills kit stored in the cupboard under the sink in DB034 and wear protective clothing including the 3M spills team mask assigned and tested for fit, treat as hazardous waste. Swab down surfaces with detergents e.g. Decon. For spills of body fluids (saliva), hormone standards or enzyme-conjugate swab down all surfaces with a 1% virkon solution at 300ml/m^2

Waste Disposal procedure

Saliva samples, standards, enzyme (HRP) -cortisol conjugate are to be disposed of via the clinical waste procedure – autoclaving and clinical waste disposal route.

TMB, Acid and ELISA waste including the micro-titre plate are to be disposed of via the hazardous waste.

Persons likely to be exposed

√ Staff	√ Student	√ Visitor	√ Contractor
☐Public	☐ Other (specify)		

Additional risks: for example circumstances where work will involve exposure to more than one substance hazardous to health; consider the risk presented by exposure to such substances in combination. Also, non-routine maintenance may present additional risk of exposure.

There are no recorded interactions between these chemicals and they are widely used routinely together, with the PPE and interventions listed then the risk of harm is very low. The Class 2 cabinet is cleaned and fumigated prior to maintenance by the engineer.

Notes:

Hierarchy of control

Change the task or process so that the hazardous substance is not required or generated.

Replace the substances with a safer alternative.

Totally isolate or enclose the process. √

Partially enclose the process and use local exhaust ventilation. √

Ensure good general ventilation.

Use a system of work that minimises the chance and degree of exposure. √

Provide personal protective equipment (PPE). √

Train and inform staff in the safe system of work and risks. √

Additional supervision. √ for undergraduates

Examination, testing and maintenance of engineering controls and/or PPE. √

Monitoring of exposure. √

Health Surveillance. √ for prolonged use of assays

Other (specify).

APPENDIX 12

	Exercise - Pre						
	Weight of sampl	Minus Weight of Crovial (1.0062g)	Volume of saliva (ml	Flow rate (mL/min	Time (min)	Conc. IgA (µg/mL)	IgA (µg/min)
1	2.878	1.8718	1.81040496	0.362080992	5	170.37	61.68774
2	2.1963	1.1901	1.15106472	0.230212944	5	122.238	28.14077
3	2.5865	1.5803	1.52846616	0.305693232	5	282.961	86.49926
4	1.1529	0.1467	0.14188824	0.028377648	5	101.796	2.888731
5	1.1372	0.131	0.1267032	0.02534064	5	93.9617	2.38105
6	3.162	2.1558	2.08508976	0.46335328	4.5	118.613	54.95972
7	1.3545	0.3483	0.33687576	0.067375152	5	367.866	24.78503
8	1.9569	0.9507	0.91951704	0.183903408	5	151.508	27.86284
9	1.306	0.2998	0.28996656	0.057993312	5	54.0507	3.134579
10	2.1824	1.1762	1.13762064	0.227524128	5	117.73	26.78642
11	2.3369	1.3307	1.28705304	0.257410608	5	250.599	64.50684
12	2.7423	1.7361	1.67915592	0.335831184	5	374.495	125.7671
13	2.2433	1.2371	1.19652312	0.239304624	5	161.05	38.54001
14	2.5406	1.5344	1.48407168	0.296814336	5	129.731	38.50602
15	2.4711	1.4649	1.41685128	0.283370256	5	149.144	42.26297
16	2.8276	1.8214	1.76165808	0.846951	2.08	108.96	92.28378
17	1.6832	0.677	0.6547944	0.13095888	5	113.898	14.91595

	Exercise - Post						
	Weight of sampl	Minus Weight of Crovial (1.0062g)	Volume of saliva (ml	Flow rate (mL/min	Time (min)	Conc. IgA (µg/mL)	IgA (µg/min)
1	2.9061	1.8999	1.83758328	0.729199714	2.52	103.44	75.42842
2	2.0526	1.0464	1.01207808	0.202415616	5	126.78	25.66225
3	2.4985	1.4923	1.44335256	0.452461618	3.19	47.785	21.62088
4	1.367	0.3608	0.34896576	0.069793152	5	128.199	8.947412
5	1.4975	0.4913	0.47518536	0.095037072	5	173.72	16.50984
6	2.9215	1.9153	1.85247816	0.561357018	3.3	124.081	69.65374
7	1.4401	0.4339	0.41966808	0.083933616	5	194.443	16.3203
8	2.4962	1.49	1.441128	0.2882256	5	94.171	27.14249
9	2.8669	1.8607	1.79966904	0.404420009	4.45	107.281	43.38658
10	2.1666	1.1604	1.12233888	0.224467776	5	142.035	31.88228
11	2.8013	1.7951	1.73622072	0.347244144	5	132.769	46.10326
12	2.9285	1.9223	1.85924856	0.371849712	5	248.617	92.44816
13	2.1659	1.1597	1.12166184	0.224332368	5	138.059	30.9711
14	1.9939	0.9877	0.95530344	0.191060688	5	82.9252	15.84375
15	1.9675	0.9613	0.92976936	0.185953872	5	160.788	29.89915
16	2.7471	1.7409	1.68379848	0.336759696	5	138.998	46.80892
17	1.5954	0.5892	0.56987424	0.113974848	5	125.128	14.26144

	Control - Pre						
	Weight of sampl	Minus Weight of Crovial (1.0062g)	Volume of saliva (ml	Flow rate (mL/min	Time (min)	Conc. IgA (µg/mL)	IgA (µg/min)
1	2.6726	1.6664	1.61174208	0.322348416	5	78.286	25.23537
2	2.9471	1.9409	1.87723848	0.375447696	5	105.276	39.52563
3	2.7165	1.7103	1.65420216	0.697975595	2.37	111.77	78.01273
4	1.415	0.4088	0.39539136	0.079078272	5	104.995	8.302823
5	1.9709	0.9647	0.93305784	0.186611568	5	121.619	22.69551
6	2.8493	1.8431	1.78264632	0.356529264	5	11.2909	4.025536
7	1.7305	0.7243	0.70054296	0.140108592	5	222.456	31.168
8	2.0687	1.0625	1.02765	0.20553	5	109.189	22.44162
9	2.3705	1.3643	1.31955096	0.263910192	5	121.099	31.95926
10	2.0684	1.0622	1.02735984	0.205471968	5	107.27	22.04098
11	2.2407	1.2345	1.1940084	0.23880168	5	124.663	29.76973
12	2.1408	1.1346	1.09738512	0.219477024	5	216.139	47.43754
13	1.8114	0.8052	0.77878944	0.155757888	5	110.673	17.23819
14	3.1077	2.1015	2.0325708	0.585755274	3.47	224.476	131.488
15	2.0018	0.9956	0.96294432	0.192588864	5	129.061	24.85571
16							
17	2.2625	1.2563	1.21509336	0.243018672	5	68.7211	16.70051

