An assessment of the internal load experienced by horse riders at different ridden gaits and the implications for rider fitness

by

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

June 2018

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Masters in Science by Research

School

Sport and Wellbeing

*Sections marked * delete as appropriate*

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An assessment of the internal load experienced by horse riders at different ridden gaits and the implications for rider fitness

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The repetitive motions used by the rider to control the horse, dampen the vertical and horizontal acceleration of the horse's trunk, and yet maintaining good horse riding posture cannot be easily replicated with the use of exercise equipment or sporting simulators. As such, determining the physiological demands of horse riding requires a mixed approach of laboratory and field testing. Previous studies have quantified oxygen uptake for different gaits (Westerling, 1983) and heart rates during race riding (Trowbridge *et al.*, 1995) when riding one horse, but different horses may necessitate different physiological demands. The aims of this study were to establish baseline fitness data of student riders, and compare the difference in heart rate of the riders when riding two different horses at three common riding gaits; walk, trot and canter. With institutional ethical approval, participants (n= 19), performed a standardised exercise test in the form of a 6- minute Astrand-Rhyming Cycle Ergometer Test to assess fitness. Two ridden 45-minute sessions one week apart, which incorporated each of the three gaits were carried out on two different horses for each rider to assess the physiological demands of different horses. Mean heart rate for each gait, each rider and each session were analysed using ANOVA. The mean heart rates for each gait were; walk 128 bpm, trot 137 bpm, and canter 149 bpm. Gait had a significant effect on the heart rate of the riders ($P=0.001$). There was no significant effect of the rider ($P=0.256$) or the horse ($P=0.374$). A post hoc pairwise Fisher comparison showed a significant difference ($P<0.05$) between walk and canter and trot and canter. There was no significant difference ($P>0.05$) between walk and trot. The results suggest that gait is the most significant factor when influencing heart rate, highlighting that gait reflects the intensity of the exercise, unlike the horse's way of going, which did not show any significant effect on the heart rate of the rider. Therefore, to improve the cardiovascular fitness of riders, increasing amounts of time in the canter gait should be encouraged.

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Acknowledgements

I would like to express my deepest gratitude to my supervisor's Dr Sarah Hobbs, Dr Rachel White and Dr Steve Atkins for all their hard work in helping me develop my study and myself during this duration of the master's thesis. The suggestions and support were incredibly valuable and constructive throughout the process. Some special thanks for the reading of many draft pieces and keeping my moments of question to a minimum.

I am particularly thankful to the members of the equine staff at both Craven College and Myerscough College, without your co-operation and support I could not have undertaken this project. I am overwhelmingly thankful to each and every student who took the time to complete the study and smiled in the process without you all I couldn't have completed my work.

A huge thank you to my wonderful and supportive colleagues for so much guidance and moral support throughout the final stages of my thesis. You've been amazing! A special thank you to Wendy Grayson, who has provided both support and encouragement throughout my higher education. To Eleanor Boden who supported my undergraduate work and continued her support and encouragement throughout my masters, the endless reassurance has helped to keep me on the right track, for that I will always be thankful.

Finally, many thanks to my parents and partner, for their infinite encouragement and constant support has enabled me to pursue my ambitions, not only in my education; but always. And to Andrew and Vinnie, for the confidence to continue my equine education.

Chapter One: Introduction

1.1. The Importance of Physiology

Physical and physiological demands of sports determine which fitness components should be targeted during training (Pearson *et al.,* 2006). Once the demands have been identified, it will aid in the identification of the fitness components required, which are most important for the sport (Vaeyes *et al.,* 2008). Once these have been decided they provide a strong foundation from which a fitness programme may be designed. The programme can be revisited and revised to accommodate the specific requirements of different disciplines (Johnson and Campbell, 2002). Individual fitness plans can also be developed to fit the individual training and fitness programmes of the horse rider and horse.

The word 'fatigue' is used to describe a variety of signs and symptoms related to the failure to sustain some form of physical activity and as such limits sporting performance (Fletcher *et al.,* 2001). Most reviews of fatigue define the word as 'an inability of a muscle group to sustain the required or expected force' (Gandevia, 2001). The difficulty with the definition is that during activity there are a variety of changes in neuromuscular function, such as an increase in temperature, which can either enhance or maintain function (Allen *et al.,* 2008). The direct causes of fatigue during sporting exercise include factors that reside in the brain known as central mechanisms, as well as the fatigue elements of the muscles themselves, known as peripheral mechanisms (Gandevia *et al.,* 1995). The study of central fatigue is largely unexplored, but with increasing evidence that increased brain serotonin can lead to an increased central fatigue, there is evidence this could be a cause in the deterioration of sport performance (Valenzuela *et al.,* 2018). Peripheral fatigue is caused from overactivity of the muscle groups resulting in a decline of function and ability to continue exercise, this originates from a non-central nervous system mechanism (Randall and Keyser, 2010).

Fatigue in equestrian sports is highly dangerous with the factors of horse fatigue and rider fatigue which will occur at different points of competition. Whilst fatigue of the horse has been studied there is a distinct lack of extensive fatigue research on the horse rider, aspects of sporting fatigue documentation can be adapted, however, horse riding is different to the motions and demands of any other sports. Similar to the demands of the horse the riders demands also change with disciplines, the variety of stabilising and movement of the muscles in all areas of equestrian sports. There is also an aspect of mental or central fatigue when competing in comparison to those in training or leisure riding (Sargent *et al.*, 2014). There is a distinct different in the physical demands on the rider for the sports of horse racing (Trowbridge *et al.,* 1995) when compared to that of endurance riding. The short bursts of high demand workloads on the jockey gain increased levels of peripheral fatigue due to the nature of the demands (Hitchen *et al.,* 2011). The 50-mile rides often carried out by experienced endurance riders would elicit central fatigue with elements of peripheral fatigue.

Fitness is often linked to injury; a high percentage of horse rider injury can be linked to horse rider falls and fatigue. There has been an increasing effort to improve the fitness of horse riders and decrease the instances of horse rider falls (McCrory and Turner, 2005). An increase of the horse rider fitness can prevent injury and reduces the severity of the injury, should it occur (Watt and Finch, 1996).

The use of baseline fitness knowledge is employed in many sports, more commonly rugby and football (Carling *et al.*, 2008). This knowledge is used to establish fitness levels, identify strengths and weaknesses and create fitness and training programmes. Once training is underway, fitness testing can be used to monitor progress (Sharkey and Gaskill, 2013). A mixture of training regimens and fitness sessions are currently used in sports such as gymnastics and American football that incorporate strength, stamina and flexibility training. This is important to ensure all aspects of the sports fitness are targeted and not just skill related areas. There are several studies highlighting the need for the equestrian industry to find information of the demands placed on riders, in order to improve the riders position and horses welfare(Meyers 2006; Douglas *et al*., 2012). The use of non-horse training in the equestrian industry is uncommon, however, over recent years there has been an increase in the media coverage in equine specific magazines and online articles of popular off-horse exercises to aid position and posture whilst riding.

1.2. The Physiological Demands for Horse riders

The exact physiological demands of the novice equestrian athlete (horse rider), whilst mounted, are unknown as most studies focus on those of elite levels, rather than the everyday or novice rider (Devienne and Guezennec, 2000). Several studies (Westerling, (1983); Trowbridge *et al.*, (1995); Bojer *et al.*, (1998) have attempted to establish the physiological demands placed on the horse rider, however, these early studies suffered limitations due to the difficulty in obtaining accurate results whilst in a field situation as the equipment was large and ineffective out of the laboratory setting. There is a difficulty in the fitting of testing equipment safely onto the horse riders, many pieces of equipment could cause harm and damage if a fall was to occur during testing due to the placement of some of the equipment on the lower back (Meyers and Sterling, 2000).

The repetitive and rotary motions and impact of the horse whilst mounted cannot be easily mimicked (Greve and Dyson, 2013). Walker *et al.* (2016) highlights that racing simulators although are good for jockeys to adapt and manipulate the position, the motions are not the same as those experienced whilst mounted on racehorses on the track. The lack of scientific studies into the demands of horse riding reduces the ability to determine appropriate and reliable methods of quantifying fitness levels and provide relevant fitness regimens for the horse rider to follow. Previous studies of the fitness of the horse rider have focused primarily on the evaluation of fitness techniques and the ability to improve the fitness of the horse rider; studies such as Boden *et al.,* (2013), who studied the effects of Pilates on the position of the horse rider. In previous research such as that by Meyers (2006), and that of Devienne and Guezennec (2000) who suggest trot and canter work whilst riding can be deemed as a form of moderate intensity exercise, with a jumping effort requiring more cardiac exertions and so deemed high intensity exercise. Moderate intensity exercise is defined physiologically as exercise which raises the heart rate to 70% of maximal and increase perspiration levels without causing extreme exertion (Swaka *et al.,* 2011).

Improving the fitness of the horse rider ultimately makes the horse the benefactor, as increased stability is expected to decrease the incidence of horse rider falls and increasing horse rider balance and strength should enhance their ability to apply the aids correctly (Steiner, 2015). Incidences of equine back pain is prevalent in the industry (Aleman, 2008) and lower back pain can also be linked to a lack of fitness and core stability (Leetun *et al.,* 2004). Horse riders should be able to balance themselves, influence the balance of the horse and be able to give clear, accurate aids throughout a full training session or competition (Wipper, 2000).

There are arguments within the equine industry of the importance of saddle fit and horse rider influence; a stable horse rider should evenly place weight across the back without causing discomfort (Fruehwirith *et al.*, 2004). In horse riding the physical influence of the horse rider is being increasingly recognised as a significant contributor to equine back pain (Greve and Dyson, 2015). The asymmetrical loading by the horse rider can be detrimental to the performance of the horse and horse rider combination (Hampson and Randle, 2015). An unstable horse rider will use their body to balance and ultimately give an uneven distribution of weight, increasing the chances of equine back injury (Murray *et al.*, 2010).

There are currently no other sports with similar repetitive motion patterns, nor many with the addition of the horse as a factor to consider when finding baseline fitness levels. Additional fitness sessions can be added to the routines of horse riders, especially those in educational centres and training.

The horse naturally has four gaits, walk, trot, canter and gallop (Alexander and Jayes, 1983). The walk is a natural four beat gait; the horses always has two hooves on the ground. The walk is slowest of the four gaits and deemed most comfortable, due to the speed and the ease of finding balance within the gait when compared with the trot and canter (d'Eisenberg and Allen, 2016). The trot is a steady two beat gait, with a period of suspension, when the horse springs from one diagonal pair to the other. Due to this, it is more comfortable for the horse rider and the horse for the rider to rise-up and down with every other beat (Egenvall *et al.*, 2013). The canter is a three-beat gait that has a moment of suspension after each stride. The gait starts with the hind leg and moves to the front in a rocking motion. Whilst in the canter the horse rider can be in 2 seat types, a deep seat where the rider must keep sat deep in the saddle and balanced (Collins, 2006), or a light seat where more of the rider's weight should be carried by his thighs and knees and the rider should lean the upper body slightly forward, thus lessening the pressure of the seat bones in the saddle The light seat is of great value when breaking and training young horses as back muscles of a young horse need strengthening (through gymnastic exercises) before carrying the full weight of the rider with ease (USDF Training Manual, 2013).The gallop is a four-beat gait, like that of the canter, however the legs move together. The gallop feels like a fast canter and horse riders should aim to raise out of the saddle and put the weight into their heels (Podhajsky, 2013).

The point at which the participation of equestrian sport leads to an increase in horse rider fitness is reliant on the specific exercises of each training session, the temperament of the horse and effectiveness of the horse rider (Wolfram, 2015). Although not all horse riders appear to be working to the defined moderate exercise standard, some disciplines can be considered to be high intensity such as Show Jumping (Rincon *et al*., 1992), Eventing (Roberts *et al*., 2010), National Hunt Racing (Trowbridge et al., 1995), Flat Racing (Cullen *et al.*, 2015) and Polo (Wright and Peters, 2008).

1.3. Justification of the study

The horse rider's role in performance over recent years has come under scrutiny, after several years of the horse's individual performance being of upmost importance, the riders impact on overall performance has recently come into question. The increased desire for harmony between the horse and rider has encouraged horse riders to increase their ability to improve their posture and position to enable this. . Observation tools and interventions such as video analysis and physiotherapy, are now commonly available to aid horse rider development, along with training methods such as strength training and conditioning (Lagarde *et al.,* 2005). This advance in training and intervention methods has highlighted the need for horse riders to have the correct fitness levels whether a leisure or competition rider and maintain the correct posture whilst seated in the saddle (Meyners, 2004). This change represents a paradigm shift, the International Equestrian Federation (FEI, 2009) beginning to call the horse rider 'the athlete'. An athlete is defined as 'A person who is proficient in sport and/or physical exercise'. There have been slow changes made with the industry with the introduction of on/off horse exercises published in the media and companies such as Fit2Ride™ offering tailored programmes for riders to follow.

Baseline physiological demands refers to the first set of measurements which relate to physiological factors such as heart rate and $\dot{V}O_2$ (Maximal Oxygen Consumption). An understanding of the demands placed upon the horse rider, whilst mounted, is needed to have a better understanding of the physiological stress on the horse rider. These measurements can be obtained in a variety of ways, which include heart rate monitors, body weight and mass scales and breath-by-breathanalysis equipment. The demands placed on athletes varies dependent on the sport, intensity of the exercise and the fitness of the athlete for the sport.

The ability to effectively improve the horse riders' fitness using specific training programmes could be advantageous, as the overall performance of the horse and horse rider as well as horse welfare is likely to improve. The horse rider will have the ability to control their own body movement, adjust weight and pressure to ensure pressure is evenly distributed over the horses back leading to a reduced stress on the horse's musculoskeletal system.

Although there has been a notable increase in investigations into the physiological requirements of the horse rider, there is still much to learn across the industry. Developing information and evidence on topics such as metabolic costs across all abilities and a wider range of equestrian disciplines is required along with muscular strength and endurance, more specifically which of the muscles are primarily used during riding.

Chapter Two: Literature Review

2.1. Physical Activity and Health Benefits

Both exercise and physical activity has been a popular area for research within the health industry for many years (Blair *et al.*, 1995; King *et al.*, 1988; Myers, 2003), with the recent increases in health problems associated with obesity, many sports are being researched for their ability to provide the correct amount of physical activity to cause changes in health. There has been an increase in technology, which could have contributed to a society of inactivity. Brownson *et al.* (2005), suggests that improvements in television, transport and labour-saving devices both at home and work have also contributed to a sedentary lifestyle for many people. It has been highlighted by Pate *et al.* (1995) that 12% of deaths a year could be prevented with the correct prescription of exercise and physical activity. These numbers illustrate the impact that inactivity can have on an individual and the importance of encouraging a variety of exercise and regular physical activity, which plays a large role in the overall health of an individual.

2.2. Exercise and Disease Potential

Physical activity has been described as a 'Modifiable Risk Factor' in a variety of diseases (Mackay, 2004). Previous research has shown an association between regular exercise and a decrease in risk for diseases such as; cardiovascular disease, diabetes cancers and depression and anxiety (Brown and Ryan, 2003). These fitness-related diseases are the leading cause of mortality in the UK (Khaw *et al.*, 2008) and instances of these diseases seem to be increasing even with recent advances in medicine (Atkinson and Eisenbarth, 2001).

Cardiovascular disease is a term used to define an array of disorders and remains a leading cause of mortality within the UK (Lozano *et al.*, 2013). Studies which were carried out in the 80's and 90's recognised an inverse relationship between the incidence of cardiovascular disease and regular exercise (Ekelund *et al*., 1988; Sandvik *et al*., 1993). There has been a recent increase in the evidence of associations between inactivity and the increased risk of cardiovascular disease (Skielboe *et al.*, 2016).

A recent study by Myers *et al.* (2003), highlights an association between physical fitness and cardiovascular disease and physical activity. Participant recollection and cardiovascular disease risk factor determination were utilised to establish an association between patient fitness, activity level and health. Physical activity and physical fitness are often intertwined, as activity is strongly correlated with improving fitness. Physical activity is any body movement that works your muscles and requires more energy than resting (Climstein and Egger, 2017). In contrast, physical fitness is the general state of health, well-being and more specifically the ability to perform aspects of sport and occupation. Variables such as heart rate, oxygen consumption and blood lactate can be used to measure different aspects of activity, fitness and physiological adaptations to training (Constable and Palmer, 2000). However, the measurements can be influenced by not only the individual's activity pattern, genetics and environmental factors (Spence and Lee, 2003), but also by the level and type of activity used when measurements are taken. Whilst physical activity patterns show correlations between activity and mortality reduction, a correlation of mortality reduction with activity levels alone was already evident (Myers *et al.,* 2004). This study gives evidence that being relatively inactive was associated with high risk mortality, regardless of the physical fitness levels. The results were comparable to other studies which had much larger participant levels (Paffenbarger and Hyde, 1986). The study by Myers *et al.* (2004) strongly demonstrated that, within a male population, a 1000 kilocalorie (Kcal) per week increase of activity conferred 20% survival benefit, concurrent with the findings of a large cohort of studies (Paffenbarger and Hyde, 1984; Blair *et al.,* 1989). Limitations within Myers *et al.* (2004) have been acknowledged, a major one being that women weren't included within the study. However, the previous data has the shown a similar relationship with men and women between physical fitness, activity and mortality (Haskell *et al.,* 2007). The other drawback of the study was that the activity pattern data was reliant on the participants recollection which could include bias or a difference in reporting details. Nevertheless, the study has established low energy expenditure and a lower physical fitness can indicate a higher mortality risk even precluding other well-established risk factors.

In an earlier study by Blair et al. (1995), the results demonstrated how low fitness, which was defined by the lowest quartile of the treadmill testing in an age group, is an important precursor to mortality. Within this study, the participants were evaluated on their family health history, a physical examination with an inclusive blood test and a standardised maximal exertion exercise test. The participants were then monitored up until death or December 1989. The activity levels were determined as low, moderate and high, and were established by the least fit 20% being the low, middle 40% being moderate, and the top 40% being within the high fitness levels. The study confirmed that there was association between physical activity and the instance of cardiovascular disease. There was number of secondary risk factors identified such as smoking and high blood pressure. Other studies have suggested both physical activity and fitness have played the main role in combatting the other risk factors (Sesso *et al.,* 2000). This evidence strongly suggests that exercise plays a vital role in all-cause mortality and cardiovascular disease prevention.

2.3. Exercise Prescription and Dose-response Relationships

The scientific evidence provided by the sporting industry demonstrated unquestionably the beneficial effect of exercise and it can be concluded that in over 80% of people the health benefits of exercise, far outweigh the health risks associated with exercise for non-healthy populations (O'Donovan *et al.,* 2010; Garber *et al.,* 2011; Brown *et al.,* 2005). Exercise prescription refers to a tailored exercise plan for patients or athletes to follow. The FITT-VP (Frequency, Intensity, Type, Time – Volume, Progression) principle of exercise prescription is often used, which corresponds with the evidence of physical, physiological and health benefits associated with exercise (Garber *et al.*, 2011).

Exercise prescription can be used to establish the amount of physical activity required by children and adults to achieve the health and/or fitness benefits (US Department of Health and Human Services, 2008). Children and adults should be encouraged to participate in physical activity they find enjoyable but which is also age appropriate to decrease instances of injury. Prescriptions for children include unstructured physical play, with sporadic changes in intensity, there should be careful consideration of humidity for young children as thermoregulation in children is not as good as that of an adult. For older patients with heart disease risk factors exercise professionals may use the exercise prescription guidelines suggested by the American College of Sports Medicine (2017) to determine exercise which can be used to lower the risk factors discussed above.

Cardiorespiratory rehabilitation can be used for patients with Cardiovascular disease, as physical activity can be beneficial to management of the disease (Pollock *et al.*, 2000). Cardiovascular rehabilitation delivers exercise and lifestyle adjustments designed to aid in adaption to healthier lifestyles and reduce the risk factors and disability of patients with cardiovascular disease (Michaud *et al.*, 2013).

Physical activity is a proven way to reduce the risk factors associated with disease (Hallal *et al.*, 2012). In conjuntion with this research on the reductions of risk factors, there has been a copious amount of evidence provided to suggest a dose-response relationship between volume of physical activity and all-cause mortality (Slattery *et al.*, 1989). Evidence from studies which included both male and female participants indicate risks of mortality during a period of decrease activity levels is increased. One of forty-four studies, Blair *et al.* (1989), observed over 10,000 men and 3,120 women, all of which were over nineteen years of age, estimated the exercise capacity using a standardised exercise test and followed up within an average of 8 years. The results of this study highlighted the strongest association between physical fitness and mortality due to all-cause, cardiovascular disease and cancers. There was a similar pattern of results observed for both men and women. The dose response relationship was consistent with adjustments to age, smoking habit, family history and a variety of factors. This study is supported by the findings of other studies with analysis of physical activity (LaCroix and Leveille, 1996) as well as cardiorespiratory fitness (Slattery and Jacobs, 1988). This research has provided clear evidence of a need for a healthy lifestyle which includes physical activity, however, important factors such as type and duration of exercise needed to elicit the health benefits were not addressed in these studies.

2.4. Duration, Frequency and Intensity of Exercise and the Health Benefits

The duration, frequency and intensity of exercise are all relative to the health benefits the exercise causes. This area for research has become of interest to researchers due to the sedentary lifestyles adopted by society and the problems with the adherence to the specifics of exercise recommendations and prescriptions (King *et al*., 2010). In early years it was assumed without moderate intensity exercise for thirty minutes, 3 to 5 times a week, no health benefits could be achieved (Haskell *et al.,* 2007). The definitions for exercise intensities can be seen in Table 1. According to Warburton *et al.* (2006) moderate intensity exercise should be between three and six metabolic equivalents of task (MET), greater than 31 mL O_2. $Kg^{-1}min^{-1}$ and approximately 3.5-7 kcal/min.MET is the physiological measurements expressing the energy cost of physical activity. The ratio of metabolic rate (the rate of energy consumption) during specific physical activity, one MET equates to an energy expenditure of approximately 2kcalJ per kg of body weight an hour (Jette, 1990). A study by King *et al.* (1995), established the differences between moderate and high intensity exercise and found that moderate intensity exercise was enough to cause an increase in health and fitness. Over the recent years, more studies have begun to determine the most acceptable exercise recommendation for a variety of societies, by including the duration and frequency as well as intensity into the studies (Saris *et al.*, 2003; Dunn *et al.*, 2005; Janssen, 2007).

Table 1: **Exercise Level Definitions (British Heart Foundation, 2015)**

Exercise Level	**Definition**
Mild	40-54% MHR
Moderate	55-69% MHR
Intense	Equal to or greater than 70% Maximal Heart Rate (MHR- the maximal heart rate which can be attained by an individual, variable with age and fitness).

A review of the literature by Wenger and Bell (1986), highlighted the interactions between frequency, duration and intensity measures, finding that in most studies the intensity was a major factor in the training effects seen in the cardiovascular system. As the intensity of exercises increases, improvements in maximal oxygen consumption ($\dot{V}O_{2\ Max}$), a vital component in the measuring cardiovascular capacity, could also be seen to increase (Weston *et al.*, 2014). Therefore, intensity of the exercise seems to be important factor when the fitness program is aiming to increase the $\dot{V}O_{2\ Max}$ of an individual (Emerenziani *et al.*, 2013). It was noted that in some studies there were health benefits seen with frequencies as low as 2-3 times per week, especially within participants with low starting fitness levels. As $\dot{V}O_{2\ Max}$ is improved to around 50ml/kg/min, an increase to 4 times a week was required to produce the gains within cardiovascular health and strength (Pratley *et al.,* 1994). Duration was another vital component when improving cardiovascular health and fitness, and an improved response to exercise. Longer durations of work create higher responses, however, improvements in the $\dot{V}O_{2\ Max}$ are similar for durations of 15 to 25 minutes versus 25 to 30 minutes. For durations over 35 minutes, increased improvements can be observed.

The duration of the exercise, as well as accumulations of exercise over a specific time-period became an interesting topic due to the low adherence to strenuous exercise prescriptions (Kraemer, 1997; McArdle *et al.,* 2010). A study by Boden *et al.* (2013), took 16 horse riders and split them into Rider Specific Training and Traditional Neuromuscular Training 3 times a week for 8 weeks; the duration was determined by the rider carrying out the exercises. No significant difference was observed between the two groups for resting heart rate and fitness exercise results. This is supported by the findings of Murphy *et al.* (2002), who states that aerobic fitness changes in 3 similar programmes of brisk walk could be observed including two which were accumulated and a single session. This study was over an 18-week period of 30 min per exercise per day. It has been argued by Murtagh *et al.* (2005), that 20-minute walking exercise was too low to cause any true changes to the cardiovascular system. The study compared 20-minute walking bouts to 10-minute walking bouts, 3 times a week over a 12-week period. The participants completed a standardised exercise test and had health parameters measured. As the intensity of the exercise is vital for causing physiological changes within the systems of the body this could be a reason for a contradiction in results of these studies. On the other hand, there is a large amount of evidence to suggest that both continuous or accumulated exercise, produce some improvements in cardiovascular fitness (Murphy *et al.*, 2009).

Over time, there was an analysis of the benefits of walking or strenuous exercise for health of over 70,000 females, captured via a questionnaire (Manson and Greenland, 2002). All women were post-menopausal and were asked a series of questions in relation to physical activity, duration and intensity, and health records were obtained to monitor the health of the individuals. The data showed evidence of an inverse relationship between cardiovascular health risks and baseline activity level scores and also a risk reduction of 30% in those who took part in walking exercise or vigorous exercise. Results, although observational have indicated that women at both levels of exercise intensity had evidence of health benefits and cardiovascular benefits. This study highlights that traditional exercise programs of cycling and running, may not be the only way to maintain health and this offers the opportunity to begin to explore alternatives.

