2015 Equine Trust Summer Scholarship

Smart Textiles for Equine Vibrational Therapy

Primary Researchers - Fisher, H and Joseph, F

Colab – Auckland University of Technology
Auckland, New Zealand

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This research project investigated the use of smart textiles for equine vibration therapy with a focus of integrating technology into textile-based products.

Smart or interactive textiles are an emerging area experiencing huge global growth (Markets and Markets, 2013). A leading area of application development is within the medical and healthcare sector. The benefits that smart textiles have brought to the medical and healthcare industry, such as bio-monitoring and therapeutic areas, have not been so readily incorporated in other areas such as animal care, this project looked at possibilities to do so.

Stage one of the project began in early December 2015 with an investigation into the use of vibration technology and current vibration motors available on the market. After conducting current and historical research into the use of vibrations for therapeutic and medical purposes, in both humans and animals a literature review was completed. This literature and product analysis review can be found as Appendix One – Literature and Product Review.

During the research onto vibration therapy, meetings with Auckland University of Technology (AUT) Physiotherapists were attended. This meeting raised important issues regarding the use of vibration therapy, whilst also making me aware of current research where vibration therapy is being investigated for use in human rehabilitation.

Throughout this summer research project, regular meetings with AUT Electrical Engineering staff were attended where power options and motor types were discussed and tested.

Stage two of the project involved the testing of a variety of vibration motors, which were purchased from around the country, to determine their specifications. Once an appropriate motor design and specifications were determined, a custom motor was build specifically for this investigation. This allowed for a range of frequencies and amplitudes to be achieved. It was evaluated that this custom build motor would be the most appropriate in terms of accomplishing the correct frequency while having the option of programming this motor to provide multiple settings for use within a vibration therapy device.

A range of fabrics was developed for testing; three fabric thicknesses and densities were created to determine the effect these fabrics had on the absorption or dispersion of the vibrations. Integration strategies were established, combining textiles and technology, testing was then initiated to determine results.

For the smart textile investigation, felted fabrics were created that removed the need for wires within the device. These felted fabrics integrate fibres, which are conductive and can provide power to the vibration motor.

The testing procedure, results and fabric construction processes and testing can be found in Appendix Two – Practical Investigation.

This summer project aimed at developing a first stage-working prototype, the timeframe of the project did not allow for this stage to be reached. However the fundamental elements needed to create a working prototype have been accomplished and are included in more detail in the larger report.

This project shows that there are further research and development opportunities for the use of new technology and textile techniques to be used and integrated into equipment for the use in equine care.

Appendices One – Literature and Product Review

Vibration based products and their use within both equine and human healthcare and wellbeing are growing in popularity. The aim of this investigation is to gain an understanding of the controversial topic of vibration therapy prior to developing integration strategies to combine vibrations with a textile based product for equine care. This report will analyse how vibrations are used within human healthcare and if these uses are transferable to the equine industry. Vibration as a form of massage will be explored both in a historical and contemporary setting while examining currently available products.

The Practice of Massage within Humans

Massage is a technique that has been used for thousand of years as a method of rehabilitation and relaxation (Pornratshanee, 2005). It is widely used within the human athletic community with athletes, coaches and other sports personal who embrace the therapeutic benefits of massage (Pornratshanee, 2005). Haussler, 2009, defines massage "…as the manipulation of the skin and underlying soft tissue either manually… or with an instrument or machine… for therapeutic purposes" (p. 850). Claimed benefits of massage therapy comprise of "… reduced muscle tension and soreness, reduced muscle spasm, reduced neurological excitability, and an increase sense of wellbeing" (Scott & Swenson, 2009, p. 689). Shadowing in the footsteps of human athletic training, equine athletes are increasingly becoming exposed to massage therapy as a common part of their training (Scott & Swenson, 2009). Equine massage employs a range of techniques originally established for humans, (Scott & Swenson, 2009), with vibration therapy becoming a common, at home form of massage therapy for equine athletes.