	Control - Post						
	Weight of sampl	Minus Weight of Crovial (1.0062g)	Volume of saliva (ml	Flow rate (mL/min	Time (min)	Conc. IgA (µg/mL)	IgA (µg/min)
1	2.4296	1.4234	1.37671248	0.275342496	5	155.38	42.78272
2	2.8244	1.8182	1.75856304	0.351712608	5	131.099	46.10917
3	2.6356	1.6294	1.57595568	0.776332847	2.03	171.164	132.8802
4	1.1632	0.157	0.1518504	0.03037008	5	100.431	3.050098
5	2.297	1.2908	1.24846176	0.2972528	4.2	128.82	38.29211
6	2.7981	1.7919	1.73312568	0.346625136	5	136.392	47.2769
7	1.7103	0.7041	0.68100552	0.136201104	5	250.79	34.15787
8	2.5442	1.538	1.4875536	0.368206337	4.04	99.7874	36.74235
9	2.4052	1.399	1.3531128	0.27062256	5	123.15	33.32717
10	1.8662	0.86	0.831792	0.1663584	5	100.595	16.73482
11	2.6244	1.6182	1.56512304	0.313024608	5	158.433	49.59343
12	2.0779	1.0717	1.03654824	0.207309648	5	240.746	49.90897
13	2.385	1.3788	1.33357536	0.266715072	5	149.745	39.93925
14	2.9818	1.9756	1.91080032	0.42939333	4.45	112.113	48.14057
15	1.5356	0.5294	0.51203568	0.102407136	5	167.523	17.15555
16	2.351	1.3448	1.30069056	0.260138112	5	164.242	42.7256
17	2.9482	1.942	1.8783024	0.849910588	2.21	58.5628	49.77314

APPENDIX 13

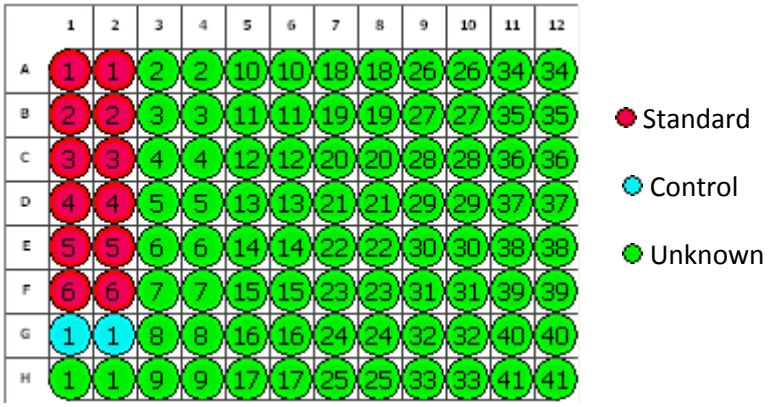


Figure. Plate layout for s-IgA assay

APPENDIX 14

	1	2	3	4	5	6	7	8	9	10	11	12
A	NSB	NSB	Ctrl-L	Ctrl-L	Unk-7	Unk-7	Unk-15	Unk-15	Unk-23	Unk-23	Unk-31	Unk-31
B	Zero	Zero	Ctrl-H	Ctrl-H	Unk-8	Unk-8	Unk-16	Unk-16	Unk-24	Unk-24	Unk-32	Unk-32
C	0.012 Std	0.012 Std	Unk-1	Unk-1	Unk-9	Unk-9	Unk-17	Unk-17	Unk-25	Unk-25	Unk-33	Unk-33
D	0.037 Std	0.037 Std	Unk-2	Unk-2	Unk-10	Unk-10	Unk-18	Unk-18	Unk-26	Unk-26	Unk-34	Unk-34
E	0.111 Std	0.111 Std	Unk-3	Unk-3	Unk-11	Unk-11	Unk-19	Unk-19	Unk-27	Unk-27	Unk-35	Unk-35
F	0.333 Std	0.333 Std	Unk-4	Unk-4	Unk-12	Unk-12	Unk-20	Unk-20	Unk-28	Unk-28	Unk-36	Unk-36
G	1.000 Std	1.000 Std	Unk-5	Unk-5	Unk-13	Unk-13	Unk-21	Unk-21	Unk-29	Unk-29	Unk-37	Unk-37
H	3.000 Std	3.000 Std	Unk-6	Unk-6	Unk-14	Unk-14	Unk-22	Unk-22	Unk-30	Unk-30	Unk-38	Unk-38

Figure. Plate layout for cortisol assay

APPENDIX 15

Participant Number	Pre exercise	Week 1			Week 2			Week 3			Week 4			Post exercise	Pre control	Post control
		1	2	3	1	2	3	1	2	3	1	2	3			
1	21.06.10 12pm	29th JUNE	30th JUNE	2nd JULY	5th JULY	7th JULY	9th JULY	12th JULY	14th JULY	15th JULY	19th JULY	21st JULY	22nd JULY	26.07.10 1:00pm	20.05.10 12pm	17.06.10 12pm
2	17.05.10 12pm	24th MAY	26th MAY	28th MAY	1st JUNE	2nd JUNE	[redacted]	7th JUNE	9th JUNE	10th JUNE	14th JUNE	16th JUNE	16th JUNE	21.06.10 12pm	5.07.10 11:30am	28.7.10 29.07.10 11:30 [redacted]
3	17.05.10 4.15pm	20th MAY	21st MAY	[redacted]	27th MAY	27th MAY	28th MAY	2nd JUNE	3rd JUNE	4th JUNE	7th JUNE	9th JUNE	9th JUNE	10.06.10? 4pm	1.07.10 4.15pm	28.07.10 [redacted]
4	3.06.10 1pm	7th JUNE	8th JUNE	9th JUNE	15th JUNE	[redacted]	18th JUNE	23rd JUNE	24th JUNE	25th JUNE	29th JUNE	[redacted]	1st JULY	8.07.10 12:30pm	21.07.10 11.30	11.08.10 4.00
5	7.06.10	9th JUNE	10th JUNE	11th JUNE	14th JUNE	16th JUNE	17th JUNE	23rd JUNE	24th JUNE	25th JUNE	28th JUNE	1st JULY	2nd JULY	7.07.10 9.30am	15.07.10 4pm	13.08.10 9am
6	22.06.10 10am	28th JUNE	[redacted]	2nd JULY	5th JULY	7th JULY	9th JULY	13th JULY	14th JULY	16th JULY	19th JULY	20th JULY	21st JULY	26.07.10 1:15pm	18.05.10 9am	18.06.10 9 am
7	25.06.10 9am	28th JUNE	30th JUNE	2nd JULY	7th JULY	8th JULY	9th JULY	13th JULY	14th JULY	[redacted]	[redacted]	22nd JULY	28th JULY	2.08.10 1.30pm	18.05.10 9am	15.06.10 9am
8	F 21.05.10 11am	24th MAY	25th MAY	28th MAY	1st JUNE	3rd JUNE	[redacted]	[redacted]	10th JUNE	11th JUNE	14th JUNE	17th JUNE	18th JUNE	21.06.10 3pm	25.07.10 11am	23.07.10 11am
9	28.06.10 12pm	29th JUNE	30th JUNE	1st JULY	5th JULY	6th JULY	7th JULY	12th JULY	13th JULY	14th JULY	19th JULY	21st JULY	22nd JULY	26.07.10 1pm	20.05.10 12pm	28.06.10 12pm
10	21.05.10 1pm	24th MAY	26th MAY	28th MAY	1st JUNE	2nd JUNE	[redacted]	7th JUNE	8th JUNE	10th JUNE	14th JUNE	15th JUNE	16th JUNE	21.06.10 12pm	5.07.10 11:30am	29.07.10 11:30
11	24.05.10 3.30pm	24th MAY	26th MAY	28th MAY	1st JUNE	2nd JUNE	3rd JUNE	9th JUNE	10th JUNE	11th JUNE	16th JUNE	17th JUNE	16th JUNE	21.06.10 3pm	5.07.10 11.00	2.08.10 1.30pm
12	30.06.10	5th JULY	7th JULY	8th JULY	13th JULY	14th JULY	16th JULY	19th JULY	21st JULY	22nd JULY	28th JULY	29th JULY	30th JULY	2.08.10 2.30pm	18.05.10 10.30am	15.06.10 9am
13	30.06.10	5th JULY	7th JULY	8th JULY	13th JULY	14th JULY	16th JULY	19th JULY	21st JULY	22nd JULY	28th JULY	29th JULY	30th JULY	2.08.10 2.30pm	18.05.10 10.30am	15.06.10 9am
14	21.07.10	21st JULY	22nd JULY	23rd JULY	28th JULY	29th JULY	30th JULY	4th AUG	5th AUG	6th AUG	10th AUG	11th AUG	12th AUG	13.08.10 9.30am	7.06.10 1.25pm	7.07.10 9.00
15	2.06.10 12:30pm	5th JUNE	9th JUNE	10th JUNE	15th JUNE	16th JUNE	17th JUNE	21st JUNE	22nd JUNE	23rd JUNE	29th JUNE	30th JUNE	1st JULY	8.07.10 12:30pm	22.07.10 12:30	1.09.10 12:30
16	2.06.10 12:30pm	5th JUNE	9th JUNE	10th JUNE	15th JUNE	16th JUNE	17th JUNE	21st JUNE	[redacted]	23rd JUNE	29th JUNE	30th JUNE	1st JULY	8.07.10 12:30pm	[redacted]	1.09.10 12:30
17	11.06.10 1.00pm	14th JUNE	16th JUNE	17th JUNE	23rd JUNE	24th JUNE	25th JUNE	29th JUNE	1st JULY	2nd JULY	6th JULY	7th JULY	8th JULY	16.07.10 3:30pm	30.07.10 1 PM	2.09.10 11.00

