BACHELOR THESIS

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The effect of infrared-vibration therapy on the equine muscle tone

- Bachelor thesis -

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Statutory Declaration

I declare that I have written and completed the enclosed thesis entirely by myself and only the defined sources and study aids were used.
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Wageningen, 3rd of July 2014

Abstract

The purpose of the study was to investigate if infrared-vibration therapy does have an impact on the equine muscle tone. Moreover, was the effect of infrared-radiation examined concerning the before and after effect as well as the influence on different muscle groups on the left and right hand side of the horses` body. In line, the company hhp-home health products wanted to gain scientific evidence of the therapeutic effect of their product, an infrared-vibration therapy blanket for horses. The research therefore, investigated for the effect of the hhp-horse blanket in terms of the equine muscle tone.

The study included 24 horses of different breeds and ages which were tested on their muscle tone in resting position before and after applying the infrared-therapy. The group of horses was split into a treatment group and a placebo control-group. The muscle tone was tested by using a pressure algometer and an evaluation of an equine physiotherapist. Both methods were applied on four different muscle groups as well as on the left and right side. Trigger-points were used to determine the muscle tone of every muscle group.

The changes of the muscle tone before and after applying the infrared-vibration therapy blanket were evident. Significant differences in muscle tone occurred in all muscle groups within the treated group after usage of therapy; predominantly a decrease of muscle tone was recognised. The placebo group in turn, did not show any significant differences and therefore, confirms the results. Furthermore, did the results show that the therapy does not affect the balance between left and right, but treats the equine body evenly.
A positive effect of the infrared-vibration therapy blanket could have been scientifically proven. Further examinations concerning long-term effects and other positive influences on the equine body might be of interest and are recommended. Further approved positive effects on rideability and welfare of horses might attract more customers and would boost the market of alternative therapy methods, next to conventional medicine, within the equine market.

Zusammenfassung

Das Ziel der Studie war die Ermittlung des Einflusses von Infrarot-Vibration-Therapie auf den Muskeltonus bei Pferden. Untersucht wurde der vorher-nacher-Effekt der Therapie auf verschiedene Muskelgruppen, jeweils links- sowie rechtsseitig. Innerhalb des Projektes, welches von der Firma hhp-home health products begleitet wurde, wurde nach wissenschaftlich relevanten Ergebnissen zur Optimierung der Produktentwicklung, sowie der Vermarktung für hhp geforscht. Aus diesem Grund widmet sich diese Studie der Untersuchung des Einflusses der hhp Pferdetherapie-Decke auf den Muskeltonus des Pferdes.

Die Studie beinhaltete 24 Pferde verschiedenster Rassen und Altersgruppen, welche auf Ihren aktuellen Muskeltonus bevor und nach Nutzung der Therapie untersucht wurden. Die an der Studie teilnehmenden Pferde wurden in 2 Gruppen unterteilt, zum einen die behandelte und die placebo- Gruppe. Der Muskeltonus wurde mittels eines Druckalgomters und der Bewertung einer Pferde-Physiotherapeutin jeweils vor und nach der Anwendung der Therapie untersucht. Beide Messmethoden wurden an jeweils 4 verschiedenen Muskelgruppen, sowie links- und rechtsseitig angewandt.

Der Tonus der Muskeltgruppen wurde mit beiden Methoden an ihren jeweiligen Trigger-points erfasst und bewertet.

Die Ergebnisse der Untersuchung zeigten deutliche Unterschiede des Muskeltonuses zwischen vor und nach der Behandlung. Innerhalb der behandelten Pferde-gruppe konnten signifikante Unterschiede des Tonuses in allen Muskelgruppen festgestellt werden. Der Tonus in dieser Testgruppe wurde erkennbar gesengt durch die Anwendung der Therapie. Dieses Ergebnis konnte durch die Werte der Placebo-gruppe bestätigt werden, da diese keinerlei signifikante Unterschiede aufzeigte. Des Weiteren konnte festgestellt werden, dass die Behandlung die Balance zwischen Rechts und Links in keiner Weise beeinflusst und somit den Körper des Pferdes gleichmäßig therapiert. Diese Ergebnisse bestätigen somit, dass die Infrarot-Vibration-Therapy den Muskeltonus bei Pferden signifikant beeinflusst.
Weitere Untersuchungen der Wirkungsweise dieser Therapie zur Optimierung und Vermarktung des Produktes werden empfohlen. Zukünftige Untersuchungen auf mögliche Verbesserung der Rittigkeit und Wohlbefinden des Pferdes können zu einem gesteigerten Interesse der Kunden führen und die Zielgruppe möglicher Neukunden erweitern.

Contents Page

List of abbreviations and definitions

IR	Infrared
IRVT	Infrared-vibration therapy
PA	Pressure algometer/ pressure algometry
Pic	Picture
Tab	Table
Fig.	Figure
M.	Muscle (lat. Musculus)
Lig.	Ligament
ATSB	andullation therapy system-blanket (Infrared-vibration therapy)
PPTs	Pressure pain thresholds
PEMF	Pulsed electromagnetic fields
M1	M. Brachiocephalicus
M2	M. Longissimus dorsi
M3	M. Biceps femoris
M4	M. semi tendinosus

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1. Introduction

The equine sport is based on the healthy and athletic body of the horse. Riders, breeders and trainers do set their focus on the improvement of equine performance. The quality of performance is in both sectors, sport as well as leisure riding, based on the health condition of the horse. One of the most influencing factors concerning health and performance is the function of the equine muscles.
The contraction of the muscles is responsible for the movement of the body (Alexander, 1977). Via Tendons and ligaments, most muscles are connected to the bones, which are moved by the contraction of the muscles. Muscles are flexible and therefore, elastically stretchable to a certain extend (Snow; Valberg, 1994).
The higher the muscle tone, the lower the flexibility. A too high muscle tone could lead to limited mobility, pain and spasm-like symptoms.

In equine medicine, the term “back-pain” is often used for a complex symptomatology which is connected to tension in the back muscles, limitations of the riding comfort and general performance degradation.
The cause of back pain can be pathological changes, ill-fitting saddles or a lack of equestrian skills. Often there occurs a circle of tension and blockades that leads to pain which causes further tension up to movement asymmetries and lameness (Kalinowski, 2007). In conventional therapy glucorticoides, non-steroidal antiphlogistica, muscle relaxants and analgetica are often used to lower the muscle tone and therefore the back pain. Besides, paramedical treatments like acupuncture, osteopathy and pulsed electromagnetic fields are used. The results of treatment have so far been largely unsatisfactory. Therefore, the question arises of whether infrared-vibration therapy (andullation/ heat treatment) has a better success.
In human medicine, infrared radiation achieved to be a successful treatment in the last years concerning back pain symptoms. Due to heat exposure, the peripheral blood vessels widen and the blood flow increases, which leads to an improved oxygen and nutrient supply. By using heat treatment, muscles become extensible and relax (Turner, 2001).

For the equine medicine, corresponding infrared radiation treatments have been developed which make it possible to treat the entire horse's body with long-wave infrared radiation. Subjectively, this method leads to satisfying results concerning equine back pain, more precisely, the muscle tone, so an investigation about the objective proof of the treatment was conducted.
The assumption of the study result leads to the hypothesis that, as in humans, a relaxation through improved blood flow of the muscles will take place in horses which will be measurable by algometric parameters as well as an evaluation of an equine physiotherapist.

1.1. Problem definition

Since tensed muscles and blockades are common health and consequently performance issues, the equine market and research does investigate in solutions known from the human sector. Although, equine physiotherapists and several massage techniques did already enter the market, the scientific evidence of improvements concerning the animal’s health and welfare is comparably low.

Knowing that a high muscle tone in horses during resting time could cause blockades and hence weak performance, as well as back pain, this study will investigate if the usage of infrared-vibration therapy will influence the equine muscle tone.

1.2. Research objective

This research is aiming to investigate if the use of infrared-vibration therapy does influence the muscle tone in horses. The influence of infrared-vibration therapy in horses will be measured and checked for its effect.

1.3. Research questions

Main question:
Does the infrared-vibration therapy influence the muscle tone in horses?

Sub questions:

1. Does the infrared-vibration therapy influence the horses` muscle tone after first application of the program "relax" on medium level for 15 minutes?
2. Does the infrared-vibration therapy lower the muscle tone in horses?
3. Is there a correlation between the measurement outcomes of the equine physiotherapist and the pressure algometer?
4. Is there a difference between the measurement outcomes of the muscle tone per muscle group before and after applying the therapy blanket?
5. Is there a correlation between the left and right side of the equine muscle tone before and after applying the infrared-vibration therapy blanket?

2. Literature review

2.1. Infrared-vibration radiation

Thermotherapy belongs to the physical therapy methods.
For centuries already, heat treatment is known as an effective therapy to cure muscle- blockades and pain. In Roman times, the tepidarium, a room with hot walls and floor which are heated by burnt gas, was invented to prepare athletes for the Olympic Games (RUKU, 2005).
For back pain heat-treatment in horses, most often a solarium, sauna or thermium (IR) are used. Besides, warm compresses could lead to certain effects. Concerning this study, the effectiveness of IR radiation will be explained.
Infrared is electromagnetic radiation with longer wavelengths than those of visible light, extending from the nominal red edge of the visible spectrum at 700 nanometers (nm) to 1 mm. This range of wavelengths corresponds to a frequency range of approximately 430 THz down to 300 GHz. Most of the thermal radiation emitted by objects near room temperature is infrared.
IR radiation got discovered in 1801 by astronomer and physicist Friedrich Wilhelm Herschel. Herschel separated sunlight and withal discovered the rainbow spectrum by using a prism. Afterwards he measured the temperature of the different coloured light rays. The temperature in the range of 780 nm to 1000 µm, which is IR, was significantly higher than within the range between red and violet (Meffert and Piazena, 2002).