The most common forms of massage currently employed by massage therapists in humans are known as Classic Western or Swedish massage (Moraska, 2005). Techniques used within these forms of massage include a combination of techniques, such as effleurage, friction, petrissage, tapotement and vibration, depending on the clinical advantage that is desired (Pornratshanee, 2005). Common massage techniques used in equine massage are similar to those used in humans. Equine massage therapists practice effleurage, friction and vibration, the same techniques used in human massage while also using compression, direct pressure and myofascial release (Scott & Swenson, 2009).

Although vibration massage is relatively new to horse care it has been used within human medicine since the 1940's (Beck, 2010). The Russian Space program during the 1960's utilised whole body vibration on cosmonauts during their time in space to help with the prevention of muscle atrophy and osteopenia (Rita, Lee & Scott, 2011). Its use in human athletes expands to vibration massage also being used on "…stroke victims, patients suffering from multiple sclerosis, arthritis, rheumatism, cerebral palsy, Parkinson's disease…" while expanding to an alternative intervention in preventing and treating osteoporosis (Albee, 2010, para. 1).

Vibration massage can provide a range of therapeutic effects. When applied lightly vibration massage facilitates muscle relaxation and release of tension, however when pressure is applied it creates a stimulating effect (Beck, 2010). Its therapeutic effects also expands to pain management where it can be used as a drug-free pain relief, which is becoming recommend by universities around the world such as the Ohio State University Medical Centre (Mulcahy, 2015). Prolonged exposure to the vibrations creates an anesthetizing effect, generating numbness in the afflicted area.

The use of Vibrations within Equine Care

The use of vibration is becoming increasingly popular among the horse community with uses within training facilities, rehabilitation centres and at home (Vitafloor, 2015). Vibration is a form of massage that stimulates a specific muscle group or area through vibration (shaking) sometimes used as a pre-event technique (Morsaska, 2005). The technique involves a continuous tremulous movement, which is conveyed through a practitioner's hand and arm or a mechanical device (Beck, 2010). Vibration "…can be classed as a type of friction" and is commonly used on muscular areas of the body refraining from bony areas (Beck, 2010, p.337).

An article written in 2010 by Richard Albee discusses the potential benefit of equine vibration therapy, while considering the opinion of Bill Casner, the co-owner of Winstar Farm, an American Thoroughbred breeding and racing farm in Kentucky. Casner states that "[t]his therapy can help … remodel bone much more rapidly and effectively to stay ahead of damage. If they [horses] have stronger bones to begin with, and keep strengthening it during training, we may avoid common injuries" (2010, para. 19). Casner learnt about vibration therapy and its potential beneficial use in equine athletes from the studies of Clinton Rubin, the director of the Centre of Biotechnology, State University of New York who's studies on vibration therapy have been funded by NASA (Albee, 2010). With one of Rubin's first clinical trials involving a sheep and a vibration plate, the 34% increase in bone density caught Casner's attention and he continued to follow Rubin's research for a following 7 years. Rubin's trial comprised of placing the hind legs of the sheep onto a vibration plate at a frequency of 30 hertz for 20 minutes per day (Albee, 2010). The optimum reward this therapy is hoped to give both horse owners and trainers is the ability to increase bone strength to allow for better preparation of the horse for stresses and rigors induced by athletic training (Albee, 2010).

Vibrations can be produced either manually or mechanically. The number of vibrations created via a massage therapist (manually) ranges from 5 to 10 vibrations per second (Beck, 2010). However, mechanical vibrations can be customised to a desired rate to create a range of vibrations from 10 to 100 per second (Beck, 2010). Mechanical vibrations are seen as one of the favourable forms of mechanical massage (Kellogg, 1895). Mechanical vibrations can be grouped under the type of vibrations they produce (Beck, 2010). The three most common forms of vibrators that are available commercially are oscillation vibrators, orbital vibrators and 'the thumper' (Beck, 2010). Each type of vibration produces a different action; the oscillating vibration creates a linear back and forth motion (Beck, 2010). The orbital vibrators produce a circular movement and 'the thumper' creates a pounding action, which focuses the vibration into the muscle rather than along the surface (Beck, 2010).