APPENDIX 16

T-Test

[DataSet14] C:\Users\Matt\Documents\MSc Thesis\IgAAmmended.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	52.1960	9	27.07620	9.02540
	Post_Exercise	38.5821	9	22.43983	7.47994
Pair 2	Pre_Control	29.0262	8	21.57014	7.62620
	Post_Control	51.2953	8	34.68414	12.26270

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Post_Exercise	9	.444	.231
Pair 2	Pre_Control & Post_Control	8	.830	.011

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Post_Exercise	13.61395	26.40546	8.80182
Pair 2	Pre_Control - Post_Control	-22.26912	20.63714	7.29633

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Post_Exercise	-6.68309	33.91098	1.547	8
Pair 2	Pre_Control - Post_Control	-39.52221	-5.01604	-3.052	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Post_Exercise	.161
Pair 2	Pre_Control - Post_Control	.019

T-Test

[DataSet14] C:\Users\Matt\Documents\MSc Thesis\IgAAmmended.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	33.2681	8	40.46964	14.30818
	Post_Exercise	33.2064	8	26.31030	9.30209
Pair 2	Pre_Control	40.0860	8	38.97797	13.78079
	Post_Control	34.4378	8	16.51096	5.83751

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Post_Exercise	8	.855	.007
Pair 2	Pre_Control & Post_Control	8	.553	.155

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Post_Exercise	.06166	22.58208	7.98397
Pair 2	Pre_Control - Post_Control	5.64822	32.85734	11.61682

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Post_Exercise	-18.81743	18.94076	.008	7
Pair 2	Pre_Control - Post_Control	-21.82120	33.11765	.486	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Post_Exercise	.994
Pair 2	Pre_Control - Post_Control	.642

T-Test

[DataSet13] C:\Users\Matt\Documents\Chez\Results\Chez SPSS\Cortisol.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	2.7342	7	.56812	.21473
	Post_Exercise	3.0525	7	.61599	.23282
Pair 2	Pre_Control	2.8876	7	1.21740	.46013
	Post_Control	3.8191	7	1.04871	.39638

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Post_Exercise	7	.492	.262
Pair 2	Pre_Control & Post_Control	7	.430	.335

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Post_Exercise	-.31834	.59827	.22612
Pair 2	Pre_Control - Post_Control	-.93159	1.21800	.46036

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Post_Exercise	-.87164	.23497	-1.408	6
Pair 2	Pre_Control - Post_Control	-2.05805	.19487	-2.024	6

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Post_Exercise	.209
Pair 2	Pre_Control - Post_Control	.089

T-Test

[DataSet13] C:\Users\Matt\Documents\Chez\Results\Chez SPSS\Cortisol.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	2.9603	7	.28214	.10664
	Post_Exercise	3.2593	7	.48129	.18191
Pair 2	Pre_Control	3.2165	7	.55709	.21056
	Post_Control	2.9173	7	.45609	.17239

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Post_Exercise	7	.748	.053
Pair 2	Pre_Control & Post_Control	7	-.382	.397

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Post_Exercise	-.29891	.32892	.12432
Pair 2	Pre_Control - Post_Control	.29923	.84419	.31907

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Post_Exercise	-.60311	.00528	-2.404	6
Pair 2	Pre_Control - Post_Control	-.48152	1.07997	.938	6

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Post_Exercise	.053
Pair 2	Pre_Control - Post_Control	.385

T-Test

[DataSet15] C:\Users\Matt\Documents\Chez\Results\Chez SPSS\Cortisol.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	2.7342	7	.56812	.21473
	Pre_Exercise_After	3.2018	7	.40982	.15490
Pair 2	Post_Exercise	3.3154	6	.60118	.24543
	Post_Exercise_After	2.9408	6	.51189	.20898

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Pre_Exercise_After	7	.502	.251
Pair 2	Post_Exercise & Post_Exercise_After	6	.664	.151

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Pre_Exercise_After	-.46758	.50698	.19162
Pair 2	Post_Exercise - Post_Exercise_After	.37464	.46357	.18925

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Pre_Exercise_After	-.93645	.00130	-2.440	6
Pair 2	Post_Exercise - Post_Exercise_After	-.11184	.86112	1.980	5

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Pre_Exercise_After	.050
Pair 2	Post_Exercise - Post_Exercise_After	.105

T-Test

[DataSet15] C:\Users\Matt\Documents\Chez\Results\Chez SPSS\Cortisol.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	2.9603	7	.28214	.10664
	Pre_Exercise_After	3.0651	7	.18850	.07125
Pair 2	Post_Exercise	3.2593	7	.48129	.18191
	Post_Exercise_After	3.2311	7	.36429	.13769

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Pre_Exercise_After	7	.329	.471
Pair 2	Post_Exercise & Post_Exercise_After	7	.830	.021

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Pre_Exercise_After	-.10475	.28303	.10697
Pair 2	Post_Exercise - Post_Exercise_After	.02818	.27067	.10230

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Pre_Exercise_After	-.36651	.15701	-.979	6
Pair 2	Post_Exercise - Post_Exercise_After	-.22215	.27851	.275	6