Analogical to the analysis of ultraviolet radiation, IR radiation is separated into sub-ranges (Richter and Schmidt 2002):

IR-A	0, 78- 1, 4 µm (short-wavelength or near IR radiation, NIR)
IR-B	1, 4- 3, 0 µm (middle/ medium IR radiation)
IR-C	3, 0- 1000 µm (long-wavelength or far IR radiation, FIR)

The effect of IR radiation on the body depends on wavelength, quantity and frequency (Meffert and Piazena, 2002). Whereas long-wave IR radiation can be absorbed completely in the upper dermal layer, IR-A and IR-B can enter deeper layers (Richter and Schmidt, 2002). Target structures of the IR radiation within these wave-lengths are absorbing bonds (so called chromophores), especially water- and organic chemical bonds. Due to low quantum energy, IR radiation could only warm up but can not modify chemically. This even obtains for high energy denseness which is realisable via laser (Meffert and Piazena, 2002). With a skin depth of maximal 0, 5 mm, IR radiation gets absorbed up to 80% within the 0, 1-0, 2 mm thin epidermis and 20% of the IR radiation reaches the top layer of the dermis, the stratum papillare, at a depth of approximately 0, 5 mm. Until there, the free nerve cords, as well as the smallest vasculatures are located which are responsible for the cognition of heat and the microcirculation-system of the skin. Therefore, the heat gets noticed immediately, the thermoregulation-system gets activated and via blood circulation the heat attains convectively the inner body (Richter at al. 2000; Richter and Schmidt, 2002).

IR radiation stimulates the natural oscillation of molecules. Thereby, the energy level of the tissues increases, which in turn leads to equivalent physical effects such as increased blood flow, relaxation of muscles, anti-inflammation and pain relief. Furthermore, the encouragement of enzymes leads to an activation of the metabolism (Dickreiter, 2001). The heat radiation causes a reflex reduction of the muscle tone to enable the musculature to relax to reduce the production of own metabolism heat. The mechanism of pain relief is not completely explained yet, but seems to be based on the quick removal of Bradykinin, Histamin and Prostaglandinen caused by increased blood flow and lymph activity (Dickreiter, 2001).

Moreover, does IR radiation, when exposed frequently, have a positive and permanent effect (comparable with sporting activity) on the circulatory system. This effect includes a decrease of systolic and diastolic blood pressure by widening the blood vessels (Meffert and Piazena, 2001); further an increase of heart frequency and cardiac output (Brasch et al., 1989, Lindner and Brinkhaus, 2000, Meffert und Piazena, 2001, Franz et al., 2002), as well as an improvement of the peripheral haemodynamics (Bäumler, 1990).

The above stated facts are referred to humans. There is no corresponding information for horses available yet.

In contradistinction to sauna, where heat gets transported conductively, thus via hot air, the heat transmission of IR radiation takes place via electromagnetic waves (Kurz, 2002, Richter and Schmidt, 2002a). In this way, the atmospheric temperature while IR radiation could be kept lower, which anon relieves the metabolism (Richter and Schmidt, 2002a).

2.2. Infrared-vibration therapy by hhp-home health products

The method of infrared-vibration therapy is not as common in the equine sector as in the human therapy system. Therefore, most studies published do concern the effect

of IRVT in humans. In 2003/ 2004 the IRVT-producer hhp assigned the SPOREG, Ambulantes Rehabilitationszentrum, Offenbach to investigate if the application of their Andullation-system does have impact on back pain and muscle tone in humans. The study is based on the knowledge that an increased muscle tone leads to blockades which in turn cause back pain and stiffness (Stutz, 2003). A lack of blood flow could lead to malnutrition of the muscle tissue which on the other hand often results in chronic stiffness of the affected tissue. The affected muscle tissue also lacks the ability to contract properly. The results are multiple persistent muscle tension as well as a decreased trunk static (Stutz, 2003).
The application of the Andullation-system shows distinguishable improvement of blood flow, relaxation of muscles, pain reduction and annulment of lymph accumulation (Stutz; Gebel, 2003). Moreover, the study result proved an improvement in the mobility of the spine, decreased muscle tone and stimulation of the body fluid-system (Stutz; Gebel, 2003).

Another former study (hhp-home health products, 2013) has proven a positive effect of the blanket concerning the horses` circulation. The study included 67 horses and pictured the circulation of the horses before, during and after applying the blanket. Before (1) using the therapy system the circulation was relatively low. 8 minutes after starting the program the circulation already improved (2) and resulted in an increased status after finishing the therapy (3) (vide pic.1).

Pic.1: Study results of circulation test (source: www.hhp.de; 2013)

2.3. Infrared-vibration therapy on horses

The investigations about the effect of IRVT on horses are not as developed as in humans; nevertheless, in 2007 Kalinowski did an examination about the effect of a thermium with infrared-C radiation on horses concerning back pain and muscle tone. The research pointed out that the tension and pressure reaction of the muscles decreased significantly (≤ 0,001) after applying the IRVT for 14 days daily. Furthermore, all horses tested showed highly improved results concerning rideability. Kalinowski`s study demonstrated that treatment with infrared-C radiation in a thermium has positive influence on horses with back problems. Advantages of treatment with infrared-C radiation are therapeutic success and good tolerance.

2.4. Pressure algometry

Pressure algometry (PA) uses to be a mechanical instrument to quantify pressure pain thresholds within musculoskeletal structures in man (Fischer, 1987; Vanderweeën et al., 1996). Pressure pain threshold (PPT) is defined as the minimal amount of pressure that produces pain (Meussen, 2005).

Furthermore, PA has the potential to provide an objective assessment of nociception and aid in localising pain to affected structures (Keating et al., 2001). Reference PPTs within the axial skeleton of normal horses have been documented (Haussler and Erb, 2003, 2006). In addition, PA provides a more quantitative evaluation of musculoskeletal pain than manual palpation does (Kosek et al., 1993; Chambers et al., 1994). In 2006, Haussler detected that the presence of pain can be identified and also differentiated from adjacent nonpainful landmarks by using PA. Consequently, PA forms a potential modality for objectively measuring PPTs in horses.

2.5. Muscle tone

Commonly, two terms are used clinically to identify muscle tension: muscle tone and muscle spasm. Unfortunately, both terms are ambiguous because they are used with conceptually different meanings.

Muscle tension depends physiologically on two factors: the basic viscoelastic properties of the soft tissues associated with the muscle and/or on the degree of activation of the contractile apparatus of the muscle.

2.5.1. Definitions related to muscle tone

Definitions collected by Simons and Mense, 1998:

"Elastic stiffness" (physics definition): "in an elastic system: the steady force required to produce unit displacement" (Thewlis, 1979, p. 311). This definition explicitly excludes rate of movement as a consideration and corresponds to the physics (and engineering) definition of elasticity, which is the resistance encountered by moving something a certain distance.
"Elasticity": "the property whereby a body, when deformed, by an applied load, recovers its previous configuration when the load is removed. According to Hooke's law the stress (applied force) is proportional to the strain (resulting movement) within the elastic limit" (Thewlis, 1979, p. 111). Again, velocity is not a consideration.
"Stiffness" (common usage: two definitions): something that is stiff is "not easily bent, rigid, inflexible" and "firmer than liquid in consistency, thick or viscous" (Collins English Dictionary, 1991, p. 1517). The first definition concerns simple displacement or deformation and is measured as elasticity. The second definition is measured as resistance to rate of movement, is a more inclusive definition, and is measured as viscoelastic stiffness.
"Tone" (specific, as defined in this study): measured as elastic or viscoelastic stiffness in the absence of contractile activity.

"Tone" (general): Measured as elastic or viscoelastic stiffness including any involuntary contractile activity.

2.5.2. Clinical usage of muscle tone

Hypertonia is generally used to mean increased muscle tone. It includes a variety of conditions like spasticity, dystonia, rigidity and muscular contracture (Poewe, 1989). Each of these conditions is associated with a particular diagnosis, but the origins and mechanisms of the increased tone may be utterly different (Simons 1998).

2.6. Substitutional therapy method: Pulsed electromagnetic fields

According to Biermann, 2013:
"Physiotherapy is an important cognate health profession and became an essential aspect of care in elite sports. The equestrian sport is catching up rapidly with other sports in using the professional service of physiotherapists, in particular for musculoskeletal disorders (Mc Gowan, 2007). One of the treatment modalities used in physiotherapy is electrotherapy, or electrical stimulation, which is characterized by a variety of different methods and techniques that all use electric current. Pulsed electromagnetic fields (PEMF) is often included as part of this group of modalities and is widely used in human and veterinary medicine (Porter, 1998; Bromiley, 1993), where manufacturers promote a large variety of beneficial applications and effects. One of these applications is back pain, which has been known as a performance-limiting factor in sport horses for decades.
As yet, both the mechanism of action and the clinical effects of PEMF are controversial. However, the concept of evidence-based medicine can provide the clinical evidence for efficacy, even when the basic mechanism of treatment is not clearly understood (Akai, 2002). Most research in the field of PEMF has been performed in human medicine.
Auer et al. (1983) described beneficial effects for the repair of cortical stress fractures of Metacarpus III using PEMF, whereas Sanders-Shamis et al. (1989) did not find any significant differences in bone healing of surgically induced cortical lesions of cIII/Metatarsus III between a PEMF and control group. A review of the literature for magnetic fields in equine medicine showed that the number of randomized, controlled, double-blind studies is limited (Ramey 1999)."

Biermann`s study (2013) was not able to prove a significant decrease in pain pressure thresholds (PPT) by using pulsed electromagnetic fields (PEMF), therefore this study is going to investigate if another alternative modality, namely infrared-vibration therapy does have impact on the PPT in horses.

3. Material and Methods

3.1. Study design

A cross-sectional, placebo-controlled field study was performed, consisting of a two-day therapy period. The horses were randomly assigned into two groups. One group (19 horses) was treated with the andullation therapy system-blanket (ATSB; "hhp-home health products") for 15 minutes using the program "relax" on "medium"-level. The other group (5 horses) was only covered with the IRVT-blanket without switching on the program. The turned off blanket was also covering the horses for 15 minutes. All horses were examined of their current muscle tone of the following muscles: M. brachiocephalicus, M.biceps femoris, M.semi tendinosus and the longest dorsal muscle. The muscle tone was assessed by using a pressure algometer ("Baseline Push-Pull Force Gauge") and an evaluation of an equine physiotherapist. The assessment was conducted directly before and after applying the ATSB.