Vibration therapy is shown to not only stimulate the skeleton, helping to form more bone and tissue in response to the force of the vibrations but it enhances circulation increasing the body's ability to heal and repair (Albee, 2010). Although the theory behind how vibration can increase bone density is still not fully understood, it is believed that the vibrations activate the mechanosensors within the bone cells (Wysocki, Butler, Shamliyan & Kane, 2011). During the training process of young horses, the bone undergoes a remodelling process. Casner explains remodelling as a process that happens to the bone, "[t]here are bone cells called osteoclasts that remove the damaged bone. Then another type of bone cells (osteoblasts) start replacing bone and building it up. But at first the bone starts to weaken" (Albee, 2010, para. 12). It is during this time that young horses are vulnerable to injuries (Albee, 2010). A clinical trial conducted by Rubin in 2009 showed that mechanical stimulation forced the bone and cartilage to adapt, increasing cartilage thickness while another trial revealed that the osteoclastic activity was reduced by vibrations but osteoblastic activity was increased which boosted the remodelling process (Albee, 2010). This remodelling process is stimulated via the mimicking of muscle contractions (Albee, 2010). Casner states that:

> Muscles vibrate when they contract. It's a tiny vibration we can't feel, but it can be measured. That vibration in humans is generally in the 27 to 35 hertz range. The muscles of all mammals are very similar in their cellular makeup. The stimulation effect seems to occur anywhere from 20 hertz up to about 55 hertz. This seems to be the range in which we see a response in bone cells and muscle cells. (Albee, 2010, para. 18).

A number of studies have been conducted on humans, which focus on whole body vibration therapy. These studies prove an increase of circulation to both the bone and muscle (Wysocki, Butler, Shamliyan & Kane, 2011). The increase of circulation through vibration has been proven to raise skin temperature and reduce the build up of lactic acid due to the increased blood flow (Imtiyaz, Vegar, Shareef, 2014). The increase in circulation and skin temperature can help with the warm-up stage, preparing the body prior to athletic training/activity without using vaulable engery on typical warm-up routines (Albee, 2010).

Equine Based Vibration Products

With the claimed benefits of vibrational therapy, a range of products for both humans and horse have made their way to the market. A current prototype for a custom-fitted cast is said to heal bones and wounds from 38%-80% faster through the use of vibrational therapy (Buhr, 2014). Although this product is currently focused on humans, the equine industry has access to products ranging from vibrational plates to blankets through to chips with Nano Vibration Technology.

Figure 1. Vitafloor. (n.d.). *Vitafloor VMO.* From Vitafloor. Retrieved from http://www.vitafloor.com/ Reprinted with

Equine vibration platforms such as Vitafloor and Equivibe provide whole body vibration. These products require the horse to be standing on a platform ranging in size, from the smallest being 90cm x 200cm and the largest anywhere between 3.5m - 4.5m in width. The frequency of vibration provided by both platforms is between 10-60 Hertz (Equivibe, n.d.). Viafloor contains 2 – 3 vibration motors within the platform (Vitafloor, n.d.). The type of vibration used within Equivibe is a vertical vibration, which runs the length of the plate, which they believe that this is a more natural form of vibration (Equivibe, n.d.).

Figure 2. EquiVibe. (n.d.). *EquiVibe 3072.* From EquiVibe. Retrieved from http://www.equivibe.com/Reprinted with

Other products that are less cumbersome and easy to transport are Equissage and Sportzvibe. Equissage consists of a back pad that is placed on the horses back in the saddle position. It contains two rechargeable batteries, which sit either side of the vibration motor that is positioned in the middle of the pad all of which are risen above, sitting on top of the pad itself. A hand held unit is also available to provide vibration directly to specific areas such as the neck and legs. Equissage contains a Cycloid vibration motor that delivers a 3 dimensional vibration, which generates vibrations in a circular, horizontal and vertical direction creating a deep tissue treatment (Equissage, n.d.). Cyclodial Massage which is non-aggressive, natural and one of the safest forms of therapy around that has no side effects. The benefit of a 20-minute session will last between 5 – 8 hours while a 10-minute session can be used to warm-up and cool-down pre and post activity (Equissage Red, n.d.). Althrough these product and therapy is not a cure it significantly speeds up the healing process of a range of conditions and provides ongoing treatment.

