THE EFFECT OF LIGHT THERAPY ON HEART RATE, BEHAVIOUR AND SURFACE TEMPERATURE IN HORSES

Chloe Parrett

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PROJECT DECLARATION

"This project report is the result of the independent work of Chloe Parrett. All other work reported in the text has been attributed to the original authors and is fully referenced in the text, and listed in the Reference Section".

Student Name:- Chloe Parrett

Student Signature:-

Date:-

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Abstract

With the vastly growing rate of the Equine Therapy Industry, therapists are looking for more and more products and techniques to use within their treatments to ensure they stand out as a therapist. One of the less common but ever increasing products is the Photizo Vetcare light therapy device. The UK's only supplier Danetre Health Products has commented on the growing rate of the product with rate of sales only equalling 100 devices sold in the first year of trading alone (2013), however, in 2017 this is now at over 100 devices a month. Although the device was originally intended for horse owners, therapists are now the top purchasers of this product each month. Despite the increasing uses for Light Therapy in the UK, little research is available particularly within horses.

Light therapy has many uses including use for musculoskeletal disorders such as pain reduction (Laakso and Cabot, 2005), skin abrasions (Brem *et al.,* 2004), Tendon and Ligament injuries (Fung *et al.,* 2002) and reducing cell death (Karu, 1998). It has been discovered through recent work in the field that light therapy is useful in treating horses suffering from Laminitis, it was shown that after just a few minutes use every day, Laminitis was resolved (Photizo, 2016a). Despite these factors, research into the specific Photizo Vetcare device is extremely limited with only anecdotal case study evidence available online.

A controlled small-scale pilot study was carried out to observe the effect of light therapy on heart rate, behaviour and surface temperature on four mares and three geldings. The study was carried out over a three-week period that included one 10-minute light therapy session per week. Light therapy treatment was carried out by a suitably qualified therapist who had attended a training day in using the device supplied by Danetre Health Products itself.

A 10-minuete light therapy treatment resulted in a significant decrease of heart rate $p<000.1$. The session also resulted in a significant increase of positive responses observed from the horses and a significant decrease in negative responses observed $p<0001$. However light therapy had no significant effect on surface temperature of the horse $p=0.37$. The results suggest that light therapy is an

effective tool for relaxing, reducing heart rate and encouraging positive behaviour in horses.

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1.0 Introduction

1.1 The Equine Complementary therapy industry

The equine industry's economic value increased between 2011 and 2015, with the total consumer spending in the industry being valued at around £3.8 Billion in 2011 and £4.3 Billion in 2015 (Beta-uk.org, 2017). This money was generated from goods and services in the industry, among other services, the therapy industry is included in this data. In the UK in 2015 there were 446,000 horse-owning households, with the number of horses in the UK at the time totalling 944,000. This figure includes privately owned horses, loaned horses and horses in business i.e. riding schools and clubs. With an increase in horse ownership and the large amount of money that is spent on horses in the industry and more knowledge of health care comes an increase in therapy for horses. These can be traditional forms such as physiotherapy, chiropractic, osteopathy and massage but also an increase in other more holistic complementary therapies such as zoo pharmacognosy and Reiki. The integration of these therapies is more accepted in current times but are complementary and not a replacement for conventional veterinary medicine. A recent review of the industry showed that 62% of British horse owners are willing to spend money on non-essential items for their horses (Beta-uk.org, 2017). This is a high figure and it can be determined that horse owners have disposable income in which they can afford complementary therapy for their horses as well as 'essential items' such as food and bedding (Beta-uk.org, 2017).

Equine Therapists are now using more techniques to aid the treatments the horses are given with continuing professional development (CPD) courses readily available and increasing scientific research in the areas. One of these therapies that has increased is Light therapy (LT). This form of therapy is also referred to as photomedicine, photo biomodulation and is often described as LED/infrared therapy as the devices carry both red and Infrared rays via Light emitting diodes. The doses of these can vary and on the market currently there are devices in which you can set the dosage of waves to the patient or you can purchase devices which have a pre-set dose for the job that it is intended for. The device used in this study is the Photizo Vetcare, which has a 31 second pre-set dosage of 633nm Red and 850nm Infrared

wavelengths. The Photizo Vetcare is intended for animals and because of its pre-set dosage, for smaller animals you would use the device on the affected area once and for larger animals you would need to use it two or three times (Rose, 2017). Making the device versatile for therapists who treat a variety of animals.

1.2 The use of light therapy in this industry

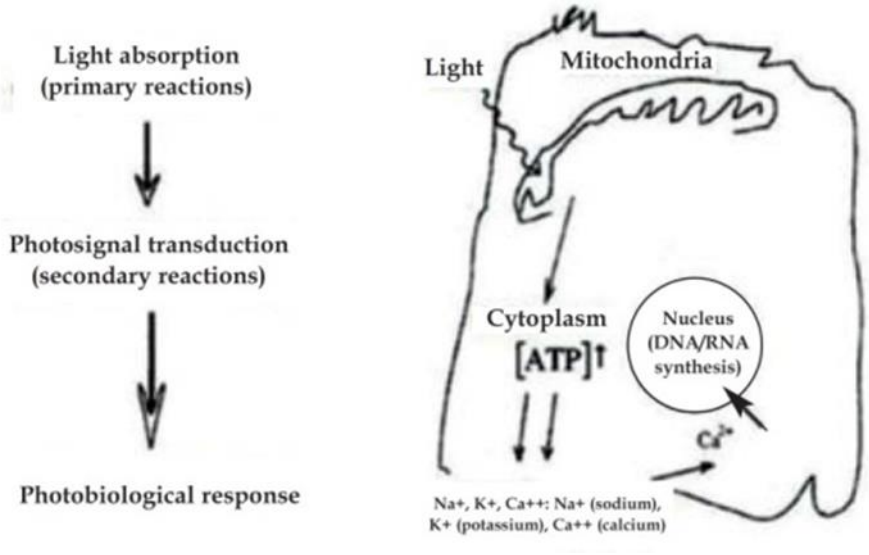
Light being used as a clinical modality has increased over the last decade (Borsa *et al.,* 2013) which is also confirmed by Dantre Health Products, the UK's only supplier of Photizo products. In the first year, Dantre sold 100 devices, however, in 2017 the company were selling over 100 devices per month with the device being sold to horse owners, veterinarians and also equine therapists. Beneficial factors of using light therapy for musculoskeletal disorders include pain reduction (Laakso and Cabot, 2005), skin abrasions (Brem *et al.,* 2004), Tendon and Ligament injuries (Fung *et al.,* 2002) and reducing cell death (Karu, 1998). It has been discovered through recent work in the field that light therapy is useful in treating horses suffering from Laminitis, it was shown that after just a few minutes use every day, Laminitis was resolved (Photizo, 2016b). Light therapy is also regularly used to treat muscular pain in equines as the LEDs penetrate the skin and get to work healing the affected area (Photizo, 2016a). This finding shows how versatile the device is for horse owners and therapists, having multiple uses extends the products purpose and makes it more desirable.