3.2. Horses

24 horses of different breeds and ages in regular leisure training and competition on low level (German E to L level) were studied. None of the horses was out of training or under veterinary care due to acute back pain or lameness. However, the responsible physiotherapist had noticed variable stiffness and uneasiness in most of the horses. The group of horses included 7 mares and 17 geldings with a mean age of 13 years and a mean height at the withers of 1, 66 m. All horses were privately owned, and all owners gave informed consent. All horses were stabled the same way and in the same stable. Furthermore, feeding, pasture management and outer influences concerning the local area were the same for all horses. All horses were out on the pasture daily from 8 am till 5 pm and are stabled in boxes during the night. All horses were trained around 4-5 times a week. All owners confirmed that the training does exist of 15-20 minutes warm up (walk and easy trot), approximately 15-20 minutes of medium collected work (including walk, trot and canter), followed by another 15 minutes cooling down consisting of easy trot and walk. To ensure same circumstances during the study, precisely the days when measurements were taken, all horses were kept in their boxes to create identical prerequisites. During the study period none of the horses participated in competitions. To avoid an unknown situation for the horses, the IRVT was introduced to all horses once before applying the therapy by letting them sniff and watch the blanket.

3.3. Andullation Therapy

Andullation is a new biophysical therapy. It is based on the effect of bringing the body fluids into a pulsating modus. The body fluids will be set into vibes by launching frequencies of specific wavelengths (hhp-home health products, 2014).

3.3.1. hhp Horse blanket (therapy system)

The used andullation therapy system was an infrared-vibration blanket for horses from the company hhp-home health products. The blanket enacts 18 vibe-aggregates which enable 3 different programs and intensities which can be controlled by a remote control. The blanket size is one-size, particularly 145cm.
Programs:

- Warm-up
- Relax
- Massage

Intensities:

- Soft
- Medium
- Intense

Pic.2: hhp therapy system horse blanket (source: www.hhp.de; 2014)

3.4. Algometry

Algometric measurements were made with the horses standing tied up in front of their boxes or at their usual grooming place. One examiner measured the muscle tone and another person recorded the results. A pressure algometer, Baseline Push-Pull Force Gauge with a 1-cm2 steel tip and a calibrated range of 10 KG x 100 gm/cm2 was used to determine the muscle tone over 4 points of the neck, back and the hind quarters of the horses. The 4 points to measure the muscle tone were located at the M. brachiocephalicus, M.biceps femoris, M.semi tendinosus and the longest dorsal muscle, respectively at each site, therefore in total 8 points were measured. The pressure algometer was set on the trigger-points of each muscle. These trigger points enable an evaluation of the muscle tone by applying pressure until the horse shows a reaction. The algometer was pressed on these points until the horse showed a reaction like a side movement away from the pressure, pinned back ears, head swing as possible bite threat or queasy facial expressions. As soon as a reaction was shown, the pressure got released and the value readable at the measurement was recorded.

Pic.3: Pressure algometer put on trigger-point of the longest dorsal muscle (source: author)

3.5. Pressure/ Muscle tone Testing

The muscle tone of the horses got evaluated by an equine physiotherapist by using the point-by-point exploration technique of the muscle stress-points (trigger-points). The trigger-points allow an evaluation of the muscle tone by observing the reaction of the horse when applying pressure to that point. The physiotherapist did determine and fix the trigger-point of each muscle and put pressure on it by using one finger. The pressure got increased slowly until the horse showed a reaction. The reaction could have been a side movement away from the pressure, pinned back ears, head swing as possible bite threat or queasy facial expressions. As soon as a reaction was shown, the pressure got removed and the therapist ranked the reaction-pressure-relation into a number from 1 to 5, whereas 5 labelled a very high and 1 a very low muscle tone. The reaction of the horses was not scored as such, but the muscle tone which the physiotherapist evaluated by fumbling the trigger points. These measurements were executed on all 4 muscles on the right and left side and before and after applying the IRVT.

Pic.4: Manual muscle tone testing of equine physiotherapist (point-by-point exploration) (source: author)

3.6. Muscle groups

M. Brachiocephalicus

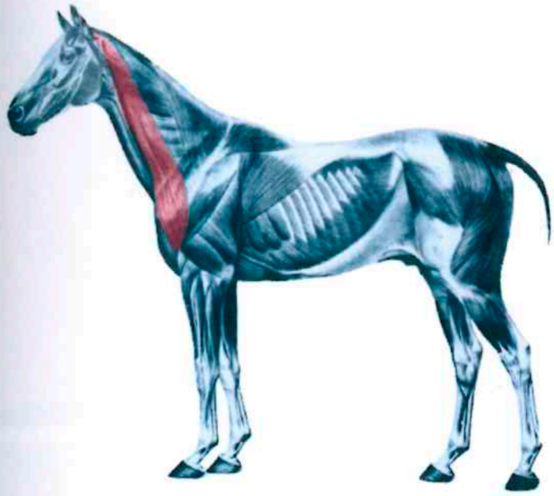
Origin:

- Attaches the base of the skull (mastoid process of temporal bone) and first cervical vertebra to the upper bone in the front leg (humerus) (Pic. 5)

Appendage:

- Long, wide muscle that extends from the horse's head to the frontleg
- Covers the cranial aspect of the point of the shoulder, aiding in the movement of the leg and shoulder
- Acts as a lateral flexor of the neck

The M. Brachiocephalicus is responsible for the forward movement of the front leg as well as the lateral flexion of the head and neck. Furthermore, the M. Brachiocephalicus adducts the limp and forms the dorsal border of jugular groove.



Pic.5: M. Brachiocephalicus (source: www.horsecurator.com)

M. biceps femoris

Origin:
- Dorsal- and transverse process of the last 3 sacral vertebrae
- Positioned at the hind frame of the ischium and connected ventrally at the Tuber ischiadicum

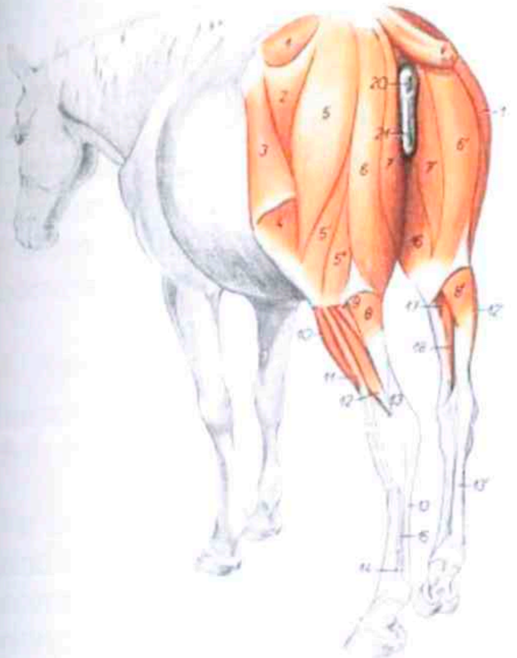
Appendage:
- Forms the proximal third of the tibia
- Is a lateral part of the common calcanean at the calcaneal tuberosity
- Via aponeurosis connected to the patella

M. semi tendinosus

Origin:
- Last sacral vertebra, as well as 1. and 2. caudal vertebra
- Ventrally at the Tuber ischiadicum

Appendage:
- Proximal third of the tibia
- part of the common calcanean at the calcaneal tuberosity

The muscle group of M. biceps femoris (No.5 in pic.6) and M. semi tendinosus (No.6 in pic 6) is responsible for the stretching and immobilisation of the hind limbs (Ellenberger; Baum, 1932). These are also called "the engine" of the horse (Girtler et al., 2003), which fulfil several tasks. During the stance phase the knee joint gets stretched by the hind limb muscles which are located cranial to the pivot point to push the hull forward. In the swing phase the distally positioned muscles provoke the flexion of the knee joint (Schamhardt et al., 1991).
The M. semitendinosus and the vertebra-head form the hind limb outline of the croup.



Pic.6: Equine hind limb muscles (source: www.o.quilet.com)

M. logissimus dorsi

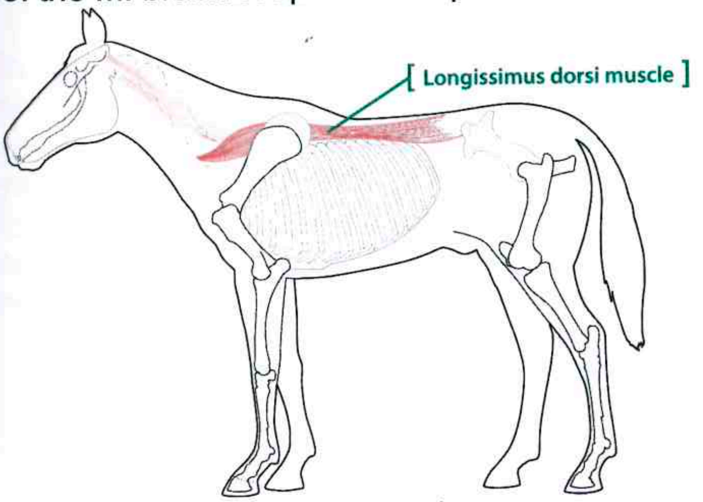
Origin:

- with broad aponeurosis on lig. supraspinale from 3./4. thoracic vertebra till 6. lumbar vertebra.

Appendage:

- medial at proximal humerus in combination with the end-filament of the M. teres major.

The M. longissimus dorsi (pic.7) forms the most important backwards pulling muscle of the all over extremities during deflexion of the point of shoulder. As an antagonist of the M. brachiocephalicus it pulls forward the torso of the horse.



Pic.7: M. Longissimus dorsi (source: www.eastcrowsaddlery.com)

3.7. Statistical Analysis

Significant differences of algometric measurements before and after the andullation therapy and placebo treatments were analysed using a paired t-test (P < ,05). Significant correlations were analysed by using a nonparametric correlation test, Spearman`s rho (P< ,05).
Before testing differences and correlations concerning the effect of IRVT, the correlation of the two methods got compared.