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Pre_Exercise_After	.365
Pair 2	Post_Exercise - Post_Exercise_After	.792

T-Test

[DataSet5] C:\Users\Matt\Documents\MSc Thesis\Blood Pressure.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E	126.056	9	11.0692	3.6897
	SBP_Post_E	122.667	9	13.1529	4.3843
Pair 2	SBP_Pre_C	110.278	9	42.7355	14.2452
	SBP_Post_C	126.167	9	10.5594	3.5198
Pair 3	DBP_Pre_E	85.222	9	8.8956	2.9652
	DBP_Post_E	85.500	9	10.2072	3.4024
Pair 4	DBP_Pre_C	75.500	9	30.1310	10.0437
	DBP_Post_C	86.278	9	5.6187	1.8729

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SBP_Pre_E & SBP_Post_E	9	.734	.024
Pair 2	SBP_Pre_C & SBP_Post_C	9	.857	.003
Pair 3	DBP_Pre_E & DBP_Post_E	9	.648	.059
Pair 4	DBP_Pre_C & DBP_Post_C	9	.399	.288

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E - SBP_Post_E	3.3889	9.0477	3.0159
Pair 2	SBP_Pre_C - SBP_Post_C	-15.8889	34.1282	11.3761
Pair 3	DBP_Pre_E - DBP_Post_E	-.2778	8.1052	2.7017
Pair 4	DBP_Pre_C - DBP_Post_C	-10.7778	28.3616	9.4539

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	SBP_Pre_E - SBP_Post_E	-3.5658	10.3436	1.124	8
Pair 2	SBP_Pre_C - SBP_Post_C	-42.1222	10.3444	-1.397	8
Pair 3	DBP_Pre_E - DBP_Post_E	-6.5080	5.9524	-.103	8
Pair 4	DBP_Pre_C - DBP_Post_C	-32.5785	11.0229	-1.140	8

Paired Samples Test

		Sig. (2-tailed)
Pair 1	SBP_Pre_E - SBP_Post_E	.294
Pair 2	SBP_Pre_C - SBP_Post_C	.200
Pair 3	DBP_Pre_E - DBP_Post_E	.921
Pair 4	DBP_Pre_C - DBP_Post_C	.287

T-Test

[DataSet1] C:\Users\Matt\Documents\MSc Thesis\Blood Pressure.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E	118.625	8	10.7030	3.7841
	SBP_Post_E	109.125	8	7.2789	2.5735
Pair 2	SBP_Pre_C	119.250	8	7.6765	2.7141
	SBP_Post_C	111.750	8	7.5829	2.6810
Pair 3	DBP_Pre_E	77.250	8	9.6732	3.4200
	DBP_Post_E	72.188	8	5.0634	1.7902
Pair 4	DBP_Pre_C	81.688	8	4.2421	1.4998
	DBP_Post_C	73.813	8	8.7421	3.0908

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SBP_Pre_E & SBP_Post_E	8	.431	.287
Pair 2	SBP_Pre_C & SBP_Post_C	8	.392	.337
Pair 3	DBP_Pre_E & DBP_Post_E	8	.277	.507
Pair 4	DBP_Pre_C & DBP_Post_C	8	.410	.313

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E - SBP_Post_E	9.5000	10.0214	3.5431
Pair 2	SBP_Pre_C - SBP_Post_C	7.5000	8.4134	2.9746
Pair 3	DBP_Pre_E - DBP_Post_E	5.0625	9.5970	3.3931
Pair 4	DBP_Pre_C - DBP_Post_C	7.8750	7.9989	2.8280

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	SBP_Pre_E - SBP_Post_E	1.1219	17.8781	2.681	7
Pair 2	SBP_Pre_C - SBP_Post_C	.4662	14.5338	2.521	7
Pair 3	DBP_Pre_E - DBP_Post_E	-2.9608	13.0858	1.492	7
Pair 4	DBP_Pre_C - DBP_Post_C	1.1878	14.5622	2.785	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	SBP_Pre_E - SBP_Post_E	.031
Pair 2	SBP_Pre_C - SBP_Post_C	.040
Pair 3	DBP_Pre_E - DBP_Post_E	.179
Pair 4	DBP_Pre_C - DBP_Post_C	.027

T-Test

[DataSet7] C:\Users\Matt\Documents\MSc Thesis\Body Composition.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E	34.563	8	14.7191	5.2040
	Fat_Percent_Post_E	33.338	8	14.1907	5.0172
Pair 2	Fat_Percent_Pre_C	32.600	6	15.6435	6.3864
	Fat_Percent_Post_C	32.667	6	17.7304	7.2384
Pair 3	FatFree_Percent_Pre_E	65.438	8	14.7191	5.2040
	FatFree_Percent_Post_E	66.663	8	14.1907	5.0172
Pair 4	FatFree_Percent_Pre_C	67.367	6	15.6450	6.3871
	FatFree_Percent_Post_C	67.333	6	17.7304	7.2384
Pair 5	TotalMass_kg_Pre_E	76.278	9	9.2560	3.0853
	TotalMass_kg_Post_E	76.889	9	9.0899	3.0300
Pair 6	TotalMass_kg_Pre_C	75.800	7	9.9763	3.7707
	TotalMass_kg_Post_C	76.029	7	9.3229	3.5237

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Fat_Percent_Pre_E & Fat_Percent_Post_E	8	.995	.000
Pair 2	Fat_Percent_Pre_C & Fat_Percent_Post_C	6	.993	.000
Pair 3	FatFree_Percent_Pre_E & FatFree_Percent_Post_E	8	.995	.000
Pair 4	FatFree_Percent_Pre_C & FatFree_Percent_Post_C	6	.993	.000
Pair 5	TotalMass_kg_Pre_E & TotalMass_kg_Post_E	9	.963	.000
Pair 6	TotalMass_kg_Pre_C & TotalMass_kg_Post_C	7	.993	.000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Post_E	1.2250	1.5462	.5467
Pair 2	Fat_Percent_Pre_C - Fat_Percent_Post_C	-.0667	2.8619	1.1684
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Post_E	-1.2250	1.5462	.5467
Pair 4	FatFree_Percent_Pre_C - FatFree_Percent_Post_C	.0333	2.8654	1.1698
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Post_E	-.6111	2.4952	.8317
Pair 6	TotalMass_kg_Pre_C - TotalMass_kg_Post_C	-.2286	1.3187	.4984

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Post_E	-.0677	2.5177	2.241	7
Pair 2	Fat_Percent_Pre_C - Fat_Percent_Post_C	-3.0701	2.9367	-.057	5
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Post_E	-2.5177	.0677	-2.241	7
Pair 4	FatFree_Percent_Pre_C - FatFree_Percent_Post_C	-2.9737	3.0404	.028	5
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Post_E	-2.5291	1.3069	-.735	8
Pair 6	TotalMass_kg_Pre_C - TotalMass_kg_Post_C	-1.4482	.9910	-.459	6

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Post_E	.060
Pair 2	Fat_Percent_Pre_C - Fat_Percent_Post_C	.957
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Post_E	.060
Pair 4	FatFree_Percent_Pre_C - FatFree_Percent_Post_C	.978
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Post_E	.483
Pair 6	TotalMass_kg_Pre_C - TotalMass_kg_Post_C	.663