The optimal intensity for exercise is controversial, but it is clear the intensity of the exercise is vital health benefits of exercise to be seen. A study by Lee and Paffenberger (2000), evaluated the activity levels of men, with the activity categories of light, moderate and vigorous. Those who completed moderate and vigorous exercise saw the biggest decrease in cardiovascular health risks. Those who undertook light intensity saw non-significant decrease in the risk factors for cardiovascular disease. The findings of the study support that at least moderate exercise is required to decrease the risks of cardiovascular disease and mortality in an exercising population. Another study investigated the idea of relative intensity, using the Borg Scale of Perceived Exertion (Figure 1) and the risk of coronary heart disease; this study also highlighted that the higher the perceived exertion the lower the risk of disease (Lee, 2003).

Rating of Perceived Exertion
Borg RPE Scale

6		How you feel when lying in bed or sitting in a chair relaxed. Little or no effort.
7	Very, very light	
8		
9	Very light	
10		
11	Fairly light	
12		Target range: How you should feel with exercise or activity.
13	Somewhat hard	
14		
15	Hard	
16		
17	Very hard	How you felt with the hardest work you have ever done.
18		
19	Very, very hard	
20	Maximum exertion	Don't work this hard!

Figure 1: **The Borg ratings of perceived exertion (Borg 1982).**

The American College of Sports Medicine (ACSM) recommends that moderate exercise should be carried out in order to see health benefits. To support this, Branch *et al.* (2000) evaluated a 12-week training programme on pre-menopausal women and found that moderate intensity exercise was enough to cause a change in cardiovascular response to exercise. The participants were split to 40% $\dot{V}O_{2\ Max}$ or 80% $\dot{V}O_{2\ Max}$ training groups. The $\dot{V}O_{2\ Max}$ improved in both groups with no significant difference between the groups. Aisikainen *et al.* (2002) also found moderate intensity walking to cause similar fitness changes. Gormley *et al.* (2008), reviewed the cardiovascular effects of vigorous exercise versus moderate exercise; it was found that if the intensity could be held then vigorous exercise intensities will cause a larger improvement in cardiovascular fitness. In an observational study by Manson *et al.* (1999), over 70,000 women were observed to establish an association between walking, vigorous exercise and prevention of heart disease. A strong inverse association between physical activity and risk of heart disease was found. It has been indicated that walking in high quantities over a week and regular vigorous exercise induced a similar reduction in coronary events. These studies posed limitations, such as that by Branch *et al.* (2000), with small sample sizes, as well as reporting errors in observational studies. On the other hand, there is ample evidence of the ability of moderate intensity exercise to decrease the risk factor associated with heart disease and increase health benefits. In accordance with the literature above it can be suggested that all prescriptions of physical activity should aim to be moderate or above to realise significant health benefits.

2.5. Measuring Demands of exercise and Energy Expenditure

Over recent years there has been a large increase in improvements in the technology used for measuring energy expenditure, and as a consequence this has enhanced our understanding of the topic (Martin *et al.,* 2012; Pontzer *et al.,* 2016). During physical activity, direct calorimetry and direct heat production measurements are impractical and inaccurate, due to changes in sweat, heat and body mass whilst exercising (Adams *et al.,* 2016). It is suggested that indirect calorimetry measurements using oxygen consumption are more reliable and accurate for measurements of energy expenditure (Oshima *et al.,* 2017). This form of assessment has become common practice in exercise physiology due to ease and reliability of measurement, in comparison to direct measures (Vanreterghem *et al.,* 2017). Participants in studies using oxygen consumption as an indirect measure of energy expenditure usually walk, run or cycle on a static exercise machine such as a treadmill or cycle ergometer wearing gas analysing equipment, with the data recorded over time (Andersson, 2016). This form of indirect calorimetry does have limitations though, as in order for the oxygen consumption to energy expenditure calculations to be correct, all the Adenosine Triphosphate (ATP) must be created using aerobic processes only. If the ATP is formed by anaerobic processes, the measure of aerobic function is no longer accurate (Barclay, 2017). Double Labelled Water (DLW) for the measurement of energy expenditure, the DLW methodology utilises the naturally occurring stable isotopes of water to assess energy expenditure, body composition and water flux in humans (Westerterp, 2018). The basis of DLW methodologies follow the decline in enrichment of the stable isotopes of oxygen and hydrogen in body water after the initial labelling of the body water pool (Speakman, 1997).

For some sports such as horse riding, their nature presents a new set of challenges. Collection of data in a laboratory setting is impossible for gaining accurate and relevant information about the activity being carried out. Unlike sports such as running, cycling and rowing there are no machines or equipment which mimic the motion patterns of a horse sufficiently to assess the physiological demands of horse riding. There have been several attempts to create artificial horses for the purpose of exercise and teaching (Kim *et al.,* 2015). Most machines only mimic the action of the walk, trot and canter cannot simulate the reactive movements of the horse and response of the rider that would affect the energy expenditure of the rider. However, Walker *et al.* (2016) concluded that the mechanical racehorse simulator was useful for teaching the position of the jockey, conversely the mechanical horse movement varied from the real horse, highlighting the need for infield research when assessing riders. In order to fully understand the energy expenditure of riding in field conditions alternative equipment and techniques are required.

For activities such as horse riding where laboratory testing is difficult it is possible to estimate energy expenditure through the use of a maximal $\dot{V}O_2$ test and heart rate analysis during activity (O'Reilly *et al.*, 2015). Using this method, the participant will complete a maximal exercise test on a treadmill or cycle ergometer where heart rate is measured (Jenkins *et al.*, 2017). The heart rate measurements are then used to create what is referred to as a 'HR-$\dot{V}O_2$ curve' which estimates how much oxygen is being consumed when at certain heart rates; this is a form of calibration (Kienner and Blakey, 2014). Heart rate is then measured during the activity, which allows a measure of energy expenditure to be determined. There are some limitations for this technique such as the process is time consuming, as there is a need for individual curves for each of the individual athletes to ensure accuracy of the technique (Montoye *et al.*, 2015). Within previous equestrian research into horse riders and the physiological demands, the studies have not directly used the technique, but have established the use of $\dot{V}O_{2\ Max}$ for physical fitness measurements (Meyers et al, 1992; Meyers 2006). Other studies have compared the $\dot{V}O_2$ -HR calibration, with gas analysis (Westerling, 1983) and highlighted that although the technique of predictions is limited the use within the sport for novices can be beneficial. The use of these techniques used in horse rider studies for energy expenditure has been questioned by Ruowei *et al.* (1993) in a review of exercise physiology testing. The review discussed how the heart rate assessment of energy expenditure allows for good results, but only when the same type of exercise is used to create the calibration curve for estimations. As such, using a maximal treadmill or cycle ergometer test may not be representative of the energy expenditure or physical fitness that is needed for horse riding.

In the past, the most common equipment used to test for oxygen consumption, was the Douglas Bag technique. The Douglas bag was designed in 1911, this measurement devicecould be used in both laboratory and in field testing. The technique has several limitations in sampling duration as well as measurement resolution are evident within the literature. Further, the bags restrict freedom of movement and impose additional air resistance. This is a clear drawback in the study of physical fitness (Rosdahl *et al.*, 2010). The newer analysis systems can offer breath-by-breath analysis promptly allowing for more information to be gathered from the same exercise session. There are static and portable breath by breath analysis, which increase ease of data gathering as well as function for energy expenditure experiments.

An example of breath-by-breath analysers include the Oxycon Mobile portable system, which has been commercially available since 2003. There have been three recent reports on the Oxycon Mobile system (Attinger *et al.*, 2006; Perret and Mueller, 2006; Verges *et al.*, 2006), which show a variable result regarding the strength of the system, however reliability of the analyser was not noted in the reports. A study by Rosdahl *et al.* (2006) showed that there are differences between the Douglas bag and Oxycon Mobile Portable System V1. However, with the Oxycon Mobile Portable System V2 $\dot{V}O_{2\ Max}$ was estimated correctly. The $K4b^2$ is another of breath-by-breath respiratory system that is being used in the field for exercise physiology, which contains both oxygen and carbon dioxide analyser. This analyser has been confirmed within various studies to be accurate in measurements of cardiovascular expenditure (Maiolo *et al.*, 2003; Duffield *et al.*, 2004).

There has been a notable study to compare the Douglas bag to the K4b^2. Parr *et al.* (2001), which found that the ventilation was similar but the K4B^2 analyser significantly underestimates the fractional content of oxygen in expired air (FEO_2) and overestimated fractional content of carbon dioxide in expired air ($FECO_2$) at work rates over 200W due to the 70ml threshold that the flow meter contains. The software allows for the first 70ml of both FEO_2 and $FECO_2$ to be discounted from computed expired CO_2 concentration. However, the software also allows for adjustments in volume of O_2 and the resulting $\dot{V}O_2$ which is the same as measured by the Douglas bag method. McLaughlin *et al.* (2001) also compared the K4b^2 with the Douglas bag during the cycle ergometer test. The study also reported that the K4b^2 measurements were significantly higher, but the real differences were small.

The gold standard for gas exchange is still the use of the Douglas Bag for field testing, despite the viability and reliability of newer portable machines which have been tested against the Douglas Bag method in many studies (Duffield *et al.*, 2004; Schrack *et al.*, 2010). Duffield *et al.* (2004), established that when comparing the conventional methodologies to portable machines, the metabolic values of both $\dot{V}O_2$ and VCO_2 were overestimated, however, the reliability of the results was consistent in a test and retest condition. This work was contradicted by Schrack *et al.* (2004), when comparing the techniques stated there was no significant difference between the values, his views are supported by the findings of Hausswirth *et al.* (1997). The sample size variations within the different studies may account for the difference in results. The testing and methodologies were not all of the same nature, this too could have a significant impact on the results of the studies. Even with variations within the results, it can be assumed that the $K4b^2$ is currently the most reliable and accurate measure of gas analysis and energy expenditure. As with most portable gas analysers a pack must be worn on the person at all times, however, for high risk sports such as horse riding this could prove problematic should the rider fall from the horse. The pack could cause significant injury to the hips and back.

A method that is commonly used to estimate the aerobic capacity from exercise heart rate response to submaximal power outputs is the 6 Minute Astrand Rhyming Cycle Test (Patton *et al.,* 1982). This test uses a common method for estimating $\dot{V}O_{2Max}$ from heart rate measures at sub-maximal exercise. In these tests, heart rate is plotted against work rate or $\dot{V}O_2$. To use the nomogram a line is plotted for each subject from the heart rate measurement from the fitness test, across to the workload of the fitness test. The line crosses the $\dot{V}O_2$ estimate as seen in Figure 2.

Whilst the nomogram is a commonly used procedure to estimate an athlete's $\dot{V}O_{2\ Max}$ without pushing participants to absolute exhaustion, there are still some limitations. The formula used to estimate maximal heart rate has a standard deviation margin of +/- 11 beats per minute (Davis and Brewer, 1993). Despite this, the estimation of $\dot{V}O_{2\ Max}$ can provide useful information for those in fitness programmes and sports where sub-maximal exercise is common. This low-cost method of testing makes it popular and useful for education purposes (Caspersen *et al.,* 1985).

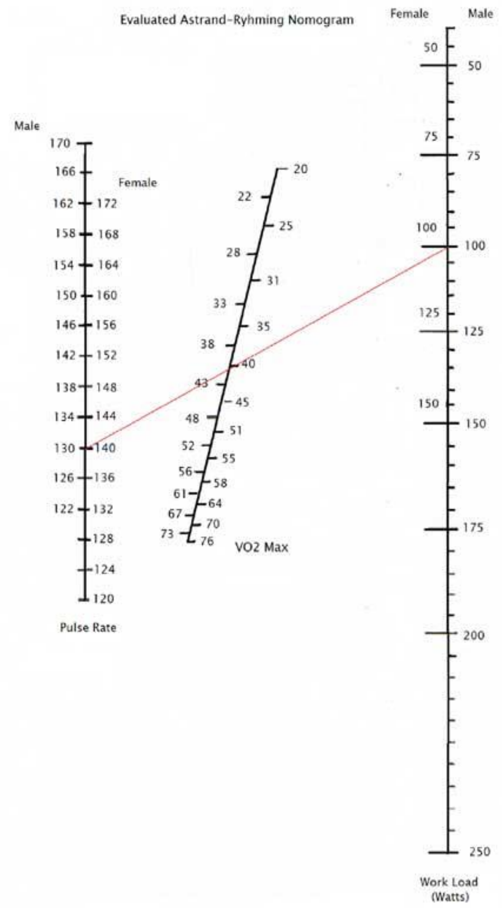

Figure 2: Astrand-Rhyming Nomogram (BrianMac, 2017)

2.6. Energy Expenditure in Sport

The testing for energy expenditure for exercise and health benefits will usually have a cycle ergometer or a treadmill exercise test, some studies have a self-evaluation or personal recall of activities (O'Reilly, 2015). These studies focus mainly on exercises carried out on equipment and fail to assess the energy expenditure of common sporting activities, and how the activity can affect the health of the individual.

Technological advances of video games have allowed for the development of video game sports, examples include the Nintendo Wii and X-Box Kinect. These video games allow for kinetic movement rather than the static movement of those normally playing video games. The effects of these types of exercise and physical activity has been researched for their health benefits, and the more active participant involvement. Researchers have looked at the addition of active video games to teenagers normally sedentary video gaming lifestyle, finding that the small addition of the active video games can influence the BMI and body composition of overweight and obese individuals (Maddison *et al.,* 2011). Peng *et al.* (2011), stated active video games can significantly increase physiological parameters, such as heart rate, $\dot{V}O_2$ and energy expenditure. The values were similar to those found whilst carrying out normal physical activity and can encourage light to moderate exercise for a variety of individuals. A study carried out by Graf *et al.* (2009), looked at the energy expenditure of two active video games (Dance Dance Revolution and Nintendo Wii Sports) in children. Energy expenditure for these video games can be compared to moderate-intensity walking, and can be seen as a safe, fun and viable means of promoting energy expenditure, for children who spend a considerable amount of time playing sedentary video games.

Cycling is an increasingly popular sport and is a conventional form of exercise, this form of exercise can elicit significantly high energy expenditure, dependant on the intensity of the cycling along with many other factors. An early study by M_CCole *et al.* (1990), measured the Oxygen uptake of a variety of cyclists whilst riding at speeds of 30-40 miles per hour. The study found that changes in the bikes set up can significantly decrease of $\dot{V}O_2$ of the rider. Hulton *et al.* (2010), used indirect calorimetry to establish energy expenditure of daily cycling activities and found that cycling can elicit 4.2 Metabolic Equivalent of Task. Cycling shows greater fat utilisation if the activity is eccentric (Penalillo *et al.,* 2014). Cyclists working at 69% $\dot{V}O_{2Max}$, at approximate speeds of 20-40 kilometres per hour, putting the exercise in the moderate range. Both mechanical power output and pedal speed were responsible for variables in metabolic costs of cycling (McDaniel *et al.*, 2002). McDaniel *et al.* (2002) explains that the pedal speed has an influence over muscle shortening velocity and therefore significantly affects energy expenditure. This is an important aspect of cycling efficiency. This is an important portion of energy expenditure studies and has been researched heavily. Wehbe *et al.* (2015) studied the reliability of cycle ergometer power tests in a sports team and concluded that the test was significantly reliable and could be used for tracking changes in performance. An early study established that a 1.8% in efficiency could result in an 10% difference in the max sustained by an individual (Horowitz, 1994). This and other studies have suggested that efficiency of cyclists may decrease energy expenditure. However, Moseley and Achten (2004) found that there was little difference between the efficiency of recreational and elite cyclists, and this would not be an appropriate indicator of success in elite cyclists.

Rowing is a non-weight bearing sport, with an increasing amount of research for metabolic cost of the sport (Kramer *et al.*, 2015). Whilst rowing the athlete uses large muscle groups and engages large amounts of core strength engaging muscles surrounding the spinal column and pelvis (Haff and Triplett, 2015). A study of energy expenditure and fat oxidation in rowing, found the physiological parameters were similar to that seen in cycling exercise, however, fat oxidation was 45% higher for rowing than cycling activity (Egan *et al.*, 2015). Hagerman *et al.* (1978) suggested 70% of rowing energy comes from aerobic power and 30% from anaerobic. There has been conflicting research surrounding cycling and rowing energy costs, which has led to discrepancies in energy costs indicating that cycling elicits more energy expenditure than rowing and vice versa. In 1988, Hagerman *et al.* established in untrained males and females, who completed both cycling and rowing ergometer tests, rowing elicited the most energy expenditure. There have been suggestions that the increases of energy expenditure could be due to unfamiliarity of muscle recruitment for rowing (Cole *et al.*, 2004).

Football requires both strength and endurance training in order to be successful within the sport due to the length of the match times and the distance which the players can travel during the game. The American College of Sports Medicine illustrates that the range of METs for football ranges from 7 – 10 dependant on the game type. In a study by Bangsbo *et al.* (2006), it was established that although football players perform intermittent work with low-intensity for 70% of the game, heart rate and body temperature suggested that average oxygen uptake for elite football players is around 70% of maximal. Rodriguez and Iglesias (1990), studied football players, both elite and recreational, finding the relative $\dot{V}O_2$ was approximately 50% of $\dot{V}O_{2\,Max}$ for all players combined. However, this was lower than previously measured and predicted values for the energy expenditure of the football players. There are major individual differences in the physical demands of players during a game related to physical capacity and tactical role in the team. This difference could be due to predictions based on Heart Rate- $\dot{V}O_2$ regression overestimating the energy expenditure when compared to the telemetric systems used in the study.

Table 2: Average Heart Rates Observed in Sports

Sport/ exercise	Average Heart Rate Observed (bpm)
Video Game (Goa *et al.*, 2015)	110
Cycling (Thomson *et al.*, 2015)	140
Football (Silva *et al.*, 2017)	175
American Football (Lin *et al.*, 2017)	168
Running (Long Distance) (Hohmann *et al.*, 2016)	130
Running (Sprint) (Sanders *et al.*, 2017)	190

2.7. Horse Rider Activity and physiological demands

Horse riding activities have evolved from working animals used for farming land and transport to a competition and leisure activity (Liljenstrolpe, 2009). It is no longer necessary for the use of equines for work, however, there are still over 3 million people involved with horses within the UK according to the British Horse Society (2015). Even with large amounts of participation across the world, there is little information on the use of horse riding as a form of healthy exercise (O'Rielly, 2015). There have been several studies which have increased the body of information on body composition, blood markers as well as $\dot{V}O_2$ and heart rate. A study in America looked at the body composition of rodeo athletes; both the body fat and lipid profiles were deemed within the normal ranges. The average of the body fat percentage was 12%, for those competing in rough stock, roping and barrel racing. Rough stock participants had a lower body fat percentage than those of steer wrestling, it is thought that a larger body mass is more desirable within their discipline (Meyers *et al.,* 1992). A study by Meyers and Sterling (2000), observed college equestrian athletes and noted that body weights and BMI fell within the normal ranges for female athletes. However, when performing fitness tests equestrian athletes were below average, and suggested that the lack of physical fitness training in equestrian sport could be adding to the increasing injury rates. Aerobic sports such as distance running and swimming, produced lower averages than reported for college level equestrian athletes, the averages of hockey, softball and rodeo were all similar to those found for other equestrian sports (Meyers and Sterling, 2000). A study of college eventing riders by Roberts *et al.* (2009), reported an average body fat percentage of 21%, whilst Meyers (2006) reported a body fat percentage of 23% in novice college female riders. Although Meyers (2006) used a short intervention and suggested that there was no significant change to body composition in a short time, there are indications that equestrian training may have an effect on body composition over time.

During the study of rodeo athletes, the estimated $\dot{V}O_{2\ Max}$ reached a similar level to those of basketball, water polo and gymnastics with ranges of 47-50 ml/Kg/Min in men. These ranges were lower than those seen in endurance sports such as cycling and running, however, the athletes possessed an above average aerobic capacity (Meyers *et al.,* 1992). Twenty-Four female horse riders were studied and the average $\dot{V}O_{2\ Max}$ during a treadmill test was much lower than those previously seen in an earlier study. Although lower $\dot{V}O_{2\ Max}$ results, are expected for the female population, the author of the study noted that the fitness levels of the riders were highly variable (Meyers and Sterling, 2000).

The body of knowledge for physiological demands is growing and more riders are beginning to see and treat themselves as athletes. The majority of those who ride in the UK are classified as ‘novice’. Novice riders are defined as those who compete at low levels and have not achieved a ‘professional’ status, those who have recently started riding can also be classified as novice. There is still room for future studies and development of physiological and internal loading of horse riders in a variety of settings.

2.8. Aims and Objectives

The purpose of this study was to establish the physiological demands on college student horse riders during riding, how much of their maximal capacity is required in riding efforts, whether this varies between the horses ridden and the difference in demands between the walk, trot and canter, gaits during a planned, 45-minute riding session.

The aims of this study are to:

1. Establish baseline horse rider fitness profile, in a laboratory environment, on a group of equine college students on equine courses (Minimum level 2 British Horse Society and between the ages of 16-25).
2. Establish baseline heart rate measurements of the same group of horse riders whilst performing a riding task on two different horses each on two separate occassions.
3. To quantify the percentage of the maximal efforts used from the laboratory testing to the field testing.
4. To quantify heart rate responses to riding different types of movements such as the walk, trot, and canter.
5. To establish if horse riding could be effective as an exercise to improve fitness levels.

The objectives of this study are to:

1. To perform an Astrand - Rhyming test to establish a baseline maximal values, for heart rate and $\dot{V}O_{2\ Max}$.
2. To perform a 45-minute horse riding session to gain the heart rate data of the participants.
3. To monitor riders in a riding lesson, obtaining the perceived exertion of the riders following the participants riding lesson.

The hypotheses tested in this study were:

H1: There will be a significant difference in heart rate between the three gaits: walk, trot and canter during the 45-minute ridden exercise.

H2: There will be a significant difference in heart rate when riding two different horses.

H3: The percentage of maximal heart rate used will exceed the moderate intensity set by the American College of Sports Medicine.

H4: Horse riding can be used as an effective exercise to improve the cardiovascular fitness.

Chapter Three: Methodology

3.1. Designing the Study

The methodological design for this investigation was critical to the success of the study; a structured design to answer the research question and any added questions the research study brought up. The design included a determination of the data required to perform the research; methods of both accurate and easy data collection; method of analysis and reliable interpretation (Punch, 2000).

Kelly (1999) suggests that there are four key points the research design must address;

1. Design the research for appropriate collection and data analysis
2. Frame of the research in terms of research questions
3. Use the data to answer the research questions
4. Determine what is necessary to answer those questions

The two main types of research methodologies which can be used are; qualitative and quantitative (Table 3).

Table 3: Comparison of data collection methods (Kelly 1999)

	Qualitative	Quantitative
Definition	Measurements with words	Analysis with numbers
Data Type	Nominal or ordinal	Interval or ratio
Data Gathering	Interviews Observations Focus groups Archives Open question Questionnaires	Close question Questionnaires Test Investigations Numerical data (i.e. time, weight)
Data Analysis	Interpretive Non-parametric tests	Parametric statistical tests
Criticisms	Biased Time- Consuming	Omits some information

3.2. Variables of the Data

Table 4: Example of variables within the data

Variable	Description
Sample ID	This is an identifier used to reference a particular sample.
Horse Ridden	The horse which the rider completed the riding sessions on.
Horses way of going	This is how the horses have been described to be going by the rider. e.g. Lazy/Forward going.
Health status of the rider	This is the health status of the rider. e.g. free from illness/injury

3.3. Pilot Study

A pilot study was performed to ensure the methodology was correct in accordance with the advice of Lancaster (2015). The purpose of the pilot study was to ensure the use of equipment and layout of the ridden session was correct, and then to use the results to obtain the timings and patterns within the heart rate data and develop data processing methods to gain valid results within the final study. In addition, this was an opportunity for the researcher to discuss with staff members the correct way the equipment will be used and the running of the ridden sessions during the data collection process.

A single rider was selected to perform one Astrand Rhyming cycle test and one ridden session. The rider was chosen at the appropriate level of fitness and ability, so riders are able to perform both areas of the testing correctly and without any ethical concerns. The rider performed the tests on two different days. The rider was asked to perform a six-minute Astrand-Rhyming test, wearing a heart rate monitor, cycling at 60 watts per minute. The heart rate of the participant determined if any extra workload needed to be added. The subsequent test required the rider to participate in a 45-min riding session, which was timed as described in table 5.

Table 5: Pilot study timings for ridden session (Single Rider).

Time of session	Gait	Minutes in gait
1-5	Walk	5
5-10	Trot	5
10-12	Canter	2
12-15	Walk	3

15-20	Trot	5
20-22	Canter	2
22-25	Walk	3
25-30	Trot	5
30-35	Walk	5

3.3.1. Results from pilot study

Astrand Rhyming Test

The data from the Astrand Rhyming test was collated and the estimated $\dot{V}O_{2Max}$ calculated using an Astrand-Rhyming Nomogram.

Table 6: Heart rate and estimated $\dot{V}O_{2\ Max}$ for pilot study data (n=1)

Timing	Heart rate (bpm)	Estimated $\dot{V}O_{2\ Max}$ (ml/kg/min)
Resting	80	
3 Minutes	110	
5 Minutes	157	
6 Minutes	158	33.9

Ridden Session

The data from the ridden session was collected and placed into excel, then descriptive statistics calculated.

Table 7: Descriptive data of the ride session (n=1)

Gait	Average HR
Walk	126 +/- 3

Trot	130 +/- 2
Canter	140 +/- 0.7

Figure 3 shows the continuous heart rate of the rider throughout a session. This highlights the high heart rate peaks and low throughs which aid in establishing the gait and any anomalies in the data sets.