4. Results

4.1. Verification of methodology

To scan if the executed methodology, to be specific, the use of a pressure algometer and the assessment of an equine physiotherapist were adequate and compliant, the correlation between these two methods got tested. By using the test of nonparametric correlation, spearman`s rho (P < 0.05), the two examination results got compared. The test was adapted to both groups, placebo and treatment.
The test results show, that there is a significant correlation (P = ,000; marked green) between the outcome of the pressure algometer and the equine physiotherapist concerning both groups, placebo (table 1) and treatment (table 2).

PLACEBO GROUP	**Equine physiotherapist**	**Pressure algometer**
Correlation Coefficient	- ,860	- ,860
P-value	,000	,000

Tab. 1: Result of correlation test between physiotherapist and PA outcome within placebo group (n=80)

TREATED GROUP	**Equine physiotherapist**	**Pressure algometer**
Correlation Coefficient	- ,844	- ,844
P-value	,000	,000

Tab. 2: Result of correlation test between physiotherapist and PA outcome within treatment group (n=305)

In figure 1 and 2 this significance is shown by comparing the outcomes of the physiotherapist and PA. The physiotherapist assessed ordinal, precisely, from 1 to 5, whereas 5 indicates the highest possible muscle tone and 1 the lowest. The PA values range from 0, 0 to 22, 0, whereby 0, 0 indicates the highest possible muscle tone and 22, 0 the lowest. Both figures, concerning treatment and placebo group do show that the evaluations of the two methods do correlate with each other. The higher the physiotherapist value, the lower the PA value.

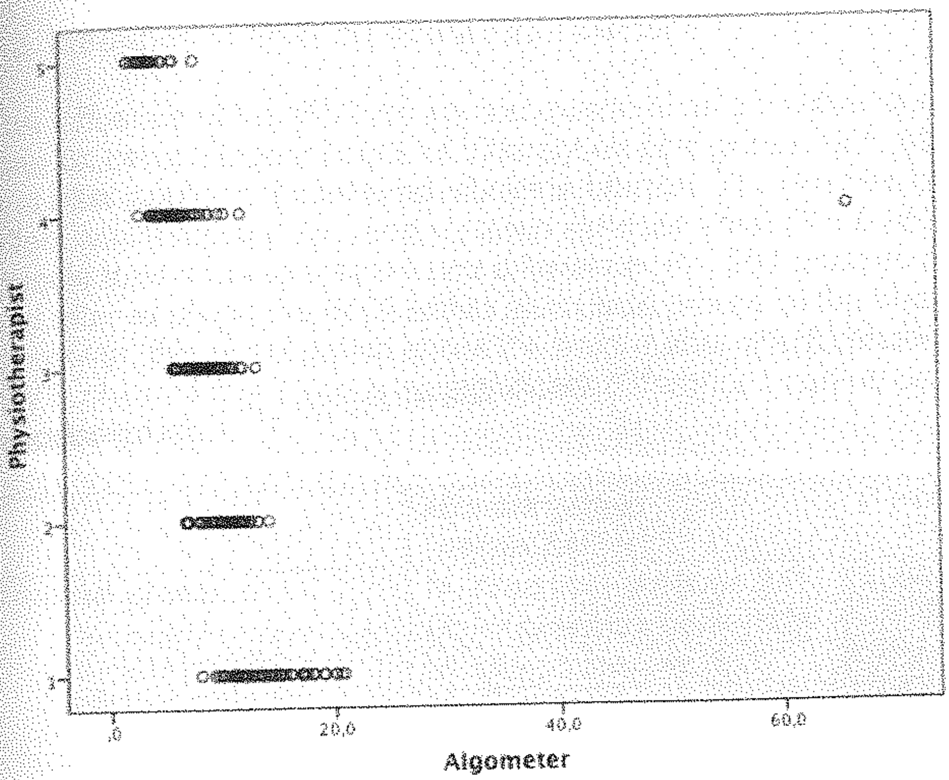


Fig.1: Result of comparison between the outcomes of physiotherapist and PA in treatment group (n=305)

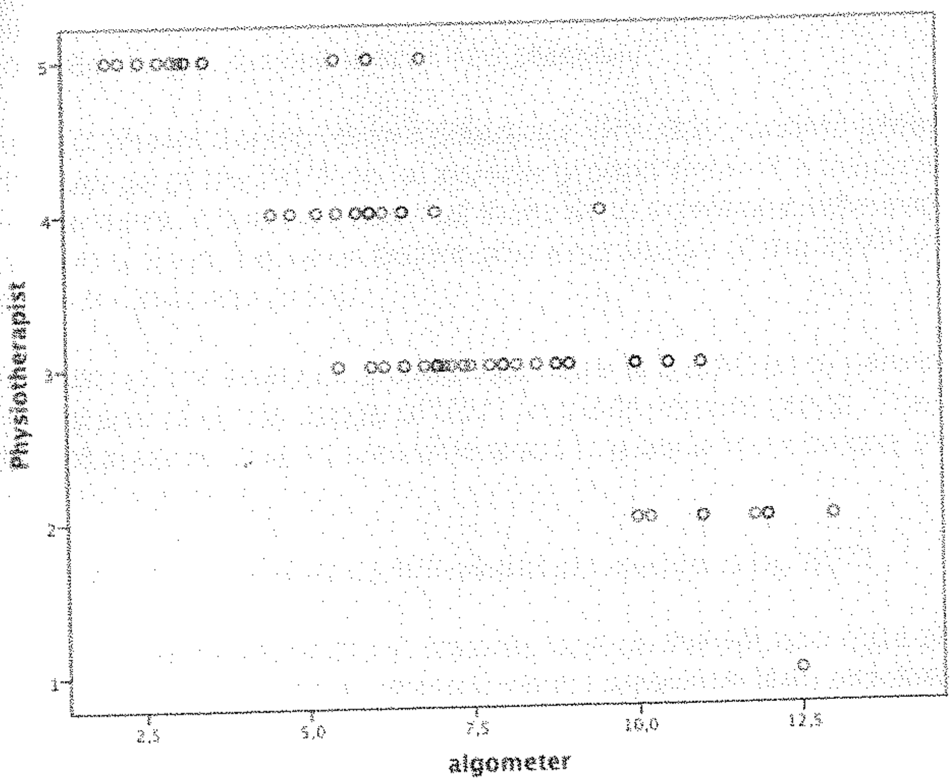


Fig.2: Result of comparison between the outcomes of physiotherapist and PA in placebo group (n=80)

Due to this result, further tests only included the outcome of the PA to simplify testing conditions. The significant correlation allows the elimination of one of the method outcomes.

4.2. Influence of IRVT on equine muscle tone

The influence of the IRVT on equine muscle tone got tested by measuring the muscle tone on certain trigger points of different muscle groups (M1, M2, M3 and M4) before and after applying the infrared-vibration-blanket. The analysis of the before-after effect was executed by using a paired samples t-test ($P < 0.05$). The analysis of the muscle tone showed a significant difference (P= ,000; marked green) between before and after applying the IRVT within all muscle groups of the treated testing group. Moreover, the investigation about the before-after effect concerning the usage of IRVT, showed that there is no significant difference (marked orange) within the placebo group.

	Muscle group (before&after)	P-value
Treated group	M. brachiocephalicus (M1)	,000
	M. longissimus dorsi (M2)	,000
	M. biceps femoris (M3)	,000
	M. semi tendinosus (M4)	,000
Placebo group	M. brachiocephalicus (M1)	,571
	M. longissimus dorsi (M2)	,388
	M. biceps femoris (M3)	,074
	M. semi tendinosus (M4)	,653

Tab.3: Results of differences between before and after IRVT within all muscle groups and sample groups (treatment and placebo)

Table 3 shows the significant difference (P= ,000; marked green) between before and after usage of the IRVT on all muscle groups within the treatment group. Furthermore, it can be seen that there is no significant difference (P= ,074 - ,653; marked orange) between before and after usage of the IRVT on all muscle groups within the placebo group.

To sum up, the analysis proved that there is a difference between the muscle tone before and after the usage of IRVT in the treatment group. The placebo group in turn did not show any significant difference in muscle tone before and after applying the IRVT.

4.3. Correlation between left and right concerning IRVT

The correlation between the muscle tone on the left and right side of the equine body got analysed by using a nonparametric correlation test, precisely, the Spearman`s rho test ($P< 0.05$). The muscle tone got measured on the left and right hand side, as well as before and after applying IRVT. Therefore, it could be tested if the values differ between left and right and before and after. The result indicates if the balance between left and right will be influenced by IRVT. Once again, the treatment and the placebo group were analysed separately.

			Equine physiotherapist	Pressure algometer
Treated group	Left and right before IRVT	Correlation Coefficient	,730	,730
		P-value	,000	,000
	Left and right after IRVT	Correlation Coefficient	,773	,773
		P-value	,000	,000
Placebo group	Left and right before IRVT	Correlation Coefficient	,812	,812
		P-value	,000	,000
	Left and right after IRVT	Correlation Coefficient	,796	,796
		P-value	,000	,000

Tab.4: Results of correlation test between left and right before and after IRVT within treatment (n=76) and placebo (n=17) group

The analysis of the correlation (tab.4) between the left and right hand side proves that there is a significant correlation (P= ,000; market green) between left and right as well as before and after applying the IRVT in the treatment and placebo group.