Figure 3. Equissage. (n.d.). *Equissage Back Pad.* From Equissage Niagara Therapy. Retrieved from http://www.niagara.com.au/equissage/ Reprinted with permission

Sportz-Vibe is one the most integrated forms of vibration technology. This massage rug, which comes with a detachable hood, contains 4 massage panels (Sports-Vibe, n.d.). These panels work alternately on both sides of the horses back, which contain the options of two treatment settings that last for 20-minute intervals (Sports-Vibe, n.d.). The vibrating panels can be positioned in 8 different sections within the rug on either side of the hindquarter, saddle area, shoulders and neck (Sports-Vibe, n.d.). The massage rug is breathable, washable and adjustable to fit a range of horse builds but cannot be used for more than 3 sessions per day on a single horse (Sports-Vibe, n.d.).

Figure 4. Sportz-Vibe. (n.d.). *Massage Therapy Rug.* From Sportz-Vibe. Retrieved from https://www.sportzvibe.com/horses.php Reprinted with permission

With the rapid growth in new technology horse owners and trainers now have the option of a Nano Vibration Technology (NVT) tag for their horses. Shuzi has created a horse tag that contains 2 Shuzi NVT chips that can be applied to the bridle, saddle or an ankle strap (Shuzi Pets, n.d.). These chips are programmed with NVT, which produces a subtle energy frequency that vibrates on a cellular level (Shuzi Pets, n.d.).

Throughout this investigation there appeared to be a wide range of scientific research and papers on the investigation of vibration therapy. However these papers were focused on human investigations and there was minimal equine based vibration therapy/massage research and data available. Nonetheless, this being said, there are a number of products within the equine commercial sector that provides vibration therapy products. Although these vibrational products range in sizes and shapes, they all claim to provide the benefits of vibration therapy. Aiding in recovery by promoting healing, and increasing circulation, the equine vibration therapy also oxygenates blood and muscles, prevents lactic acid and toxin build-up, encourages relaxation, increases bone density and helps in the treatment of soft tissue, joint injuries and laminitis (Equissage, n.d.). Owners and trainers, therapists and vets along with rehabilitation centres use these products with successful trainers such as Peter Moody and Kentucky Derby Triple Crown winners backing the use of these products (Equissage, n.d.).

Figure 5. Shuzi Pets. (n.d.). *SHHM001 Horse Medallion.* From Shuzi Pets. Retrieved from http://www.shuziqi.co.nz/shop/pet-products/116-equine.html Reprinted with

Appendices Two – Practical Investigation

STAGE ONE

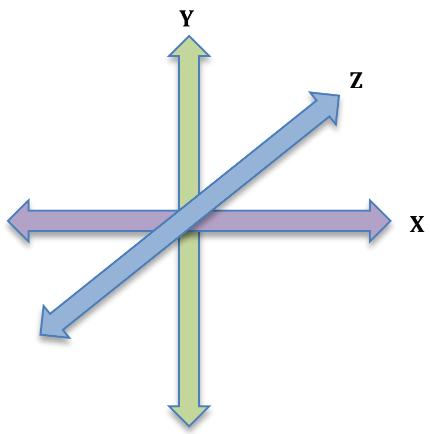
Vibration Motors:

The aim of this investigation is to integrate vibration-based technology into practical, non-invasive and easy to use textile products such as bandages or wraps for the equine industry. With the intent of creating a therapeutic effect to increase blood flow and muscle temperature to aid in warm up and increase healing time of injuries, as a textile designer it was important to gain an in-depth understanding of vibration motors. The specifications of vibration motors and their vibration direction would help influence and develop fabrics that will embrace their characteristics, while helping with integration strategies.

A variety of common vibration motors were purchased from around the country with the objective of testing the specification of the motors. The size, weight, voltage, frequency, current and revolutions per minute (RPM) were all tested and analysed. The testing of these vibration motors allowed for a greater understanding of the motors and certain specifications that needed to be adjusted or amplified to produce the correct requirements.