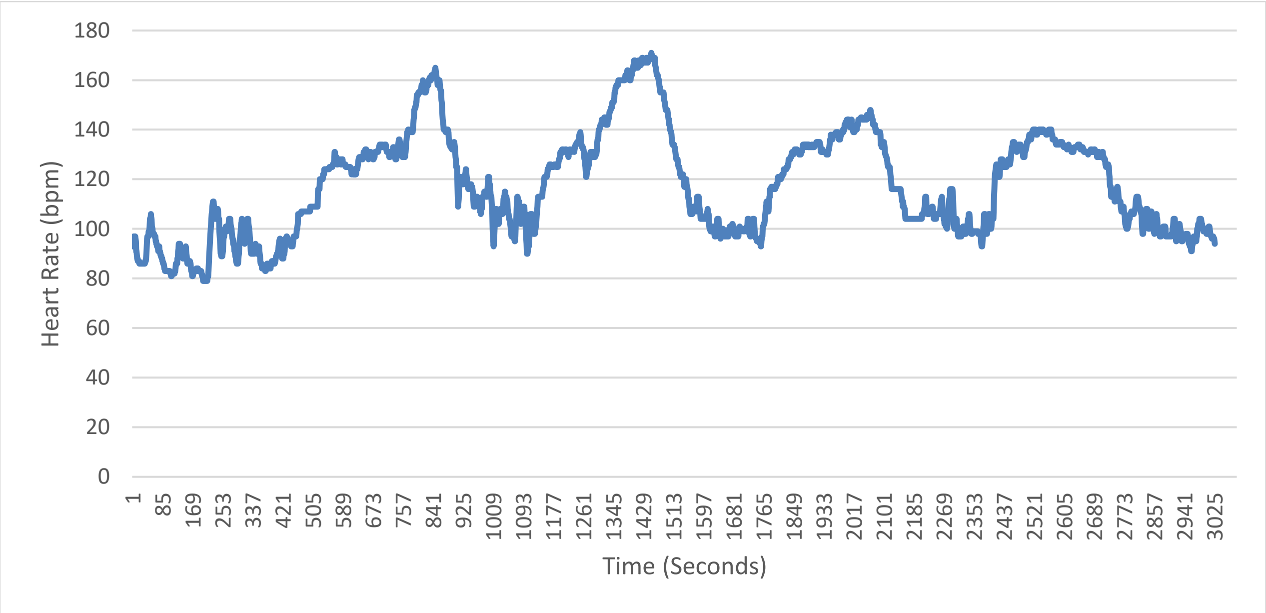

Figure 3: The continuous heart rate of the rider throughout the ridden session.

3.3.2. Summary of the pilot study

The pilot study highlighted the importance of asking candidates how they felt during the completion of the 6-minute Astrand test and also how the candidates should be encouraged during the final minutes of the test. The layout of the session was agreed in order to ensure the horses were able to comfortably carry out the session, along with the college ridden sessions throughout the day.

3.4 Methodology

Twenty-one candidates, a mixture of female (n=19) and male (n=3), were selected to participate in the study, however, only nineteen of those completed all aspects of the study(n=19). The participants were students at two equestrian education colleges in the North of England Myerscough College and Craven College. Data were collected between 2nd February and 2nd March 2017. All participants were deemed healthy and able to take part following the completion of Consent form (Appendix 1) and PAR-Q+ questionnaire (Appendix 2).

The study was approved by the Ethics review panel at the University of Central Lancashire (ethics number -STEMH 493), with all procedures conforming to the requirements of the Declaration of Helsinki, with respect to all aspects of data collection, processing, analysis and storage. Separate risk assessments were developed for the Astrand Rhyming test and the mounted session to ensure that the risks were identified and minimised for each activity. The consent form (Appendix 1) and Information Sheet (Appendix 3) regarding the study were given to the participant and they were made aware of the risks of taking part prior to signing the consent form. A PAR-Q (Appendix 2) questionnaire was given to the participants to ensure their health was unlikely to be compromised. Participants consented to their participation, to the use of their data and also that the health information provided in the PAR-Q was correct. All participants had the right to withdraw at any point throughout the study prior to data collection being complete in accordance with the best protocol.

3.4.1. Candidate Characteristics

The participants completed a baseline fitness test and both ridden sessions. The mean and range of the age, height and weight measurements can be seen in table 8.

Table 8: Mean ($^{+/-}$ SD) of age, height and weight measurements of the participants (n=19)

	Mean	Standard Deviation	Range
Age (yrs)	18	2	18-20
Height (cm)	169	8	158-188
Weight (kg)	64	10	50-82

The selection of the participants was based on the participants age (16+) and riding ability (stage 2 BHS or similar recognition and above). These pre-selection criteria ensured that each of the riders were at a similar and appropriate skill level to carry out the required technical movements correctly and safely.

The maximal heart rate was calculated, using a common methodology described by Nikolidis (2015) 223-1.4 * Age so the percentage of maximal loading during the ridden sessions could be obtained. The heart rate reserves provide's the crucial information required in order to calculate the target heart rate zones of the individual. The heart rate reserve of the participants was calculated using the Karvonen formula (Maximal Heart Rate – Resting Heart Rate) as described by Camerada *et al.*, (2008). Resting heart rate was gained using the heart rate monitor before performing the Astrand Rhyming test when the participant was asked to sit for 2 minutes. The average maximal heart rate and rate reserve is displayed in table 9.

Table 9: Descriptive data for the maximal heart rate and the heart rate reserve of the participants (n=19)

	Maximal Heart Rate	Heart Rate Reserve
Mean	195 +/- 2	130 +/- 2

3.4.2 Astrand-Rhyming 6-minute Cycle Test

Prior to undertaking the predictive Astrand-Rhyming cycle test all participants had total body mass measurements using the Tanita BC-601 and stature measured using the Seca 213 stadiometer, all participants wore light breathable clothing such as leggings and light tops, shoes and socks were removed. All measurements were taken in the morning, before any of the sessions were undertaken, each participant had eaten breakfast prior to measurements. A Wahoo TICKR^{TM} heart rate monitor (Wahoo Fitness, Atlanta) was fitted with the chest strap placed approximately inferiorly to the xiphosternal joint, as shown in plate 1. Once fitted the monitor was activated and the device transmitted heart rate data at 60 samples per minute using Bluetooth, which was recorded on an iPhone 6 that was connected to it.

Plate 1: Placement of heart rate monitor on the horse riders chest (Amazon, 2017).

Before starting the test, the Monark cycle ergometer, was set to the height of the participant in accordance with the instructions of Haff and Dumke (2012) in the Laboratory Manual of Exercise Physiology. This was done by ensuring the participant's hip lined up with the seat height, and once mounted the participant could reach the pedals and also sit comfortably for the entire test, as shown in plate 2.

Plate 2: Astrand Rhyming cycle ergometer set up on a Monark bike (Institute of Sports and Spines 2014).

The following protocol for the Astrand-Rhyming Cycle Ergometer test has been adapted to that stated by Eston and Reilly (2013) in the Kinathropometry and Exercise Physiology Laboratory Manual. The workload for the test was calculated using the following equation: Resistance x Cadence = workload, as discussed by Waggner *et al.* (2015). The participants were allowed 10-minutes to warm up before starting the Astrand-Rhyming test; this was done with no workload added. The participant was asked to achieve 60 watts per minute before the test started and the 1kg mass for workload was added to the ergometer as stated by Eston and Reilly (2013).

The test continued for 6 minutes, with the participant asked to keep the same consistent Cadence. Heart rate was recorded at 3 minutes, 5minutes and 6 minutes, if the heart rate had not reached 125 bpm at three minutes an extra 0.5kg was added to the ergometer, and extra workload noted. The heart rates were taken at both 5 and 6 minutes to ensure the heart rate was constant, if the heart rate had changed the highest heart rate was taken as suggested by Vancampfort *et al.,* (2014). Due to the high heart rates observed by the participants, the lower heart rate which allowed for the use of the nomogram was used to estimate the $\dot{V}O_2$ for the capacity test. The nomogram used was the modified nomogram used by Astrand and Dahl (1954) shown in figure 5. To estimate the $\dot{V}O_{2\ Max}$ the following calculation was used $\dot{V}O_{2\ Max}$ = (0.00193* workload + 0.326) / (0.769 * HR – 56.1) * 1000.

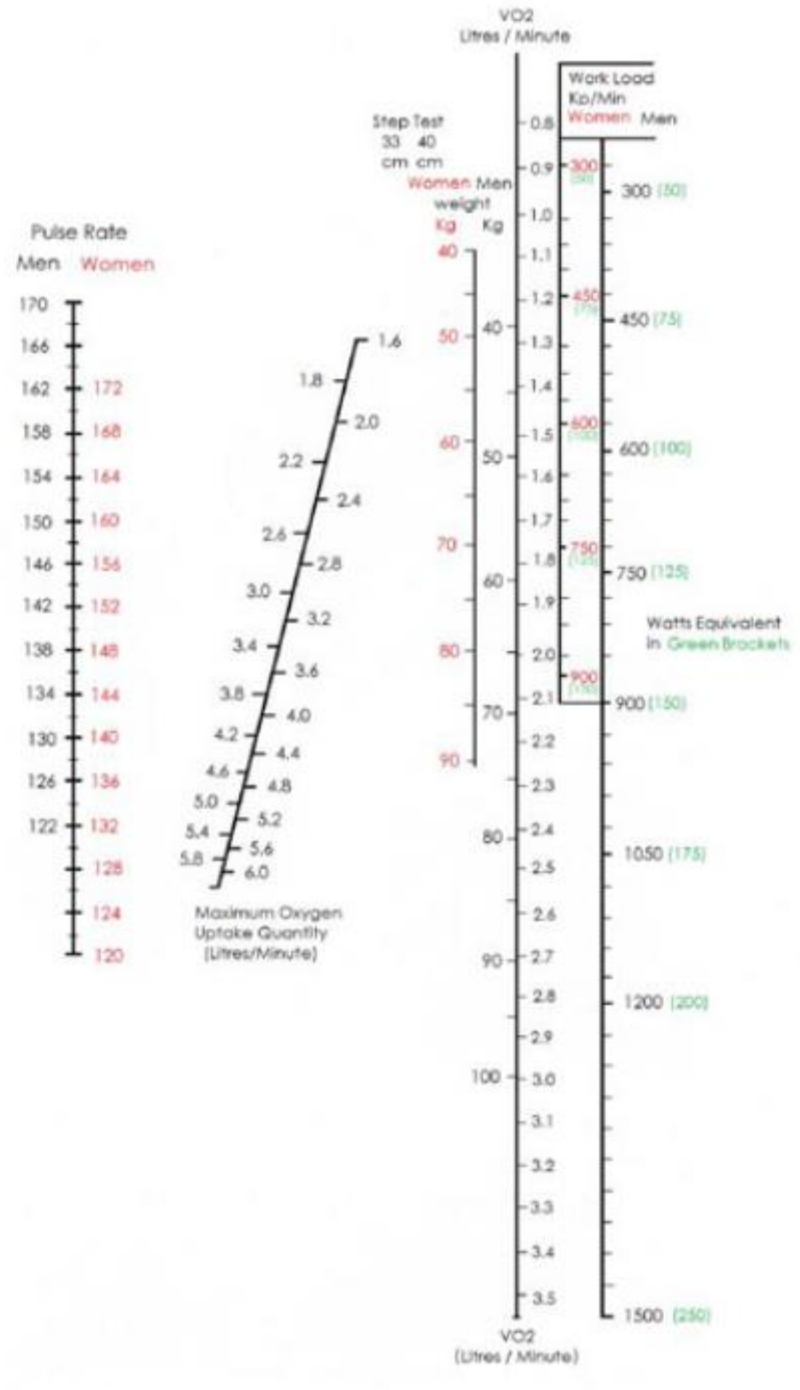

Figure 5: The modified Nomogram used by Astrand and Dahl (1954) (American College of Sports Medicine, 2013).

3.4.3 Ridden Session

The participants were asked to take part in a randomised two structured ride sessions on two different horses. Outline structure of the session is highlighted in table 10. The riders were asked to ride in a 35-minute session on two separate occasions, riding different horses for session one and two. All riders rode in groups and rode different horses, 30 different horses were used, and their details can be found in appendix 9. Prior to each session, a Wahoo TICKR™ heart rate monitor (Wahoo Fitness, Atlanta) was fitted, with the chest strap placed approximately inferiorly to the xiphosternal joint. Once fitted the monitor was activated and the device transmitted heart rate data at 60 samples per minute using Bluetooth, which was recorded on an iPhone (5 or above) that was connected to it. The structure of the lesson was explained prior to commencement and then verbal instructions given throughout to ensure that the timings of each gait were consistent with the lesson plan. One minute and 30 second reminders were given at the end of each gait phase, so riders could prepare to move up or down the gaits. The riders had to ride the horses in the given gait but could circle, change the rein and use small transitions through the gaits, if required for the horse's benefit. Any spooking or rider falls were made a note of for recognition of anomalies. The sessions were also videoed to assist in separating the heart rate data into each gait correctly during data processing.

Following the ridden sessions, the riders filled in a questionnaire on the horse's way of going (Appendix 4). A second questionnaire (Appendix 5) was given to riders to gain perceived exertion rates during the session, which gaits the rider found the most demanding and if any specific body parts were aching during the ride.

Table 10: Main study ridden session structure

Time of session (mins)	Gait	Minutes in gait
0-5	Walk	5
5-10	Trot	5
10-12	Canter	2
12-15	Walk	3
15-20	Trot	5
20-22	Canter	2
22-25	Walk	3
25-30	Trot	5
30-35	Walk	5

Table 10 shows the structure for the sessions and the time within each gait, the varying times within the gaits were decided based on the horse's ability, fitness and amount of work within a college day. The longer timings within walk and trot were for the horses to regain breath and energy, as the college horses do not regularly undertake interval training type exercise. Following discussions with the yard manager, it was decided two minutes of canter would be ample time to gain heart rate data, without causing distress to the horses, due to their fitness. Figure 6 is an example of the heart rate data taken from one rider in the first session and shows how the heart rate data was split and extracted visually for patterns along with numerical data.

3.5. Data Processing

Data was downloaded from each iPhone and then imported into Excel. Each raw HR trace was separated by gait and an average value calculated for each gait across the whole of the session. Due to the nature of the ride sessions, the data was cleaned, and the middle 2 minutes of each section of the walk and trot was used and all of the canter gait. All the rider's averages were collated and overall averages for both rides calculated including mean and standard deviation. An example of a section of the ride session is shown in Figure 6, periods of walk were used to calculate an average heart rate for walk, 3 periods of trot and 2 periods of canter, consistent with the ridden session plan.

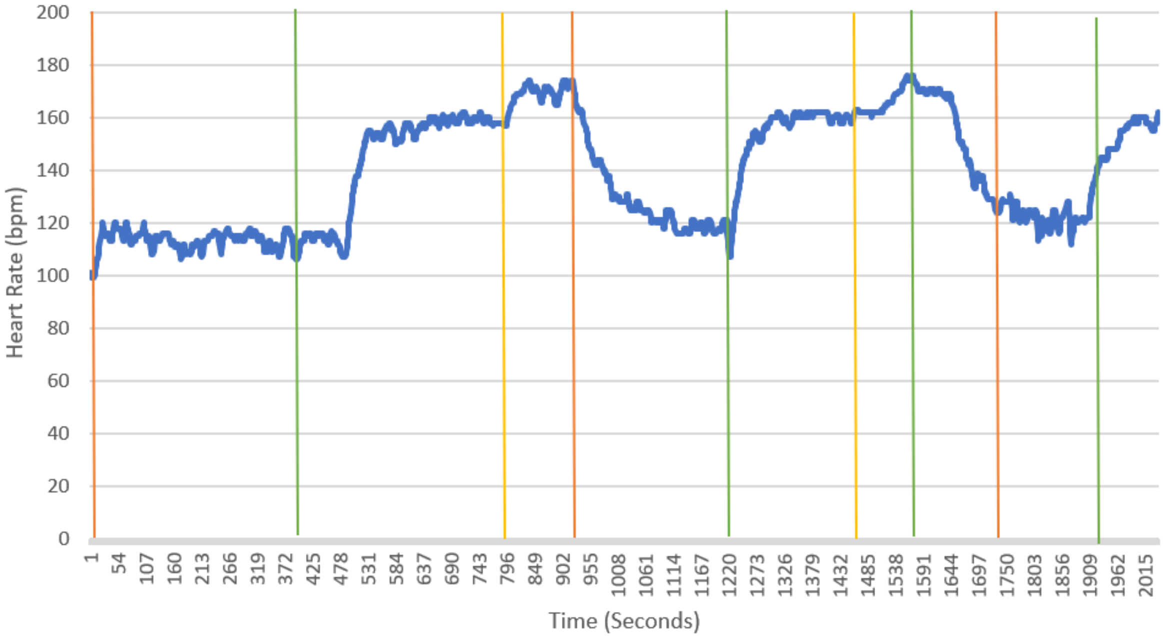

Figure 6: Heart Rate trace of Rider 1 (part of session 1), with bars to show extraction of heart rate data for each gait. **(Orange – walk begins, Green- trot begins, and yellow- canter begins).*

3.6. Statistical Analysis

Data was collated and processed in Microsoft Excel and then into Mini Tab[17] for analysis. The descriptive statistics for individuals and collated data were generate including means and standard deviation. An Anderson-Darlington Test for normality was performed, where normality can be accepted when P>0.05, and it can be stated with 95% confidence that the data fits the normality curve.

A 2 by 3 Analysis of Variance (ANOVA) test was performed for the heart rate data to compare between ride one and ride two (were different horses were ridden) and across the three gaits walk, trot and canter. Probability for the ANOVA test was set at P<0.05. Confidence intervals were also calculated for data analysis. Following the ANOVA, where statistical differences were noted a pairwise Fisher test was conducted to establish between which gaits the differences existed.

The data from the questionnaires was analysed qualitatively using a chi-squared test and … analysed with the quantitative heart rate data, to explore if the rider perception of the work efforts for the gaits complement and agreed with the results of the heart rate data. The rider's perception of the different horses was analysed in the same way.

Chapter Four: Results

All data was tested for normality using an Anderson- Darling normality test; walk, trot and canter heart rates for both rides one or two. All data was deemed normally distributed (P>0.05) as P was greater than 0.05.

4.1. Baseline Fitness Test (Astrand-Rhyming)

The riders were asked to perform a sub-maximal exercise test to establish a baseline fitness measurement, and provide an estimation of $\dot{V}O_{2\ Max}$. The descriptive data for the baseline fitness test can be seen in Table 11.

The results highlight a variation between each rider with the effects of the test, at 3 minutes the heart rate was at 143.11±16.42 bpm (Mean±SD), when the heart rate for estimation is taken at 6 minutes the heart rate is 174.84 ± 11.35 bpm (Mean± SD). The $\dot{V}O_{2\ Max}$ estimation was 20.48 ± 0.23 ml/kg (Mean±SD).

Table 11: Descriptive Data for Baseline fitness test

	Mean	**Standard Deviation**
Resting Heart Rate (bpm)	65	9
3 Minute Heart Rate (bpm)	143	16
5 Minute Heart Rate (bpm)	170	14
6 Minute Heart Rate (bpm)	175	11
$\dot{V}O_{2\ Max}$ Estimation (ml/kg)	20.5	0.2

Figure 7 displays the average heart rate for the participant group during the Astrand-Rhyming test. A rapid increase of heart rate can be observed between resting heart rates and three minutes. The heart rate then gradually increases between three and five minutes before a plateau between five and six minutes.

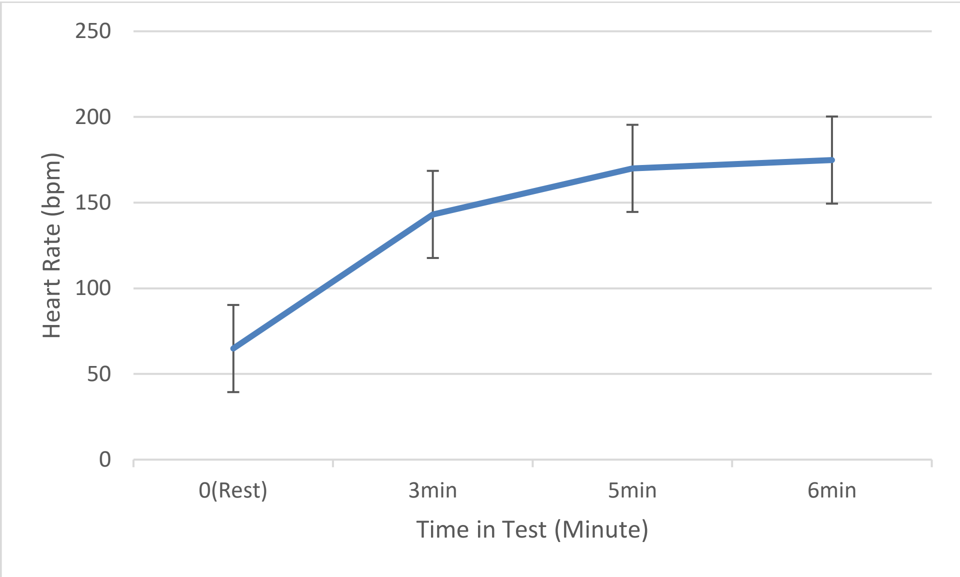

Figure 7: Astrand-Rhyming average heart rate (Mean +/-SD) increase during the test (n=19)

4.2. Ridden Session Heart Rate

4.2.1 Ride Session One

The riders were asked to perform a standardised 45-minute ridden session wearing a heart rate monitor. The descriptive data for the first ridden session can be seen in table 12.

Table 12: Descriptive data of heart rate (bpm) for ride session one for the group (n=19)

	Mean	Standard Deviation
Ride 1		
Walk	127	19
Trot	136	17
Canter	147	21
Ride 2		
Walk	129	15
Trot	137	16
Canter	150	17

4.2.3 Comparison of Ride Session One and Two

Figure 8 compares the average heart rates for both ride one and ride two of the ridden sessions carried out by the participants. The figure shows the differences between the gaits showing slight yet none significant differences in heart rate between the walk and trot. significant differences were observed between the walk and canter and also the trot and canter (P=0.005).

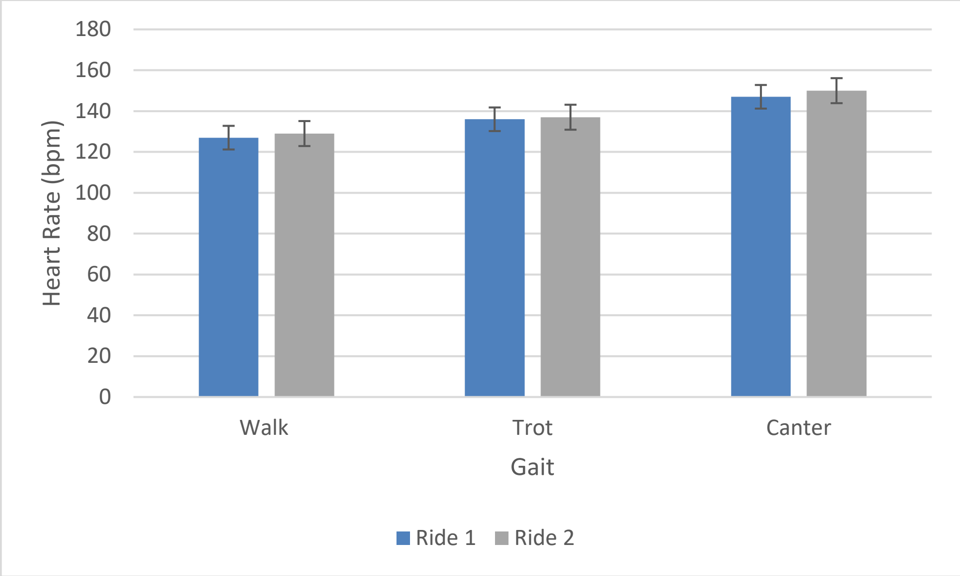

Figure 8: Average Heart Rate (bpm) (including standard deviation) for ride one and ride two of the ridden sessions for the group (n=19)

The percentage of the maximal heart rates calculated at the beginning of the study, being used during each of the gaits were established, as seen in figure 9. All gaits require over 60% of the participants maximal heart rate.

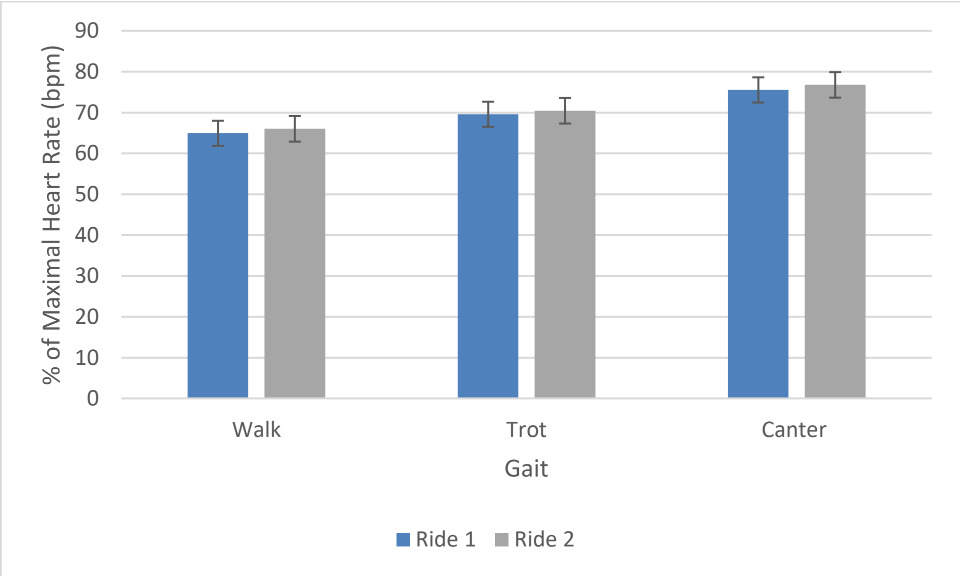

Figure 9: Average percentage maximal of heart rate (bpm) (including standard deviation) for ride one and ride two of the ridden sessions for the group (n=19)

4.2.4 Analysis of Variance testing

An Analysis of Variance (ANOVA) test was carried on the heart rate data and included the effect of gait, rider and ride. The results of the ANOVA indicated that the gait had a significant effect on the heart rate (P = 0.001), but there was no significant effect of the rider (P=0.256) or the horse (ride) (P=0.374).

A Fisher Pairwise Comparison, post-hoc test, was performed to establish where there was a significant difference between the gaits. There was a significant difference between Walk and Canter (P= < 0.005) and Trot and Canter (P=0.001). There was no significant difference between Walk and Trot (P= > 0.05).