5. Discussion

5.1. Methodology and samples

Analysing the chosen methodology and samples used for this study, it can be mentioned that the sample size was adequate to gain significant results (vide 4.Results). Nevertheless, the methodology needed to be verified by comparing the outcomes of both methods, PA and assessment of the equine physiotherapist to allow substantiated predictions. The result of the outcome comparison of both methods fits the statement that the PA, as well the equine physiotherapist assessed the muscle tone with the same gradient within the treatment and placebo group, therefore the two methods do correlate with each other (vide Tab.1+2; fig. 1+2). The correlation of these two outcomes allows the general statement that the chosen measurement tools were also adequate.
Moreover, the method of point-by-point exploration instead of flexion testing was conducted to ensure an objective evaluation. Flexion testing is already known as examination method from former studies (e.g. Biermann et al., 2013) but was evaluated as non-fitting method for the current research. The participating equine physiotherapist stated that flexion testing could already influence the muscle tone after first examination taken before the usage of IRVT. During flexion testing, several ligaments, tendons and muscles get stretched, thus affected by the manual movements of the physiotherapist. Due to this stretching and flexing of the equine physic, the muscle tone would be influenced by other factors than the IRVT. The point-by-point exploration in turn, sets small stimuli on certain trigger points which do not affect the general status of the muscle tone. The applied pressure to these trigger points does just indicate the PPT and does not have any therapeutically influence on tendons, ligaments or muscles. In addition, these trigger points were also utilisable for positioning the PA. Since flexion testing does not take place at one specific position, by using flexion testing, the PA would not have been as comparable to the assessment of the physiotherapist as using point-by-point exploration. Whereby, the

trigger points of the muscles were utilisable for the point-by-point exploration as well as the PA.
Therefore, the method of point-by-point exploration was used as evaluating tool in this study.

5.1.1. Evaluating the reaction of horses during assessments

The evaluation of the horses` reaction to the assessments of the muscle tone, PA and point-by-point exploration was conducted by interpreting the animals' body language and movements. The pressure given by the equine physiotherapist as well as by the PA got applied until a reaction of the horse was recognised. These reactions could have been pinned back ears or a movement away from the pressure (3.4; 3.5). The evaluation of that specific point, when exactly to release the pressure, was relatively demanding due to the fact that every horse does react differently to the pressure. The reaction does depend on the horse's disposition, temperament and form of the day in addition to its current muscle tone. Therefore, the accuracy of the outcomes can not be determined as completely objective. Nevertheless, the test results of the correlation test between the assessment of the PA and physiotherapist do show significance, which at least affirms an equal interpretation of the horses` reactions concerning both methods. Consequently, this research did not compare single muscle tone values but the before-after effect of every horse with each other, experiencing that every horse possesses its individual status of muscle tone when resting.

5.1.2. Pressure algometry as measurement tool to evaluate equine muscle tone

Looking at former studies, PA developed to be an objective and non-invasive method used to measure mechanical nociception in horses (Haussler, 2006). In 2006, Haussler described PA as a quantitative and repeatable tool for assessing the presence of musculoskeletal pain in horses. Moreover, in earlier research and clinical trials, PA showed wide variations in responses between animals (Haussler, 2006; De Heus, 2010). In 2012, Zimmermann et al suggested that the technique of PA might be a more useful method for the quantification of intra-individual responses to treatment rather than a reliable detection of pain response. Sullivan et al. (2008) did support the usage of PA as an objective tool with which to evaluate the effect of commonly used but scientifically unproven treatment modalities. Although PA is a widely used technique for examination of pain thresholds in human medicine (Nussbaum, 1998; Ohrbach, 1989), the assessment of certain pressure pain stimulus-response function in animals is demanding due to the difficulty of manually applying a constant rate of pressure. Neither in human medicine nor in veterinary medicine, has a standard pressure rate been established (Biermann, 2013). For humans, pressure rates do vary between 0, 2 and 1 kg/cm2/s (Treede, 2012). In former studies of horses, a relatively high pressure rate of 10 kg/cm2/s has been used. This choice was explained by the high number of measurement sites per horse (Haussler, 2006; Sullivan, 2008).

5.2. The influence of IRVT on equine muscle tone

The study was aiming at investigating if the use of IRVT does have an effect on the equine muscle tone. Especially the effect of IRVT after first application was of interest. The research did base on the experimental test of using the IRVT once on an adequate sample group (vide 5.1.). The test results do show that there is a significant difference (P= ,000)) between before and after using the IRVT in every tested muscle group within the treatment group (Tab.3). This difference permits the statement that the muscle tone is lowered by the single use of IRVT (vide annex 1: data overview sheet). This result is further supported by the controlling placebo group, which in turn did not show any significant difference (Tab.3) in muscle tone between before and after applying the IRVT. The tables 5 and 6 show the example of the before-after effect within the first muscle M. brachiocephalicus (M1) of the treatment and placebo group. The PA value indicates the outcome of the pressure testing, whereas a low value indicates a high muscle tone and vice versa. In table 5 it can be seen that the muscle tone got lowered after IRVT in almost every sample. Although, few exceptions can be visibly observed, the result is still scientifically significant (Tab.3).

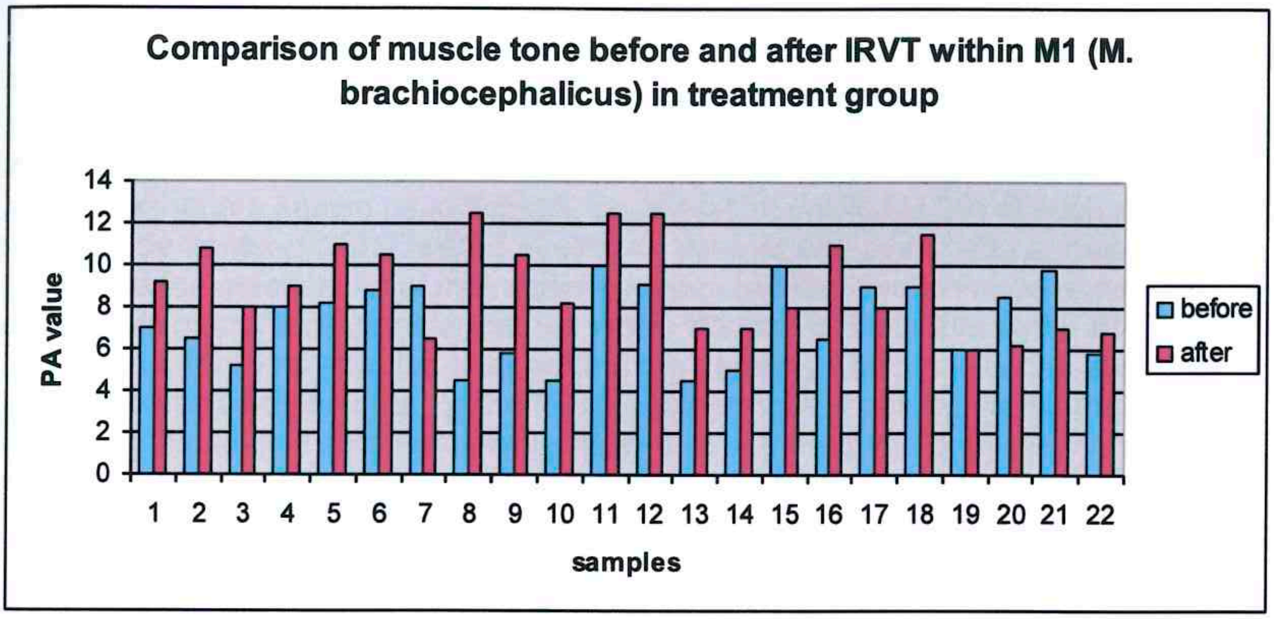


Fig.3: Diagram of before and after difference in muscle tone in treatment group in M1

Within the placebo group (Tab.6), it can be noticed that the before-after effect is not as clear as in the treatment group (Tab.5). Looking at table 6, it can even be apprehended that the muscle tone in few samples did increase after applying IRVT. The few samples that showed a lowered muscle tone within the placebo group also only demonstrated a slightly visible change. Again, the result is still significantly proven as not different (Tab.3). The effect of an increased muscle tone after applying the IRVT without switching it on could lead to the assumption that the additional weight and coating of the IR blanket did cause qualm in the horses that made them tense their muscles.

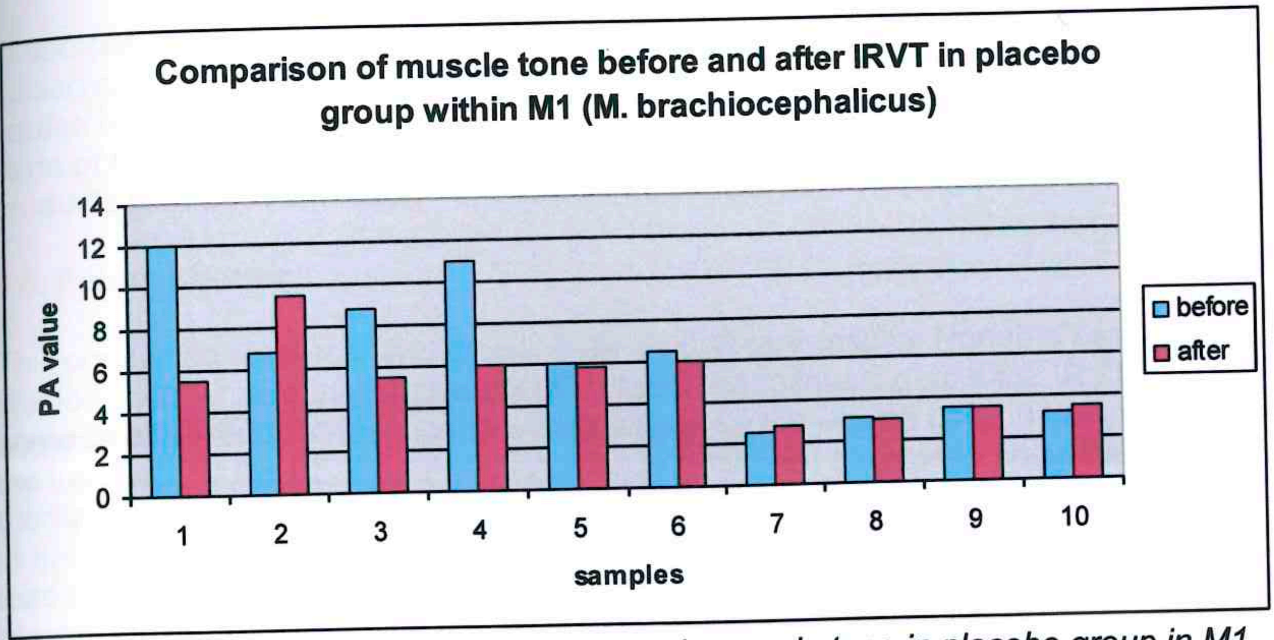


Fig.4: Diagram of before and after difference in muscle tone in placebo group in M1

In addition, the treatment group individuals did show several signs and body language that are known as indicators for relaxation (Williams 2014) such as lowered necks (vide annex-pic.3), lowered eyelids or even closed eyes (vide annex-pic. 1+2) as well as the mechanism of intermittent upward patellar fixation (vide annex-pic. 4+5). Most often these signs appeared within the first 6-9 minutes of the IRVT and continued until some minutes after ending the therapy, which allows the assumption that the horses did relax during the IRVT. Furthermore, it can be stated that the increased blood flow and therefore temperature of the equine body, which was already proven by hhp-home health products (vide 3.3.1. Pic.2) does lead to a decreased muscle tone. Hence, these research studies are coherent with the statement of Dickreiter (2010) that IR radiation does increase blood flow, metabolism and causes a decrease of the muscle tone.