2.0 Literature Review

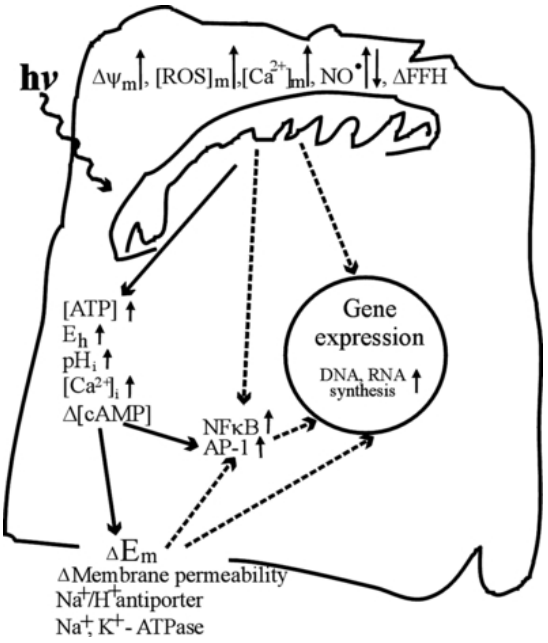
2.1 Light therapy and its physiological effects in animals

Light therapy works on a cellular level and stimulates the formation of an excited state of oxygen (reactive oxidised series) which in turn stimulates cellular energy known as adenosine triphosphate (ATP). Light therapy stimulates the activity of cytochrome c oxidase in the mitochondria, ATP production is enhanced by light therapy known as coherent light (Rose, 2017). The optimal wavelength energises the cytochrome B structure allowing the structure to donate electrons to the electron transport chain at a greater rate to increase the production of ATP (Rose, 2017). Cytochrome B structure is a small protein which is water soluble and is an essential component in the electron transport chain and in the formation of ATP. As ATP is known as the cells power house and energy source, it is the source of energy the body needs in order to heal itself (Wesley *et al.,* 2007). This therefore suggests that light therapy can encourage the natural process of healing as an increase in ATP stimulates DNA and RNA synthesis which are needed to start the healing process (Rose, 2017).

In order for light therapy to be effective light absorption needs to be considered. Light absorptions are dependent on wavelength and when tissues are targeted with the appropriate wavelength it causes primary reactions in the in the mitochondria, this then begins a cycle of secondary responses (Photo signal transduction and amplification) in the cytoplasm and the nucleus and membranes, enabling the appropriate response (Chaves *et al.,* 2014). This is shown in The Karu Model (Figure 1)



(Figure 1) – The Karu Model- Simplified version. (Chaves *et al.,* 2014)



(Figure 2) – The Karu Model. Original and indepth verision (Karu, 2008)

The combination of red light and infrared wavelengths can activate secondary enzymes and messenger cells which stimulate immune cells and tissue regeneration (Karu, 2008). It is proved that mitochondria are able to communicate with the nucleus of the cell (Ryan and Hoogenraad, 2007). Stimulating the mitochondria enables the signals to be sent to the nucleus in order to repair the cells, stimulating the proliferation and remodelling phases and responses in the cells (Ryan and Hoogenraad, 2007). This process helps to repair vital structures like capillaries,

enabling an increased blood flow and getting oxygen to cells in the body, particularly in soft tissues, organs and hard tissue allowing a greater chance at regeneration and remodelling (Karu, 2008). Red light therapy is able to reduce pro-inflammatory chemicals (NF-kb) and increase the activity of white blood cells (Leucocytes). Light therapy increases cell metabolism in neurons whose function has been impaired by toxins and increases the action potential of nerve cells which helps to improve proprioception (Rose, 2017).

2.2 Light Therapy and research in humans and rats.

Light Therapy is typically used in wound healing, but more physiological effects have been analysed (Brem *et al.,* 2004). Injury resulting in wounds can be very stressful for the horse and or the human and research has shown that high heart rates correspond to stress (Schmidt *et al.,*, 2010). The quality of life for the animal could be interrupted due to the possible decrease in movement but also can become an emotional problem as seen in humans (Brem *et al.,* 2004).

There is currently little research on the effects of light therapy on horses, however there are several studies on rats and humans. Although these studies do not focus on horses directly, it is possible to relate the information to horses as the physiological responses are thought to work in the same way for horses, dogs, humans and rats (Corti, 2014). Both humans and horses have the ability to work as athletes, pushing their bodies to the limit.

The light therapy device used in this study has a combination of LED and Infrared wavelengths which are 633nm Red and 850nm Infrared. In 2016 a pilot study was carried out which involved using infrared waves for production of ATP in fibroblasts and osteoblasts (Quirk *et al.,* 2016). Both Fibroblasts and osteoblasts are cells involved in the healing process. Fibroblasts produce collagen and extra cellular matrix both of which help in regenerating new tissue (Bainbridge, 2013). Osteoblasts are involved in regeneration of bone tissue (Gasparini, 2017). The Quirk *et al.,* (2016) study involved using different doses of Infrared wavelength to aid healing of the femur in rats. The results of this study showed that light therapy has a positive effect on ATP formation in fibroblasts but not in osteoblasts. Using light therapy showed an 80% increase in ATP production of fibroblasts at 660nm than 830nm,

which was twice the size of the values for osteoblasts at either wavelength (Quirk *et al.,* 2016). The pilot study had a large sample size of 21 rats and the method was approved by the university's ethics committee despite the fact that the study had a mortality rate of 14.2% which is very high. However there was a control group for this study which improves the validity and shows that the treatment was successful in aiding healing of the femur. The control group received an intramedullary pin and received no infrared radiation. However, as the study used one radiographer to analyse the radiographs, the findings are subjective. It could also pose as a limitation as there is no verification from another radiographer. The Quirk *et al.,* (2016) paper does not state how experienced this radiographer is either, which potentially could reduce the validity. Hammerberg *et al.,* (2016) stated that the inter-rater agreement between veterinarians is low, especially if the veterinarian is less experienced. It could be more beneficial for the Quirk *et al.,* (2016) study to have three radiographers to analyse radiographs, this change would ensure verification from other radiographers.

Another study used 30 rats in order to determine the effects of Light therapy on burn healing (Al-Watban and Andres, 2003). It was discovered that light therapy had a significant effect on the healing of an artificially prepared wound. During a period of 21 days, the control animal healed within that time naturally. However, when using the Light therapy device 3 times a week, rats healed completely by 14 days. These results show that the LEDs had a positive effect on wound healing. Using this information from what we know regarding light therapy and rats, it is understood that horses can benefit from this type of therapy even though horses are a different size to the rats and have very different anatomy. The physiology of the tissues and how these heal are the same. Using rats within a study allows the scientist to gain a more precise result as the sample sizes are much larger than with horses. This is because rats are much cheaper to keep and are easier to use in the study, this could be a potential reason as to why Quirk *et al.,* (2016) used rats for their pilot study as the study was a new pilot at the time of research. Both of these studies have a high sample size, meaning that the results can be seen as valid. To add to their validity both groups had a control group which futher enhanced the validity.

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NASA have researched the advantages of using light therapy in space. Due to the fact that astronauts do not have access to extensive medical care when in space, light therapy would enable them to access some health care to improve quality of life in space (Whelan *et al.,* 2001). Whelan *et al.,* (2001) highlights the importance of LEDs on humans. It is discussed that users of LED therapy saw a 40% improvement in musculoskeletal injuries in navy seal participants. Not only did the review see benefits in healing musculosketal injuries the review also stated that the US Salt Lake City submarine crew saw a 50% faster healing rate in wounds (7days) compared to the 14-day average that the control group experienced. This evidence further suggests to us that Light therapy is beneficial for all living tissues and would indicate the beneficial use to astronauts in space, but also for animals on earth.

Laser therapy was first used in 1963 (Choy, 1988) and has since been a vital piece of veterinary and human medicine. Laser therapy is often confused with light therapy when discussing light therapy due to its popularity however they are not the same. An article was written debating whether light or laser therapy was more beneficial and through the pros and cons were weighted for each argument. It was concluded that light therapy is more beneficial than laser therapy as it had only one disadvantage according to the study, which were less precise wavelengths. When compared to the disadvantages caused by laser therapy which were: potential eye hazards to both the patient/client and the practitioner, the higher costs of devices, the fact that laser therapy cannot be used on the whole body and then the most important factor, Laser therapy was responsible for causing an unnatural response in the body (Starwynn, n.d.). It seems that the use of light therapy is safer and has better outcomes for both practioners and animals.

Further investigating the comparisons between LED and Laser were Chaves *et al.,* (2014), they concluded that the light therapy is as effective as laser therapy since they both have similar biological effects, with the differences being non-significant (Chaves *et al.,* 2014). According to Karu (2008) the property of coherence is lost during the process of interaction of light with body tissue this not being a prerequisite for the process of photostimilation or photoinhibitation.