4.3. Heart Rate Traces

A heart rate trace which displays the most common reaction of the heart rate to the gait can be seen in figure 10. (Orange bars highlight the start of walk, green start of trot and yellow beginning of canter). It is clear to see the increasing demands of the riders throughout the session.

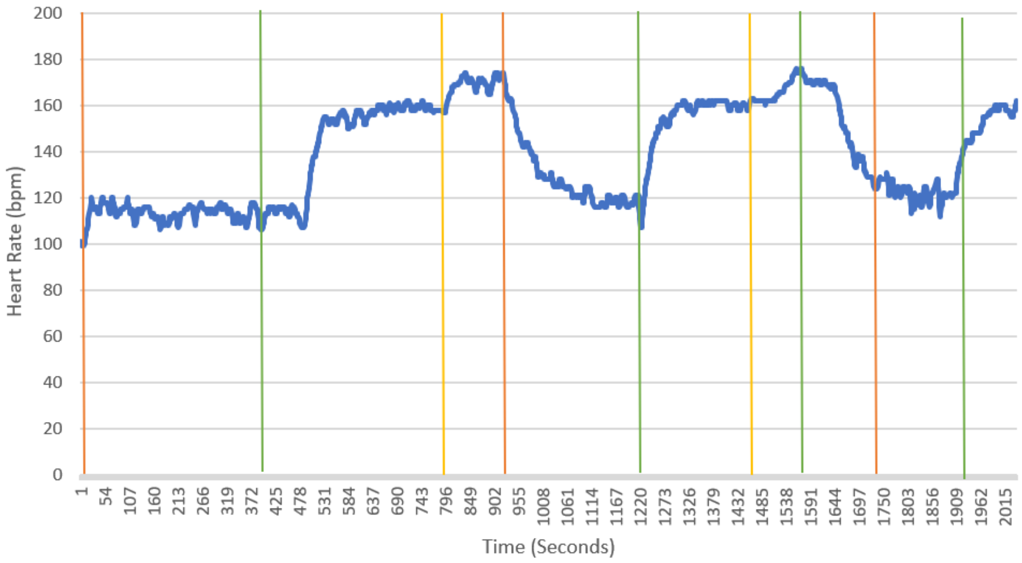

Figure 10: Example of a typical raw heart rate trace (bpm) seen in the group of riders from one of the ridden sessions. **(Orange – walk begins, Green- trot begins, and yellow- canter begins).*

An interesting heart rate trace can be seen in figure 11, this figure shows a different trace to that seen commonly amongst the riders. There are large peaks between the canter and walk gaits, which were not observed in other riders.

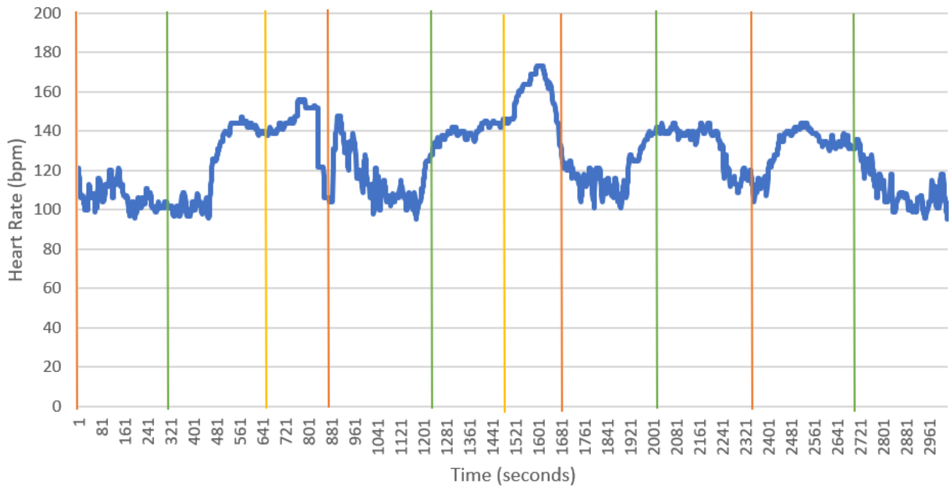

Figure 11: Example raw heart rate trace (bpm) from one rider who did not show a typical pattern. **(Orange – walk begins, Green- trot begins, and yellow- canter begins).*

4.4. Questionnaire Data

4.4.1. Horses way of going questions

Riders were asked a series of questions after the ride which discussed the horse's way of going. During both sessions 78% of riders had ridden the horse prior to the ridden session and 21% of the riders had never ridden the horse before they completed the ridden session.

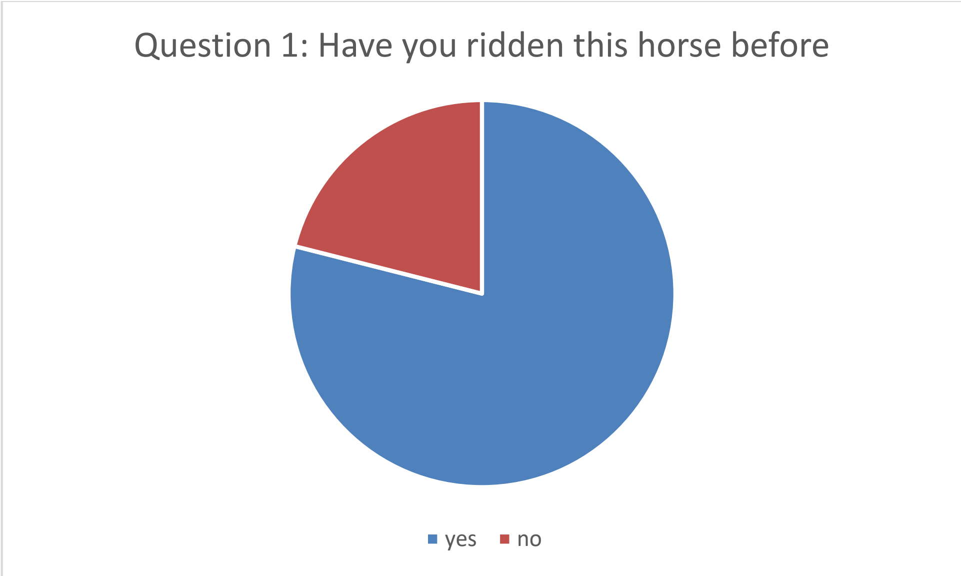

Figure 12: Percentage of riders who had ridden versus those who hadn’t ridden the horses they rode, for both ride one and two (n=19).

Figure 13 and figure 14 display word clouds from the responses to the open questions about the horse’s way of going for both ride sessions. Generally, riders said horses had ‘gone well’, with ‘being on the forehand’ a common theme throughout. ‘Struggled to keep in gait’ was a theme commonly found in ride two sessions. The larger the word the more riders felt the horses way of going was under that category, these perspectives highlight how the rider felt the horse went which is commonly thought to affect the heart rate.

Figure 13: Word cloud of the rider responses for the horses way of going for ride session one (n=19).

Figure 14: Word cloud of the rider responses for the horse's way of going for ride session two (n=19).

During the first ridden session, 63% of the riders stated their horses were moving forward from the leg, whilst 37% stated their horses were not moving forward from the leg in the paces. In the second ridden session, 58% of the riders stated the horse was moving forward from the leg, whilst 42% stated the horse was not moving from the leg in the paces.

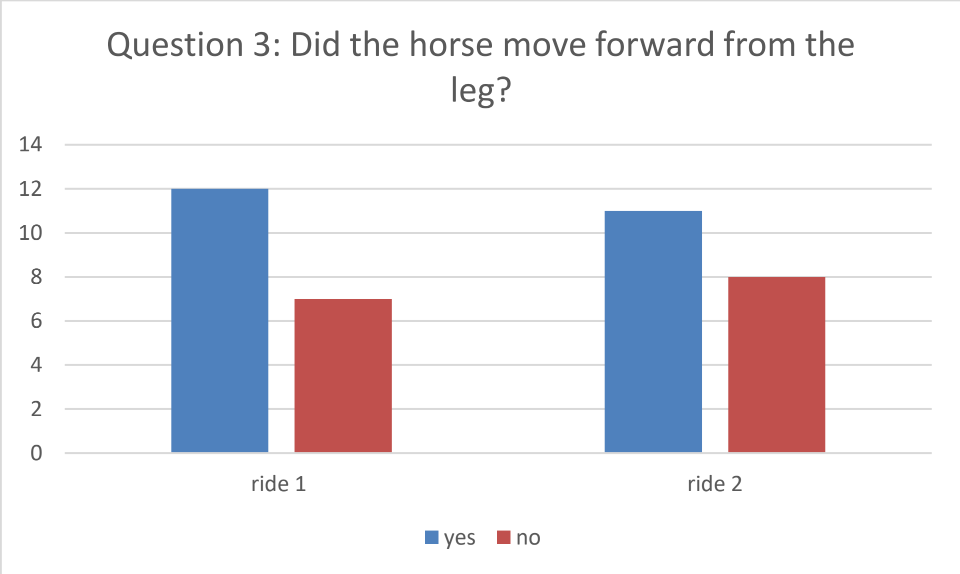

Figure 15: Riders perception of if the horse was moving forward from the leg during the sessions, for ride one and two (n=19).

During the first ridden session 68% of the rides stated the horses remained consistent throughout the session, 32% however stated there was variation within the application of the leg aids. In ride two, only 47% of riders stated that there was consistency within the horse's way of going, and 53% experienced variations.

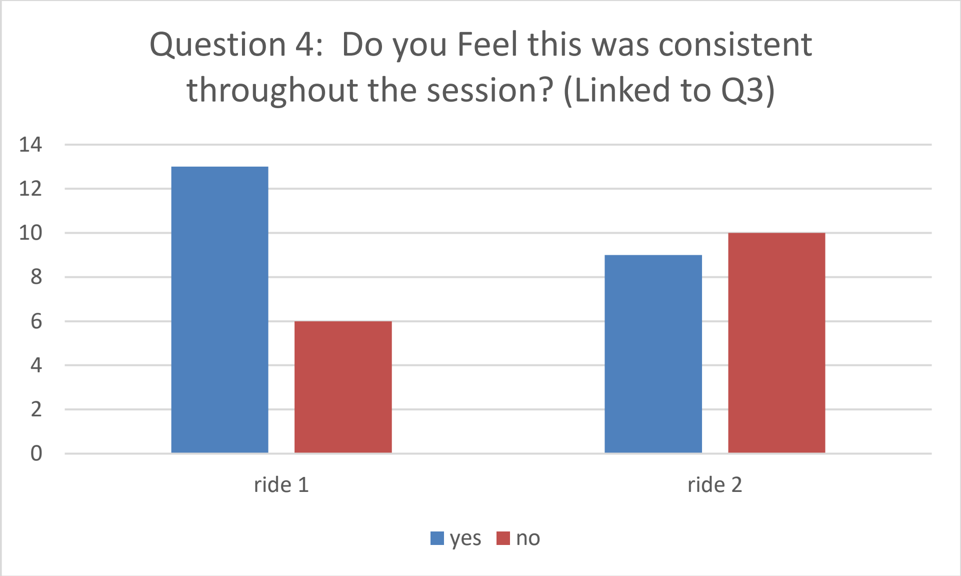

Figure 16: Riders perception of if the horse was consistently moving forward from the leg during the sessions, for ride one and two (n=19).

For ride one, 10 participants answered Question 5 (linked to question four) asking the riders to decide when they believed the horses changed in the session. The most common answer was half way through (5 participants), end of session (3 participants) and then 1 participant for each first 10/ last 15 minutes.

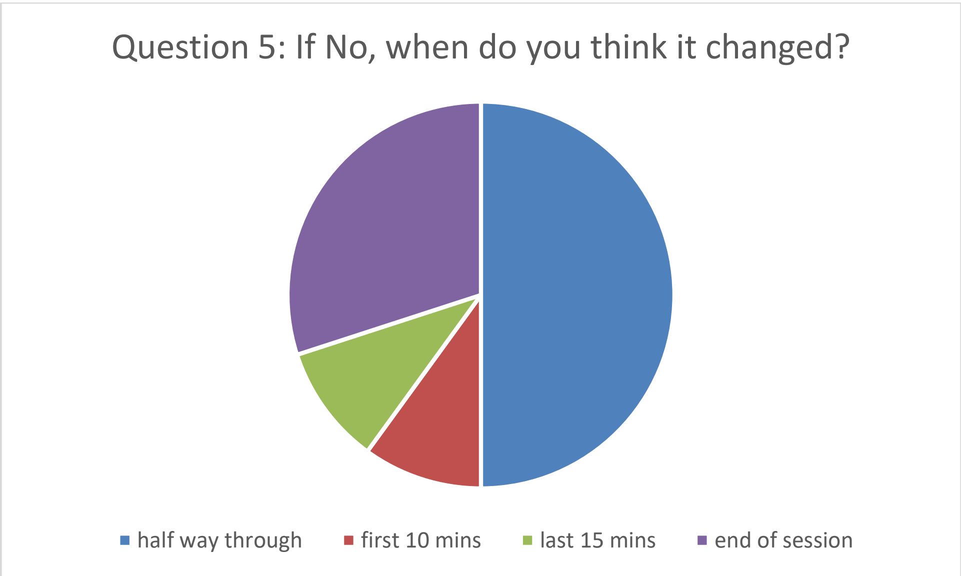

Figure 17: Riders perception of when the horses way of going changed during the session for ride one (n=10).

For ride two, 6 participants answered Question 5 (linked to question four) asking the riders to decide when they believed the horses changed in the session. The most common answer was half way through (3 participants), then 1 participant for end of session, first 10/ last 15 minutes.

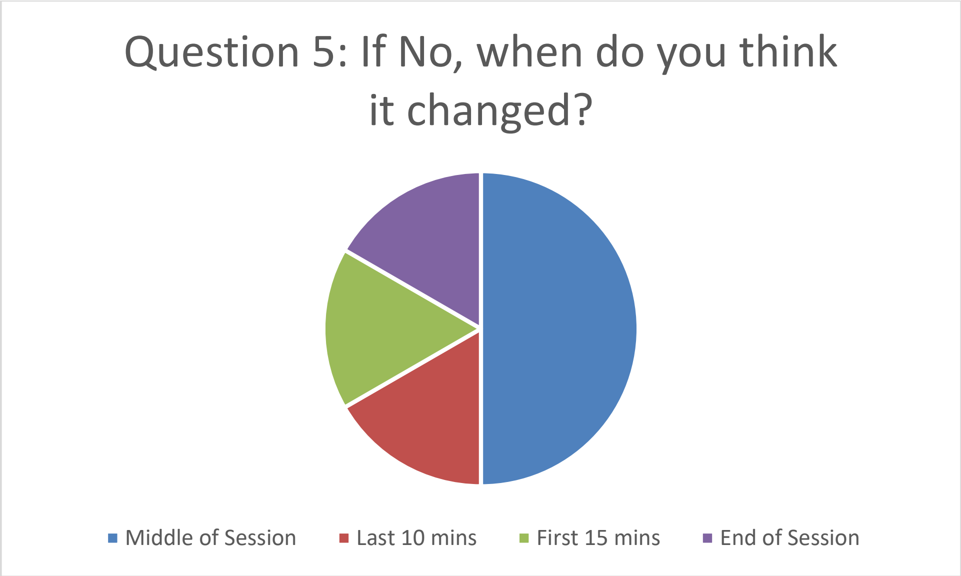

Figure 18: Riders perception of when the horse's way of going changed during the session for ride two (n=6).

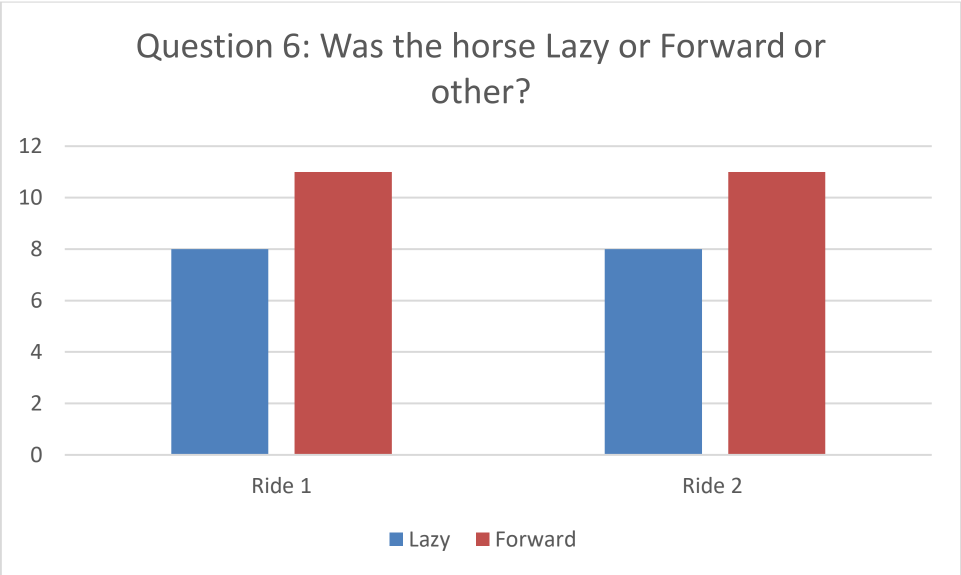

Figure 19: Riders perception of if the horses were lazy or forward during the ride (n=19)

Figure 19 shows the amount of lazy versus forward horses in each of the ride sessions, for both ride one and two the riders indicated more forward horses (11) than lazy horses (8).

4.4.2 Rider perception of exertion

Figure 20 shows the rates of exertion given from participants for both ride one and ride two using a Borg scale. The average exertion rating from ride session one was 13 and ranged between 10 – 16. The average exertion rating from ride session two was 14 and ranged from 11- 16. The mode for both rides were 14. Following running a Kruskal Wallis test there was no significant correlation between the exertion scores and heart rate elicited by riders.

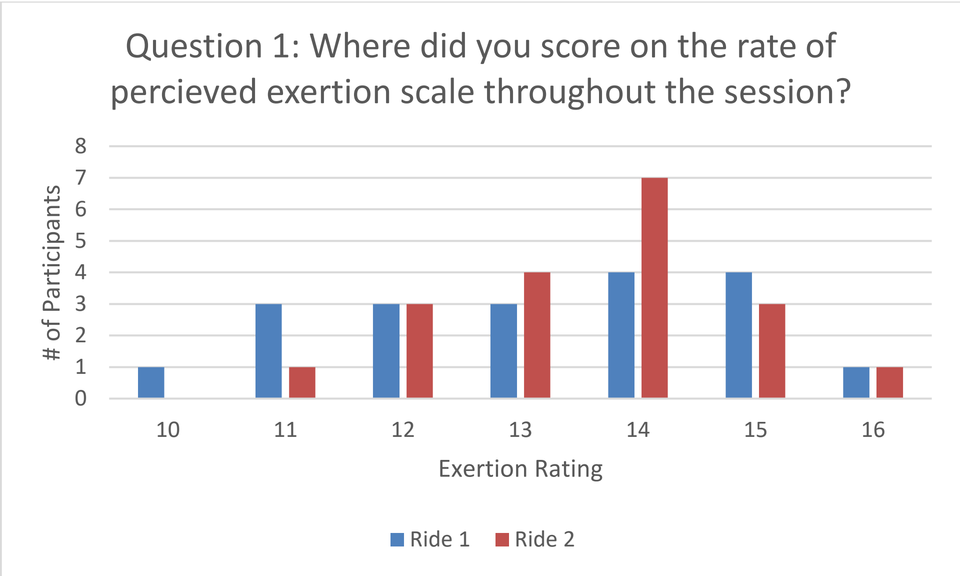

Figure 20: The perceived exertion of the participants throughout the ridden sessions (n=19)

Figure 21 and 22 shows if the participants believed their exertion remain consistent throughout the session. During ride one, three participants highlighted that it felt as though exertion rate stayed consistent throughout, this decreased to two participants for ride two. Table 14 and 15 show the actual heart rates of the riders who answered the exertion rating was the same throughout the whole session, for some of the riders there was 10 beats per minute difference between gaits.

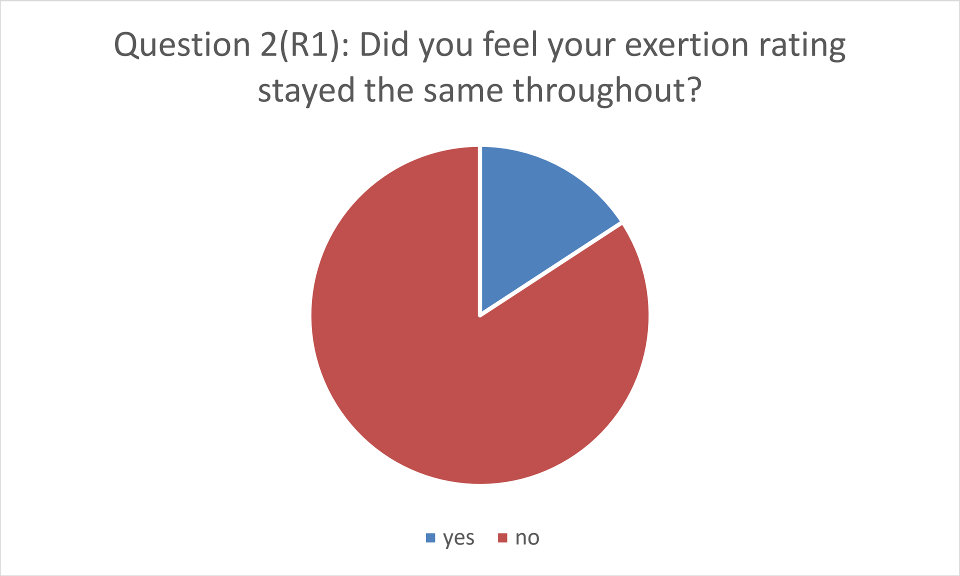

Figure 21: Participant perception of if the exertion rate stay consistent throughout ride session one

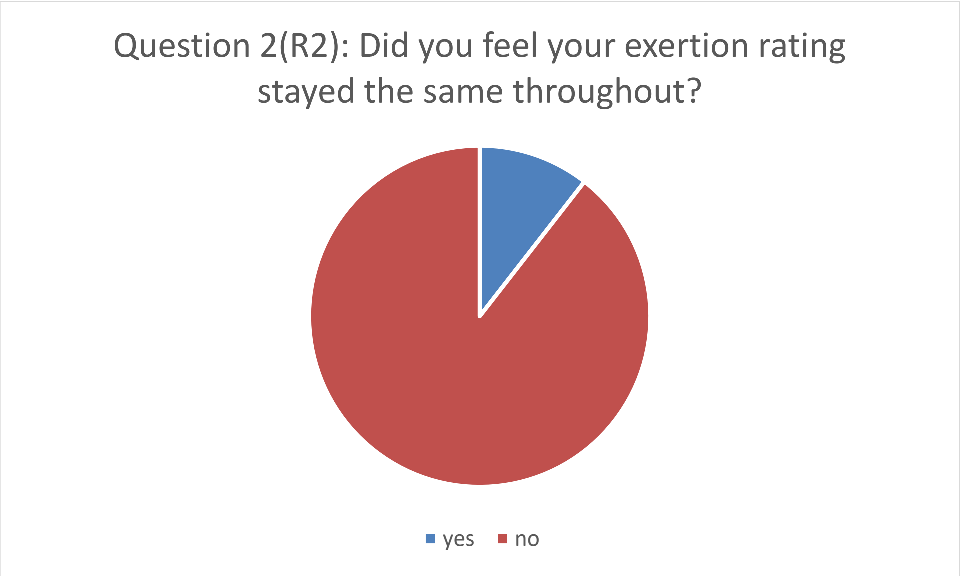

Figure 22: Participant perception of if the exertion rate stay consistent throughout

ride session two.

Table 14: Mean heart rate (bpm) of participants which answered yes, the exertion felt the same throughout for ride one (n=3).

	Walk	**Trot**	**Canter**
Rider 3	120	112	133
Rider 4	130	124	133
Rider 13	111	109	109

Table 15: Mean heart Rate (bpm) of participants which answered yes, the exertion felt the same throughout for ride two (n=2).

	Walk	**Trot**	**Canter**
Rider 3	156	145	156
Rider 4	157	151	152

Figure 23 and 24 highlights where the exertion rates changed with the majority of participants stating the exertion rates changed in the middle of the session or after the first canter. The most common response for why participants felt the exertion rate had changed was that they were not used to staying in the gaits for so long. The second common response was that they were struggling to keep in the correct gaits.

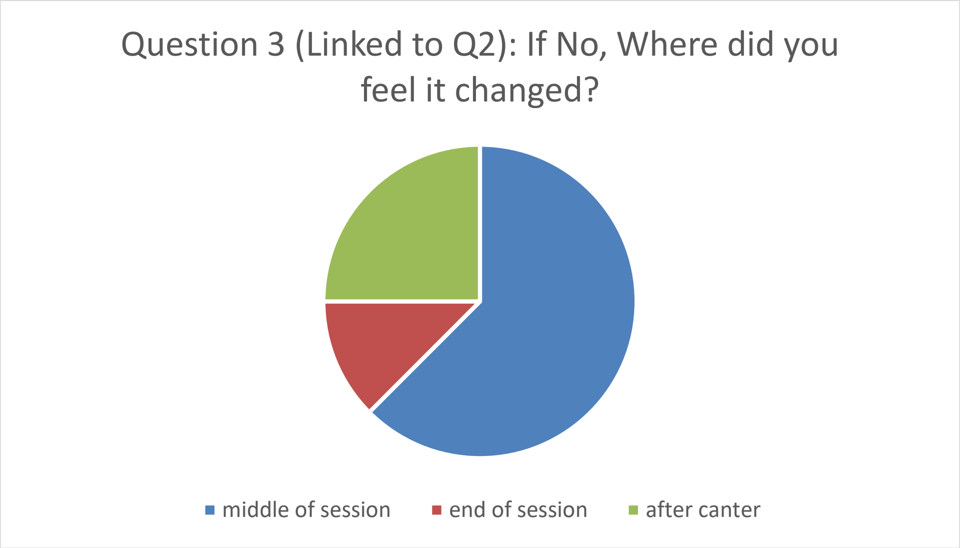

Figure 23: where the participants felt the exertion rating changed for ride session one.