T-Test

[DataSet6] C:\Users\Matt\Documents\MSc Thesis\Body Composition.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E	27.629	7	12.7916	4.8348
	Fat_Percent_Post_E	27.986	7	11.9910	4.5322
Pair 2	Fat_Percent_Pre_C	27.213	8	11.7005	4.1367
	Fat_Percent_Post_C	26.987	8	11.5470	4.0825
Pair 3	FatFree_Percent_Pre_E	72.371	7	12.7916	4.8348
	FatFree_Percent_Post_E	72.014	7	11.9910	4.5322
Pair 4	FatFree_Percent_Pre_C	72.788	8	11.7005	4.1367
	FatFree_Percent_Post_C	73.013	8	11.5470	4.0825
Pair 5	TotalMass_kg_Pre_E	63.943	7	5.8366	2.2060
	TotalMass_kg_Post_E	63.557	7	6.3416	2.3969
Pair 6	TotalMass_kg_Pre_C	63.075	8	6.3281	2.2373
	TotalMass_kg_Post_C	63.238	8	6.3644	2.2502

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Fat_Percent_Pre_E & Fat_Percent_Post_E	7	.979	.000
Pair 2	Fat_Percent_Pre_C & Fat_Percent_Post_C	8	.951	.000
Pair 3	FatFree_Percent_Pre_E & FatFree_Percent_Post_E	7	.979	.000
Pair 4	FatFree_Percent_Pre_C & FatFree_Percent_Post_C	8	.951	.000
Pair 5	TotalMass_kg_Pre_E & TotalMass_kg_Post_E	7	.996	.000
Pair 6	TotalMass_kg_Pre_C & TotalMass_kg_Post_C	8	.996	.000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Post_E	-.3571	2.6894	1.0165
Pair 2	Fat_Percent_Pre_C - Fat_Percent_Post_C	.2250	3.6378	1.2862
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Post_E	.3571	2.6894	1.0165
Pair 4	FatFree_Percent_Pre_C - FatFree_Percent_Post_C	-.2250	3.6378	1.2862
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Post_E	.3857	.7313	.2764
Pair 6	TotalMass_kg_Pre_C - TotalMass_kg_Post_C	-.1625	.5780	.2044

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Post_E	-2.8444	2.1301	-.351	6
Pair 2	Fat_Percent_Pre_C - Fat_Percent_Post_C	-2.8163	3.2663	.175	7
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Post_E	-2.1301	2.8444	.351	6
Pair 4	FatFree_Percent_Pre_C - FatFree_Percent_Post_C	-3.2663	2.8163	-.175	7
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Post_E	-.2906	1.0620	1.396	6
Pair 6	TotalMass_kg_Pre_C - TotalMass_kg_Post_C	-.6457	.3207	-.795	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Post_E	.737
Pair 2	Fat_Percent_Pre_C - Fat_Percent_Post_C	.866
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Post_E	.737
Pair 4	FatFree_Percent_Pre_C - FatFree_Percent_Post_C	.866
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Post_E	.212
Pair 6	TotalMass_kg_Pre_C - TotalMass_kg_Post_C	.453

T-Test

[DataSet9] C:\Users\Matt\Documents\MSc Thesis\Calculated V02.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	29.2267	9	5.98010	1.99337
	PostExercise	34.2279	9	9.71427	3.23809
Pair 2	PreControl	42.0765	8	17.09489	6.04396
	PostControl	34.9006	8	8.46685	2.99348

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PostExercise	9	.710	.032
Pair 2	PreControl & PostControl	8	.475	.234

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PostExercise	-5.00125	6.90504	2.30168
Pair 2	PreControl - PostControl	7.17589	15.04662	5.31978

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PostExercise	-10.30893	.30644	-2.173	8
Pair 2	PreControl - PostControl	-5.40340	19.75519	1.349	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PostExercise	.062
Pair 2	PreControl - PostControl	.219

T-Test

[DataSet9] C:\Users\Matt\Documents\MSc Thesis\Calculated V02.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	43.3900	8	6.29571	2.22587
	PostExercise	57.1426	8	15.40763	5.44742
Pair 2	PreControl	50.4193	8	8.92279	3.15468
	PostControl	55.9005	8	12.25591	4.33312

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PostExercise	8	.228	.587
Pair 2	PreControl & PostControl	8	.267	.523

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PostExercise	-13.75258	15.25863	5.39474
Pair 2	PreControl - PostControl	-5.48111	13.09413	4.62948

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PostExercise	-26.50911	-.99604	-2.549	7
Pair 2	PreControl - PostControl	-16.42808	5.46586	-1.184	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PostExercise	.038
Pair 2	PreControl - PostControl	.275

T-Test

[DataSet11] C:\Users\Matt\Documents\MSc Thesis\IPAQ.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	1.3333	9	.50000	.16667
	PostExercise	1.8889	9	.78174	.26058
Pair 2	PreControl	1.7500	8	.70711	.25000
	PostControl	1.8750	8	.64087	.22658

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PostExercise	9	.107	.785
Pair 2	PreControl & PostControl	8	.552	.156

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PostExercise	-.55556	.88192	.29397
Pair 2	PreControl - PostControl	-.12500	.64087	.22658

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PostExercise	-1.23346	.12235	-1.890	8
Pair 2	PreControl - PostControl	-.66078	.41078	-.552	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PostExercise	.095
Pair 2	PreControl - PostControl	.598

T-Test

[DataSet10] C:\Users\Matt\Documents\MSc Thesis\IPAQ.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	2.5000	8	.53452	.18898
	PostExercise	2.3750	8	.51755	.18298
Pair 2	PreControl	2.1250	8	.35355	.12500
	PostControl	2.2500	8	.88641	.31339

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PostExercise	8	.775	.024
Pair 2	PreControl & PostControl	8	.342	.407

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PostExercise	.12500	.35355	.12500
Pair 2	PreControl - PostControl	-.12500	.83452	.29505

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PostExercise	-.17058	.42058	1.000	7
Pair 2	PreControl - PostControl	-.82268	.57268	-.424	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PostExercise	.351
Pair 2	PreControl - PostControl	.685

T-Test

[DataSet16] C:\Users\Matt\Documents\MSc Thesis\Metalyser data (CHEZ).sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	METExePre	4.8222	9	.74125	.24708
	METSExePost	3.9478	9	.64160	.21387
Pair 2	METSRestPre	.7889	9	.41667	.13889
	METSRestPost	.8822	9	.89212	.29737
Pair 3	HRExePre	126.2222	9	12.16324	4.05441
	HRExePost	114.5556	9	14.80803	4.93601
Pair 4	HRRestPre	74.8889	9	9.34672	3.11557
	HRRestPost	68.6667	9	6.34429	2.11476
Pair 5	VO2KGExePre	16.7778	9	2.68225	.89408
	VO2KGExePost	13.8056	9	2.29326	.76442
Pair 6	VO2KGRestPre	2.5556	9	1.66667	.55556
	VO2KGRestPost	2.2119	9	.85326	.28442
Pair 7	EE_Exercise_Pre	335.7402	9	41.30474	13.76825
	EE_Exercise_Post	276.1276	9	33.12760	11.04253
Pair 8	EE_Rest_Pre	56.0782	9	30.33766	10.11255
	EE_Rest_Post	48.7406	9	14.03529	4.67843