5.3. The influence of IRVT on the left-right balance of the equine muscle tone

Another aim of the research was to investigate if the IRVT does have any impact on the balance between the left and right hand side of the equine physic, more precisely the muscle tone. To prove if there is an effect on this balance, a correlation test between both sides, respectively, before and after applying the IRVT was conducted (vide annex-tab.11-14). The test results indicate that there is no difference between the muscle tone on the left and right side concerning before and after IRVT (Tab.4). Therefore, it can be stated that the IRVT does not influence the balance between left and right. This test result describes that there was already a correlation between both sides before using IRVT as well as after. Consequently, it can be stated that the IRVT does affect both sides of the equine body in the same way, therefore, the chance of a loss of balance between left and right due to the IRVT equals zero. This outcome allows the assumption that the setup and array of the IR-vibe aggregates of the IR blanket are adequate. In addition, this correct setup of the blanket-structure can be underpinned by the test results of the before-after effect of all muscle groups. All muscle groups (M1-M4) did show a significant difference (Tab.3) after using the IRVT, therefore the IR blanket seems to be an appropriate method to give therapy to the whole equine body.

In comparison, former studies concerning alternative therapy methods such as pulsed electromagnetic fields (Biermann, 2013) did only cover specific parts of the equine body, e.g. thoracic spine. Thus, these methods can only be applied on certain parts of the body and therefore also just treat these parts. The hhp-home health products blanket in turn allows a whole-body therapy.

5.4. Future studies

This conducted research already generated significant results. Nonetheless, future studies could enable even more specific outcomes to investigate if the IRVT by hhp-home health products has more positive effects on the equine body. The results of the influence of the IRVT on the equine body (Tab.5+6) did clearly show that the therapy does effect the muscle tone positively when switched on. The placebo group in turn, did even show few negative influences when switched off. This result could lead to a prospective study to prove if the covering of horses with heavy or static blankets does affect the animals` wellbeing. The current test result indicates that this assumption can be made, due to the fact that some horses did experience qualm during and after being covered with the blanket for 15 minutes (switched off). Knowing that even non-therapeutic horse winter blankets do already have a certain weight, a study concerning the influence of heavy blankets on horses` welfare could bring interesting results in regard to optimization of horse blankets in general and further the IRVT.

In addition, further research concerning the long-term effect of the IRVT would be interesting to investigate if the muscle tone would be set down permanently when applying the blanket frequently. Moreover, further effects on the equine body caused by IRVT might be examined. These effects could be increased removal of body fluids (e.g. lymph fluids) or an optimization of lactate exploitation knowing that these effects might be traced back to increased blood flow.

Reflecting the used methodology, it can be stated that the muscle tone testing by using trigger points for the PA as well as checking point for the equine physiotherapist is adequate. Both testing methods did correlate with each other and did bring significant results. Therefore, the chosen methodology could be recommended. Nevertheless, the higher the sample size, the higher the reliability of the result, hence an increased sample size might be chosen for future research.

6. Conclusion

To conclude the results of the performed research it can be stated that the IRVT by hhp-home health products does have a positive impact on the equine muscle tone. The first hypothesis, namely if the IRVT does influence the equine muscle tone after first application, can be confirmed. The current research did cover the difference of the muscle tone just before and after applying the therapy without investigating in the long-term effect of IRVT; therefore this thesis can be affirmed. Furthermore, the examination if the muscle tone got lowered by using IRVT, showed also endorsement. The equine muscle got lowered within all treated horses as well as in every muscle group. Hence, the single use of the IRVT does lower the muscle tone significantly.

Also the measurement techniques did bring the same outcome, thus both methods are verified as reliable and can be seen as appropriate. Concerning the correlation between left and right, it can be stated that the therapy does not influence the balance between left and right. Accordingly, the equine body got treated evenly.

Comprising, all hypothesis erected can be affirmed.

6.1. Limitations

The conducted study was limited in certain ways. The given time frame of 10 weeks did not enable a long-term study of the influence of the IRVT. Furthermore, the number of horses, hence sample size, was limited to 24. A higher number of samples could have resulted in more valid test results with a higher reliability. Moreover, the results might have been more reliable if all horses would have been the same age, trained at same level and in best case educated by the same trainers or riders to exclude influencing factors like training schedules of the animals or equestrian skills of the riders.

6.2. Recommendations

When developing therapy treatments for horses, research about the animals` response and reaction is indeed indispensable but difficult to conduct diagnostically conclusive. The reaction of animals sometimes needs to be more interpreted than analysed due to the fact that the participants can not express themselves clearly by telling where the pain is located or when the applied pressure becomes unacceptable. The current research tried to include these factors and developed objectively significant results. The test results bring up recommendations about optimization of the therapy blanket. Although, this study did not aim for it and further, did not clearly outline any significant results, it can be assumed that the weight and wearing comfort of the hhp-blanket might get adjusted to the reaction of the placebo group. More precisely, the placebo group did show few negative reactions in terms of being covered with the blanket without being switched on. The increased muscle tone after covering the horses with the switched-off blanket indicated a cause of uneasiness in these horses. This indisposition might be caused by the weight and wearing comfort of the blanket, since there have not been any other differences of the circumstances. On the other hand, did the treated group show a lowered muscle tone, which proves that the weight and comfort at least do not affect the treatment pivotally. However, optimized wearing comfort and lighter weight could probably even increase the positive effect of the blanket.
Focussing on the positive effect on the equine muscle tone after single use, the company could set an adjusted marketing and sales strategy on the, then, new target group. Knowing that already one application does have an impact on the horses, the idea of renting out the product would be an option. By implication, a service of mobile IRVT treatment might be developed.
Possible future research might bring further optimisation options; therefore, scientific investigations concerning the effect of the IRVT should be involved in future marketing and sales procedures.

7. Acknowledgements

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References

Akai, M., Hayashi, K., 2002. Effect of electrical stimulation on musculoskeletal systems; a meta-analysis of controlled clinical trials. Bioelectromagnetics 2002; 23:132–43.

Alexander, R., McN., 1977. Terrestrial locomotion. In: Alexander, R.McN., Goldspink, G. (Eds.), Mechanics and Ernergetics of Animal Locomotion. Academic Press, London.

Auer, J.A., Burch, G.E., Hall, P., 1983. Review of pulsing electromagnetic field therapy and its possible application to horses. Equine Vet J 1983; 15: 354–60.

Ariizumi, M., Okada, A., 1983. Effect of whole body vibration on the rat brain content of serotonin and plasma corticosterone. European journal of applied physiology and occupational physiology.

Bäumler, H., H. P., Scherf, R., Aurisch, D., Strangfeld, H., Siewert, H., Meffert, K., Dittman, J., Plettig u. N. Sönnichsen, 1990. Einfluss einer Serie von Infrarot-Ganzkörperbestrahlungen auf Fließeigenschaften des Blutes und die Hämodynamik. Perfusion 4, 138-144.

Bayerns Pferde 05/2001. Die Muskulatur des Pferdes. [online] Available at www.dlv.de [assessed on_2nd of March 2014].

Biermann, N.M., Rindler, N., Buchner, H.H.F., 2013. The Effect of Pulsed Electromagnetic Fields on Back Pain in Polo Ponies Evaluated by Pressure algometry and Flexion Testing. A Randomized, Double-blind, Placebo-controlled Trial. Elsevier. Journal of equine veterinary science. 2013. p. 1-8.

Brasch, E., Gall, J., Kleinschmidt, H. u. Senn, E., 1989. Verlauf von Kreislaufparametern und Temperaturmessungen an verschiedenen Körperregionen bei Infrarot-Hyperthermie nach dem Verfahren von Heckel. Z. Phys. Med. Baln. med. Klim. 18, 77-84

Bromiley, M.W. 1993. The machines and their uses. In: Equine injury, therapy and rehabilitation. 2nd ed. Oxford, UK: Blackwell; p. 77–84.

De Heus, P., Van Oossanen, G., Van Dierendonck, M.C., Back, W. 2010. A pressure algometer is a useful tool to objectively monitor the effect of diagnostic palpation by a physiotherapist in Warmblood horses. J Equine Vet Sci 2010; 30:310–21.

Dickreiter, B., 2001. Neues aus der Infrarot-Forschung. Infrarot-Strahlung für die Praxis. Erfahrungsheilkd. 50 (1), 25-30.

Ellenberger, W., Baum, H., 1932. Handbuch der vergleichenden Anatomie der Haustiere. Berlin, Springer Verlag, 17. Aufl.

Fischer, A.A., 2011. Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold.

Girtler, D., 2003. Zur Biomechanik der Hintergliedmaße beim Pferd - Einfluss der Anhebung der Trachten auf das Sprunggelenk. Pferdeheilkunde 19 (2003) 3 (Juli/August) 345-348

Haussler, K.K., Erb, H.N., 2006. Mechanical nociceptive thresholds in the axial skeleton of horses. Equine Vet J 2006;38:70–5.