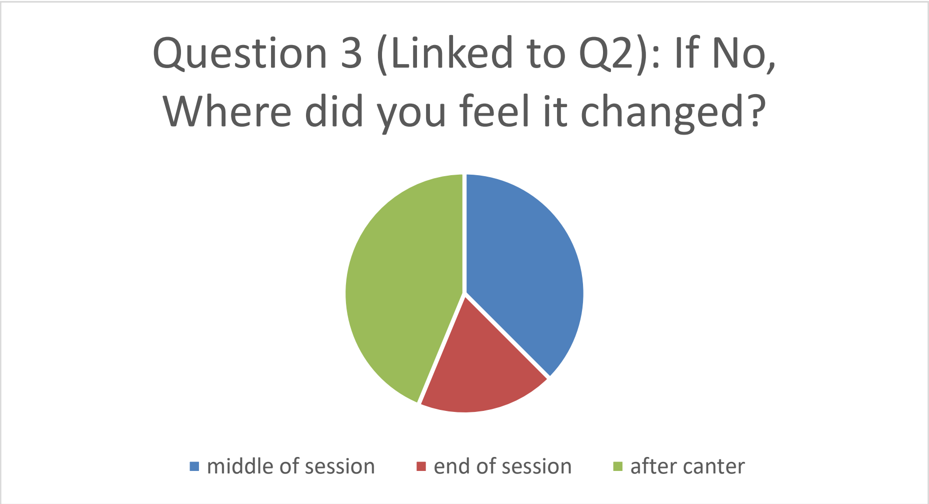

Figure 24: where the participants felt the exertion rating changed for ride session two.

Figure 25 and 26 shows if the participants felt out of breath during the ridden sessions. During both rides the riders were out breath throughout the session.

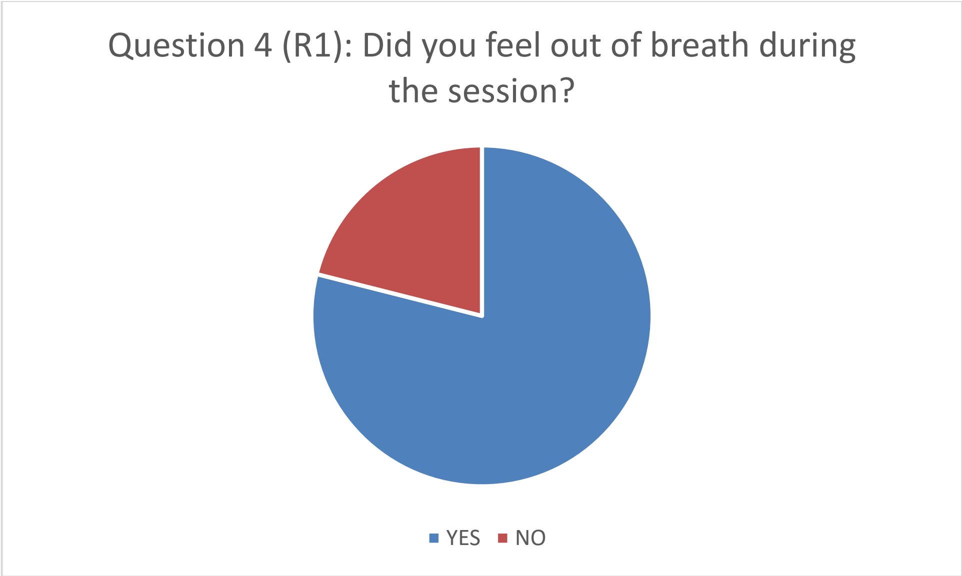

Figure 25: rider’s perception of feeling out of breath in the session during ride one

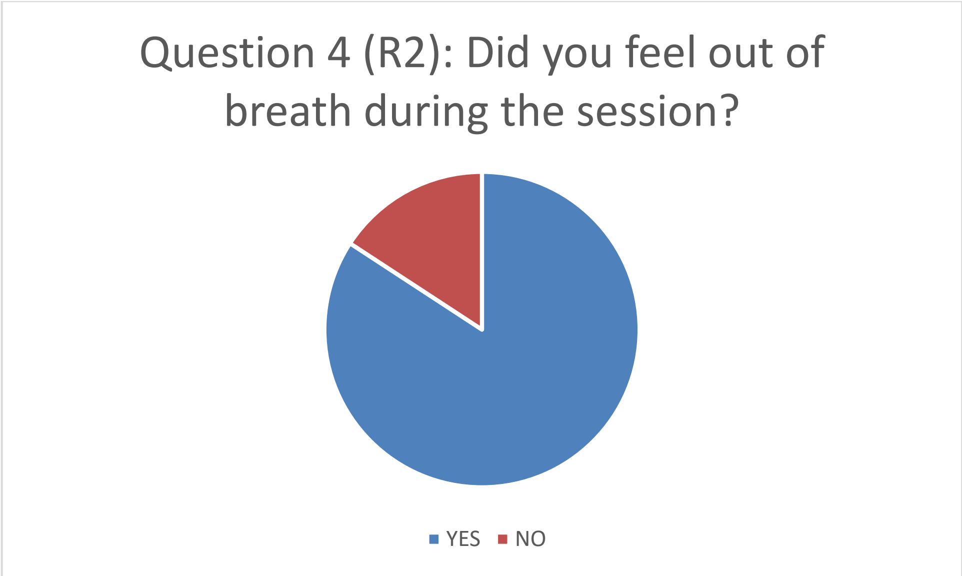

Figure 26: rider’s perception of feeling out of breath in the session during ride two

Figure 27 shows when the participants believed they began to feel out of breath, for both ride sessions one and two. It is clear, that after canter was where a large majority of participants began to feel out of breath.

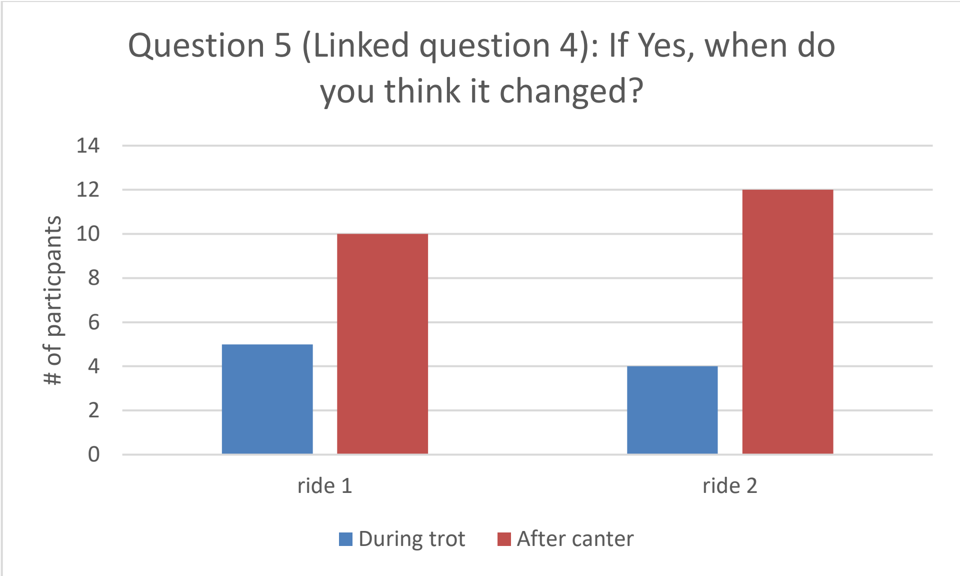

Figure 27: Riders perception of when they began to feel out of breath in the ride sessions

Figures 28, 29, 30 are linked to question six for ride session one on the rider's questionnaire, which asks which gait they believed was most demanding. Figure 28 shows that for most rider's canter was the most demanding in their own opinion. Figure 29 relates to the actual heart rate from the data collected on heart rate monitors, and compliments the riders thought of canter being the most demanding gait. Figure 30 shows how many riders selected the right gait as the most demanding in relation to their heat rate. More participants selected a different gait to what was shown in the heart rate.

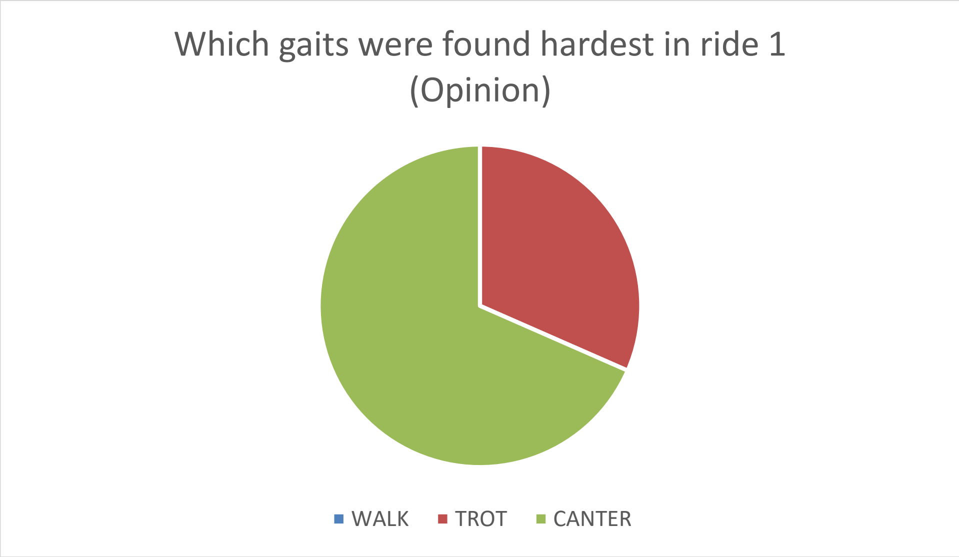

Figure 28: Riders perception of the most demanding gait throughout session during ride one

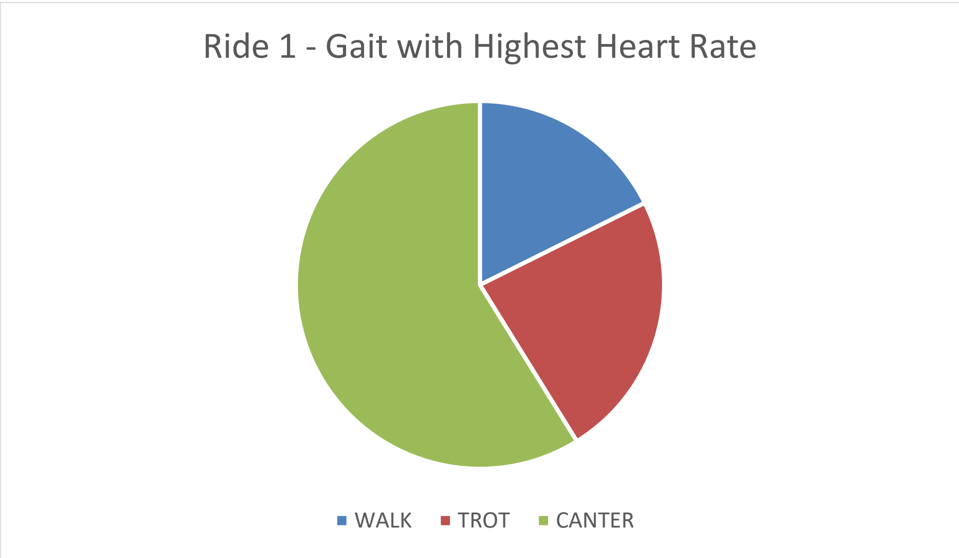

Figure 29: the gait which elicited the highest heart rate in the sessions for ride session one

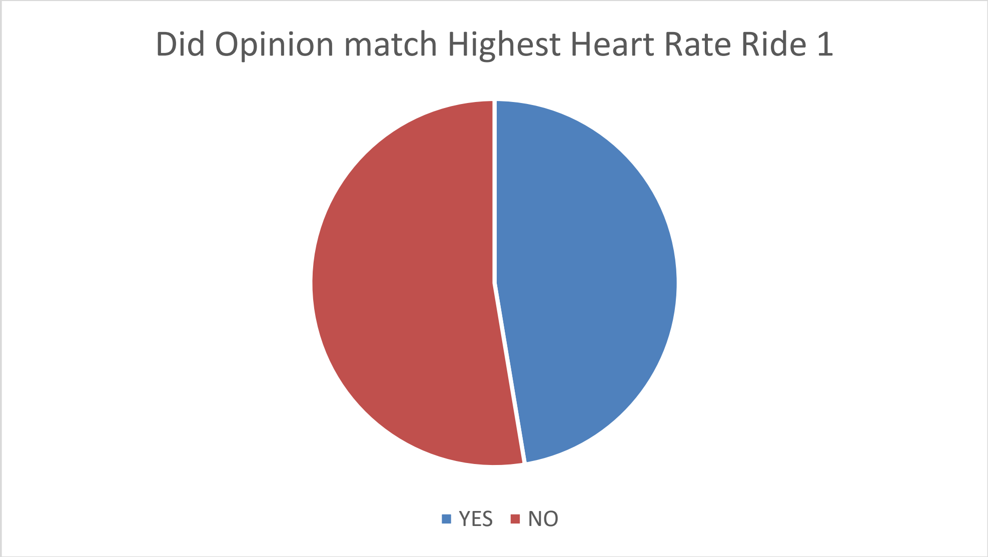

Figure 30: Amount of participants who matched their perceived demanding gait and actual heart rate

Figures 31, 32, 33 are linked to question six for ride session two on the rider's questionnaire, which asks which gait they believed was most demanding. Figure 31 shows that for most rider's canter was the most demanding in their own option. Figure 32 relates to the actual heart rate from the data collected on heart rate monitors, and compliments the riders thought of canter being the most demanding gait. Figure 33 shows how many riders selected the right gait as the most demanding in relation to their heat rate. More participants selected the right gait to what was shown in the heart rate.

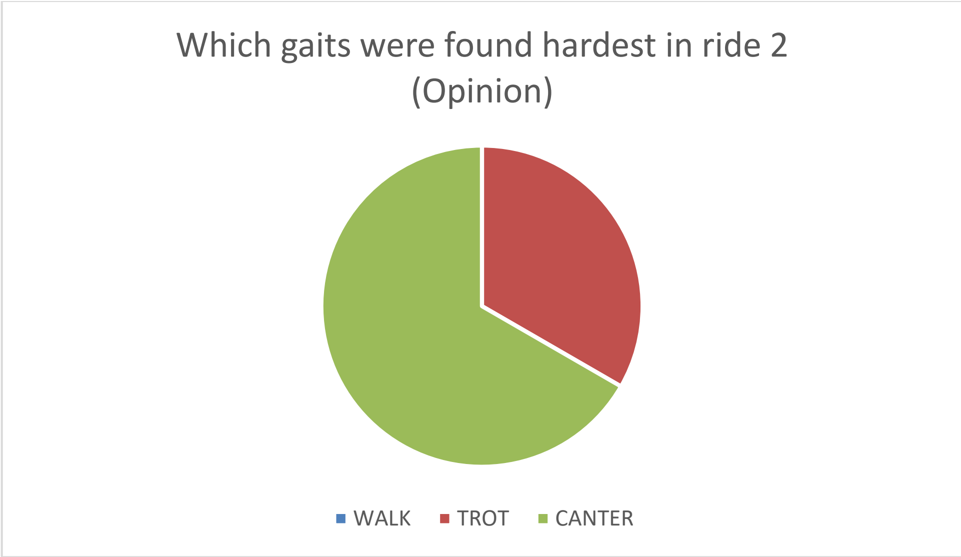

Figure 31: Riders perception of the most demanding gait throughout session during ride two

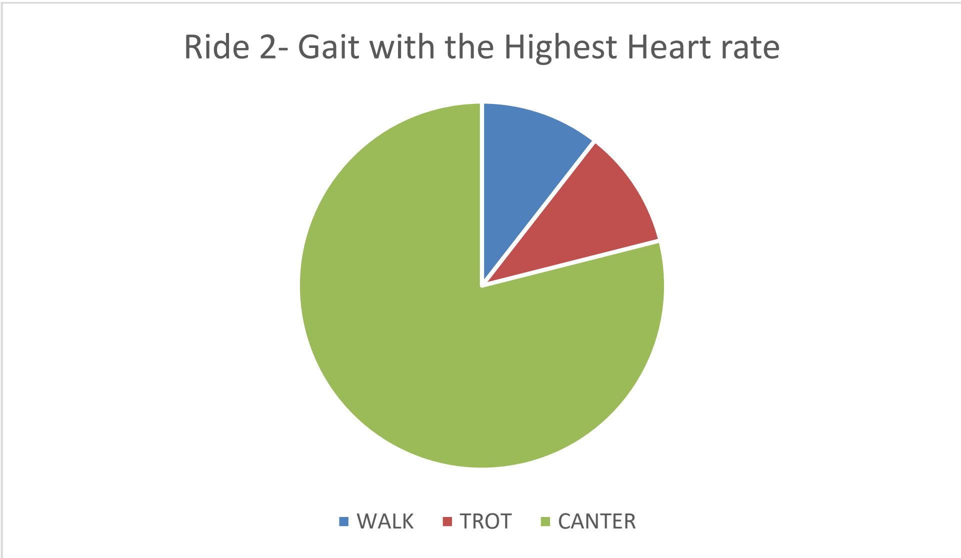

Figure 32: the gait which elicited the highest heart rate in the sessions for ride session two

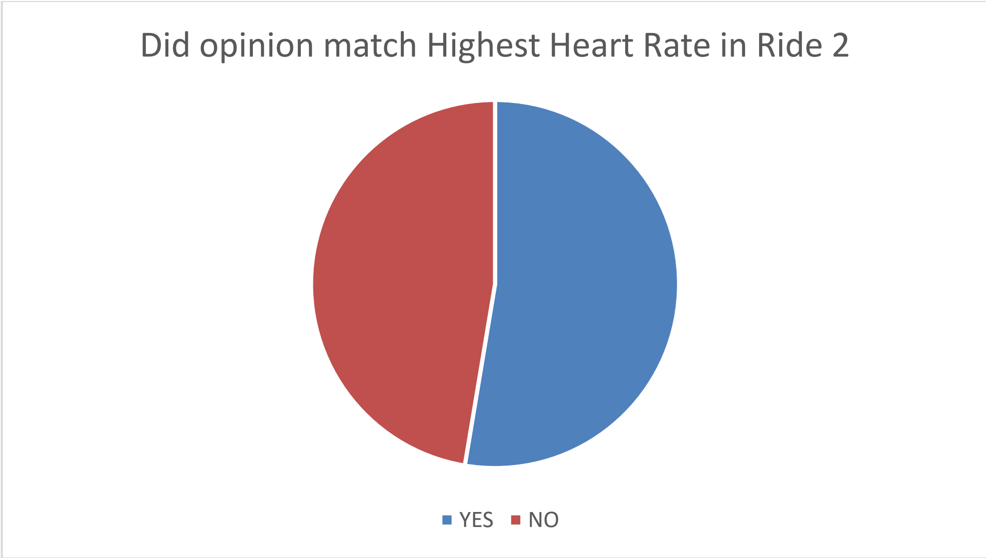

Figure 33: amount of participants who matched their perceived demanding gait and actual heart rate

Figure 34 and 35 highlight what the riders thought was causing them to feel more demands within these gaits. The most common reason was keeping a good rhythm, kicking forward for those on lazy horses and holding the horse back for those on the more forward horses.

Figure 34: Word cloud of the rider responses for the reasons why the ride was demanding for ride session one (n=19)

Figure 35: Word cloud of the rider responses for the reasons why the ride was demanding for ride session two (n=19)

Figure 36 and 37 show the areas of the body which ached during the ridden sessions, the most common area in both sessions were the legs, followed by the back. For each rider which stated they did not normally feel aches in the specific places stated, suggested the horse played the biggest role in the areas of which they ached. Which links into the previous question of why they thought the gait was most demanding.

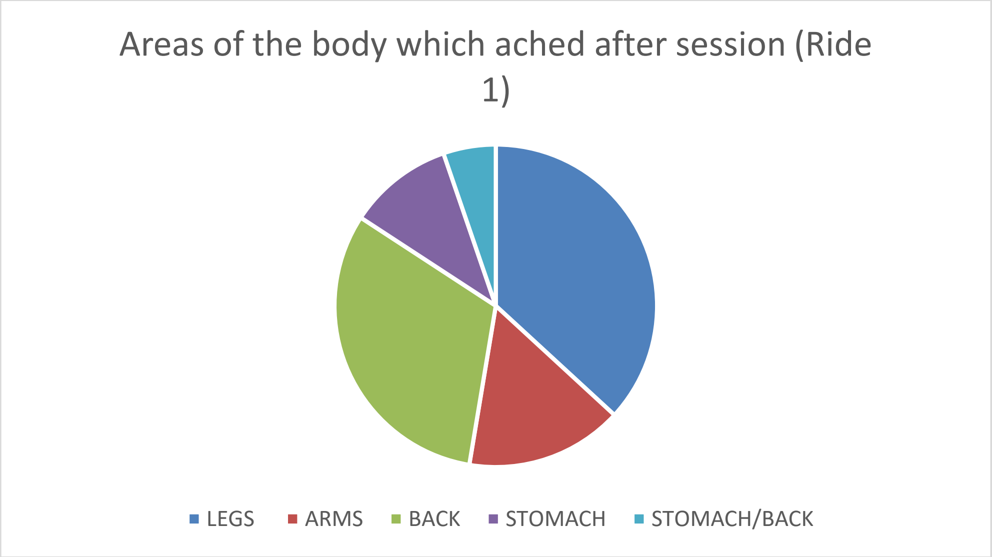

Figure 36: Riders perception of the areas of the body which ache after the first ride session (n=19)

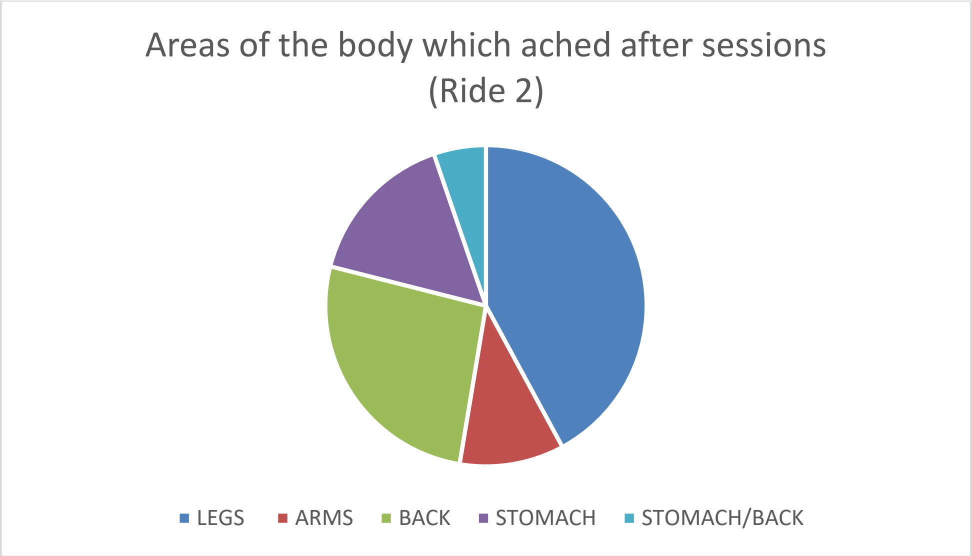

Figure 37: Riders perception of the areas of the body which ache after the second ride session (n=19)

Chapter Five: Discussion

The study collated baseline capacity data using an Astrand-Rhyming cycle test, with student horse riders (n=19), the riders were asked to perform a standardised ridden session on two separate occasions, riding different horses. Heart rate data was collected throughout all the testing, and $\dot{V}O_{2\ Max}$ estimated from the heart rate data.

From the results of the current study H_1 (there will be a significant difference in heart rate between the three gaits: walk, trot and canter during the 45-minute ridden exercise), can be accepted for the canter gait against walk and trot. However, it can be rejected for the comparing the walk and trot gaits. H_2 (There will be a significant difference in heart rate between ride one and ride two), can be rejected according to the data from this study. H_3 (The percentage of maximal heart rate used will exceed the moderate intensity set by the American College of Sports Medicine), can be accepted for all three gaits as over 60% of the maximal heart rate was required for the riders to perform the ridden test. H_4 (Horse Riding can be used in the exercise prescription to improve the fitness of the cardiorespiratory system) can be accepted based on the results of the study.

5.1. Physical Activity

As previously described by Pearson *et al.* (2006), the understanding of the physical and physiological demands of sports are important to determine the off-horse exercises required to improve on horse fitness. This study has given an insight into the internal loading of the rider whilst mounted and may be used to identify the fitness components suggest by Vaeyes *et al.* (2008). As the developments into the physiological demands of horse riders whilst mounted expand the knowledge base, the fitness programmes of horse riders can be revisited and re-designed continuously, especially for the range of different disciplines (Johnson and Campbell, 2002).

As discussed in the introduction, fatigue is used to describe the variety of signs and symptoms related to failure to sustain the physical activity, and limit the sport performance (Fletcher *et al.*, 2001). The results from the questions around fatigue and areas which ached following the ride, the most common answer was the legs this could be linked to fatigue, as this has also been described as ‘inability of the muscle group to sustain required or expected force (Gandevia, 2001). However, there was a variety of areas suggested by the riders, as with the variations in the physical activity required of the riders there were a variety of changes in the neuromuscular functions which could explain the differences seen between riders (Allen *et al.*, 2008). The increases observed in horse rider falls has recently been linked with horse rider fitness and fatigue (McCrory and Turner, 2005), in increasing the fitness of horse riders may decrease the instances and severity of injury should it occur (Watt and Finch, 1996).

5.2. Baseline capacity

The use of baseline fitness data is commonly used across a variety of sports (Carling *et al.*, 2008), with the knowledge being commonly used to identify the strengths and weaknesses of the athlete. The baseline fitness data observed in the current study identified that the riders struggled to perform the fitness test, although the test was unlike their current sport, the test process should not have been so hard for the age group of the participant. It is highly likely that many of the participants had not performed a fitness test previously and did not take part in any other sport or exercise activity. Due to this several of the participants did not finish the fitness test process. Meyers and sterling (2000) similarly to the current study found that when performing fitness test’s, the equestrian athletes were below average and concerns about the lack of physical training in equestrian sports could be leading to an increase in injury rates observed in college level equestrians. The averages observed in other college level sports varied in comparison the equestrian levels.