Light therapy and Laser therapy are described non-coherent and coherent respectively (Rose, 2017). Non-coherent light describes the photons in the wavelength, being non-coherent means that the photons are at different frequencies and oscillate in different directions. Light therapy is a form of non-coherent light. Coherent light means that the photons in the wavelength are at the same frequency and are all at the same direction, therefore producing a beam of light which is seen as laser. Laser light will not diffuse out and therefore stays in the beam unlike coherent light, meaning that coherent light can be more harmful to the therapist administering the laser. The body has the ability to adapt this incoherent light to coherent in the body and studies have shown that the body can produce coherent light from non-coherent light when used over certain and specific areas, usually acu-points (Rose, 2017). This also gives light therapy an advantage over laser as the light is the same when applied over these points, giving the device an extra use. Using this on acupressure points when used in therapy sessions may also have a therapeutic effect.

2.3 Thermal Imaging

Another form of assessment is generally used in therapy sessions and veternairy medicine to assess heat spots within an animals body is Thermal Imaging. Thermal imaging is a non-invasive technique, for the horse and operator but also in the sense that it does not give out any radiation that potentially could damage the skin (Redaelli *et al.,* 2014). The thermal imaging camera enables the operator to see different electromagnetic waves that cannot be seen with a human eye. The electromagnetic waves change colour in accordance to how much radiation is emitted, the hotter an object the more radiation is emitted (Redaelli *et al.,* 2014). Red and white colours are the hotter temperatures and the blue colours represent the colder temperatures, however most cameras are equipped with a key on the side of the screen allowing the colours to accurately represent what radiation is being emitted, making it easier for the operator to understand what the image is representing. Cameras can have different colour settings which can make it difficult for the operator to distinguish between the colours as to what they mean. The camera in this study, the flir C3 has two colour settings.

Heat is a main sign of inflammation and studies on rats have shown that having a camera that can show exactly what radiation is being emitted in each area will allow the therapist to witness and the veterinarian to diagnose in order to relieve any pain/inflammation the animal is experiencing (Sanchez *et al.,* 2008). Rats and horses have differences regarding size and in particular heart rate, however the physiology of the tissues in the body are similar in composition and healing rate (Gerdts *et al.,* 2015). Thermal imaging cameras can be preventative in terms of identifying future problems, by highlighting variations in the horse's body that have not yet lead to clinical problems (Redaelli *et al.,* 2014). Thermal imaging the surface of the body will allow the changes in heat to show clearly however the external air temperature may become a limitation in the study. Other studies have discussed this factor and one study commented to say an air temperature of 70.7°F (21°C) was the optimum temperature to be able to achieve consistent results and easily compare the limb with the edema to the control limb (Sanchez *et al.,* 2008). Vollmer and Möllmann (2017) discuss the difficulties with thermal imaging outside and discuss the wind-chill factor that can cause the temperature to differ. With the nature of this study, the horses will not be situated in a house therefore the air temperature is harder to control. Meaning that the temperature is likely to change from day to day, and wind chill is likely to become a limitation in the study because it has the potential to influence the temperature of the animal.

Thermal imaging cameras can also be used to detect illegal, performance-enhancing drugs (Eddy, Van Hoogmoed and Snyder, 2001). Thermography units can be very sensitive, even capturing flexor tendon injuries before the horse has shown clinical signs (Eddy, Van Hoogmoed and Snyder, 2001). A study by Fonseca *et al.,* (2006) was carried out to evaluate the effectiveness of thermography in the diagnosis of thoracolumbar problems in quarter horse athletes. The study used a total of 24 horses that were all referred to a clinic in Brazil all with back complaints (Fonseca *et al.,* 2006). This chosen method is not representative of the whole of the equine population using only quarter horses so should be used with care in regards to other breeds. Using a range of horses would ensure the study is valid when discussing thermography for horses. In order to improve the validity of this study Fonesca (2006) should have ensured the cohort were a range of breeds however the sample size is an excellent size and can therefore suggest that the results are representative

of the quarter horse breed. Horses were scanned using the thermography camera before surgery to see the effectiveness for thoracolumbar problems within the horses . It was concluded that thermal imaging cameras are effective tools for post-surgical factors for this reason. Using a thermal imaging camera in the present study will allow potential changes in the surface of the skin to be captured.

2.4 Heart Rate

Heart rate monitors (HRM) are used in today's training methods for a number of reasons. HRM enables the trainer to train their horse to the limit, getting their horse fitter and fitter for the season ahead. They also allow veterinarians to be able to spot potential flaws within the heart, for example, heart murmurs (Essner *et al.,* 2013). This technology is extremely vital in all aspects of the equine industry, especially in within therapy. After a therapy session from the treadmill, the horse's heart rate (HR) must return to normal which is around 38-40 bpm (Marlin and Nankervis, 2013) and 30-40bpm (Kang *et al.,* 2012). A study by Schmidt *et al.,* (2010) concluded that heart rate was an indication of stress within the horse. This was shown through cortisol levels and the relationship between those two factors when the horses were on a trailer (Schmidt *et al.,* 2010). In the study high heart rates corresponded to stress levels resulting in high heart rates meaning the horses were stressed when loading. The HR of the horses within my own study will show if the animals are put under stress when undergoing a Light Therapy session.

Heart rate monitors are reliable (Essner *et al.,* 2013) and produced similar results to an ECG in this study on dogs, however there were times where the heart rate monitor did over or under estimated the heart rate. A later study, using a heart rate monitor on humans also claimed it was reliable and the results from the monitor were similar to the ECG (Vasconcellos *et al.,* 2015) but it was also claimed that on occasion it did produce incorrect readings. However, generally it was an effective tool to measure the heart rate of the horse without the need for an ECG . The two studies were looking at different parameters and used a different cohort and species yet the fact it was on the whole still reliable ensures that the equipment is likely to be reliable in this case. The heart rate of the horses within my own study will show if the animals are put under stress when undergoing a light therapy session.

2.5 Equine Behaviour and facial pain

The behaviour of the horses is also something as a therapist is important to understand within the session. Understanding the behaviour of the horse will allow the therapist to truly understand what the horse is telling them, if they are comfortable or unhappy. Therefore in the current study the behaviour exhibited from the animal during a session will be displayed on an ethogram. This will allow us to effectively evaluate the behaviour exhibited during the session (Hage *et al.,* 2014).

Dyson also discusses facial expressions in terms of being tacked up and when handling in the stable. Dyson says that 'for many years I have observed that horses when they are uncomfortable show differences in their facial expressions' and goes on to comment how 'owners and riders are slow to recognise pain and lameness' (Ahttv.org, 2017). Dyson believes it is vital to understand what they are horses are saying when ridden and this principle is the same when undergoing therapy. It is important to understand what the horse is telling the therapist/owner In order to fully interpret what is presented, especially in the case of pain/wellbeing as it is important the welfare of the animal is paramount.

Equine responses' to ridden work were documented by Dyson *et al.,* (2017). The horse's facial expressions in particular were investigated by initially a team of 14 equine professionals, horse owners and lay horse people. From this pilot study the ethogram used was developed and changed to accommodate a large range of people involved and then the pictures were given out to a larger group of people to examine and note down the different facial expressions.

The horses were split into two groups, lame and sound. However, the cohort that took part in the study were not aware and only the headshots of the animals were used to determine which were 'in pain' or ones that were sound. All horses were examined by Dyson before the study to determine if they were lame or not (Ahttv.org, 2017). In accordance to the groups hypothesis facial expressions for lame horses had a higher pain score than horses of the control group ($P < 0.001$) and this score lowered after the images of the horses under sedation were presented ($P < 0.05$). This itself was able to prove that horse's facial expression is an indication of

pain. However, this study was a subjective evaluation meaning that it was the opinion of a cohort which determined this outcome. By using a combination of professional and lay people Dyson was able to ensure fascial pain was not a factor to how experienced a person is and rather what they feel the image is expressing. A subjective study will mean that the validity is questioned, but Dyson has ensured that the cohort is varied meaning the validity is increased.