Vibration Direction:

Specific motors produce vibrations in different directions. The optimal position of the vibration motor within the product will depend on the direction of the vibrations and its end use. As discussed earlier in appendix one, equine and human vibration products use oscillating, orbital and compression based vibrations. The direction of the vibrations produced from the motors acquired for trial in this investigation are distributed along the x, y and z-axis (Precision Microdrives, n.d.).



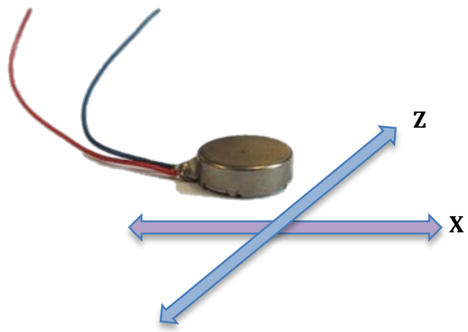


Figure 1. Fisher, H. (2015). Shaftless Motors direction of vibration (pancake/coin motors)

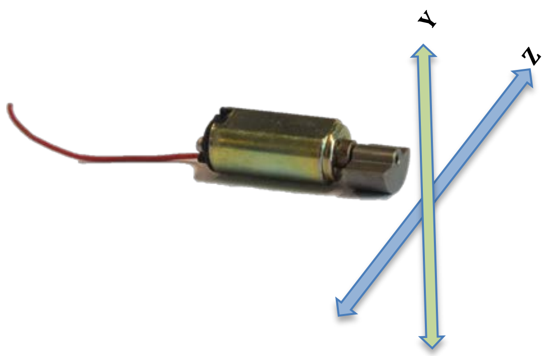


Figure 2. Fisher, H. (2015).. DC and Pager Motors direction of vibration

Equipment used for Testing:

Oscilloscope (Tektronix TPS2012B)- Oscilloscopes allow the electrical signals to be seen via a graph as they vary over time. They can measure both time-based and voltage-based elements. The measuring tools use signals from the vibrations to quantify frequency and amplitude.

Dual power supply (TTI EL302RD)

Current clamp meter (Tektronix A622 AC/DC current clamp meter)

Force Sensing Resistor 38mm Square x 83mm

Process for testing frequency and amplitude:

An energised vibrating motor was placed upon the resistive pressure sensor. Variations in resistance of the resistive pressure sensor were detected by monitoring the current flowing though the resistor when it was supplied from 12 V dc. The current was monitored using a current clamp meter. The readings were measured on the oscilloscope from the captured graphs, which record the amplitude and frequency of the vibrations.

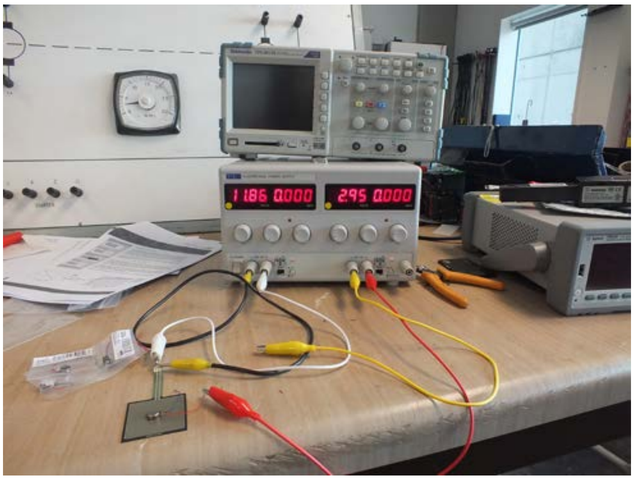


Figure 3. Fisher, H. (2016*)*. Set up of equipment used for testing

Initial Motor Testing:

Initial testing of the acquired vibration motors revealed what type of motor would be suitable for the integration within fabric while providing important details on the specifications of the motors in regards to frequency and voltage requirements.