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	METExePre & METSExePost	9	.459	.214
Pair 2	METSRestPre & METSRestPost	9	.003	.994
Pair 3	HRExePre & HRExePost	9	.729	.026
Pair 4	HRRestPre & HRRestPost	9	.385	.306
Pair 5	VO2KGExePre & VO2KGExePost	9	.488	.183
Pair 6	VO2KGRestPre & VO2KGRestPost	9	.073	.851
Pair 7	EE_Exercise_Pre & EE_Exercise_Post	9	.149	.703
Pair 8	EE_Rest_Pre & EE_Rest_Post	9	.194	.617

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	METExePre – METSExePost	.87444	.72421	.24140
Pair 2	METSRestPre – METSRestPost	-.09333	.98345	.32782
Pair 3	HRExePre - HRExePost	11.66667	10.23474	3.41158
Pair 4	HRRestPre - HRRestPost	6.22222	9.05232	3.01744
Pair 5	VO2KGExePre - VO2KGExePost	2.97222	2.53982	.84661
Pair 6	VO2KGRestPre - VO2KGRestPost	.34367	1.81575	.60525
Pair 7	EE_Exercise_Pre - EE_Exercise_Post	59.61254	48.95451	16.31817
Pair 8	EE_Rest_Pre - EE_Rest_Post	7.33754	30.85382	10.28461

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	METExePre – METSExePost	.31777	1.43112	3.622	8
Pair 2	METSRestPre – METSRestPost	-.84928	.66261	-.285	8
Pair 3	HRExePre - HRExePost	3.79955	19.53379	3.420	8
Pair 4	HRRestPre - HRRestPost	-.73600	13.18045	2.062	8
Pair 5	VO2KGExePre - VO2KGExePost	1.01994	4.92450	3.511	8
Pair 6	VO2KGRestPre - VO2KGRestPost	-1.05204	1.73937	.568	8
Pair 7	EE_Exercise_Pre - EE_Exercise_Post	21.98278	97.24231	3.653	8
Pair 8	EE_Rest_Pre - EE_Rest_Post	-16.37880	31.05389	.713	8

Paired Samples Test

		Sig. (2-tailed)
Pair 1	METExePre – METSExePost	.007
Pair 2	METSRestPre – METSRestPost	.783
Pair 3	HRExePre - HRExePost	.009
Pair 4	HRRestPre - HRRestPost	.073
Pair 5	VO2KGExePre - VO2KGExePost	.008
Pair 6	VO2KGRestPre - VO2KGRestPost	.586
Pair 7	EE_Exercise_Pre - EE_Exercise_Post	.006
Pair 8	EE_Rest_Pre - EE_Rest_Post	.496

T-Test

[DataSet12] C:\Users\Matt\Documents\MSc Thesis\Metalyser data (CHEZ).sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	METSRestPre	1.2750	8	.77229	.27304
	METSRestPost	.9338	8	.15847	.05603
Pair 2	METExePre	5.0375	8	1.10704	.39140
	METSExePost	4.3213	8	1.04316	.36881
Pair 3	HRRestPre	75.8750	8	12.15892	4.29883
	HRRestPost	71.1250	8	5.48862	1.94052
Pair 4	HRExePre	116.7500	8	16.22828	5.73756
	HRExePost	109.8473	8	9.25973	3.27381
Pair 5	VO2KGRestPre	4.3750	8	2.61520	.92461
	VO2KGRestPost	3.4166	8	1.15227	.40739
Pair 6	VO2KGExePre	17.7500	8	3.84522	1.35949
	VO2KGExePost	15.1375	8	3.69843	1.30759
Pair 7	EE_Rest_Pre	92.9727	8	54.84226	19.38967
	EE_Rest_Post	66.2078	8	34.43265	12.17378
Pair 8	EE_Exercise_Pre	360.6935	8	77.10697	27.26143
	EE_Exercise_Post	316.2261	8	75.55323	26.71210

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	METSRestPre & METSRestPost	8	.158	.708
Pair 2	METExePre & METSExePost	8	.589	.124
Pair 3	HRRestPre & HRRestPost	8	.142	.738
Pair 4	HRExePre & HRExePost	8	.561	.148
Pair 5	VO2KGRestPre & VO2KGRestPost	8	.257	.539
Pair 6	VO2KGExePre & VO2KGExePost	8	.623	.099
Pair 7	EE_Rest_Pre & EE_Rest_Post	8	.249	.552
Pair 8	EE_Exercise_Pre & EE_Exercise_Post	8	.556	.153

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	METSRestPre – METSRestPost	.34125	.76338	.26990
Pair 2	METExePre – METSExePost	.71625	.97620	.34514
Pair 3	HRRestPre - HRRestPost	4.75000	12.61235	4.45914
Pair 4	HRExePre - HRExePost	6.90275	13.42980	4.74815
Pair 5	VO2KGRestPre - VO2KGRestPost	.95838	2.57246	.90950
Pair 6	VO2KGExePre - VO2KGExePost	2.61250	3.27760	1.15881
Pair 7	EE_Rest_Pre - EE_Rest_Post	26.76495	57.03450	20.16474
Pair 8	EE_Exercise_Pre - EE_Exercise_Post	44.46741	71.95557	25.44013

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	METSRestPre – METSRestPost	-.29696	.97946	1.264	7
Pair 2	METExePre – METSExePost	-.09987	1.53237	2.075	7
Pair 3	HRRestPre - HRRestPost	-5.79419	15.29419	1.065	7
Pair 4	HRExePre - HRExePost	-4.32485	18.13035	1.454	7
Pair 5	VO2KGRestPre - VO2KGRestPost	-1.19225	3.10900	1.054	7
Pair 6	VO2KGExePre - VO2KGExePost	-.12764	5.35264	2.254	7
Pair 7	EE_Rest_Pre - EE_Rest_Post	-20.91709	74.44698	1.327	7
Pair 8	EE_Exercise_Pre - EE_Exercise_Post	-15.68895	104.62377	1.748	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	METSRestPre – METSRestPost	.247
Pair 2	METExePre – METSExePost	.077
Pair 3	HRRestPre - HRRestPost	.322
Pair 4	HRExePre - HRExePost	.189
Pair 5	VO2KGRestPre - VO2KGRestPost	.327
Pair 6	VO2KGExePre - VO2KGExePost	.059
Pair 7	EE_Rest_Pre - EE_Rest_Post	.226
Pair 8	EE_Exercise_Pre - EE_Exercise_Post	.124

APPENDIX 17

T-Test

[DataSet1] C:\Users\Matt\Documents\MSc Thesis\IgAAmmended.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	36.7330	8	27.12802	9.59120
	Pre_Control	30.2062	8	21.34832	7.54777

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Pre_Control	8	.849	.008

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Pre_Control	6.52676	14.41692	5.09715

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Pre_Control	-5.52609	18.57960	1.280	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Pre_Control	.241

T-Test

[DataSet2] C:\Users\Matt\Documents\MSc Thesis\IgAAmmended.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	43.7202	8	39.55021	13.98311
	Pre_Control	38.9059	8	39.43920	13.94386

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Pre_Control	8	.072	.865

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Pre_Control	4.81423	53.79441	19.01920