This baseline data of the study could be used in conjunction with a fitness programme for the participants and be used to monitor their progress throughout a given time-frame (Sharkey and Gaskill, 2013). The use of additional off horse programmes should be encouraged, the programmes should target the whole of the sports fitness and not just skill specific areas, such as balance and strength. This suggestion has been made previously by Meyers (2006) and Douglas *et al.* (2012).

5.3 Baseline Capacity Testing

The participants were asked to perform a sub-maximal exercise test to determine the $\dot{V}O_{2\ Max}$. It was clear throughout the test that many of the participants found the test increasingly hard, with elevated heart rates past those normally seen for the test, increases in respiration rate was observed by the researchers, along with comments on the difficulty of the session on the individual riders. There was also a small number of original participants which were unable to finish the fitness test.

This could be due to the test being a cycle test, however, the test seemed most fitting in posture and muscle recruitment to the participants current sport. During cycling, similarly to horse riding the riders are required to recruit muscles of the thighs to aid stabilisation, whilst the calves provide the power required to push the rider into the rising trot and to apply to the forward aids of the canter (Williams and Tabor, 2017). The core musculature surrounds the hips, stomach and back these muscles are recruited in order to provide the stability of the trunk whilst mounted and to absorb the movements of the gait (Alexander, 2012). However, the horse riders do not usually have exaggerated movements on the lower and limbs like in cycling the rotatory movement of the legs is unlike their current sport.

The $\dot{V}O_{2\ max}$ data for this study was considerably low for the ages of the participants, this could suggest that the chosen sub-maximal exercise test was not suitable for the profile of the sport. However, it was the closest test which replicated the position of the rider and also the repetitive motions experienced whilst horse riding. These low measurements of the Astrand-Rhyming fitness test may indicate how the strengthening and conditioning of young equestrian athletes is lacking and less productive than that seen in other sports (Wolfram, 2013). It could be stated that a more practical approach should be taken to encourage college equestrian athletes to take part in exercise and fitness other than horse riding, as been suggested in previous studies (Meyers, 2006; Boden, 2013).

5.4. Horse riding and Physiological Demands

The current study is one of several studies which have aimed to identify the physiological demands placed upon a rider whilst mounted. With over 3 million people involved with horses in the UK (BHS, 2015), there is still little information available on the use of horse riding for sport and a form of healthy exercise (O’Reilly, 2015). Although body composition was not noted for this study, Meyers and Sterling (2000) have previously suggested that in college level equestrian athletes both bodyweights and BMI fell within the normal ranges. The average body weight observed in the current study fell within the normal ranges for the age of the participants. It has previously been stated that the introduction of a short exercise programme, had no significant effect on the body compositions observed in the equestrian athlete and so horse riding may have an effect on the body composition over time (Roberts *et al.*, 2009; Meyers 2006).

The findings of this study suggest that canter is the most physiologically demanding gait ($P<0.05$), when compared with walk and trot, during a structured ridden session. Previous studies have published an increase of physiological parameters, such as $\dot{V}O_2$, a measure of the volume of oxygen that is used by the body to convert the energy from food intake into the energy molecules required for exercise and heart rate, as the gait speed increases. Other studies have suggested that as gait increases so does the intensity of the exercise (Westerling 1983; Devienne and Guziennec, 2009; Roberts *et al.,* 2009). An apparent reason suggested by Douglas *et al.* (2012) is that a faster gait adopts a naturally more forward seat and position therefore creating an increase in the need for control and stability of the trunk and legs. This requirement for the control, induces a higher recruitment of musculature leading to a higher intensity of exercise and an increase on the internal load experienced by an individual. This suggestion was further supported by Lovett *et al.* (2005), who during kinematic studies highlights the changes in rider posture throughout a variety of gaits. The repetitive and rotary movements described by Williams and Tabor (2017), explain the variations in the position required for differing gaits. During the rising the trot thigh activation is required along with more centre of mass changes. However, the canter riders need to stabilise the body and keep the centre of mass consistent, this requires a high level of muscle activation in the legs back and core. It has been further suggested by Douglas that the canter requires an increase in the muscular contraction in order to maintain posture due to the changes in the ground force reactions and orientation of the trunk due to motion of the canter. The present study supports this theory with the measurements of heart rate. The mean heart rate for walk, trot and canter increase and decrease with the speed of the gait.

Whilst riding there is not only the influence of the gait but also the horse's way of going, such as forward going, when the horse is moving forward with little need for aid from the rider some may also be strong and unwilling to stop or laid back where the horse requires a hard application of the 'go' aids and the riders ability (Hampson and Randle, 2015). The intensity of the session is also determined by the exercises and gaits used by the instructor and riders (Alexander and Jayes, 1983; d'Eisenberg and Allen, 2016). Manoeuvres such as lateral work for dressage, moving horses into collected and extended gaits and lead changes all require the movement of the trunk is changing location and the centre of balance is also needs to be maintained (Egnevall *et al.,* 2013). The changes of movement may come in quick or slow succession throughout ridden sessions and so there is a need for a variety of trunk control to maintain the correct centre of gravity and balance whilst mounted (Collins, 2006; Podhajsky, 2013).

All gaits and movements may recruit more muscles than normal walk-trot-canter activities, due to the unique physiological stress each discipline and movement of equestrian sport places on both the horse and rider (O'Reilly *et al.,* 2015). Disciplines which include the fourth gait of canter and jumping elements, may require higher levels of rider fitness and ability in order to maintain the correct position and balance over a fence and adopt the light seat position (Rincon *et al.,* 1992). The level of discipline is also an area for which variations in data may occur, the athletic rider should have developed both fast and slow twitch muscles fibres which require different uses of oxygen consumption. The ability to switch between the fibre types is crucial to success, fast twitch fibres will be used to adapt a jump position required for fences. Whereas, the slow twitch fibres will aid in the maintaining of the position, particularly in the light seat, during cross country events (Roberts *et al.*, 2009). The leisure rider should have well developed slow twitch fibres, in order to maintain position and balance whilst mounted, with some ability to recruit fast twitch fibres for any jumping elements.

Similarly, to O'Reilly *et al.* (2015), there was a trend that some walk averages were significantly higher than that of the higher gaits for some participants, and higher than the averages presented in the previous research. These participant's data, disagreed with previous findings in other studies that heart rate would increase as the gaits progressed (Westerling, 1983). This is likely to be because of the design of the ridden sessions, when the riders transitioned from canter to walk. The heart rates had large peaks following the canter periods which could suggest the canter elements had a significant effect on the walk elements of the session. This was further supported as the use of data from final 2 minutes of the gait producing a lower mean for the walk gait for those affected by the previous gait. Transitions between the gaits and movements within the gait may also affect the results. The time within the gaits were low, in order to suit the horses at both colleges, which would not commonly complete sessions with a certain number of minutes within a gait. The lowering of the calculation numbers may have caused the lowering of the results. During the actual ridden session, the horse and rider would not commonly spend designated time within a gait, nor would they keep within one gait for prolonged periods.

The breed and temperament of the horses were thought to play a role in differences seen between ridden sessions. Devienne and Guzennec (2000), suggested that the nature and going of the horse being ridden may have an influence on the internal load experienced by participants. The current study however, did not report a significant effect between the ridden sessions and ultimately the impact of the horse. The data presented by Devienne and Guzennec suggests that horses that need to be 'pushed forward', would increase the energy expenditure of the rider. This was also a common response of the riders in the current study, as they felt that kicking forward was more demanding.

The kinematic studies carried out on equestrian riders highlight that much of the muscle activity required from the riders is utilised in the postural control of the hips and core areas (Terada *et al.,* 2004). This could explain why riders of the current study felt aching areas of the back and stomach when answering the questionnaire, along with the participants ideas that kicking forward caused the aching of the legs, back and stomach. Maintaining of the centre of balance and posture could be affected by the horse's natural way of going within a gait (Moore, 2010). Whilst horses were not directly compared within this study, innate differences in the horses used within a college setting compared to the jumping and dressage breeds likely to have been used within the previous studies could also have an effect of the internal loading and perception measurements taken in this study.

5.5. Heart rate

Internal load for this study was measured using heart rate and was continuously measured during the ridden sessions. Heart rate can be used as a measurement to gauge of exercise intensity and also as a way to estimate the energy expenditure in activities (Astrand and Rodahl, 1977; Rouwei *et al.*, 1993). The average heart rate for every minute in each gait, was calculated for each rider, which produced a variation of results.

The average overall for all the riders was calculated and it was found that the heart rate was highest in canter, with significant differences (P<0.05) between the canter and the walk and trot. The high differences within the gait could be linked to the short time in the gait, in comparison to the other gaits, however this was required in order to ensure the horses used in the test were able to perform without affecting welfare. The riders were also unused to staying in the canter gait for two minutes without resting the horses. This data was further supported by the rider's answers to the questionnaire data, where the canter was the most commonly answered for the gait with the highest exertion.
Whilst looking at the raw heart rate traces from the riders, an interesting trace pattern was visible for three of the participants. There were significant spikes in heart rate seen from the canter to walk periods, this could have affected the high heart rate data seen in walk for the participants. Past studies that have examined the different gaits, by considering them individually with rest in between the gaits, rather than without rest such as the current study. This allowed there to be less interference from the gait previously ridden on the gait being tested. This face along with the breed and discipline requirements may have led to discrepancies within the varying studies.

Heart rate has been measured in a variety of studies with various equestrian activities. Roberts *et al.* (2009), completed a study on heart rates within the different gaits of an eventing competition. The data observed in this studies dressage test is similar to the heart rates elicited in the canter gait, but higher than the average heart rate for canter in this study. This could be due to the nature of eventing riders being fit enough to carry out three phases unlike those riding at college level. Although the dressage was noted to have the lowest heart rate of the 3 events found in eventing, it can be suggested that dressage still elicits a high enough heart rate for fitness and health benefits. The heart rates seen in the current study for walk is substantially high in comparison to the previous data, however this could be due to the sequence of canter to walk in the ridden session.

The walk was notably higher than data in both mean measurements and peak, but when only taking the middle 3 minutes of 5 minutes the average heart rate lowered but not in line with current research. The rising trot was significantly lower than that seen in previous data, the trot commonly came after the walk gaits when the riders heart rates had stabilised. This could be due to a number of factors including the nature of the trot, size and speed of the trot, size of horse, fitness and experience of the rider to perform the rising trot (Westerling 1983; Terada, 2000). Within the sitting trot the previous factors would be paramount to the heart rate achieved by the riders, but rather than the experience to perform rising trot, the rider needs an increased balance to keep themselves stable and in the correct position. The range of horses in the study went from small Welsh ponies to large riding and Warmblood type horses, therefore the speed and stride of the trot varied considerably.

The canter gait was lower on average in comparison to the previous literature. However, even with the heart rates considerably lower in the present study, patterns within the heart rate data matched that of the current literature. Heart rate increased as the gait intensity increased. This pattern was observed within the heart rate mean, especially in the when taking the data from the middle three minutes of each five-minute bout of walk and trot and the entire two minutes of the canter gait. To lower the instance of the previous gait affecting the current gait.

The range of heart rates for other sports like cycling, rowing and rugby have comparable ranges to equestrian sports. The heart rate observed in the all three of the gaits are similar to that of rowing and cycling, which contradicts the data from the fitness test were the riders elicited high heart rates in the limited time frame. Both these exercise methods have been reported to increase health benefits (Hagerman *et al.,* 1988; Warburton *et al.*, 2006).

For individual heart rates, the canter gait elicits similar heart rates to rugby and heart rates present during the advanced sections dance revolution video games. Both of these demanding activities have been reported to reach intensities desired to produce health benefits when completed for optimal amounts of time (Coutts *et al.*, 2003; Sell *et al.,* 2008). Therefore, it could be suggested as the canter gait for horse riding elicits similar heart rates, that horse riding would provide the intensity required to produce health benefits for those participating within the sport.

5.6. Perceived Exertion

The current study asked the participants a series of questions to establish how the riders felt during and after the ride. The questions also explored how the riders thought the horse went. The variety of answers from the questionnaire gave some interesting points related to questionnaire. Although, with the heart rate data no significant difference was observed between the rides, which linked to the effect of the horse, the questionnaires common responses to the difference between gaits were all linked to the horse. Borg *et al.* (1987), stated that there was a linear correlation increase seen with heart rate and perceived exertion, this could suggest that the horse’s way of going does in fact influence the rider, or is a causable factor for the heart rate. There were discrepancies in opinions between the rides around the consistency of the horses, with over 30% of riders suggesting a variance in the horse’s way of going with the common answer for where the riders felt change was half way through a session. At this point the horses and riders have completed walk, trot and canter, this could cause the horses to lose forward impulsion during the second half of the test, and for some riders this may become more demanding physically and physiologically throughout the session.

The riders perceived ratings varied across both rides however the mode for both rides were 14, this suggests that on average horse riding would lay in the ‘somewhat hard’ category (Williams, 2017) with the task varying from light to hard in the perception of the rider. This is an important factor when trying to select the intensity of horse riding on the riders, because physiologically the task lays in the moderate exercise bracket, where some riders have stated the task as hard.

5.7. Health and Equine Activity

The baseline fitness data for the current study suggests a reasonably fit participant population, the data supports the idea that horse riding may be in fact a viable and enjoyable health benefiting exercise. Just as with other forms of exercise, this fact would be subject to the use of the correct intensity exercise for the optimal amount of time. For the majority of health publications, a metabolic equivalent of task to be 4-6 or a rated moderate exercise for 30 minutes, and in some cases a smaller amount of time but higher frequency of the activity, can not only improve health benefits but decrease the changes of gaining disease (DeBusk *et al.,* 1990; Murphy and Nevill, 2002; Warburton *et al.,* 2006; Haskell *et al.,* 2007). The data from the study is similar to that found by O'Reilly *et al.* (2015), who states that the walk and trot of horse riding was on the border of moderate MET level. This along with the evidence of higher Metabolic Equivalent of Task ratings for canter gaits which fit well within the ranges for moderate exercise indicate the ability for horse riding to be used as part or all of an exercise regime for individuals.

Blair *et al.* (1989) suggests that burning of 1000 kcal per month would provide health benefits to average subjects. With the total energy expenditure of an average 45-minute ridden session providing 194 kcal it is possible to achieve 1000 kcal per week with a reasonable amount of effort (O'Reilly *et al.,* 2015). It is important to note that an individual would have to understand which gaits provided the correct intensity and the gaits and discipline they choose will greatly affect the results of the calorie burning exercise. The canter gait has the beneficial intensity with walk and trot having the least benefit.

5.8. Exercise prescription

Exercise prescription refers to the tailored exercise programme for patients or athletes to follow (Garber *et al.,* 2011). The prescription of exercise can be used to establish the recommended amount of physical exercise required for an individual to achieve both health and fitness benefits. Under the recommendations of the American College of Sports Medicine (2015), horse riding provides the necessary intensity to elicit health benefits in a variety of individuals. This is further supported by the findings of Branch *et al.,* (2000), who also states that moderate intensity is enough to see improvements in the cardiovascular response to exercise.

The intensity of exercise can be explained in many ways however, the most common way is to establish target heart rate zones (British Heart Foundation, 2015), for the majority of horse riders all three gaits elicit moderate exercise intensity, however, for some individual riders the exercise was intense. The intensity of the exercise is a major factor in improving cardiovascular fitness (Wenger and Bell, 1986), with an increase of intensity and increase in cardiovascular fitness can be seen (Weston *et al.,* 2014). It can therefore be suggested that horse riding under the correct intensity (moderate – intense) would provide the relevant intensities to improve the cardiovascular fitness of those taking part. In sports providing the correct intensity health benefits can be seen in as little as 2-3 time per week, with those starting with low fitness having a more rapid change (Emerenziani *et al.,* 2013). The longer the time in the work the more cardiovascular fitness is improved (Jackson, 2004), with observed $\dot{V}O_2$ measurements improving more rapidly for durations over 35 minutes. Consequently, the horse riding activity adapted in the current study could provide the beneficial intensity and duration for the improvement of fitness.

5.9. Improving horse rider fitness

From the baseline data of the fitness test, in the current study, it can be suggested that the addition of off-horse rider exercise would be beneficial. In particular, for both colleges and universities providing equine studies, were students should be encouraged to undertake extra fitness programs. During the ridden sessions, the riders are working between moderate and intense exercise which requires high cardiorespiratory efficiency. Additional cardiovascular exercise training could provide benefits to the riders within ridden sessions.

Skill and strength training can also be beneficial. Improving the strength of the muscle and the muscles ability to utilise oxygen, would reduce the metabolic cost of the repetitive movements of horse riding. The key muscle groups for strength training are the legs, arms and core. These can be improved by using both static exercises, such as weight lifting, or dynamic activities such as squats, lunges and burpees which encourage both strength and cardiovascular fitness.

Improvements in the core strength of riders would be provide benefits for rider performance. The core strength of riders provides the stability and balance required for horse riding. In strengthening the core muscles, the body systems would be more efficient in the ability to hold and move the body in the variety ways required in the ridden session undertaken by the horse riders.

Chapter Six: Limitations of Current Study

It is important to note this research was carried out in a working college environment which required thorough ethics examination, to ensure the study did not impede on the progress of the students, therefore some limitations occurred which were out of the researchers control. There was no maximal test used in this study, which is commonly gold standard for exercise testing. Instead a more suitable sub-maximal exercise test which predicted heart rate was used, to increase participant completion.

A criticism of the current study includes a loss of rider groups due to timetabling and a decrease in riders on the university riding teams. However, it has been suggested by Houser (2007) that by using power calculations, it could be determined if nineteen participants was a large enough sample size to gain sufficient statistical power. The power calculations for this sample were determined following data collection and statistical analysis and suggest that nineteen is a sufficient sample size to gain statistical power.

There were uncontrollable factors when selecting to test riders in a natural ride situation. For example, the sessions were carried out in the large indoor arena which in theory could have an impact on the results; although all students and horses were habituated to riding in the large indoor arena; not only for the purpose of the research but also for the safety of the students. However, the weather is a factor which would need to be taken into consideration as high winds and stormy weather as this could potentially could affect the riders heart rate and horse behaviour. Fortunately, during the data collection period there was no adverse weather observed.

An unexpected aspect which was not addressed prior to the data collection was the mental preparation required before training and riding. The 'desire' and 'want' to succeed or improve has been highlighted through the research. The results could have been affect by the attitudes of the participants in the exercise test (Ekkekakis and Lind, 2006). However, it is felt that those carrying out the exercise test with friends were highly motivated in line with findings of Eys *et al.* (2006), possibly due to the nature of team spirit. During team sports are understood to enable individuals to contribute more effort due to an increase of enjoyment.

It was overestimated that the equestrian students would be as enthusiastic for all aspects of the study as the research was linked to their courses and hobby. It was expected that the attitude of students may impact attendance of the sessions, although this was addressed in the methodology by the disregard of the data for any participant who did not attend both ride one and ride two sessions and the Astrand-Rhyming exercise test.

The use of heart rate to predict maximal oxygen consumption ($\dot{V}O_2$) has limitations such as the researcher's ability to understand and use the nomogram and the calculations, the use of gas analysers to measure absolute maximal oxygen consumption would have been more suitable. However, it wasn't fundamental to the findings of this study. The gas analysers would have been ideal to be used in the ridden sessions and Astrand data, to monitor gas exchange. During the ridden session this would highlight the physiological responses second by second, rather than overall prediction, which would allow for more accurate comparisons and correlations to be drawn.

Chapter Seven: Suggestions for further research

The knowledge and understanding the different physiological demands of horse riders at a variety of levels from novice to professional and a range of disciplines from dressage, jumping and endurance riding. This information would be beneficial for the development of discipline specific training programmes. This study can be used as preliminary work for research in this area. Further research is needed into the attitudes of the equestrian athlete towards fitness and understanding the demands placed on their bodies during a ridden exercise. This will enable the development of suitable and manageable additional exercise regimes for the horse rider to assist in the improvement of rider fitness specific to demands and the position of the rider whilst mounted.

Chapter Eight: Conclusion

This study has provided an account of the internal loading in the measurement of heart rate of horse riders in a given 45- minute ridden task and suggested the need for off-horse rider exercise. Two ridden sessions were used to determine the internal loading placed on the rider in different gaits and riding two different horses.

This project was undertaken to establish the baseline fitness data of a participant group. To determine the physiological demands placed on the horse rider during a structured 45-minute ridden session similar to that of the schooling sessions used to train horses and riders. To ascertain how much of the rider's maximal capacities were used in the session, establish the variability between riding different horses and the differing demands between the walk, trot and canter gai

ts.

The most significant findings of the current study were that the canter gait has the greatest impact on the heart rate ($P < 0.005$). However, there were no significant differences found between riding the two different horses.

The information provided by this study adds to the current knowledge and research of horse rider demands across different disciplines and aspects of the sport. The low fitness test results, although test type could be a factor, suggest that the addition of off-horse exercise should be encouraged in horse riders. In accordance with the American College of Sports Medicine, horse riding could provide cardiovascular improvements in individuals due to the heart rates achieved in the different gaits, in particular the canter. To use horse riding as a tool to improve the fitness of horse riders, the canter gait should be used more frequently, if the horse is able, and for longer durations, should the horse be able to maintain the gait. If the study was performed again, more time to recruit the participants would be given to allow for a wider range of participants. Additional fitness parameter measurements which would be beneficial for riders such as flexibility, could be taken to give a more rounded picture of the rider group in the study.

In conclusion, the findings suggest that horse riding is a moderate/intense exercise depending on the gait and could provide health and fitness benefits, not only to riders but other athletes should they choose to take part in the sport.

References

- **Adams, W.M., Hosokawa, Y., Adams, E.L., Belval, L.N., Huggins, R.A. and Casa, D.J.** (2016). Reduction in body temperature using hand cooling versus passive rest after exercise in the heat. *Journal of science and medicine in sport*. ***19*(11).** 936-940.
- **Aleman, E.** (2008). A review of equine muscle disorders. *Neuromuscular Disorders.* **18(1).** 277-287.
- **Alexander, R. and Jayes, A.S.** (1983). A dynamic similarity hypothesis for gaits of quadrupedal mammals. *Journal of Zoology.* **20(1).** 135-152.
- **Allen, D.G., Lamb, G.H. and Westerbland, H.** (2008). Skeletal muscle fatigue: Cellular mechanisms. *Physiological Reviews.* **88(1).** 287-323.
- **American College of Sports Medicine.** (2013). ACSM guidelines for exercise testing and prescription. *Lippincott, Williams and Wilkins.*
- **American College of Sports Medicine.** (2013). *Revised Astrand Rhyming Nomogram* [ONLINE]. Available at: https://www.brianmac.co.uk/articles/pictures/article171f1.jpg [Accessed 8 June 2017].
- **Anderson, L., Orme, P., Naughton, R.J., Close, G.L., Milsom, J., Rydings, D., O'Boyle, A., Di Michele, R., Louis, J., Hambley, C. and Speakman, J.R.** (2017). Energy intake and expenditure of professional soccer players of the English premier league: evidence of carbohydrate periodization. *International journal of sport nutrition and exercise metabolism*. **1(1).** 1-25.
- **Asikainen, T.M., Miilunpalo, S., Oja, P., Rinne, M., Pasanen, M., Uusi-Rasi, K. and Vuori, I.** (2002). Randomised, controlled walking trials in postmenopausal women: the minimum dose to improve aerobic fitness? *British Journal of Sports Medicine***. *36*(3).** 89-194.
- **Astrand, P., Cuddy, T.E., Saltain, B. and Stenberg, J.** (1964). Cardiac output during submaximal work. *Journal of Applied Physiology.* **19(2).** 268-274.
- **Astrand, P.-O. and Rodahl, K.** (1977). Applied work physiology. in Textbook of Work Physiology. 2nd ed. McGraw-Hill Book Co., New York. 447–480.
- **Atkinson, M.A. and Eisenbarth, G.S.** (2001). Type 1 diabetes: new perspectives on disease pathogenesis and treatment. *The Lancet*. *358*(9277). 221-229.

- **Attinger, A., Tuller, C., Souren, T., Tamm, M., Schindler, C. and Brutsche, M.H.** (2006) Feasibility of mobile cardiopulmonary exercise testing. *Swiss Medicine Weekly*. **136(1).** 13–18.
- **Bangsbo, J., Mohr, M. and Krustrup, P.** (2006). Physical and metabolic demands of training and match-play in the elite football player. *Journal of sports sciences*. **24(07).** 665-674.
- **Barclay, C.J.** (2017). Energy demand and supply in human skeletal muscle. *Journal of Muscle Research and Cell Motility*. **1(1).**1-13.
- **Becklace, M.R., Frank, H., Dagenais, G.R., Ostiguy, G.L. and Guzman, C.A.** (1965). Influence of age and sex on exercise cardiac output. *Journal of Applied Physiology*. **20(5).** 938-947.
- **Bell, W.** (1973). Anthropometry of the young adult college rugby player in wales. *British Journal of Sports Medicine.* **7(1).** 298-299.
- **Blair, S., Kohl, H. and Barlow, C.** (1995). Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men. *JAMA.* **273(1).** 1093–1098.
- **Blair, S., Kohl, H. and Paffenbarger, R**. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *JAMA*. **262(1)**. 2395–2401.
- **Boden, E., Randle, H. and Brigden, C.** (2013). The effects of rider specific pilates on rider position from a lateral view: a six week study. *Analysis of Sport.* **IX.** 239.
- **Bojer, M., Lotzerich, H. and Trunz, E.** (1998). A fitness check for riders in consideration of a functional anatomy analysis of riding. *Journal of Sports Medicine.* **19(1).** 56.
- **Borg, G.A.** (1982). Psychophysical bases of perceived exertion. *Medicine and science in sports exercise*. **14(5).** 377-381.
- **Branch, J. D., Pate, R.R. and Bourque, S.P.** (2000). Moderate intensity exercise training improves cardiorespiratory fitness in women. *Journal of Women's Health. Gender-Based Medicine.* **9(1).** 65–73.
- **Brian Mac**. (2017). *Astrand Rhyming Nomogram* [ONLINE]. Available at: https://www.brianmac.co.uk/cycle6min.htm [Accessed 13 July 2017].
- **Brown, K. W. and Ryan, R. M.** (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*. ***84*(4).** 822-848.