A more recent study in 2018 researched horse's fascial responses to bitting (Cook and Kibler, 2018). The study resulted horses exhibited a higher number of 'behavioural signs of pain' when they were bitted (behaviour = 23) than when the bit was removed from the horse for 35 days (behaviour = 2). This study was carried out via an owner based 'optional' questionnaire which was given to them when they purchased a 'bit less bridle' from the author of the paper. This way of collecting data is firstly subjective as he was carefully selecting his audience in a way that may seem objective. Participants might have felt pressured to return the questionnaire and were already interested in the effects of a bit less bridle prior to research commencing. Thus, the validity of the study is compromised.

Cook was the CEO of the company 'bitless bridle' in the US therefore it was in his best interest for the results of the study to be beneficial to his income and livelihood (Cook and Kibler, 2018). Again, potentially invalidating the results. It would have been more appropriate for this study to have an ethogram produced by professionals and carried out by a randomised control group like the Dyson *et al.,* (2017) study. Another way that Cook and Kibler (2018) could have carried out this in a different way would be to use a similar system to McBride *et al.,* (2004) who used a 5 level scoring system to determine how horses reacted to massage therapy. Although this way is not as precise as Dyson *et al.,* (2017) it would control the study if carried out by an independent person. This would be more effective rather than the owners of the horses who have purchased the bridle and therefore have an invested interest in the product.

A study by (Ijichi *et al.,* 2014) discovered that lameness was not a sole indicator of the severity of damage or degeneration. Factors such as personality were looked at in this study and the prelimary findings of this investigation showed that personality

plays a part in the way a horse may express himself for pain or injury. The study is very new and small, and more research is needed to discuss whether this fact is viable but as a starting factor this study is potentially ground-breaking as pain is commonplace for welfare and veterinary experiments. The large sample size of this study further improves the validity of these preliminary findings.

2.6 Study aim

This current study aims to observe the effect of light therapy on three parameters of the horse, Heart rate, Behaviour and Surface Temperature. Seven horses are to be involved in the study, all taking part in three short 10-minute sessions over the space of three weeks. Current research proves that Light Therapy is beneficial in humans and rats, however further research need to be undertaken to establish the effects of Light Therapy on horses and as indicated by the literature review there is little research within Equine Light Therapy. As a result of the little research and no research into the link between light therapy, heart rate, behaviour and surface temperature in horses, this current study aims to be a small-scale pilot study to observe how horses respond to light therapy.

3.0 Materials and Method

3.1 Hypothesis

Horses heart rate will decrease as a result of light therapy

Light therapy will affect the horse's behaviour by encouraging positive responses from the horse.

Surface temperature of the areas treated will have a significant change as a result of the light therapy.

3.2 Null Hypothesis

Horses heart rate will increase as a result of light therapy

Light therapy will not affect the behaviour of the horse

Surface temperature of the areas treated will not have a significant change as a result of light therapy.

3.3 Subjects

Seven horses were used in the study of 3 geldings and 4 mares (mean age of 16, age range 10-21). The cohort consisted of six cob types, one Irish sports horse. All horses are from the same yard, Greenwich Equestrian Centre, as it is familiar to the horses which aids in preventing stress and spooking which could affect the study. The horses are in American barn stabling and have regular turn out at weekends. All horses are part of a working programme with students at the college and used in the riding-school associated with the college. The horses in the study are colour co-ordinated according to their behaviour and handling ability. Five horses in the study are 'green' which means that they are safe to handle and are of generally good nature. One horse is considered an 'orange' horse which means that only the more experienced students should handle her. One of the subjects is a 'red' horse which means that only staff and very highly skilled students to handle. All horses are considered sound and veterinary permission was given for the horses to have the

light therapy session given by a suitability qualified induvial who had undertaken the correct qualifications to apply light therapy treatment.

3.4 Equipment

During each session the horses were connected to a Polar RS800Cx heart rate monitor with a Wearlink transmitter which transmitted the readings to a wearable watch. The monitor was situated around the girth line in order to accurately measure heart rate at every two-minute interval of the session. The girth line of the horses was dampened to ensure the monitor was able to read the heart rate more effectively.

A FLIR C3 thermography camera was set up 10metres from the horse to accurately measure the surface temperature of the horse's body throughout the ten minute session. Images are to be taken at every two-minute interval through the session and four minutes pre and post treatment. Taking the pictures in this way allowed the changes in surface temperature to be assessed throughout the session and to be observed on the FLIR Tools programme to determine exact temperature at certain points. A fellow student was on hand throughout all the horse's sessions, recording the heart rate values and taking the pictures on the camera. This operator also turned on/off the video camera which allowed the behaviours of the horses to be assessed. The recording commenced 5 minutes before the session began and 5 minutes after the session ended, this extra minute was to account for technical issues.

An ethogram which had been previously devised allowed the behaviours experienced during the session to be noted and later calculated. The video camera is able record the entire session from start to finish so that it can be reviewed and no behaviour would be missed. Verbal communication between the therapist and the camera would ensure that any activity that might not be captured on the camera could be noted, in the event that heart rate or behaviour was to suddenly change for example, people outside the therapy barn. The ethogram devised for this study is in Table 1.

Behaviour	Code	Description of Behaviour
Relaxed eyes	RE	
Head is still	HS	
Licking and Chewing	LC	
Lower lip relaxed.	LLR	
Ears relaxed	ER	
Head lowering	HL	
Tense Eyes	TE	
Deep Breathing	DB	
Shallow Breathing	SB	
Pawing the ground	PTG	
Fidgeting	F	
Swishing tail	ST	
Ears flat back	EFB	
One ear forward one ear back	OEFOEB	
Nostrils move	NM	
Head Moves	HM	
Ears forward	EF	
Lowered Head	LH	
Still Body	SB	
Sneezing/Snorting	S&S	
Wall Chew	WC	
Rest Hind	RH	
Long Blinks	LB	

Table 1: Ethogram devised for current study to determine behaviours observed in light therapy sessions (Green = Positive, Blue = Neutral, Red = Negative).

The device which is applying the light therapy is the Photizo Vetcare. Supplied by Danetre Health Care (the UK's main distributor). This device supplies both infrared and red light via LED (light emitting diodes) in parameters of 633nm (red) and 850nm (infrared). Both of these wavelengths are in each dose simultaneously. The light covers a 4.7cm2 area.

Every session took place in the farrier's barn at Greenwich Equestrian Centre allowing a constant environment that all horses in the study are comfortable and

familiar with preventing stress levels and heart rate to increase. This constant environment allows a control for research purposes but also allows replication.

3.5 Procedure

Horses were prepared for the light therapy sessions prior to making their way over to the therapy barn this included taking off the horse's rugs. Rugs could affect the surface temperature of the horse. Taking the rugs off the horses ten minutes before the beginning of the light therapy session ensured the horses would return to normal surface temperature. This would ensure that the surface temperature is not being compromised or influenced by heat trapped by the rug.

During this ten minute period of waiting the horses had their hooves picked out and all stable arrangements were made. After the waiting time had ended, Horses were led to the therapy barn and once in there connected to the POLAR RS800Cx heart rate monitor. The set up of which consisted of the heart rate monitor and a roller to secure the monitor in place throughout the session. A wet sponge was used on the horse to dampen the right hand side girth area to make obtaining the results easier.

Once the horses were ready to begin the session the video camera was turned on and a timer was started to ensure the data collection timings were correct to begin the session. After four minutes the heart rate was recorded via the accompanying watch with the monitor. The light therapy commenced at this moment and at every two-minute interval the heart rate of the horse was recorded on a table and a thermal image taken on the FLIR C3.