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Pre_Control	-40.15902	49.78748	.253	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Pre_Control	.807

T-Test

[DataSet2] C:\Users\Matt\Documents\MSc Thesis\IgAAmmended.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	2.9400	5	.67375	.30131
	Pre_Control	3.4800	5	.99458	.44479

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Pre_Control	5	.387	.519

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Pre_Control	-.54000	.96122	.42987

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Pre_Control	-1.73351	.65351	-1.256	4

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Pre_Control	.277

T-Test

[DataSet2] C:\Users\Matt\Documents\MSc Thesis\IgAAmmended.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise	2.8711	7	.26587	.10049
	Pre_Control	2.7987	7	.92430	.34935

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Pre_Exercise & Pre_Control	7	-.073	.876

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Pre_Exercise - Pre_Control	.07237	.98025	.37050

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Pre_Exercise - Pre_Control	-.83421	.97895	.195	6

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Pre_Exercise - Pre_Control	.852

T-Test

[DataSet1] C:\Users\Matt\Documents\MSc Thesis\Blood Pressure.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E	126.056	9	10.6491	3.5497
	SBP_Pre_C	109.833	9	42.6292	14.2097
Pair 2	DBP_Pre_E	84.611	9	8.0769	2.6923
	DBP_Pre_C	73.944	9	29.3305	9.7768

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SBP_Pre_E & SBP_Pre_C	9	.387	.303
Pair 2	DBP_Pre_E & DBP_Pre_C	9	.382	.310

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E - SBP_Pre_C	16.2222	39.7399	13.2466
Pair 2	DBP_Pre_E - DBP_Pre_C	10.6667	27.2844	9.0948

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	SBP_Pre_E - SBP_Pre_C	-14.3245	46.7690	1.225	8
Pair 2	DBP_Pre_E - DBP_Pre_C	-10.3060	31.6393	1.173	8

Paired Samples Test

		Sig. (2-tailed)
Pair 1	SBP_Pre_E - SBP_Pre_C	.256
Pair 2	DBP_Pre_E - DBP_Pre_C	.275

T-Test

[DataSet1] C:\Users\Matt\Documents\MSc Thesis\Blood Pressure.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E	118.625	8	11.1795	3.9526
	SBP_Pre_C	119.750	8	7.6485	2.7042
Pair 2	DBP_Pre_E	77.938	8	10.9982	3.8884
	DBP_Pre_C	83.438	8	6.4056	2.2647

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SBP_Pre_E & SBP_Pre_C	8	.826	.012
Pair 2	DBP_Pre_E & DBP_Pre_C	8	.105	.804

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	SBP_Pre_E - SBP_Pre_C	-1.1250	6.5014	2.2986
Pair 2	DBP_Pre_E - DBP_Pre_C	-5.5000	12.1302	4.2887

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	SBP_Pre_E - SBP_Pre_C	-6.5603	4.3103	-.489	7
Pair 2	DBP_Pre_E - DBP_Pre_C	-15.6411	4.6411	-1.282	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	SBP_Pre_E - SBP_Pre_C	.639
Pair 2	DBP_Pre_E - DBP_Pre_C	.241

T-Test

[DataSet1] C:\Users\Matt\Documents\MSc Thesis\Body Composition.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E	31.914	7	14.9259	5.6414
	Fat_Percent_Pre_C	30.400	7	14.6870	5.5511
Pair 2	Fat_kg_Pre_E	23.643	7	15.2175	5.7517
	Fat_kg_Pre_C	22.043	7	14.6138	5.5235
Pair 3	FatFree_Percent_Pre_E	68.086	7	14.9259	5.6414
	FatFree_Percent_Pre_C	69.600	7	14.6870	5.5511
Pair 4	FatFree_kg_Pre_E	47.029	7	9.0271	3.4119
	FatFree_kg_Pre_C	47.157	7	9.5845	3.6226
Pair 5	TotalMass_kg_Pre_E	70.775	8	13.3190	4.7090
	TotalMass_kg_Pre_C	70.113	8	13.9967	4.9486

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Fat_Percent_Pre_E & Fat_Percent_Pre_C	7	.966	.000
Pair 2	Fat_kg_Pre_E & Fat_kg_Pre_C	7	.988	.000
Pair 3	FatFree_Percent_Pre_E & FatFree_Percent_Pre_C	7	.966	.000
Pair 4	FatFree_kg_Pre_E & FatFree_kg_Pre_C	7	.945	.001
Pair 5	TotalMass_kg_Pre_E & TotalMass_kg_Pre_C	8	.982	.000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Pre_C	1.5143	3.8882	1.4696
Pair 2	Fat_kg_Pre_E - Fat_kg_Pre_C	1.6000	2.3409	.8848
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Pre_C	-1.5143	3.8882	1.4696
Pair 4	FatFree_kg_Pre_E - FatFree_kg_Pre_C	-.1286	3.1367	1.1856
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Pre_C	.6625	2.6662	.9426

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Pre_C	-2.0817	5.1103	1.030	6
Pair 2	Fat_kg_Pre_E - Fat_kg_Pre_C	-.5650	3.7650	1.808	6
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Pre_C	-5.1103	2.0817	-1.030	6
Pair 4	FatFree_kg_Pre_E - FatFree_kg_Pre_C	-3.0296	2.7724	-.108	6
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Pre_C	-1.5665	2.8915	.703	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Pre_C	.343
Pair 2	Fat_kg_Pre_E - Fat_kg_Pre_C	.121
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Pre_C	.343
Pair 4	FatFree_kg_Pre_E - FatFree_kg_Pre_C	.917
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Pre_C	.505

T-Test

[DataSet2] C:\Users\Matt\Documents\MSc Thesis\Body Composition.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E	28.833	6	15.2930	6.2433
	Fat_Percent_Pre_C	28.433	6	13.9609	5.6995
Pair 2	Fat_kg_Pre_E	20.050	6	10.6577	4.3510
	Fat_kg_Pre_C	19.600	6	9.6503	3.9397
Pair 3	FatFree_Percent_Pre_E	71.167	6	15.2930	6.2433
	FatFree_Percent_Pre_C	71.533	6	13.9745	5.7051
Pair 4	FatFree_kg_Pre_E	48.967	6	9.7770	3.9915
	FatFree_kg_Pre_C	48.750	6	8.7817	3.5851
Pair 5	TotalMass_kg_Pre_E	69.017	6	4.0425	1.6503
	TotalMass_kg_Pre_C	68.350	6	3.8775	1.5830

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Fat_Percent_Pre_E & Fat_Percent_Pre_C	6	.992	.000
Pair 2	Fat_kg_Pre_E & Fat_kg_Pre_C	6	.992	.000
Pair 3	FatFree_Percent_Pre_E & FatFree_Percent_Pre_C	6	.992	.000
Pair 4	FatFree_kg_Pre_E & FatFree_kg_Pre_C	6	.987	.000
Pair 5	TotalMass_kg_Pre_E & TotalMass_kg_Pre_C	6	.975	.001

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Pre_C	.4000	2.3134	.9445
Pair 2	Fat_kg_Pre_E - Fat_kg_Pre_C	.4500	1.6610	.6781
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Pre_C	-.3667	2.3166	.9458
Pair 4	FatFree_kg_Pre_E - FatFree_kg_Pre_C	.2167	1.8104	.7391
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Pre_C	.6667	.9026	.3685