- **Brown, W.J., Ford, J.H., Burton, N.W., Marshall, A.L. and Dobson, A.J.** (2005). Prospective study of physical activity and depressive symptoms in middle-aged women. *American journal of preventive medicine*. **29(4).** 265-272.
- **Brownson, R. C., Boehmer, T. K and Luke, D.** (2005). Declining rates of physical activity in the United States: what are the contributors? *Annual Review of Public Health*. **26(1).** 421–43.
- **Busch, A.J., Barber, K.A., Overend, T.J., Pebso, P.M.J. and Schachter, C.L.** (2007). Exercise for treating fibromyalgia syndrome. *The Cochrane Library.*
- **Camarda, S.R.D.A., Tebexreni, A.S., Páfaro, C.N., Sasai, F.B., Tambeiro, V.L., Juliano, Y. and Barros Neto, T.L.D.** (2008). Comparison of maximal heart rate using the prediction equations proposed by Karvonen and Tanaka. *Arquivos brasileiros de cardiologia*. ***91*(5)**.311-314.
- **Carling, C., Reilly, T. and Williams, A.M.** (2008). *Performance assessment for field sports*. Routledge.
- **Caspersen, C., Powell, K. and Christenson, G.** (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports*. **100 (2)**. 127-131
- **Catersano, A., Patrick, B.T., Edenfield, W.L. And Batson, M.J.** (1997). The effects of a basketball season on aerobic and strength parameters amongst college men: starters vs reserves. *Journal of Strength Conditioning Research.* **11(1).** 21-24.
- **Climstein, M. and Egger, G.** (2017). Physical Activity: Generic Prescription for Health. *Lifestyle Medicine: Lifestyle, the Environment and Preventive Medicine in Health and Disease*. **1(1).** 181.
- **Cole, P.J., LeMura, L.M., Klinger, T.A., Strohecker, K. and McConnell, T.R. (2004).** Measuring energy expenditure in cardiac patients using the Body Media (TM) Armband versus indirect calorimetry: A validation study. *Journal of Sports Medicine and Physical Fitness*. **44(3).** 262.
- **Collins, D.** (2006). Dressage Masters: Techniques and Philosophies of four legendary trainers. *Rowman and Littlefeild.*
- **Constable, S. and Palmer, B.** (2000). The process of physical fitness standards development (No. HSIAC-SOAR-2000-001). HUMAN SYSTEMS INFORMATION ANALYSIS CENTER.

- **Coutts, A., Reaburn, P. and ABT, G. (**2003). Hearth rate, blood lactate concetration and estimated energy expediture in a semi-profesional rugby league team during a match: case study. *Journal of sports sciences*. ***21*(2).** 97-103.
- **d'Eisenberg, B. and Allen, S.** (2016). The art of riding a horse or description of modern manege: in its perfection. *BookBaby.*
- **Davis, J.A. and Brewer, J.** (1993). Applied physiology of female soccer players. *Sports Medicine*. ***16*(3).**180-189.
- **DeBusk, R. F., Stenestrand, U., Sheehan, M. and Haskell, W. L.** (1990). Training effects of long versus short bouts of exercise in healthy subjects. American Journal of Cardiology. **65(1).** 1010–1013.
- **Delextrat, A. and Cohen, D.D.** (2008). Physiological testing of basketball players: towards a standard evaluation of aerobic fitness. *Journal of Strength and Conditioning.* **22(4).** 1066-1072.
- **Department for Environment, Food and Rural Affairs.** (2014). Joint research in the horse industry in Great Britain. *DEFRA*. London.
- **Devienne, M. and Guezennec, C.** (2000). Energy expenditure of horse riding. *European Journal of Applied Physiology*. **82(1).** 499–503.
- **Docherty, D.**, **Wenger, H.A. and Neary, P.** (1988). Time motion analysis related to physiological demands of rugby. *Journal of Human Movement Studies.* **14(1).** 269-277.
- **Douglas, J.L., Price, M. and Peters, D.M.** (2012). A systematic review of physical fitness, physiological demands and biomechanical performance in equestrian athletes. *Comparative exercise physiology*. **8(1).**53-62.
- **Duffield, R., Dawson, B.,, Pinnington, H. C. and Wong, P.** (2004). Accuracy and reliability of a Cosmed K4b2 portable gas analysis system. *Journal of Science Medicine in Sport*. **7(1).** 11–22.
- **Dunn, A.L., Trivedi, M.H., Kampert, J.B., Clark, C.G. and Chambliss, H.O.** (2005). Exercise treatment for depression: efficacy and dose response. *American journal of preventive medicine*. **28(1).** 1-8.
- **Egenvall, A., Bystrom, A., Weishaupt, M.A. and Recepstorff, L.** (2013). Horse-rider interaction. In: Equine Locomotion. *Saunders Elsevier. Philadelphia.*
- **Ekelund, L., and Haskell, W.** (1988). Physical fitness as a predictor of cardiovascular mortality in asymptomatic North American men. *New England of Journal Medicine*. **319(1).** 1379–1384.

- **Ekkekakis, P. and Lind, E**. (2006). Exercise does not feel the same when you are overweight: the impact of self-selected and imposed intensity on affect and exertion. *International journal of obesity*. ***30*(4).** 652.
- **Emerenziani, G.P., Migliaccio, S., Gallotta, M.C., Lenzi, A., Baldari, C. and Guidetti, L.** (2013). Physical exercise intensity prescription to improve health and fitness in overweight and obese subjects: a review of the literature. *Health*. **5(6)**.113.
- **Eston, R. and Reilly, T.** (2013). *Kinanthropometry and exercise physiology laboratory manual: tests, procedures and data: volume two: physiology*. Routledge.
- **Eys, M.A., Beauchamp, M.R. and Bray, S.R**. (2006). A review of team roles in sport. *Literature reviews in sport psychology*. **1(1).** 227-255.
- **Fawkner, S.G. and Armstrong, N.** (2003). Oxygen update kinetic response to exercise in children. *Sports Medicine.* **33(9).** 651-669.
- **Federation Equestre Internationale.** (2009). Rules for Dressage Events. *Switzerland.*
- **Fletcher, G.F., Balady, G.J., Amsterdam, E.A., Chaitman, B., Eckel, R., Fleg, J., Froelicher, V.F., Leon, A.S., Piña, I.L., Rodney, R. and Simons-Morton, D.A.** (2001). Exercise standards for testing and training. *Circulation*. **104(14).** 1694-1740.
- **Fox, E.L., and Matthews, D.K.** (1996). The physiological basis of physical eduction and athletics. *WB Saunders. Philadelphia.*
- **Fox, E.L., Bowers, R. and Foss, M.** (1988). The physiological basis of physical education and athletics. 4th Edition. *WB Saunders. Philadelphia.*
- **Freedson, P., Katch, V.L., Sady, S. and Weltman, A.** (1979). Cardiac output differences in males and females during mild cycle ergometer exercise. *Medicine and Science in Sports.* **11(1).** 16-19.
- **Fruehwirith, B., Peham, C., Scheidl, M. and Schobesberger, H.** (2004). Evaluation of pressure distribution under an English saddle at walk, trot and canter. *Equine Veterinary Journal*. **36(1).** 754-757.
- **Gandevia, S.C.** (2001). Spinal and supraspinal factors in human muscle fatigue. *Physiological Reviews.* **81(4).** 1725-1789.

- **Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B.A., Lamonte, M. J., Lee, I.M., Nieman, D.C. and Swain D.P.** (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Medicine and Science in Sports Exercise*. **43(1).** 1334–59.
- **Gastin, P.B.** (2001). Energy system interaction and relative contribution during maximal exercise. *Sports Medicine.* **31(10).** 725-741.
- **Gillam, G.M.** (1958). Basketball: physiological basis. *National Strength Conditioning Association.* **6(1).** 44-73.
- **Gordon, N.F., Gulanick, M., Costa, F., Fletcher, G., Franklin, B.A., Roth, E.J. and Shepard, T.** (2004). Physical activity and exercise recommendation for stroke survivals. *Stroke.* **35(5).** 1230-1240.
- **Gormley, S.E., Swain, D.P., High, R.E.N.E.E., Spina, R.J., Dowling, E.A., Kotipalli, U.S. and Gandrakota, R.A.M.Y.A.** (2008). Effect of Intensity of Aerobic Training on VO~ 2~ m~ a~ x. *Medicine and science in sports and exercise*. **40(7).** 1336.
- **Graf, D.L., Pratt, L.V., Hester, C.N. and Short, K.R.** (2009). Playing active video games increases energy expenditure in children. *Pediatrics*. ***124*(2).** 534-540.
- **Greeves, L. and Dyson, S.** (2013). The horse-saddle-rider interaction. *The Veterinary Journal.* **195(1).** 275-281.
- **Haff, G. and Dumke, C**. (2012). *Laboratory manual for exercise physiology*. Human Kinetics.
- **Haff, G.G. and Triplett, N.T.** (2015). *Essentials of Strength Training and Conditioning 4th Edition*. Human kinetics.
- **Hagerman, F., Lawrence, R. and Mansfield, M.** (1988). A comparison of energy expenditure during rowing and cycling ergometry. *Medicine and Science in Sport and Exercise*. **20(1).** 479–488.
- **Hagerman, F.C., Connors, M.C., Gault, J.A., Hagerman, G.R. and Polinski, W.J.** (1978). Energy expenditure during simulated rowing. *Journal of Applied Physiology*. **45(1).** 87–93.

- **Hallal, P.C., Andersen, L.B., Bull, F.C., Guthold, R., Haskell, W., Ekelund, U. and Lancet Physical Activity Series Working Group.** (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The lancet*. ***380(9838).*** 247-257.

- **Hampson, A. and Randle, H.** (2015). The influence of an 8-week rider core fitness programme on the equine back at sitting trot. *International Journal of Performance Analysis in Sport.* **15(3).** 1145-1159.
- **Haskell, W., Lee, I. and Pate, R.** (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. **116(1).** 1081–1093.
- **Hausswirth, C., Bigard, A. X. and Le Chevalier, J. M.** (1997). The Cosmed K4 telemetry system as an accurate device for oxygen uptake measurements during exercise. *International Journal of Sports Medicine.* **18(1).** 449–53.
- **Hoare, D.G.** (2000). Predicting success in junior elite basketball players. The contribuition of anthropometric and physiological attributes. *Journal of Science Medicine in Sport.* **3(1).** 391-405.
- **Horowitz, J.F., Sidossis, L.S. and Coyle, E.F.** (1994). High efficiency of type I muscle fibers improves performance. *International journal of sports medicine*. ***15*(03).**152-157.
- **Houser, J**. (2007). How many are enough? Statistical power analysis and sample size estimation in clinical research. *Journal of Clinical Research Best Practices*. **3(3).** 1-5.
- **Hulton, A.T., Lahart, I., Williams, K.L., Godfrey, R., Charlesworth, S., Wilson, M., Pedlar, C. and Whyte, G.** (2010). Energy expenditure in the race across america (RAAM). *International journal of sports medicine*. ***31*(07).**463-467.
- **Institute of Sports and Spines.** (2014). *Astrand Rhyming cycle ergometer set up on a Monark bike* [ONLINE]. Available at: https://www.youtube.com/watch?v=bTynfzI2bWw [Accessed 8 June 2017].
- **Jackson, A.S., Blair, S.N., Mahar, M.T., Wier, L.T., Ross, R.M. and Struteville, J.E.** (1990). Prediction of functional aerobic capacity without exercise testing. *Medicine Science of Sports Exercise.* **22(6).** 863-870.
- **Janssen, I., Heymsfield, S.B., Wang, Z. and Ross, R.** (2000). Skeletal muscle mass and distribution in 468 men and women age 18-88 years old. *Journal of Applied Physiology*. **89(1).** 81-88.
- **Jenkins, L.S., Patel, L.J. and Gavin, T.P.** (2017). No difference in plantar flexion maximal exercise power output between men and women. *Sport Sciences for Health*. **13(1).**139-147.
- **Johnson, W.B. and Campbell, C.D.** (2002). Character and fitness requirements for professional psychologists: Are there any?. *Professional Psychology: Research and Practice*. **33(1).** 46.

- **Kelly, D.L.** (1999). Measurement made accessible: a research approach using qualitative, quantitative and quality improvement methods. *Sage publications*. London.
- **Khaw, K.T., Wareham, N., Bingham, S., Welch, A., Luben, R. and Day, N**. (2008). Combined impact of health behaviours and mortality in men and women: the EPIC-Norfolk prospective population study. *PLoS Med*. *5*(1). 12.
- **Kim, K.H., Kim, S.G. and Hwangbo, G.** (2015). The effects of horse-riding simulator exercise and Kendall exercise on the forward head posture. *Journal of physical therapy science*. **27(4).**1125-1127.
- **King, A.C., Haskell, W.L., Young, D.R., Oka, R.K. and Stefanick, M.L.** (1995). Longterm effects of varying intensities and formats of physical activity on participation rates, fitness, and lipoproteins in men and women aged 50 to 65 years. *Circulation*. **91(1).** 2596– 2604.
- **King, A.C., Taylor, C.B., Haskell, W.L. and Debusk, R.F.** (1988). Strategies for increasing early adherence to and long-term maintenance of home-based exercise training in healthy middle-aged men and women. *American Journal Cardiology*. **61(1).** 628–632.
- **King, D.K., Glasgow, R.E., Toobert, D.J., Strycker, L.A., Estabrooks, P.A., Osuna, D. and Faber, A.J.** (2010). Self-efficacy, problem solving, and social-environmental support are associated with diabetes self-management behaviors. *Diabetes care*. **33(4).** 751-753.
- **Kinnear, W. and Blakey, J**. (2014). *A Practical Guide to the Interpretation of Cardio-Pulmonary Exercise Tests*. Oxford University Press.
- **Kraemer, W.J., Volek, J.S., Clark, K.L., Gordon, S.E., Incledon, T., Puhl, S.M., Triplett-McBride, N.T., McBride, J.M., Putukian, M. and Sebastianelli, W.J.** (1997). Physiological adaptations to a weight-loss dietary regimen and exercise programs in women. *Journal of Applied physiology*. **83(1)**. 270-279.
- **Kramer, J.F., Leger, A., Paterson, D.H. and Morrow, A.** (1994). Rowing performance and selected descriptive, field, and laboratory variables. *Canadian Journal of Applied Physiology*. **19(2).**174-184.
- **LaCroix, A. and Leveille, S.** (1996). Does walking decrease the risk of cardiovascular disease hospitalizations and death in older adults? *Journal of American Geriatric Society*. **44(1).** 113–120.
- **Lagarde, J., Peham, C., Licka, T. and Kelso, J.A.S.** (2005). Coordination dynamics of the horse-rider system. *Journal of motor behaviour*. **37(6).** 418-424.

- **Lancaster, G.A.** (2015). Pilot and feasibility studies come of age! *Pilot and Feasibility Studies*. **1(1).** 1.
- **Lee, I. and Paffenbarger, R.** (2000). Associations of light, moderate, and vigorous intensity physical activity with longevity. *American Journal of Epidemiology*. **151(1).** 293–299.
- **Lee, I.M.** (2003). Relative intensity of physical activity and risk of coronary heart disease. *Circulation*. **107(1).** 1110–1116.
- **Leetun, D.T., Ireland, M.L., Willson, J.D., Ballantyne, B.T. and Davis, I.** (2004). Core stability measures as risk factors for low extremity injury in athletes. *Medicine and Science in Sports Exercise.* **36(6).** 926-934.
- **Leger, L.A. and Lambert, J.A.** (1982). A multistage 20-meter shuttle run test to predict VO2 Max. *European Journal of Applied Physiology*. **49(1).** 1-12.
- **Liljenstolpe, C.** (2009). Horses in Europe. *EU Equus, 32*.
- **Lind, A.R. and McNicol, G.W.** (1967). Circulatory responses to sustained hand-grip contractions performed during other exercise, both rhythmic and static. *Journal of Physiology*. **192(3).** 595.
- **Lovett, T., Hodson-tole E. and Nankervis, K.** (2005). A preliminary investigation of rider position during walk, trot, and canter. *Equine Comparative Exercise Physiology*. **2(1).** 71–76.
- **Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., Abraham, J., Adair, T., Aggarwal, R., Ahn, S.Y. and AlMazroa, M.A.** (2013). Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet*, *380*(9859). 2095-2128.
- **Mackay, J., Mensah, G.A., Mendis, S. and Greenlund, K.** (2004). *The atlas of heart disease and stroke*. World Health Organization.
- **Maddison, R., Foley, L., Mhurchu, C.N., Jiang, Y., Jull, A., Prapavessis, H., Hohepa, M. and Rodgers, A.** (2011). Effects of active video games on body composition: a randomized controlled trial. *The American journal of clinical nutrition*. ***94*(1).**156-163.
- **Maiolo, C., Melchiorri, G., Iacopino, L., Masala, S. and De Lorenzo, A.** (2003). Physical activity energy expenditure measured using a portable telemetric device in comparison with a mass spectrometer. *British Journal of Sports Medicine*. **37(1).** 445–457.

- **Manson, J., and Greenland, P.** (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *New England Journal of Medicine.* **347(1).** 716–726.
- **Manson, J., Hu, F., Rich-Edwards, J., Colditz, G., Stampfer, M., Willett, W., Speizer, F. and Hennekens, C.** (1999). A prospective study of walking as compared with vigorous exercise in the prevention of coronary heart disease in women. *New England Journal of Medicine.* **341(1).** 650–658.
- **Martin, C.K., Correa, J.B., Han, H., Allen, H.R., Rood, J.C., Champagne, C.M., Gunturk, B.K. and Bray, G.A.** (2012). Validity of the Remote Food Photography Method (Rfpm) for Estimating Energy and Nutrient Intake in near Real-Time. *Obesity*. **20(4).** 891-899.
- **Maud, P.J.** (1983). Physiological and anthropometric parameters that describe a rugby union team. *British Journal of Sports Medicine.* **17(1).** 16-23.
- **Maud, P.J. and Foster, C.** (2006). Physiological Assessment of Human Fitness. *Human Kinetics. UK*
- **McArdle, W., Katch, F. and Katch, V.** (2010). Exercise Physiology: Nutrition, Energy, and Human Performance. Wolters Kluwer Health. Champaign, IL.
- **McCole, S.D., Claney, K., Conte, J.C., Anderson, R. and Hagberg, J.M.** (1990). Energy expenditure during bicycling. *Journal of Applied Physiology*. **68(2).**748-753.
- **McCrory, P. and Turner, M.** (2005). Equestrian injuries. *J Borms Brussels M. Helbbelink Brussells.*
- **McDaniel, J., Durstine, J.L., Hand, G.A. and Martin, J.C**. (2002). Determinants of metabolic cost during submaximal cycling. *Journal of Applied Physiology*. **93(3).** 823-828.
- **McDonald, D.G. and Hodgdon, J.A.** (2012). The psychological effects of aerobic fitness training: research and theory. *Springer Science and Business Media.*
- **McLaughlin, J. E., King, G. A., Howley, E. T., Bassett, D.R. and Ainsworth, B.E.** (2001). Validation of the Cosmed K4 b2 portable metabolic system. *International Journal of Sports Medicine*. **22(1).** 280– 4.
- **Meyers, M., Wilkinson, J., Elledge, J., Sterling, J. and Coast, R.** (1992). Exercise performance of collegiate rodeo athletes. *American Journal of Sports Medicine*. **20(1).** 410–415.
- **Meyers, M.C.** (2006). Effect of equitation training on health and physical fitness of college females. *European Journal of Applied Physiology*. **98(1).** 177–84.

- **Meyers, M.C.** (2006). Effect of equitation training on health and physical fitness of college females. *European journal of applied physiology*. **98(2).** 177-184.
- **Meyers, M.C., and Sterling, J.C.** (2000). Physical, hematological, and exercise response of collegiate female equestrian athletes. *Journal of Sports Medicine and Physical Fitness*. **40(1).** 131–8.
- **Meyners, E.** (2004). Effective teaching and riding: Exploring balance and motion. Goals Unlimited Press, Montana, USA.
- **Michaud, M., Balardy, L., Moulis, G., Gaudin, C., Peyrot, C., Vellas, B., Cesari, M. and Nourhashemi, F.** (2013). Proinflammatory cytokines, aging, and age-related diseases. *Journal of the American Medical Directors Association*. **14(12)**.877-882.
- **Montoye, A.H., Mudd, L.M., Biswas, S. and Pfeiffer, K.A.** (2015). Energy expenditure prediction using raw accelerometer data in simulated free living. *Medicine and Science in Sports Exercise*. **47(8).**1735-1746.
- **Moore, J.** (2010). General biomechanics: the horse as a biological machine. *Journal of equine veterinary science*. ***30*(7).** 379-383.
- **Moseley, L., and Achten, J.** (2004). No differences in cycling efficiency between worldclass and recreational cyclists. *International Journal Sports Medicine*. **25(1).** 374–379.
- **Murphy, M. and Nevill, A.** (2002). Accumulating brisk walking for fitness, cardiovascular risk, and psychological health. *Medicine and Science in Sport and Exercise*. **34(1).** 1468–1474.
- **Murphy, M., Blair, S. and Murtagh, E.** (2009). Accumulated versus continuous exercise for health benefit. *Sports Medicine*. **39(1).** 29–43.
- **Murray, R.C., Walters, J.M., Snart, H., Dyson, S.J. and Parkin, T.D.H.** (2010). Identification of risk factors for lameness in dressage horses. *The Veterinary Journal*. **184(1).** 27-36.
- **Murtagh, E.M., Boreham, C.A.G., Nevill, A., Hare, L.G. and M.H. Murphy**. (2005). The effects of 60 minutes of brisk walking per week, accumulated in two different patterns, on cardiovascular risk. *Preventative Medicine*. **41(1).** 92–97.
- **Myers, J.** (2003). Exercise and cardiovascular health. *Circulation*. **107(1).** 2–5.
- **Myers, J.** (2003). Exercise and Cardiovascular health. *Circulation.* **107(1).** 2-5.
- **Myers, J., Kaykha, A. and George, S.** (2004). Fitness versus physical activity patterns in predicting mortality in men. *American Journal of Medicine*. **117(1).** 912–918.

- **Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., Yamazaki, T. and Froelicher, V.** (2004). Fitness versus physical activity patterns in predicting mortality in men. *The American journal of medicine*. **117(12).** 912-918.
- **Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., King, A.C., Macera, C.A. and Castandsceppa, C.** (2007). Physical activity and public health in older adults: Recommendations from the American College of Sports Medicine and the American Heart Association. *Circulation.*
- **Nikolaidis, P.T.** (2015). Maximal heart rate in soccer players: Measured versus age-predicted. *Biomed Journal*. ***38*(1).** 84-89.
- **O'Donovan, G., Blazevich, A.J., Boreham, C., Cooper, A.R., Crank, H., Ekelund, U., Fox, K.R., Gately, P., Giles-Corti, B., Gill, J.M. and Hamer, M.** (2010). The ABC of Physical Activity for Health: a consensus statement from the British Association of Sport and Exercise Sciences. *Journal of sports sciences*. **28(6).** 573-591.
- **O'reilly, C.L., Sigler, D.H., Fluckey, J.D., Vogelsang, M.M. and Sawyer, J.E. (**2015). 170 Novel approach to measuring and developing energy expenditure calculations for horseback riding. *Journal of Equine Veterinary Science*. **35(5).**456.

- **Oshima, T., Berger, M.M., De Waele, E., Guttormsen, A.B., Heidegger, C.P., Hiesmayr, M., Singer, P., Wernerman, J. and Pichard, C.** (2017). Indirect calorimetry in nutritional therapy. A position paper by the ICALIC study group. *Clinical Nutrition*. **36(3).** 651-662.
- **Paffenbarger, J.R. and Hyde, R.** (1984). Exercise in the prevention of coronary heart disease. *Preventative Medicine.* **13(1).** 3–22.
- **Paffenbarger, R. and Hyde, R.** (1986). Physical activity, all-cause mortality, and longevity of college alumni. *New England Journal of Medicine*. **314(1).** 605–613.
- **Parizkova, S.** (2012). Body fat and physical fitness: body composistion and lipid metabolism in different regimes of physical activity. *Springer Science and Business Media.*
- **Pate, R., Pratt, M., Blair, S., Haskell, W., Macera, C., Bouchard, C., Buchner, D., Ettinger, W., Heath, G., King, A., Kriska, A., Leon, A., Marcus, B., Morris, J., Paffenbarger, R., Patrick K., Pollock, M., Rippe, J., Sallis, J. and Wilmore J.** (1995). Physical activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA.* **273(1).** 402–407.
- **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. and Kriska, A.** (1995). Physical

activity and public health: a recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *Jama*. **273(5).** 402-407.