The light therapy session consisted of a ten-minute period using the Photizo on various points around the right side of the horse's body. These included: atlas, middle of neck, wither, middle of back, sacrum, point of buttock, middle of thigh, middle of ribs, middle of shoulder, and pectorals. The device is on the body for a period of a pre-set dosage of 31 seconds and was operated by a fully qualified

practioner who was under the consent of a veterinarian. The Photizo device contains both infrared and LED wavelengths at 633nm red and 850nm Infrared.

Once the light therapy session had ended, the horse stood for a further four minutes with no therapy. The reason for this was to observe and record what the behaviour, heart rate, and surface temperature response was after the session had ended. The horses were then untied and returned to their stables where their rugs were put back on if they needed it. This process was then repeated for each of the horses in turn and each horse had one session a week for a period of three weeks, totalling three light therapy sessions.

3.5 Data Analysis

The data analysis software Vassarstats was used to perform statistical tests on the data for both heart rate and behaviour which was stored on an Excel document. A one way ANOVA was performed to analyse the data for heart rate and a chi-squared was performed for the results of behaviour. The results for surface temperature were stored on Excel and the statistical analysist tool on the programme was used to perform the two-way ANOVA. For this investigation a P value of <0.05 was considered significant for all three of the statistical tests performed. Anything more of this value was considered insignificant. Heart rate data were presented as a table of means with standard deviation and an accompanying graph to visualise changes in heart rate for each horse. All graphs were presented and created using Excel and are available in the results section under the headings for the result.

4.0 Results and Statistics

4.1 Surface Temperature

The mean value before light therapy began was 24.5 °C ± 2.25 °C. Mean Value for during the sixth minute of the light therapy session 24.8 °C ± 2.32 °C. Mean Value after light therapy 24.4°C ± 2.37°C. There was no significant difference between these mean values as determined by two one-way ANOVA ($F(6,210)=1.07$, $P=0.37$). Meaning that light therapy had no effect upon surface temperature, supporting the null hypothesis

4.2 Heart Rate

The total mean heart rate for the horses is presented in a table of means in figure insert figure. There result was significant as determined by a one-way ANOVA ($F(4,24)23.58$ $p<.0001$). Heart rate decreased through the session from the study commencing to ending as a result of the light therapy session. The graph is below to show the trend presented below in Table 2.

	Before	2	4	6	8	10	After
Mean± STDEV	96.1± 22.0	59.5± 11.4	65.9± 20.9	56.3± 6.29	48.3± 12.9	46.4± 9.5	42.3± 5.8

Table 2: Table of means to show mean heart rate value of all horses at set intervals throughout 3 week period.

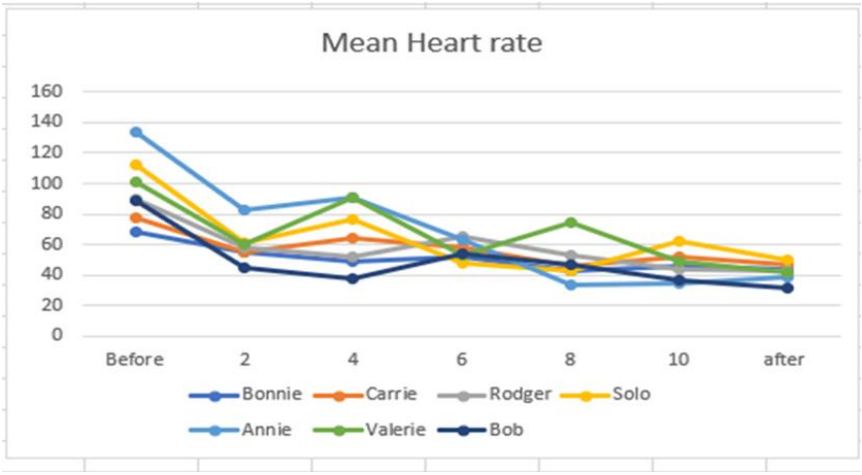

Figure 3: Graph to show mean heart rate of 3 sessions per horse

4.3 Behaviour

There is a significant difference in behaviour when light therapy was applied (x^2 (4) = 862.1 p<.0001). Negative responses decreased after treatment n= 33 (after treatment) compared with n= 49 (seen before treatment). There was an increase in positive behaviours witness after treatment n=416 compared with the 245 seen before treatment. There was also an increase in neutral behaviours seen after treatment but this increase was not as large as the increased observed with positive responses, n = 297 (neutral before) and n = 346 (neutral after). These are clearly layed out in a graph in figure 8.

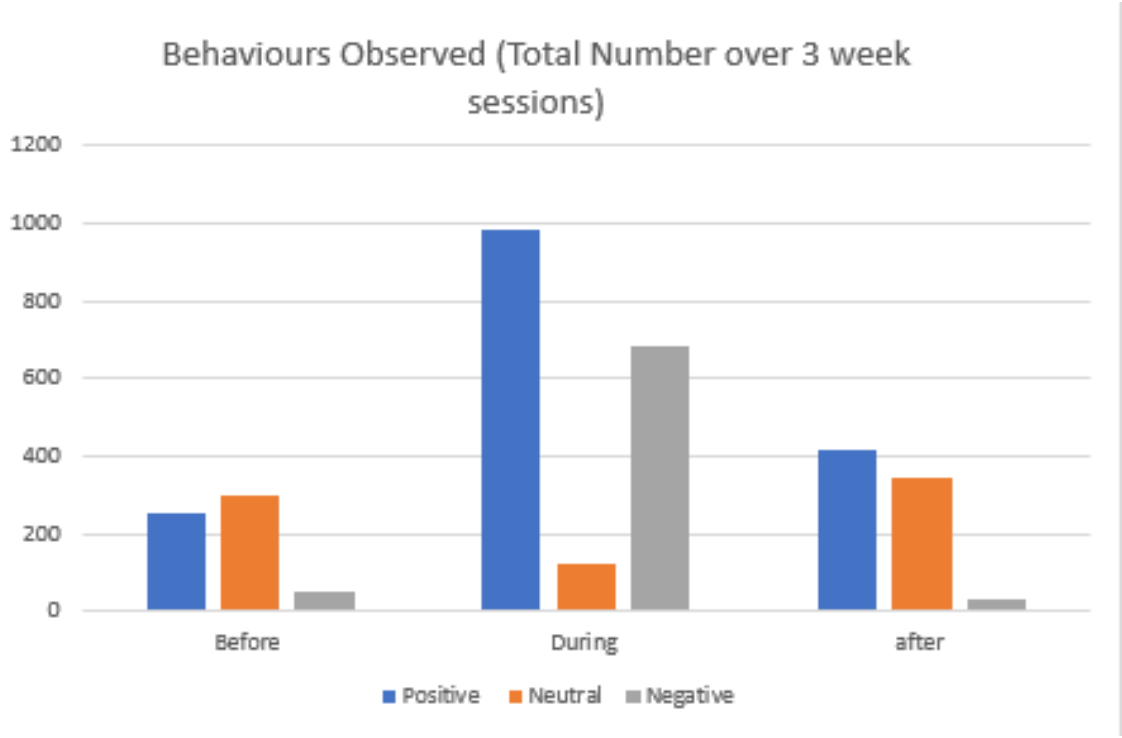

Figure 4 – Graph to show total number of behaviours over 3 week sessions.