Haussler, K.K., Erb, H.N., 2006. Pressure algometry for the detection of induced back pain in horses: a preliminary study. Equine Vet J 2006; 38:76–81.

Johnson, E.W., 1989. The myth of skeletal muscle spasm. American Journal of Physical Medicine & Rehabilitation. February 1989. Volume 68 - Issue 1, p. 1.

Kalinowski, S., 2007. Der Einfluss von Infrarot-C-Strahlung auf Rückenbeschwerden bei Reitpferden nach Behandlung in einem Thermium. Aus der Klinik für Pferde der Tierärztlichen Hochschule Hannover, 2007.

Kurz, H., 2002. Therapeutische Wirkung der Infrarot-Strahlungswärme. Info 12/2 RUKUinterne Information für den Außendienst, 1.3.

Lindner, M., Brinkhaus, B., 2000. Die Sauna – Chancen und Risiken in Prävention und Therapie. Phys. Med. Rehab. Kuror. 10, 165-175.

Mc Gowan, C.M., Stubbs, N.C., Jull, G.A. 2007. Equine physiotherapy: a comparative view of the science underlying the profession. Equine Vet J 2007;39:90–4.

Meffert, H., Piazena, H., 2001. Wirkung der milden Infrarot-A-Hyperthermie auf den Blutdruck. In: Kaase, H., Serick, F. (Hrsg.): Licht und Gesundheit 2. Symposium, Druck: Kistmacher, Berlin.

Meffert, H., Piazena, H., 2002. Wirkungen künstlich erzeugter Infrarotstrahlung auf den Menschen. Akt. Dermatologie 28, 187-192.

Nussbaum, E.L., Downes, L., 1998. Reliability of clinical pressure-pain algometric measurements obtained on consecutive days. Phys Ther 1998;78:160–9.

Ohrbach, R., Gale, E.N., 1989. Pressure pain thresholds in normal muscles: reliability, measurement effects, and topographic differences. Pain 1989;37:257–63.

Porter, M., 1998. Magnetic field therapy. In: The new equine sports therapy. 1st ed. Lexington, KY: Blood-Horse; 1998. p. 185–98.

Ramey, D.W., 1999. Magnetic and electromagnetic therapy in horses. Compend Contin Educ Vet 1999;21:553–60.

Richter, W., Schmidt, W., Schmidt, K., 2000. Infrarot-Wärmekabine als milde Ganzkörper-Hyperthermie. Z. Onkol. / J. of Oncol. 32 (4), 96-103.

Richter, W., Schmidt, W., 2002. Bemerkungen zur Wirkungsweise von Infrarot-Wärmekabinen. Dtsch. Zeitschr. Onkol., 34, 146-156.

Richter, W., Schmidt, W., 2002. Milde Ganzkörper-Hyperthermie mit Infrarot-C-Strahlung. Dtsch. Zeitschr. Onkol., 34, 49-58.

RUKU, 2005. Pferde-Thermium / Wärmestrahlungsbad. RUKU GmbH & Co. KG, Illertissen.

Sanders-Shamis, M., Bramlage, L.R., Weisbrode, S.E., Gabel, A.A., 1989. A preliminary investigation of the effect of selected electromagnetic-field devices on healing of cannon bone osteotomies in horses. Equine Vet J 1989;21:201–5.

Schamhardt, H.C., Hartmann, W., Janssen, M.O., 1991. Biomechanic of the pelvic limb of the horse. Swiss. Vet. 8, 7–10.

Simons, D.G., Mense, S., 1998. Understanding and measurement of muscle tone as related to clinical muscle pain. Elsevier, Volume 75, Issue 1, pages 1-17.

Smania, N., 2010. Eur J Phys Rehabil Med. American Association of Neurological Surgeons.

Snow, D.H. and Valberg, S.J., 1994. Muscle anatomy, physiology and adaptations to exercise and training. In Rose, R.J. and Hodgson, D.H. (eds) The Athletic Horse: principles and pratice of equine sports medicine. Philadelphia, PA, W.B. Daunders Co., 1994.

Sullivan, K.A., Hill, A.E., Haussler, K.K., 2008. The effects of chiropractic, massage and phenylbutazone on spinal mechanical nociceptive thresholds in horses without clinical signs. Equine Vet J 2008;40: 14–20.

Treede, R.D., Rolke, R., Andrews, K., Magerl, W., 2002. Pain elicited by blunt pressure: neurobiological basis and clinical relevance. Pain 2002;98: 235–40.

Turner, T.A., 2001. Diagnostic Thermography. Vet. Clin. North Am. Equine Prac.

Valberg, S.J. and Macleay, J.M., 1994. Skeletal muscle function and metabolism. Department of Clinical and Population Sciences, Collage of Veterinary Medicine, University of Minnesota, St Paul, Minnesota, USA.

Williams, J., PhD. January 2014. How to read your horse`s body language. EQUUS, issue #424.

Zimmerman, M., Dyson, S., Murray, R., 2012. Close, impinging and overriding spinous processes in the thoracolumbar spine: the relationship between radiological and scintigraphic findings and clinical signs. Equine Vet J 2012;44:178–84.

References Pictures

Pic.1: www.hhp.de (online assessed on 20.03.2014)
Pic.2: www.hhp.de (online assessed on 20.03.2014)
Pic.3: Copyright by Saskia Ehlen
Pic.4: Copyright by Saskia Ehlen
Pic.5: http://www.horsecurator.com/wp-content/uploads/2013/01/Brachiocephalicus_Sm.png (online assessed on 12.04.2014)
Pic.6: http://o.quizlet.com/rXM9x-16SONb72UqfEsvfQ_m.png (online assessed on 12.04.2014)
Pic.7: http://www.eastcrowsaddlery.com/wp-content/uploads/2010/03/website-pics-008.jpg (online assessed on 12.04.2014)

Annex

Annex 1. Data overview-sheet

			1. Muscle (Brachiocephalicus)		2. Muscle (Longissimus dorsi)		3. Muscle (Biceps femoris)		4.Muscle(Semitendinosus)	
			Before	After	Before	After	Before	After	Before	After
Horse 1	Physio	Right	2	3	4	3	3	3	4	3
	Physio	Left	5	4	3	3	3	3	3	3
	Algo	Right	12	5,5	6,5	7	10	11	6,5	7
	Algo	Left	6,8	9,5	9	8,5	8,8	10	9	8,5
Horse 2	Physio	Right	4	3	4	2	2	2	4	2
	Physio	Left	4	3	3	3	3	1	3	3
	Algo	Right	7	9,2	8	12	11,8	11,8	8	12
	Algo	Left	6,5	10,8	10	9,2	11	15	10	9,2
Horse 3	Physio	Right	5	4	3	2	2	2	3	2
	Physio	Left	5	4	3	2	3	3	3	2
	Algo	Right	5,2	8	10	11,2	11,8	13,2	10	11,2
	Algo	Left	8	9	10	11,2	8,2	10	10	11,2
Horse 4	Physio	Right	3	2	1	1	1	1	1	1
	Physio	Left	3	2	1	1	1	1	1	1
	Algo	Right	8,2	11	14,5	15	16	17,2	14,5	15
	Algo	Left	8,8	10,5	17,5	17	20	16	17,5	17
Horse 5	Physio	Right	3	5	1	2	2	3	1	2
	Physio	Left	2	4	3	2	3	3	3	2
	Algo	Right	8,8	5,5	12,5	11	12	9	12,5	11
	Algo	Left	11	6	10	13	10	11	10	13
Horse 6	Physio	Right	3	4	3	1	4	1	3	1
	Physio	Left	5	2	1	1	3	1	1	1
	Algo	Right	9	6,5	8,8	13,5	6,9	16	8,8	13,5
	Algo	Left	4,5	12,5	14	19	8	13,5	14	19
Horse 7	Physio	Right	4	2	4	3	3	2	4	3
	Physio	Left	4	3	4	3	3	2	4	3
	Algo	Right	5,8	10,5	8	11,2	10,5	12	8	11,2

	Algo	Left	4,5	8,2	6	8,2	10,5	13,2	6	8,2
Horse 8	Physio	Right	3	2	1	1	1	1	1	1
	Physio	Left	3	2	1	1	2	1	1	1
	Algo	Right	10	12,5	20	17	19	18	20	17
	Algo	Left	9,1	12,5	15	19	11	17	15	19
Horse 9	Physio	Right	4	3	3	2	3	2	3	2
	Physio	Left	4	3	3	2	2	1	3	2
	Algo	Right	4,5	7	8,2	11,5	7,2	11,5	8,2	11,5
	Algo	Left	5	7	8,2	11	11,2	13	8,2	11
Horse 10	Physio	Right	3	3	3	2	4	3	3	2
	Physio	Left	4	2	3	3	3	2	3	3
	Algo	Right	10	8	9,5	11,5	5,5	9	9,5	11,5
	Algo	Left	6,5	11	10	8,5	8	10,5	10	8,5
Horse 11	Physio	Right	3	3	2	1	3	3	2	1
	Physio	Left	3	2	4	1	3	1	4	1
	Algo	Right	9	8	11	13,5	9	9,8	11	13,5
	Algo	Left	9	11,5	6,5	11	8,5	12,5	6,5	11
Horse 12	Physio	Right	4	4	5	3	2	1	5	3
	Physio	Left	2	3	4	2	2	2	4	2
	Algo	Right	6	6	3,2	7,6	11,2	11,5	3,2	7,6
	Algo	Left	8,5	6,2	5,8	10	6,8	8	5,8	10
Horse 13	Physio	Right	2	2	2	4	1	1	2	4
	Physio	Left	3	2	2	2	2	2	2	2
	Algo	Right	9,8	7	9,2	9,2	13,2	12	9,2	9,2
	Algo	Left	5,8	6,8	11,8	8	10	11,5	11,8	8
Horse 14	Physio	Right	3	2	3	2	2	1	3	2
	Physio	Left	3	1	4	4	3	3	4	4
	Algo	Right	6,2	8,5	6	7	9	11	6	7