Figure 4. **Testing of Vibration Motors # 1**

Name/Model	Size	Weight (Grams)	Recommended Voltage	Vibration Frequency (Hertz) (At 3 volts)	Free-run current	Pressure current	Run Speed RPM
Shaftless Vibration Motor #1637	8x3.4mm	0.8 g	2.5-3.5V	140 Hz	85mA	76mA	14500–12000 min RPM
Shaftless Vibration Motor #310-101	10x3.4mm	1.2 g	3V	156 Hz	60mA	54mA	12000 RPM
Shaftless Vibration Motor VMP2	12x3.4mm	-	3V	80.65 Hz	70mA	62mA	12000 RPM

DC Vibration Motor #2265	11.6x4.6x4.8mm[1]	0.8 g[2]	2.4-3.5V	-	65mA	80mA	12500 RPM
Micro Motor Vibration / Pager MOT0260	6x12mm	-	1.5-3V	-	130mA	167mA	-

Figure 5. Fisher, H. (2016). Vibration Motors

Results and Analysis of Initial Testing:

Shaftless motors, sometimes known as pancake motors, are small and flat due to their shaftless design. These motors are fully enclosed with no moving parts, making them easily integrated into designs. The tested shaftless motors created a higher frequency than what is currently used within the Equivibe vibration plate, which is discussed in the 'equine based vibration products' section of appendix one. Due to the higher frequency that was produced, it was decided that the 'Shaftless Vibration Motor – VMP2' would be the most appropriate choice to investigate and trial further.

The DC motor and Micro Vibration Pager contains an eccentric shaft with an offset mass, which produces vibrations when it rotates. The #2265 DC motor is encased in a removable rubber sleeve that creates a flat surface for mounting the device. The motors, which contained a non-enclosed shaft, proved to be an impractical choice due to the vibrations being halted went the shaft was touched or pressed. Further testing on these motors were ceased, as the exposed shaft design was not a practical option. It was also found that when the shaft was stalled, extra current was drawn which lead to the motor heating up, which could potentially become a hazard. Housing these types of motors in fabric would not be an appropriate option.

This initial testing concluded that a custom-made vibration motor would be constructed to allow for a comparison between a commercially brought motor and a customised one. Within the design of the customised motor, it was planned to attempt to create a motor that could vary the frequency it produced.

STAGE TWO

Fabric Development:

Before commencing further testing of vibration motors, a fabric and design analysis was undertaken on current equine leg wraps, boots and bandages. Measurements, sizes, uses and materials were examined leading to a range of bandage/wrap concepts for multi use on all areas of the front and hind legs. From these investigations appropriate fabric types, fastenings and shapes were determined for development and trials integrating the vibration motors.

A felted fabric made from wool was the chosen choice of material. Felted fabrics allow for a range of textures, thicknesses and shapes to be developed while the wool fibres provide breathability, absorbency, and durability.

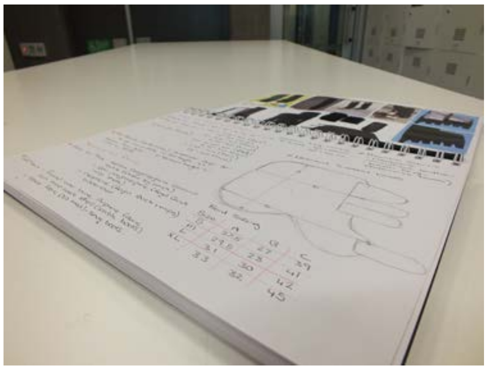


Figure 6. Fisher, H. (2016). Research and Concepts

Three thicknesses of felted wraps were created with seamless pockets for the easy incorporation of the vibration motors. These pockets would allow for easy access to the vibration motors while keeping the potential customers needs in mind by containing snap domes for practical connection of the vibration motors, delivering a choice of multiple positions for the vibration motor within the wrap itself. The Velcro straps allows for an easy fastenings and adjustability of the wrap sizing depending on the position the wrap is being used on the leg.

Fabric Construction:

Figure 7. Fisher, H. (2016). FeltLoom

The three felt thicknesses were developed to allow for testing of the vibration motors to determine the effect the fabric would have on the amplitude and frequency of the vibrations. Each batt contained the same amount of fibres and was initially made to an A3 sized shape, keeping the testings as fair as possible. These fabrics were created on the FeltLoom available at Auckland University of Technology (AUT) Textile and Design Lab.