5.0 Critical Discussion

5.1 Heart Rate

The results show that light therapy has a significant effect on heart rate in the horse. The heart rate for each horse decreased throughout each session and no horse experienced an increase in heart rate at the end of the session from the initial reading. All the horses in the study had a decrease in heart rate and this change was larger at the end of the three week sessions than at the beginning of this time period. Although the result is positive and will come as welcomed to users of the device and therapists, it does ask the question as to how much of the decrease in heart rate was a result of light therapy and not the fact that horses were stood still for a period of

time. This could have potentially been resolved by including a control group into future studies to fully observe the decrease from the light therapy. In order to do this, the control group would be a select group of horses who stood still for the same period of time but received no light therapy, by doing this is would highlight what the difference was. However despite the lack of control group the result that horses had low heart rates do suggest that horses were not stressed during the study as Schmidt *et al.,* (2010) concluded that high heart rates corresponded with stress within the horse. This means that the horses were not stressed during the light therapy treatment, which particularly in the case of Carrie, is a welcoming result for horse owners and users of the Photizo device. The reduction in heart rate and the relaxation correspondence has also been demonstrated by Mcbride *et al.,* (2004). Mcbride concluded that a low heart rate indicated that horses were relaxed however this paper was completed on massage therapy which is a physical movement on the horse. Light therapy is not physical, but it is a therapy-based paper therefore is a more effective paper to make the link between the current paper and Mcbride *et al.,* (2004). It is less effective to link the findings of the current paper to Schmidt *et al.,* (2010) due to the paper being a study surrounding transporting horses. The findings for both papers were similar and the Schmidt *et al.,* (2010) paper is a newer study demonstrating the validity of the Mcbride *et al.,* (2004) study.

Heart rate is affected by many factors that have been demonstrated in previous research ((Mcbride *et al.,* 2004), (Schmidt *et al.,* 2010)). It is more visible to see the reduction in heart rate when the light therapy was applied in the raw data than the mean table. Horses mean heart rate increased from 59.5 ± 11.4 in minute two to 65.9 ± 20.9 in minutes four. The figure for minute four overall is higher than the other treatment results and minute four had the second highest standard deviation meaning there was a high variation in heart rate result for this point in the session. This variation in heart rate could have been a result of many different factors during the session including other students distracting the horses whilst completing duties and other yard activities. It could have been the fact that horses may have moved or ‘fidgeted’ which would have increased heart rate. Heart rate quickly decreased by the sixth minute demonstrating the ability that light therapy can relax a horse enough for heart rate to decrease. All horses ended the sessions within the same heart rate range with the just outside the average resting heart rate of horses which 30-40bpm

as stated by Kang *et al.,* (2012). Horses in the current study ended the sessions on an average heart of 42.3 ± 5.8 which compared to the before value of 96.1 ± 22 further demonstrates the fact that heart rate can be influenced by light therapy. This result supports the hypothesis that horses heart rate will decrease as a result of light therapy.

5.2 Surface Temperature

The results showed that light therapy has no significant effect on surface temperature of the horse. However, there is room to suggest that coat clip may have a role to play in the surface temperature. Images of horses with no clip or were partially clipped had a 'colder' surface temperature than horses who were fully clipped on their body (only legs on) or again partially clipped on their body (blanket clip). The differences between the two can be seen in figures five and six below. This leaves the question as to whether the results of the present study would change as if the 'question' researched was different. Researching a different question such as differences between clip may have changed the outcome of this study.

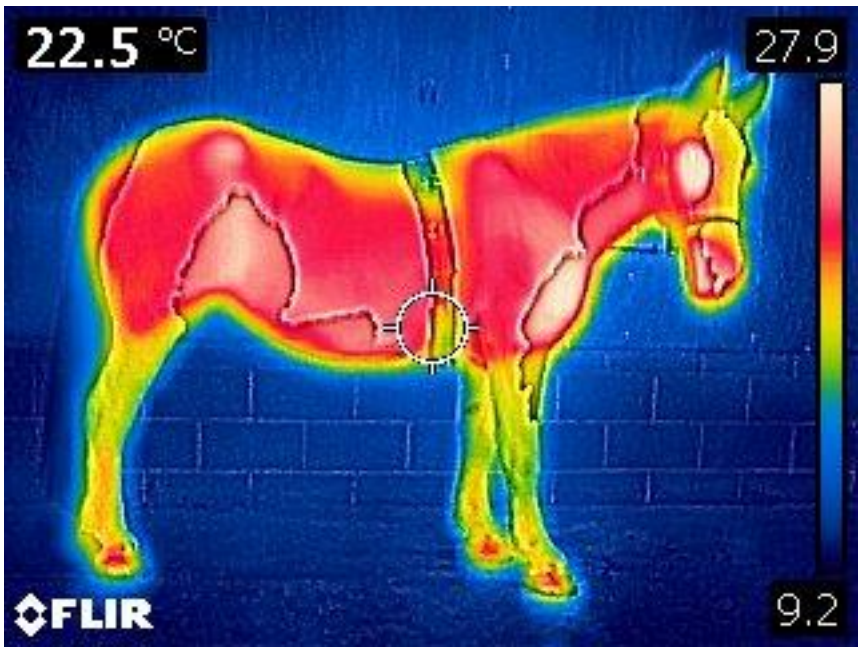

Figure 5 – FLIR image to show horse with clip (Legs on, no body coat) (Authours own image)

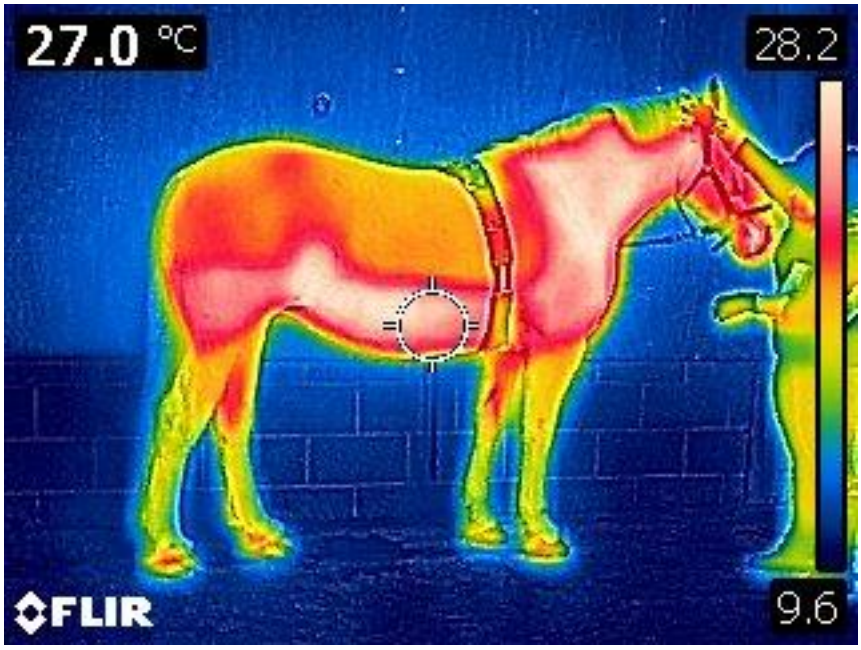

Figure 6 – FLIR Image to show horse with clip (Blanket clip)

The present study was investigating wether there was a difference in surface temperature when light therapy was applied. Despite the points where the device was placed are visable (in some cases) on thermographic images taken, the difference in the temperature is not significant (highlighted in appendices). A further improvement to the study would be to ensure all horses were fully clipped prior to the study commencing. Fonesca *et al.,* (2006) did not indicate wether the horses in their study were clipped prior to imaging. However, the camera that Fonesca *et al.,* (2006) used to take images of the thoracolumbar spine is of a much better quality than the camera used in the current study. The camera used by Fonesca *et al.,* (2006) is a DTIS 500, Emerge Vision camera which cost around $4,000 (AAEP.org, 2018). This makes the camera very expensive and is not a device the average practitioner would be able to afford. The FLIR C3 is an inexpensive camera in comparison coming in around £788.40 (FLIR Systems, 2018). This cheaper price makes the C3 an affordable option that still gives a good quality image it is just not as high quality as the camera used by Fonesca *et al.,* (2006). It was stated by Soreko and Howell (2018) that horses do not need to be clipped for thermographic imaging however the coat does need to be short and uniform in length. This does not give allowances for clip and type of clip but the fact that the coat is required to be ‘uniform’ in length does suggest that having a horse that is partially clipped may affect the result and temperature of the horse. Adapting the current study’s method could potentially have

a different outcome this adaptation could either be using horses that are only fully clipped or partially clipped or having a comparison of the two groups.