	Algo	Left	10,2	11,2	4,2	6	8,2	8,8	4,2	6
Horse 15	Physio	Right	4	4	1	1	1	2	1	1
	Physio	Left	5	4	1	1	3	3	1	1
	Algo	Right	6,5	6	11,2	11,5	11,2	11,5	11,2	11,5
	Algo	Left	3,2	6,2	10	10,5	7	8,5	10	10,5
Horse 16	Physio	Right	1	1	1	1	1	1	1	1
	Physio	Left	1	1	1	1	1	1	1	1
	Algo	Right	14,2	9,5	20,8	15,2	17,2	14,5	20,8	15,2
	Algo	Left	10	11	17	12,5	12	20,5	17	12,5
Horse 17	Physio	Right	5	4	2	1	1	1	2	1
	Physio	Left	4	4	2	1	3	4	2	1
	Algo	Right	4,2	7	11,2	13,5	14,5	15,5	11,2	13,5
	Algo	Left	4,5	10	9	12,5	10	12	9	12,5
Horse 18	Physio	Right	3	2	3	3	3	3	3	3
	Physio	Left	3	2	3	3	3	2	3	3
	Algo	Right	7	7	6	6	9	11,8	6	6
	Algo	Left	7,2	8,2	9	6	8,5	11,8	9	6
Horse 19	Physio	Right	2	1	1	1	1	1	1	1
	Physio	Left	2	1	1	1	1	1	1	1
	Algo	Right	10	13,5	14,1	15,5	11,2	14	14,1	15,5
	Algo	Left	8	8	18,1	18,1	15	12	18,1	18,1
Horse 20	Physio	Right	1	1	2	1	3	2	2	1
	Physio	Left	3	2	1	1	2	1	1	1
	Algo	Right	10	10,8	7	12	7	10,8	7	12
	Algo	Left	8,5	10,5	9,2	12	9,5	11,2	9,2	12
Horse 21	Physio	Right	4	3	3	1	3	2	3	1
	Physio	Left	4	4	4	1	3	3	4	1
	Algo	Right	4,5	6,2	8,2	12,8	11	11,5	8,2	12,8

	Algo	Left	3	6	5,5	9,8	9,5	9	5,5	9,8
Horse 22	Physio	Right	4	4	2	2	3	3	2	2
	Physio	Left	4	4	3	3	3	3	3	3
	Algo	Right	6	5,8	12	11,8	10	10,5	12	11,8
	Algo	Left	6,5	6	10	10,5	10,5	10	10	10,5
Horse 23	Physio	Right	5	5	3	3	4	4	3	3
	Physio	Left	5	5	3	3	3	3	3	3
	Algo	Right	2,5	2,8	7,2	7,5	5,2	5,5	7,2	7,5
	Algo	Left	3,1	3	7	7	6,2	6,5	7	7
Horse 24	Physio	Right	5	5	3	3	3	3	3	3
	Physio	Left	5	5	2	2	3	3	2	2
	Algo	Right	3,5	3,5	8,8	9	8	8	8,8	9
	Algo	Left	3,2	3,5	10	10,2	8,2	8	10	10,2

Annex-Tab. data overview sheet: physio: low value= low muscle tone; algo: low value= high muscle tone

Annex 2.
Age and height

Age and height of sample horses:

Mean Age:

Report

Age

Mean	N	Std. Deviation
12,88	24	6,060

Mean Height:

Report

Height

Mean	N	Std. Deviation
1,6542	24	,09921

Annex 3.
Statistical results

Correlations

			Physiotherapist	Algometer
Spearman's rho	Physiotherapist	Correlation Coefficient	1,000	-,844**
		Sig. (2-tailed)	.	,000
		N	305	305
	Algometer	Correlation Coefficient	-,844**	1,000
		Sig. (2-tailed)	,000	.
		N	305	305

Annex-Tab.1: Correlation between physiotherapist and PA in treated group

Correlations

			Physiotherapist	algometer
Spearman's rho	Physiotherapist	Correlation Coefficient	1,000	-,860**
		Sig. (2-tailed)	.	,000
		N	80	80
	algometer	Correlation Coefficient	-,860**	1,000
		Sig. (2-tailed)	,000	.
		N	80	80

Annex-Tab.2: Correlation between physiotherapist and PA in placebo group

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M1before - M1after	37	,000

Annex-Tab.3: Result of difference test between before and after IRVT within M1 (treated group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M2before - M2after	37	,000

Annex-Tab.4: Result of difference test between before and after IRVT within M2 (treated group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M3before - M3after	37	,000

Annex-Tab.5: Result of difference test between before and after IRVT within M3 (treated group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M4before - M4after	37	,000

Annex-Tab.6: Result of difference test between before and after IRVT within M4 (treated group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M1before - M1after	9	,571

Annex-Tab.7: Result of difference test between before and after IRVT within M1 (placebo group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M2before - M2after	9	,388

Annex-Tab.8: Result of difference test between before and after IRVT within M2 (placebo group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M3before - M3after	9	,074

Annex-Tab.9: Result of difference test between before and after IRVT within M3 (placebo group)

Paired Samples Test

		df	Sig. (2-tailed)
Pair 1	M4before - M4after	9	,653

Annex-Tab.10: Result of difference test between before and after IRVT within M4 (placebo group)

Correlations

			left_before	right_before
Spearman's rho	left_before	Correlation Coefficient	1,000	,730**
		Sig. (2-tailed)	.	,000
		N	76	76
	right_before	Correlation Coefficient	,730**	1,000
		Sig. (2-tailed)	,000	.
		N	76	76

Annex-Tab.11: Result of correlation between left and right before IRVT (treated group)

Correlations

			left_after	right_after
Spearman's rho	left_after	Correlation Coefficient	1,000	,773**
		Sig. (2-tailed)	.	,000
		N	76	76
	right_after	Correlation Coefficient	,773**	1,000
		Sig. (2-tailed)	,000	.
		N	76	76

Annex-Tab.12: Result of correlation test between left and right after IRVT (treated group)

Correlations

			right_before	left_before
Spearman's rho	right_before	Correlation Coefficient	1,000	,812**
		Sig. (2-tailed)	.	,000
		N	17	17
	left_before	Correlation Coefficient	,812**	1,000
		Sig. (2-tailed)	,000	.
		N	17	17

Annex-Tab.13: Result of correlation test between right and left before IRVT (placebo group)

Correlations

			left_after	right_after
Spearman's rho	left_after	Correlation Coefficient	1,000	,796**
		Sig. (2-tailed)	.	,000
		N	17	17
	right_after	Correlation Coefficient	,796**	1,000
		Sig. (2-tailed)	,000	.
		N	17	17

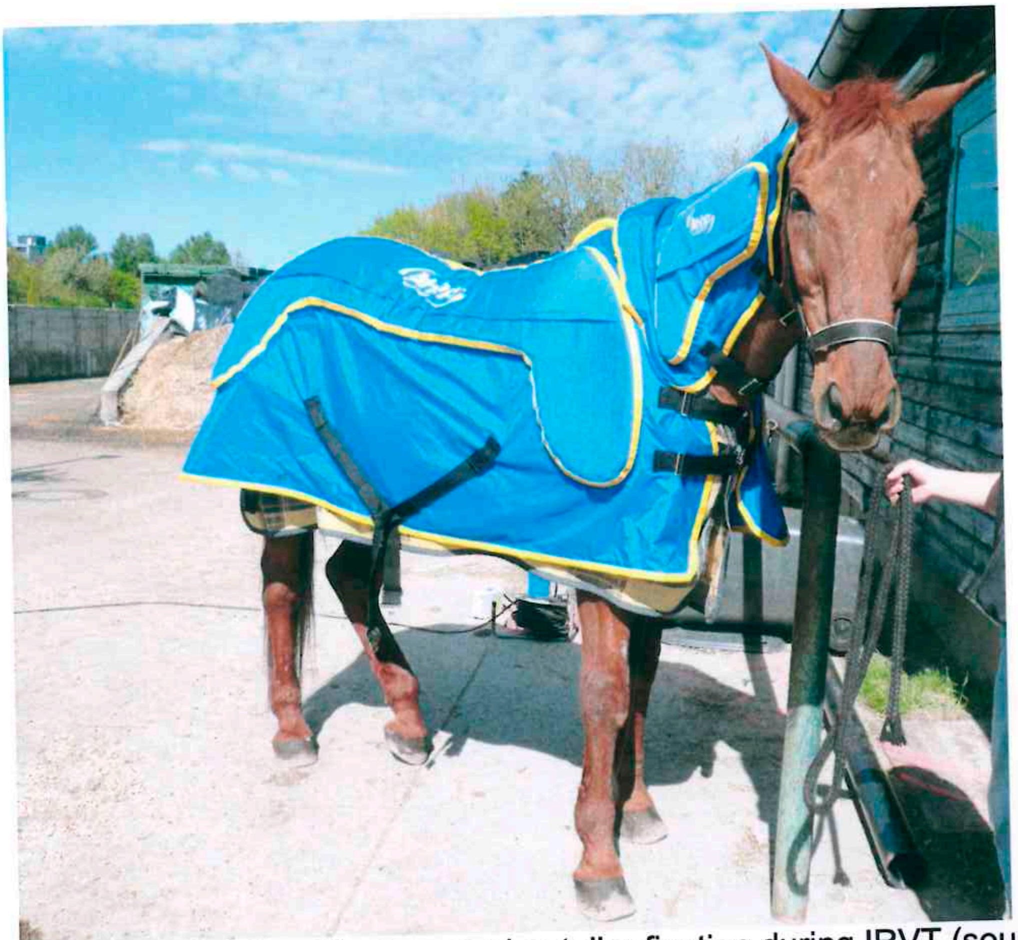
Annex-Tab.14: Result of correlation test between right and left after IRVT (placebo group)

Annex 4.
Pictures

Annex-Pic.1: Closed eyes during IRVT (source: author)

Annex-Pic.2: Closed eyes during IRVT (source: author)

Annex-Pic.3: Lowered neck during IRVT (source: author)



Annex-Pic.4: Intermittent upward patellar fixation during IRVT (source: author)

Annex-Pic.5: Intermittent upward patellar fixation during IRVT (source: author)