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Pre_C	-2.0278	2.8278	.424	5
Pair 2	Fat_kg_Pre_E - Fat_kg_Pre_C	-1.2931	2.1931	.664	5
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Pre_C	-2.7978	2.0645	-.388	5
Pair 4	FatFree_kg_Pre_E - FatFree_kg_Pre_C	-1.6833	2.1166	.293	5
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Pre_C	-.2805	1.6139	1.809	5

Paired Samples Test

		Sig. (2-tailed)
Pair 1	Fat_Percent_Pre_E - Fat_Percent_Pre_C	.690
Pair 2	Fat_kg_Pre_E - Fat_kg_Pre_C	.536
Pair 3	FatFree_Percent_Pre_E - FatFree_Percent_Pre_C	.714
Pair 4	FatFree_kg_Pre_E - FatFree_kg_Pre_C	.781
Pair 5	TotalMass_kg_Pre_E - TotalMass_kg_Pre_C	.130

T-Test

[DataSet4] C:\Users\Matt\Documents\MSc Thesis\Calculated V02.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	35.2675	8	9.64980	3.41172
	PreControl	51.4248	8	16.41452	5.80341

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PreControl	8	.651	.081

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PreControl	-16.15731	12.50588	4.42150

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PreControl	-26.61249	-5.70214	-3.654	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PreControl	.008

```
DATASET ACTIVATE DataSet19.
DATASET CLOSE DataSet18.
```

T-Test

[DataSet5]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	37.3388	8	9.98661	3.53080
	PreControl	41.0710	8	8.99614	3.18061

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PreControl	8	.325	.433

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PreControl	-3.73227	11.06025	3.91039

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PreControl	-12.97886	5.51433	-.954	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PreControl	.372

T-Test

[DataSet5] C:\Users\Matt\Documents\MSc Thesis\IPAQ.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	1.8750	8	.83452	.29505
	PreControl	2.0000	8	.53452	.18898

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PreControl	8	.000	1.000

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PreControl	-.12500	.99103	.35038

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PreControl	-.95352	.70352	-.357	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PreControl	.732

T-Test

[DataSet7] C:\Users\Matt\Documents\MSc Thesis\IPAQ.sav

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PreExercise	2.0000	8	.75593	.26726
	PreControl	1.8750	8	.64087	.22658

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreExercise & PreControl	8	.885	.004

Paired Samples Test

		Paired Differences		
		Mean	Std. Deviation	Std. Error Mean
Pair 1	PreExercise - PreControl	.12500	.35355	.12500

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference			
		Lower	Upper	t	df
Pair 1	PreExercise - PreControl	-.17058	.42058	1.000	7

Paired Samples Test

		Sig. (2-tailed)
Pair 1	PreExercise - PreControl	.351

APPENDIX 18

Fair

	$Mean_{Diff}$	SD_{Diff}	$Effect\ Size_{(d=)}$
METs_E	0.87444	0.72421	1.207439831
HR_E	11.66667	10.23474	1.139908781
Relative VO_2_E	2.97222	2.53982	1.170248285
EE_E	59.61254	48.95451	1.217712934
IgA_E	13.61395	26.40546	0.515573294
IgA_C	-22.2691	20.63714	-1.079079756
Cortisol_Exercise	-0.31834	0.59827	-0.532100891
Cortisol_Control	-0.93159	1.218	-0.764852217
Cortsiol_Pre(B&A)	-0.46758	0.50698	-0.922284903
Cortisol_Post(B&A)	0.37464	0.46357	0.808162737
Fat %_E	1.225	1.5462	0.792264908
Fat Free %_E	-1.225	1.5462	-0.792264908
Estimated VO_{2max}	-5.00125	6.90504	-0.724289794

Good

	$Mean_{Diff}$	SD_{Diff}	$Effect\ Size_{(d=)}$
METs_E	0.71625	0.9762	0.733712354
Relative VO2_E	2.6125	3.2776	0.79707713
IgA_E	0.06166	22.58208	0.002730484
IgA_C	5.64822	32.85734	0.171901316
Cortisol_Exercise	-0.29891	0.32892	-0.908762009
Cortisol_Control	0.29923	0.84419	0.35445812
Cortsiol_Pre(B&A)	-0.10475	0.28303	-0.370102109
Cortisol_Post(B&A)	0.02818	0.27067	0.104112018
SBP_E	9.5	10.0214	0.947971341
SBP_C	7.5	8.4134	0.891435092
DBP_C	7.875	7.9989	0.98451037
Estimated VO_{2max}	-13.7526	15.25863	-0.901298478

APPENDIX 19

Fair	Pre E_M	Post E_M	
IgA	52.19602	38.58207	-26.0824
Cortisol	2.734186	3.142831	14.94576

	Pre $Before_M$	Pre $After_M$	
Cortisol	2.73	3.2	17.21612
SBP	126	123	-2.38095
DBP	85	86	1.176471
Fat %	35	33	-5.71429
Fat Free %	65	67	3.076923
Mass KG	76	77	1.315789
VO_2	29	34	17.24138

	Pre R_M	Post R_M	
METs	0.79	0.97	22.78481
HR	75	68	-9.33333
Relative VO_2	2.6	2.2	-15.3846
EE	56	49	-12.5

Fair	Pre C_M	Post C_M	
IgA	29.02615	50.34309	73.44047
Cortisol	2.960341	3.259254	10.09725

	Post $Before_M$	Post $After_M$	
Cortisol	3.32	2.94	-11.4458
SBP	124	126	1.612903
DBP	85	86	1.176471
Fat %	33	34	3.030303
Fat Free %	67	63	-5.97015
Mass KG	76	76	0
VO_2	42	36	-14.2857

	Pre E_M	Post E_M	
METs	4.82	3.94	-18.2573
HR	126	114	-9.52381
Relative VO_2	16.8	13.8	-17.8571
EE	336	276	-17.8571

Good	Pre E_M	Post E_M	
IgA	33.26808	33.20642	-0.18534

Cortisol	2.960341	3.259254	10.09725

	Pre Before$_M$	**Pre After$_M$**	
Cortisol	2.96	3.07	3.716216
SBP	119	109	-8.40336
DBP	77	72	-6.49351
Fat %	28	28	0
Fat Free %	72	72	0
Mass KG	65	65	0
VO_2	43	57	32.55814

	Pre R_M	**Post R_M**	
METs	1.28	0.93	-27.3438
HR	76	71	-6.57895
Relative VO_2	4.4	3.4	-22.7273
EE	93	66	-29.0323

Good	**Pre C_M**	**Post C_M**	
IgA	40.08599	34.43777	-14.0903
Cortisol	3.216544	3.021403	-6.06679

	Post Before$_M$	**Post After$_M$**	
Cortisol	3.26	3.23	-0.92025
SBP	119	112	-5.88235
DBP	82	74	-9.7561
Fat %	27	27	0
Fat Free %	73	73	0
Mass KG	65	65	0
VO_2	50	56	12

	Pre E_M	**Post E_M**	
METs	5.04	4.32	-14.2857
HR	117	110	-5.98291
Relative VO_2	17.8	15.1	-15.1685
EE	361	316	-12.4654