The batts were colour coded depending on the density of the fabric, amount of times and speed at which the fabrics were felted during construction. The layering of felted batts helped create the pockets within the fabric while also offering difference levels of density.

Figure 8. Fisher, H. (2016). Developed fabrics

Stage two of fabric construction consisted of creating conductive felt. A range of trials were conducted with the combination of conductive fibres and wool to confirm the appropriate amount needed to conducted electricity throughout the fabric. Fabric samples were developed that provided the option of eliminating wires within the fabric, which would have run from the power source to the vibration motor. This conductive felt can be contained within the layers of the fabric providing a mouldable product without the interference of unnecessary electronics such as wires.

STAGE THREE

Felt and Vibration:

During the fabric construction stage an AUT Electrical Engineering Lecturer, Dr Craig Baguley, constructed a vibration motor. The 12 V DC motor was tested along side the VMP2 shaftless vibration motor. Although it was decided that a DC motor was not appropriate for use within fabrics due to the external spinning shaft, a casing to enclose the shaft could be constructed to protect the user and fabric from the shaft. These motors were originally stitched into the pockets of the fabric and test using the same process as the initial testing stage. A testing station was constructed to simulate the shape of a leg. The wrap was positioned and force was applied to tense the fabric, as it would be when wrapped around a leg and held in place by Velcro.

Figure 9. Fisher, H. (2016). Custom made vibration motor

Each test consisted of the motors being ran at their maximum voltage while swapping out the trial fabrics to explore the impact the felted wraps had on the frequency. The custom made DC motor was also ran at multiple voltages to determine changes in frequency and amplitude.

Figure 10. **Testing of Vibration Motors Inside Fabric Samples**

	Fabric Type	Forse (N)	Voltage (V)	Frequency (Hz)	Amplitude (mV)
Shaftless Vibration Motor VMP2	Black Felt – Dense (Sewn into pocket)	19.62 N	3V	106HZ	8.400mV
DC Motor Custom made	Black Felt – Dense (Sewn into pocket)	19.62 N	12V	56.82 Hz	189mV
DC Motor Custom made	Black Felt – Dense (Sewn into pocket)	19.62 N	7V	34Hz	43mV
DC Motor Custom made	Black Felt – Dense	19.62 N	12V	41Hz	148mV
DC Motor Custom made	Black Felt – Dense	19.62 N	7V	27.78Hz	34mV
DC Motor Custom made	White Felt – Soft	19.62 N	12V	37Hz	115mV
DC Motor Custom made	White Felt – Soft	19.62 N	7V	27.28Hz	34mV

While testing the vibrations motors it was established that sewing the motors into the fabric to hold them in place was not enough to keep them secure. The vibrations loosened and dislodged the sewing and a strap had to be created to hold the motors in place, the strap went over the motors holding them tightly within the fabric. Further development of the bandage and wrap concept would involve the construction of a fitted strap that could hold each motor securely in place within the fabric.

The tests concluded that the type of fabrics that surrounded the vibration motors had an effect on both the amplitude and frequency. The soft white felted fabric dampened the amplitude, absorbing impact created by the vibrations. It is also noted that the frequency decreased during all trials, which used the white felted fabric for both the commercial and custom motors. As the frequency and amplitude were higher during testing of the dense black felt, it is hypothesised that the density of the black felt, spreads and vibrations over a larger area without minimising frequency and amplitude.

As the specific range of frequency and amplitude for use on horses for vibration therapy is not known at this stage, the appropriate fabric can not be concluded from these findings. It is also important to note that although all possible implications were made to produce fair tested results, the results recorded could vary upon further testing.

SUMMARY

This investigation has concluded that even though the topic and findings behind past vibration therapy/massage studies are controversial; the possibility of this technology could potentially reduce injuries and aid in healing within equine healthcare. As seen throughout this investigation the potential for this technology to be integrated into textile-based products is very possible. With first stage prototypes being developed, these bandages and wraps show probable concepts for applying vibration technology to different sections of the leg. However, a specific frequency and amplitude needed to create a therapeutic effect was not determined, further testing with this technology could lead to these findings. The development of both vibration motors and textile-based equine products explores the possibilities of further integration of other technologies within a range of areas within equine care and the industry.

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