- **Patton, J.F., Vogel, J.A. and Mello, R.P.** (1982). Evaluation of a maximal predictive cycle ergometer test of aerobic power. *European Journal of Applied Physiology and Occupational Physiology*. **49(1).** 131-140.
- P**earson, D.T., Naughton, G.A. and Torode, M.** (2006). Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. *Journal of Science and Medicine in Sport*. **9(4).** 277-287.
- **Peñailillo, L., Blazevich, A. and Nosaka, K.** (2014). Energy expenditure and substrate oxidation during and after eccentric cycling. *European journal of applied physiology*. **114(4).** 805-814.
- **Peng, W., Lin, J.H. and Crouse, J.** (2011). Is playing exergames really exercising? A meta-analysis of energy expenditure in active video games. *Cyberpsychology, Behavior, and Social Networking*.**14(11).**681-688.
- **Perret, C. and Mueller, G.** (2006) Validation of a new portable ergospirometric device (Oxycon Mobile) during exercise. *International Journal of Sports Medicine*. **27(1).** 363–367.
- **Podhajsky, A.** (2013). The complete training of the horse and rider. *Double Day*.
- **Pollock, M.L., Franklin, B.A., Balady, G.J., Chaitman, B.L., Fleg, J.L., Fletcher, B., Limacher, M., Piña, I.L., Stein, R.A., Williams, M. and Bazzarre, T.** (2000). Resistance exercise in individuals with and without cardiovascular disease. *Circulation*. **101(7).** 828-833.
- **Pontzer, H., Durazo-Arvizu, R., Dugas, L.R., Plange-Rhule, J., Bovet, P., Forrester, T.E., Lambert, E.V., Cooper, R.S., Schoeller, D.A. and Luke, A.** (2016). Constrained total energy expenditure and metabolic adaptation to physical activity in adult humans. *Current Biology*. ***26*(3).** 410-417.
- **Pratley, R., Nicklas, B., Rubin, M., Miller, J., Smith, A., Smith, M., Hurley, B. and Goldberg, A.** (1994). Strength training increases resting metabolic rate and norepinephrine levels in healthy 50-to 65-yr-old men. *Journal of Applied Physiology*. **76(1).** 133-137.
- **Punch, K.F.** (2000). Introduction to social research: quantitative and qualitative approaches. *Sage Publications*. London.

- **Reilly, T. and Thomas, V.** (1976). A motion analysis of work-rate in different positional roles in professional football match play. *Journal of Human Movement Studies.* **2 (1).** 87-97.
- **Rincón, J.A.G., Turcó J.V. and Martínez, I.M.** (1992). A comparative study of the metabolic effort expended by horse riders during a jumping competition. *British Journal of Sports Medicine.* **26(1).** 33-35.
- **Roberts, M., Shearman, J. and Marlin, D.** (2009). A comparison of the metabolic cost of the three phases of the one-day event in female collegiate riders. *Comparative Exercise Physiology*. **6(1).** 129–135.
- **Rodriguez, F., and Iglesias, X.** (1998). The energy cost of soccer: telemetric oxygen uptake measurements versus heart rate-VO2 estimations. *Journal of Sport Science.* **16(1).** 484–485.
- **Rosdahl, H., Gullstrand, L., Salier-Eriksson, J., Johansson, P. and Schantz, P.** (2010). Evaluation of the Oxycon Mobile metabolic system against the Douglas bag method. *European journal of applied physiology*. ***109*(2).**159-171.
- **Rowland, T., Unnithan, V., Fernall, B.O., Baynard, T. and Lange, C**. (2002). Left ventricular response to dynamic exercise in young cyclist. *Medicine and Science in Sports and Exercise.* **34(4).** 637-642.
- **Ruowei, L., Deurenberg, P. and Hautvast, J.** (1993). A critical evaluation of heart rate monitoring to assess energy expenditure in individuals. *American Journal of Clinical Nutrition.* **58(1).** 602–607.
- **Sandvik, L., Erikssen, J., Thaulow, E., Erikssen, G., Mundal, R. and Rodahl, K.** (1993). Physical fitness as a predictor of mortality among healthy, middle-aged Norwegian men. *New England Journal of Medicine*. **328(8).** 533-537.
- **Saris, W.H.M., Blair, S.N., Van Baak, M.A., Eaton, S.B., Davies, P.S.W., Di Pietro, L., Fogelholm, M., Rissanen, A., Schoeller, D., Swinburn, B. and Tremblay, A.** (2003). How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. *Obesity reviews.* **4(2).** 101-114.
- **Sawka, M.N., Wenger, C.B. and Pandolf, K.B.** (2011). Thermoregulatory responses to acute exercise-heat stress and heat acclimation. *Comprehensive physiology*. **1(1).** 1.
- **Sawka, N.M., Leon, L.R., Montain, S.J. and Sonna, L.A.** (2011). Integrated Physiological Mechanisms of Exercise Performance, Adaptation, and Maladaptation to Heat Stress. *Comprehensive Physiology*. **1(1).** 1883-1928.

- **Schrack, J. A., Simonsick, E. M. and Ferrucci, L.** (2010). Comparison of the Cosmed K4b(2) portable metabolic system in measuring steady-state walking energy expenditure. *PLoS One*. **5(1).** 9292.
- **Sell, K., Lillie, T. and Taylor, J.** (2008). Energy expenditure during physically interactive video game playing in male college students with different playing experience. *Journal of American College Health*. **56(1).** 505–511.
- **Senitko, A.N., Charkoudian, N. and Halliwill, J.R.** (2002). Influence of endurance exercise training status and gender on post-exercise hypotension. *Journal of Applied Physiology*. **92(6).** 2368-2374.
- **Sesso, H. D., Paffenbarger, R. S. and Lee, I.M.** (2000). Physical activity and coronary heart disease in men : The Harvard Alumni Health Study. *Circulation*. **102(1).** 975–980.
- **Sharkey, B.J. and Gaskill, S.E.** (2013). *Fitness cycling*. Human Kinetics.

- **Skielboe, A.K., Marott, J.L., Dixen, U., Friberg, J.B. and Jensen, G.B**. (2016). Occupational physical activity, but not leisure-time physical activity increases the risk of atrial fibrillation: The Copenhagen City Heart Study. *European journal of preventive cardiology*. **23(17).** 1883-1893.
- **Slattery, M. and Jacobs, D.** (1988). Physical fitness and cardiovascular disease mortality The US Railroad Study. *American Journal of Epidemiology*. **127(1).** 571–580.
- **Slattery, M., Jacobs, D. and Nichaman, M.** (1989). Leisure time physical activity and coronary heart disease death. The US Railroad Study. *Circulation*. **79(1).** 304–311.
- **Spence, J.C. and Lee, R.E**. (2003). Toward a comprehensive model of physical activity. *Psychology of sport and exercise*. ***4*(1).** 7-24.
- **Steiner, H. and Kertesz, K.** (2015). Effects of therapeutic horse riding on gait cycle parameters and some aspects of behavior of children with autism. *Acta Physiologica Hungarica***. 102(3).** 1
- **Terada, K**. (2000). Comparison of head movement and EMG activity of muscles between advanced and novice horseback riders at different gaits. *Journal of Equine Science*. **11(1).** 83–90.
- **Terada, K., Mullineaux, D. Lanovaz, J. Kato, K. and Clayton, H.** (2004). Electomyographic analysis of the rider's muscles at trot. *Equine Comparative Exercise and Physiology*. **1(1).** 193–198.

- **Tesch, P.A., Colliander, E.B. and Kaiser, P.** (1986). Muscle metabolism during intense heavy resistance exercise. *European Journal of Applied Physiology and Occupational Physiology.* **55(4).** 362-366.
- **Thompson, P.D., Buchner, D., Piña, I.L., Balady, G.J., Williams, M.A., Marcus, B.H., Berra, K., Blair, S.N., Costa, F., Franklin, B. and Fletcher, G.F.** (2003). Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease. *Arteriosclerosis, thrombosis, and vascular biology*. **23(8)**. 42-49.
- **Treadwell, P.J.** (1988). Computer- aided match analysis of selected ball games, soccer and rugby union. *Science and Football.* London.
- **Trowbridge, E.A., Cotterill, J.V. and Crofts, C.E.** (1995). The physical demands of riding in a national hunt race. *European Journal of Applied Physiology*. **70(1).** 66-69.
- **United States Department of Health and Human Services**. (1996). Physical Activity and Health: A Report of the Surgeon General. Jones and Bartlett Publishers, Atlanta.
- **United States Department of Health and Human Services**. (2008). Physical Activity and Health: A Report of the Surgeon General. Jones and Bartlett Publishers, Atlanta, Ga.
- **Vaeyes, R., Lenoir, M., Williams, A.M. and Philippaerts, R.M.** (2008). Talent identification and development programmes in sport. *Sports medicine*. **38(9).** 703-714.
- **Vancampfort, D., Guelinckx, H., De Hert, M., Stubbs, B., Soundy, A., Rosenbaum, S., De Schepper, E. and Probst, M.** (2014). Reliability and clinical correlates of the Astrand–Rhyming sub-maximal exercise test in patients with schizophrenia or schizoaffective disorder. *Psychiatry research*. **220(3).** 778-783.
- **Vanhees, L., Lefevre, J., Philippaerts, R., Martens, M., Huygens, W., Troosters, T. and Beunen, G.** (2005). How to assess physical activity? How to assess physical fitness? *European Journal of Cardiovascular Prevention & Rehabilitation*. ***12*(2).** 102-114.
- **Vanrenterghem, J., Nedergaard, N.J., Robinson, M.A. and Drust, B.** (2017). Training load monitoring in team sports: A novel framework separating physiological and biomechanical load-adaptation pathways. *Sports Medicine*. **1(1).** 1-8.
- **Verges, S., Flore, P., Laplaud, D., Guinot, M. and Favre-Juvin, A.** (2006) Laboratory running test vs. field roller skiing test in crosscountry skiers: a longitudinal study. *International Journal of Sports Medicine.* **27(1).** 307– 313.

- **Wagganer, J.D., Pujol, T.J., Langenfeld, M.E., Barnes, J.T., Elder, A.J.S., Elder, C.L. and Tucker, J.E.** (2015). A Workload Selection Procedure for the Åstrand-Ryhming Test for Women. *Perceptual and motor skills*. ***120*(3).** 687-699.
- **Warburton, D.E.R., Nicol, C.W. and Bredin, S.S.D.** (2006). Health benefits of physical activity: the evidence. *Canadian Medical Association Journal*. **174(1).** 801–9.
- **Watt, G.M. and Finch, C.F.** (1996). Preventing equestrian industries. *Sports Medicine.* **22(3).** 187-197.
- **Wenger, H. and Bell, G.** (1986). The interactions of intensity, frequency and duration of exercise training in altering cardiorespiratory fitness. *Sports Medicine*. **3(1).** 346–356.
- **Westerling, D.** (1983). A study of physical demands in riding. *European Journal of Applied Physiology and Occupational Physiology*. **50(1).** 373–382.
- **Weston, M., Taylor, K.L., Batterham, A.M. and Hopkins, W.G.** (2014). Effects of low-volume high-intensity interval training (HIT) on fitness in adults: a meta-analysis of controlled and non-controlled trials. *Sports Medicine*. **44(7).** 1005-1017.
- **Williams, C., Reid, R. and Coutts, R.** (1973). Observations on the aerobic powers of university rugby players and professional soccer players. *British Journal of Sports Medicine.* **7(1).** 390-391.
- **Wipper, A.** (2000). The partnership: the horse-rider relationship in eventing. *Symbolic Interaction.* **23(1).** 47-70.
- **Wolfram, I.** (2013). The Science of Equestrian Sport: Theory, Practice and performance of the equestrian rider. *Routledge*. London.
- **Wright, L.R. and Peters, M.D.** (2008). A heart rate analysis of the cardiovascular demands of elite level competitive polo. *International Journal of Performance Analysis in Sport*. **8(2).** 76-81.
- **Wu, H.C. and Wang, M.J.J.** (2002). Relationship between maximal acceptable work time and physical workload. *Ergonomics.* **45(4).** 280-289.
- **Zolandaz, J.A., Randemaker, A.C. and Sargent, A.J.** (1995). Non-Linear relationship between O2 uptake and power output at a high intensity of exercise in humans. *Journal of Physiology.* **488(1).** 211-217.

APPENDICES

Appendix 1

CONSENT FORM

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet.	☐
2.	I have been given the opportunity to ask questions about the project and my participation.	☐
3.	I voluntarily agree to participate in the project.	☐
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	☐
5.	The procedures regarding confidentiality have been clearly explained (e.g. use of names, pseudonyms, anonymisation of data, etc.) to me.	☐
6.	If applicable, separate terms of consent for interviews, audio, video or other forms of data collection have been explained and provided to me.	☐
7.	The use of the data in research, publications, sharing and archiving has been explained to me.	☐
8.	I, along with the Researcher, agree to sign and date this informed consent form.	☐

Participant:

__________________________ ______________________________ __________________

Name of Participant Signature Date

Researcher:

__________________________ ______________________________ __________________

Name of Researcher Signature Date

Appendix 2

2017 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	**YES**	**NO**
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ________	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ________	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it ***does not limit your current ability*** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ________	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Go to Page 4 to sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

OSHF

2017 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c — If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	**YES** ☐ **NO** ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	**YES** ☐ **NO** ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	**YES** ☐ **NO** ☐

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b — If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	**YES** ☐ **NO** ☐
2b.	Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	**YES** ☐ **NO** ☐

3. Do you have a Heart or Cardiovascular Condition? *This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm*

If the above condition(s) is/are present, answer questions 3a-3d — If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	**YES** ☐ **NO** ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	**YES** ☐ **NO** ☐
3c.	Do you have chronic heart failure?	**YES** ☐ **NO** ☐
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	**YES** ☐ **NO** ☐

4. Do you have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b — If **NO** ☐ go to question 5

4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	**YES** ☐ **NO** ☐
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	**YES** ☐ **NO** ☐

5. Do you have any Metabolic Conditions? *This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes*

If the above condition(s) is/are present, answer questions 5a-5e — If **NO** ☐ go to question 6

5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?	**YES** ☐ **NO** ☐
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	**YES** ☐ **NO** ☐
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?	**YES** ☐ **NO** ☐
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	**YES** ☐ **NO** ☐
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	**YES** ☐ **NO** ☐

2017 PAR-Q+

6. Do you have any Mental Health Problems or Learning Difficulties? *This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome*

If the above condition(s) is/are present, answer questions 6a-6b — If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Do you have Down Syndrome **AND** back problems affecting nerves or muscles?	YES ☐ NO ☐

7. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d — If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐

8. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c — If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐

9. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c — If **NO** ☐ go to question 10

9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
9b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?

If you have other medical conditions, answer questions 10a-10c — If **NO** ☐ read the Page 4 recommendations

10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
10c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: ______________________

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

2017 PAR-Q+

If you answered NO to all of the follow-up questions about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:
You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that a Trustee (such as my employer, community/fitness centre, health care provider, or other designate) may retain a copy of this form for their records. In these instances, the Trustee will be required to adhere to local, national, and international guidelines regarding the storage of personal health information ensuring that the Trustee maintains the privacy of the information and does not misuse or wrongfully disclose such information.

NAME ______________________________ DATE ______________________

SIGNATURE ___________________________ WITNESS ____________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________________

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

Citation for PAR-Q+
Warburton DER, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 4(2):3-23, 2011.

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Key References
1. Jamnik VK, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation; background and overall process. APNM 36(S1):S3-S13, 2011.
2. Warburton DER, Gledhill N, Jamnik VK, Bredin SSD, McKenzie DC, Stone J, Charlesworth S, and Shephard RJ. Evidence-based risk assessment and recommendations for physical activity clearance; Consensus Document. APNM 36(S1):S266-s298, 2011.
3. Chisholm DM, Collis ML, Kulak LL, Davenport W, and Gruber N. Physical activity readiness. British Columbia Medical Journal. 1975;17:375-378.
4. Thomas S, Reading J, and Shephard RJ. Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Canadian Journal of Sport Science 1992;17:4 338-345.

Appendix 3

INFORMATION SHEET

PROJECT TITLE

The Physiological Demands of the Novice Horse Rider Whilst Mounted

INVITATION

You are being asked to take part in a research study on horse rider demands whilst mounted; the aims of this study are to:

1. Establish baseline horse rider fitness profile, in a laboratory environment, on a group of university equine students on the university equine courses.
2. Establish baseline physiological measurements of the same group of horse riders whilst performing a riding task.
3. Top quantify the percentage of the maximal efforts used from the laboratory testing to the field testing.
4. To quantify physiological responses to riding different types of movements such as the walk, trot and canter.

I am an MSc Research student, at the University of Central Lancashire, working alongside Sarah Hobbs and Steven Atkins of University of Central Lancashire and Rachel White and Eleanor Boden of Myerscough College.

This research project was approved by University of Lancashire and their Ethics committee on ………

WHAT WILL HAPPEN

In this study, you will be asked to:

1) Attend a briefing of what the study will entail and what is expected as well as, have the ability to ask any questions.
2) Give informed Consent to take part in the study
3) Fill in a questionnaire on health, lifestyle and fitness.
4) Allow body composition measurements including Weight, Height and Body Fat. This may include the use of skin fold measurements.
5) Perform a 6 Min Astrand-Cycle test, whilst wearing a heart rate monitor, working to 85% of total maximal.
6) Take part in two rides, wearing a heart rate monitor. Whilst mounted give detailed description of the exhaustion ratings and how the horse is feeling. These rating scales will be explained and discussed in a briefing before and after the ride.
7) Consent to being videoed during the ride to be able to match the fluxuations in heart rate to the activity carried out.
8) Attend a debriefing to ask any questions and receive a copy of their own results.

TIME COMMITMENT
The study will take part during 3 of the university BUCS team training sessions, in the allotted time of the sessions. The brief and de-brief will take part during an hour period, at a time to suit all candidates.
PARTICIPANTS' RIGHTS
You may decide to stop being a part of the research study at any time without explanation. You have the right to ask that any data you have supplied to that point be withdrawn, without this affecting your place on the team. No penalisation or penalty will be applied if participant don't wish to take part or withdraw from this study.
You have the right to omit or refuse to answer or respond to any question that is asked of you? You have the right to have your questions about the procedures answered, before, during and after the study.
If you have any questions as a result of reading this information sheet, you should ask the researcher before the study begins.

COST, REIMBURSEMENT AND COMPENSATION
Your participation in this study is voluntary. You will receive your results from the fitness test, ride measurements and body composition results in return for your participation.
CONFIDENTIALITY/ANONYMITY
The data we collect do not contain any personal information about you. No one will link the data you provided to the identifying information you supplied in the questionnaire. The publication of this research will not provide any links to the persons participating in this study. Information will be kept for the researcher, only for if the withdrawal of information is required. Data will be stored following the guidelines of the Data Protection Act (1998), and destroyed in the stated timeframe.
FOR FURTHER INFORMATION
Danielle Flood will be glad to answer your questions about this study at any time.
You may contact her at dflood@uclan.ac.uk, dflood2729@student.myerscough.ac.uk or in the HE Research office at Myerscough College, Preston, PR3 0RY

If you want to find out about the final results of this study, you should provide an

email to Danielle Flood.

Appendix 4

Questions for Horses Way of Going

Rider: **Horse:**

1) Have you ridden this horse before?

Yes No

2) Describe how the horse worked throughout the session (i.e- way of going)?

4) Did you feel the horse was consistent throughout the lesson?

Yes No

5) If No, when do you think this changed?

6) Would you describe the horse as:

Lazy Forward Too Forward other:

7) Any other comments:

Appendix 5

Questions for Rider

Rider: **Horse:**

1) On the Rate of Perceived exertion Scale, where do you score throughout the test?

2) Did you feel that your exertion rate stayed consistent throughout the session?

Yes No

3) If No, where did you feel it changed, and why?

4) Did you feel out of breath throughout the session?

Yes No

5) If yes, when do you think it changed?

6) Do you feel like the walk, trot or canter work was more demanding on you personally (not the horse)?

Walk Trot Canter

7) Why do you think this?

8) Are there any specific areas of the body where you feel ache in particular?

Legs Arms Stomach Back Other

9) Is this the same every session?

Yes No

10) If No, why do you think you ached in this area today?

Appendix 6

RISK ASSESSMENT – RIDING LESSON

What is the hazard?	**Who might be harmed and how?**	**Preventative steps in place?**	**Extra precautions to take**	**Actioned by:**
Leading / Handling Horses	Participants / research team • Blistering or Friction burns to hands Tread injuries to feet • Bites from horse • Kick injuries, • blows.	By ensuring correct instruction, training and supervision .regarding methods of restraint and safe handling as well as positioning of handler, horse behaviour and suitable restraining equipment. Horse Training. Protective equipment - gloves, correct footwear, Riding hat.	Make sure all research team regardless of handling horses is wearing protective equipment when required.	Participants Danielle flood Research team
Handling Horses Gooming, tacking up	Participants / Research Team • Tread injuries to feet • Bites from horse • Kick injuries, • knocked over by horse, • crushed against wall.	By ensuring correct instruction, training and supervision .regarding methods of restraint and safe handling as well as positioning of handler, horse behavior and suitable restraining equipment. Horse Training. Protective equipment - gloves, correct footwear, Riding hat. All staff etc must tie up horse when in stable	Make sure all research team regardless of handling horses is wearing protective equipment when required.	Danielle Flood Research Team Participant
Riding and horse falls	Participants- some horses may become spooked and riders could fall off.	• Continual assessment of riding ability / training of rider. • feeding/ turn out/ type of work of horse in question	Be vigilant of where horses are and if riders are in distress stop lesson.	Danielle Flood Research team Participant

		• Correct equipment hat/ footwear/extra equipment for job. • Appropriate Supervision by skilled staff. • First Aid kit available		
Slip, trip and falls	Research team	A designated area will be selected for participants to place their belongings. Space with equipment will be keep neat, tidy and clear.	Be vigilant of wear participants place belongings. Ensure that everyone knows where the equipment belongs etc.	Danielle Flood Research Team

Appendix 7

RISK ASSESSMENT – ASTRAND-RHYMING TEST

What is the hazard?	**Who might be harmed and how?**	**Preventative steps in place?**	**Extra precautions to take**	**Actioned by:**
Participant falling from the bike	Participants, when performing the task if become fatigue, co-ordination may go and lead to fall.	The participants will be given a briefing about what the test entails and how to mount and dismount the equipment. The signs of fatigue will be monitored to ensure that the participants don't just fall.	Mats will be placed at both sides of the bike in order to provide some level of protect if the rider is to fall. First aider will be present in the room whilst this test is being performed.	Participants – to read the information provided Danielle flood Research team
Over-work / fatigue	Participants – If they push them-selves during the test they may become fatigued	Participants will be closely monitored using heart rate and also giving the participants chance to express their exhaustion levels.	Protocol in place for when participants do over work. - First aider to check over - Heart rate monitor to remain on until the heart rate stabilises. - Have some sugary drinks etc for if blood sugar levels drop	Danielle Flood Research Team
Offending the participant when doing weight/body	Participants – the sensitive nature of the measurements	The reasoning for the measurements will be fully	Ensure the participant that no data will be discussed or	Danielle Flood

fat measurements	may cause offence to some participants	explained to the participants. The measurements will be taken alone with a screen if needed so the participant does not feel self-conscious or upset by the measurements taken.	displayed to anyone without anonymity.	
Slip, trip and falls	Participants Research team Researcher	A designated area will be selected for participants to place their belongings. Space with equipment will be keep neat, tidy and clear. Any spills will be cleared immediately and the appropriate signs used.	Be vigilant of wear participants place belongings. Ensure that everyone knows where the equipment belongs etc.	Danielle Flood Participants Research Team

Appendix 8

1 August 2016

Sarah Hobbs Danielle Flood
School of Sport and Wellbeing
University of Central Lancashire

Dear Sarah / Danielle

Re: STEMH Ethics Committee Application
Unique Reference Number: STEMH 493

The STEMH ethics committee has granted approval of your proposal application 'The Physiological Demands of the Novice Horse Rider Whilst Mounted'. Approval is granted up to the end of project date* or for 5 years from the date of this letter, whichever is the longer.

It is your responsibility to ensure that

- the project is carried out in line with the information provided in the forms you have submitted
- you regularly re-consider the ethical issues that may be raised in generating and analysing your data
- any proposed amendments/changes to the project are raised with, and approved, by Committee
- you notify roffice@uclan.ac.uk if the end date changes or the project does not start
- serious adverse events that occur from the project are reported to Committee
- a closure report is submitted to complete the ethics governance procedures (Existing paperwork can be used for this purposes e.g. funder's end of grant report; abstract for student award or NRES final report. If none of these are available use e-Ethics Closure Report Proforma).

Yours sincerely

Will Goodwin
Deputy Vice Chair
STEMH Ethics Committee

* for research degree students this will be the final lapse date

NB - Ethical approval is contingent on any health and safety checklists having been completed, and necessary approvals as a result of gained.

Appendix 9

Horse Number	**Details**	**Lazy or Forward**
1	Height: 15.3hh Age: 8 Type: ISH	Lazy
2	Height: 14hh Age: 12 Type: cob	Lazy
3	Height: 16hh Age: 15 Type: Irish Draft	Lazy
4	Height: 15.2hh Age: 12 Type: Welsh X	Lazy
5	Height: 15.3hh Age: 7 Type: Irish Draft	Lazy
6	Height: 14hh Age: 8 Type: Cob	Lazy
7	Height: 15hh Age: 9 Type: cob	Lazy
8	Height: 14.2hh Age: 8 Type: Welsh Cob	Lazy
9	Height: 13.2hh Age: 10 Type: Welsh	Lazy
10	Height: 17hh Age: 18 Type: Sports Horse	Lazy
11	Height: 16.3hh Age: 20 Type: Sports Horse	Lazy
12	Height: 14.2hh Age: 9 Type: Welsh X	Lazy
13	Height: 14hh Age: 16 Type: Arab X	Lazy
14	Height: 16hh Age: 5 Type: ISH	Lazy
15	Height: 15.2hh Age: 10 Type: Hunter	Lazy
16	Height: 16hh	Forward

	Age: 15 Type: Sport Horse	
17	Height: 15hh Age:10 Type: Cob	Forward
18	Height: 14hh Age: 8 Type: Welsh	Forward
19	Height: 16hh Age: 12 Type: Sport Horse	Forward
20	Height: 15.3hh Age: 19 Type: Hunter	Forward
21	Height: 14.3hh Age: 6 Type: Cob	Forward
22	Height: 15hh Age: 18 Type: Cob	Forward
23	Height: 14.3hh Age: 8 Type: Cob	Forward
24	Height: 14.2hh Age: 8 Type: Welsh X	Forward
25	Height: 15hh Age: 9 Type: Sports Horse	Forward
26	Height: 13.2hh Age: 8 Type: Welsh	Forward
27	Height: 16hh Age: 10 Type: Sports Horse	Forward
28	Height: 15hh Age: 8 Type: Arab X	Forward
29	Height: 14.3hh Age: 22 Type: Cob	Forward
30	Height: 14hh Age: 13 Type: Cob	Forward