5.3 Behaviour

Behaviour of the horses changed throughout the light therapy sessions and this behaviour change was significant ($p<.0001$). Overall, the number of negative responses exhibited from the horses reduced post treatment than were presented before treatment began. This result in itself is very pleasing and is a positive result for light therapy users. However when combined with the fact that positive and neutral responses exhibited increased after treatment it has an even stronger effect. This shows that horses are not suffering or in pain as Dyson *et al.,* (2017) ethogram study suggests.

Whilst the current study's ethogram was based upon Dyson *et al.,* (2017) it does have some flaws that should be considered when interpreting the results. There are a higher number of positive behaviours on the ethogram than negative and neutral, therefore it is very likely that the positive group of behaviours would have a higher result. Despite this factor, the results for positive group are so high that even if there was the same number of behaviours for each behaviour type, the same outcome would have been observed.

Mcbride *et al.,* (2004) used a different type of assessing behaviour. Horses in the Mcbride *et al.,* (2004) paper were 'scored' on a scale of 1-5 according to how they responded to massage on different areas. Although this method appears effective, the evaluation was completed by one person. Therefore, it is subjective. Subjective evaluations are not always the best way to analyse a situation as discovered by Hammerberg *et al.,* (2016). For example out of 86 veterinarians only 33% of them agreed on a lameness diagnosis based on subjective evaluation. There are so many different facts that affect subjective evaluations such as experience and understanding therefore it would have been more beneficial for Mcbride *et al.,* (2004) to have a scoring system similar to the ethogram presented by Dyson *et al.,* (2017) as the ethogram is deemed more objective. Based on this, the behaviour scoring system of the Dyson *et al.,* (2017) paper is more effective than the Mcbride *et al.,* (2004) system and is more up to date and concurrent. Dyson *et al.,* (2017) allows

each individual behaviour response to be assessed rather than the response as a whole. To conclude having a similar style ethogram to Dyson *et al.,* (2017) improves the validity of the current study and strengthens the study.

The natural behaviours of the horses could have impacted the results. As stated previously six of the seven horses were 'green' horses meaning that they are likely to show positive behaviours. Thus could be a reason as to why the positive result was so high. Some of the horses were a bit spooked at the light therapy device and paper in the first sessions however as this would be a normal response in industry these behaviours were left into the study and not removed.

5.4 Limitations and Further Improvements

With any small-scale research project limitations are inevitable. In the present study a control group was not present, meaning there no 'non-treatment' readings to compare to To further improve the validity of the study a control or sham group that received no treatment but were placed in the same setting for the same length of time like the Fung *et al.,* (2002) study would be necessary. This would have ensured that the all behaviours, heart rates and surface temperature readings could have had a control rather than having the four minutes pre and post treatment. Although, original thinking of the experimental design was that could a different group still be a valid way of controlling the study as horses all have different heart rates, behaviours and as discussed previously with the changes in temperature regarding clip would all differ. Increasing the number of cohorts would also improve the validity.

The horses heart rate would naturally decrease as a result of a static position. If a control group was used it would have been more effective in order to discover how much of the decrease was due to the light therapy treatment or due to the static position in the therapy barn. In this respect a control group would be interesting to see exactly what the effect is because As stated previously horses may react differently to light therapy. In order to suggest a control group both the pro's and cons for each would have to be researched deeper into the reasons why a control group would be more useful in this situation. Using the same cohort as their own control could be a possibility which has been done previously by Rietmann *et al.,* (2004) which appeared to be an effective way of controlling the study. However this

was not commented on in the paper therefore whether it can truly be accepted is not definitive. Having a separate control group such as Al-Watban and Andreas (2003) enabled the authors to observe a clear difference between both their treatment group and their control group. However, Al-Watban and Andreas (2003) were investigating different parameters than the current study, this may have been a factor as to their methodology selection. This does show that having a control group can clearly show the difference between the two groups. The current study did use the horses as their own control in some respects, as data was observed before and after treatment, which was the most effective way for this study to be carried out due to limitations of time, experience of author and suitable horses. To further improve in future, a complete control group would be an option.

One of the horses in the experiment Carrie was not comfortable being tied up in the first week of the light therapy study. Carrie had reared while still tied up and due to the fact that this was too dangerous to carry on, the idea of removing her from the study was suggested. After careful consideration and with the previous removal of another horse it was decided that Carrie would stay in the study but with a handler and a hay net as any pressure around her head can cause her to be uncomfortable thus the potential to trigger another rear. Although all of her behaviours were noted it was difficult to distinguish what was a result of eating, due to light therapy or handler related. The handler was a highly experienced member of staff who was competent in handling horses but upon reflection it was probably a better option to remove Carrie completely and carry on with a sample size of six, but we still managed to get some viable results which is why she stayed to complete a sample size of seven. Essner *et al.,* (2013) had a total of ten dogs in the study, which is a slightly higher number of participants resulting in a more viable study. Although the study would have taken longer to carry out, more viability would have been valuable to a study of this size and relevance. Although Carrie's results are concurrent with the other horses in the present study, the handler could have influenced in keeping her calmer during the collection of data. The result that horses were calm during treatment will come as welcomed to users of the device and therapists alike as it further strengthens the argument that light therapy has a positive influence on both the behaviour and heart rate of the horse.

As The Royal Greenwich Equestrian Centre is a working yard for students and a riding school for members of the public, the yard is constantly busy, noisy with people and horses moving around the yard. Horses are going in and out of the fields which are situated near the location of the study – the Farrier Barn. Students are regularly completing duties and yard work around the barn and with horses on the horse walker unexpected noises and people caused a distraction for the participants. Horses are regularly at the centre for hydrotherapy treatment and during the study horses were used on the treadmill which is situated in the therapy barn just behind the farrier barn. In an ideal situation having a completely quiet yard would be the best possible way to reduce these sudden noises and distractions however, that would not be a viable option. A paper by Rietmann *et al.,* (2004) concluded that these noises and movement can increase heart rate, which the same was seen in the present study. The factors can be difficult to control as stated above so results need to be carefully considered. Rietmann *et al.,* (2004) stated how PSA (Power Spectral Analysis) may be a more effective way at evaluating stresses in the horse rather than heart rate through a monitor or an ECG. However in order to fully understand the benefits of this, This PSA potential would need to be futher researched.

The horses in the study were colour coded according to their natural behavioural patterns, these are set by the college and not by the author. Horses who were colour coded as ‘green’ meant that the horse had a positive personality and do not often exhibit undesirable behaviours such as kicking or biting. In the present study, five of the horses were classed as ‘green’ however two of the horses were classed as red or orange. Orange horses meant that they are either likely to exhibit undesirable behaviours whilst a red coloured horse means that they are very likely to exhibit undesirable behaviours. In terms of using these horses for the study, it would have been more beneficial to have the same number of both ‘green horses’ ‘orange horses’ and ‘red horses’. This would make it a fairer representation on the equine population as a whole. However, Hadlow College’s Greenwich site is mainly catered for students studying at a lower level meaning that most of the horses at the site are of a good nature to support these students through their learning. The result of this being the possibility of red and orange horses not being accessible at the site where the study was taking place. It was considered by the author to undertake the

research project at the colleges main site. However, due to time constraints and the main site's huge number of students it was deemed impractical for this study to take place at the main site.

5.5 Strengths

Despite all these limitations the study did have areas of strength. The study was well thought out and managed to obtain all the data needed for the study to commence with little assistance which ensured that there was less room for human error. Both human participants were well trained and understood the protocol exactly. These same participants completed the whole data collection process so it was controlled. The study was also well designed to ensure that there would not be issues with carrying out the study. Areas that were particularly well designed were timings and practicality's as these had realistic time frames.

The study had a good sample size for a small-scale university project, however as discussed in the limitation section the size could be a limitation as well as a strength. A study with 7 horses enables the study to have a more effective relevance to industry as it is on more than three horses. The sample size in the present study is a similar size to Essner *et al.,* (2013) who used ten dogs to measure heart rate. Although the sample size is effective, to make it more relevant to industry having a sample size closer to Fonessca *et al.,* (2006) which was twenty-four would have a much higher relevance and validity. In order to make the present study more effective and relevant to the wider industry, increasing the number of horses could potentially lower the need for further research in the area as a higher number would be representative of the population. Despite this being the first study of its kind, as a pilot study it has advantages in being relevant to light therapy of horses.

It is important for any researcher conducting a study carried out on animals that it must be in accordance with the Animal Welfare Act 2013. This means that the horses must not be in pain or caused suffering, be free to exhibit natural behaviours and have access to food and water. Using a heart rate monitor is an effective way of measuring heart rate and stress within the horse. The study by Essner *et al.,* (2013) concluded that the Polar heart rate monitor used in the study was an effective method compared with an ECG. This finding improves the validity of the findings in the present study, making it more reliable to the equestrian industry as the current

study used a Polar monitor and this type of monitor had been deemed as reliable. Schmidt *et al.,* (2010) also concluded that heart rate was an indicator of stress in the horse, so with the heart rates being low and could indicate that horses were not stressed in the study which is a strength of the study. It means that horses were relaxed and the environment was not stressful to the horse as causing stress onto a horse could be a breach of the Animal Welfare Act 2006.

5.6 Further research potential

As a pilot study, the current study has been successful in achieving what was planned. The current study highlighted areas of weakness in the light therapy industry but also showed its' strengths and relevance to the Equine therapy industry. Especially in regards to lack of research in the area not all the areas needed were addressed through the current study and have therefore not been explored. As a result, there is a large potential for further research in the industry.

Firstly, all areas researched in this study require, or would benefit from, further research however in particular surface temperature needs further work. In order to do this successfully the future work should include research into the effects of coat and clip on light therapy specifically. However, the methodology of this study was effective therefore using a similar one would be an effective basis for future work.

Secondly, due to the quick growth of light therapy from Danetre's first year of trading to last year (2017) light therapy is expected to rise over the coming years. With the rise in therapists using the device during treatments, further research needs to be undertaken in order to fully understand other effects of light therapy rather than current understanding of light therapy for wound healing. This would only benefit therapists as they will be able to further understand what they are applying to their clients.

Finally, other parameters should be explore for example, the effect of light therapy on muscle tension and if it reduces it. This could be done via an algometer. An algometer measures pressure and pain thresholds. Other explorative routes could include light therapy and arthritis, what could the effect of this be. Both of these

routes are not explored currently but would benefit the wider therapy industry as therapists do use light therapy for both of these (Association of Merisha Therapists, 2018). This would then enable Photizo Vetcare users to have a stronger understanding of what they are using and if it is viable for the reason that they are applying it to their client or own horse.

6.0 Conclusion

To conclude, this pilot study has been successful in achieving what the study set out to acheive. With limited research into the effects of the Photizo Vetcare and light therapy in general, understanding what the effect of this new therapy is on heart rate, behaviour and surface temperature is was not previously understood in horses. Now with the understanding from this pilot study, it allows other researchers a basis to further research and improve the current study. Allowing more research to be undertaken which in turn will benefit horses, owners, therapists and veterinarians alike. The study discovered that light therapy has a significantly influences behaviour

in the horse (x^2 (4) = 862.1 p<.0001). A higher number of positive responses were observed after the light therapy than before light therapy. A lower number of negative responses were also exhibited from horses in the study. Resulting in the fact that light therapy increases positive responses from the horse and decreases negative behaviour responses.

Light therapy has a significant influence on heart rate p<.0001 by reducing the heart rate of the horse. This ensures that horses that undergo light therapy are not stressed as Schmidt *et al.,* (2010) concluded that high heart rates corresponded to stress within the horse. Mean heart rate at the beginning of the study was 96.1 ± 22bpm and decreased to 42.3 ± 5.8bpm. Resulting in all horses returning to just outside the average reading for heart rate which is 30-40bpm (Kang *et al.,* 2016). This low heart rate suggests that horses are not stressed when undergoing light therapy treatment. A result that will come as welcomed by users of the device, horse owners, veterinarians and therapists.

Light therapy has no significant difference on surface temperature of the horse (F(6,210)=1.07, P=0.37). However, it is questioned that if the original aim of the study was changed to some of the suggestions listed previously the result may have been different. However, it is a positive outcome that light therapy does not alter surface temperature of the horse, it means that horses body temperature is not influenced by light therapy which could potentially have a detrimental effect on the horses' health, though this has not been explored in depth.

There is still a need for further research within light therapy but specifically within other light therapy uses. Research is limited in the area and therapists should be informed about more of the other potential benefits of light therapy. However, for the price of the device and the benefits that are already researched, the Photizo Vetcare is a beneficial tool for therapists and owners who would like to provide some complementary therapy at home. It could allow them to provide pain reduction (Laakso and Cabot, 2005), assist in healing skin abrasions (Brem *et al.,* 2004) kickstart the healing of Tendon and Ligament injuries (Fung *et al.,* 2002).

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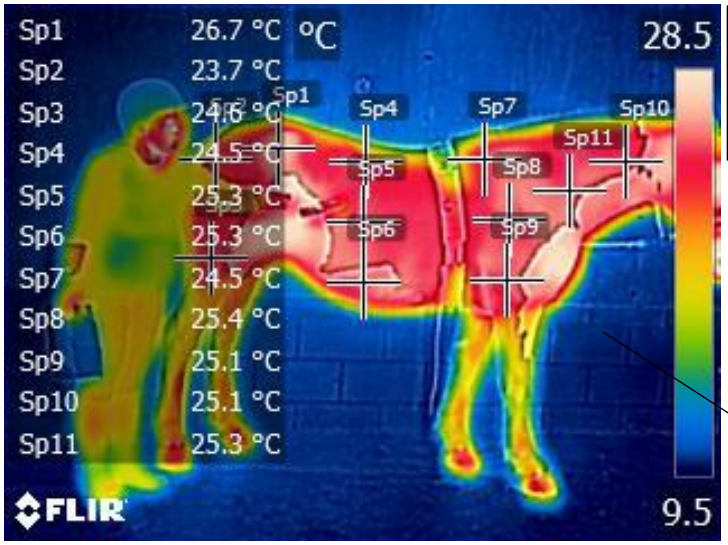
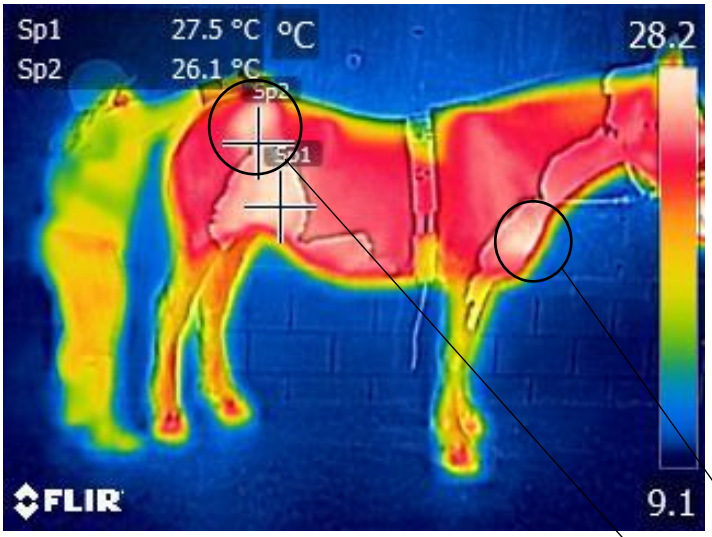
8.0 Appendices



This image also shows how the FLIR tools system was used to collect readings.

This image was the image taken before the one below.



After photizo treatment, visable, but not significant.