MEDICAL BACK BELT WITH INTEGRATED NEUROMUSCULAR ELECTRICAL STIMULATION

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Abstract: *The medical back belt with integrated neuromuscular electrical stimulation is an orthopedic device, which has two main functions. The first function is to stimulate the back muscles by using a neuromuscular electrical stimulation device that releases regular, electrical impulses. The second function of the medical back belt is the stabilization of the back after lumbar disk herniation's so that a straight posture can be realized.*
The product has the opportunity to give lumbar back support and encourage the back muscles to prevent muscle weakness. The integrated neuromuscular electrical stimulation in the belt consists out of two main components: The NMES device and the textile electrodes. By activating the NMES device it transmits electrical impulse to the textile electrodes, which can prickle the muscles.
In the future, this product possibly can make a straight posture of the back and simultaneously stimulation of the back muscles possible.

1. Introduction/ Hypothesis

During and after disk herniation's the back muscles are weak and need to be protected and stabilized. Therefore doctors and physiotherapists make use of different therapies to built up the back muscles to occur further disk herniation's and to support the healing process. Furthermore they make use of orthopedic devices like elastic corsets and temporary trunk orthosis. Usually orthopedic devices can be very helpful and relieving because of the stabilization of the back but if patients make predominantly use of this devices they will take over the function of the muscles. The muscles will not be stimulated any more so they get weaker every day. [1] Muscle weakness will be a big problem because most of disc herniation's occur because of weak and feebly muscles in the back because they were not able to hold the backbone and movements in lateral and dorsal direction and rotational motions.[2] Thus there is a need for a product, which has the possibility to hold and stabilize the backbone and stimulate the muscles so they can accomplish their natural function.

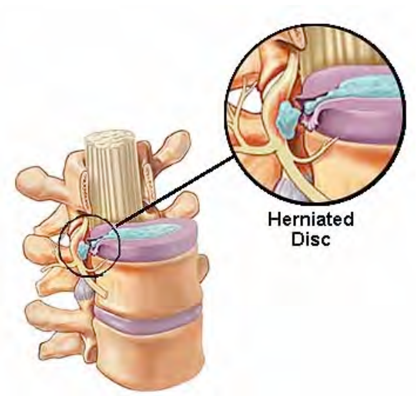

Figure 1: disk herniation

2. Materials and Methods

Since the ultimate product is a paramedic device, the construction of the back belt had to be planned carefully and a number of different elements require extensive testing. The first priority of the project was to internalize the medical background. Terms like construction of the back, back muscles, electrotherapies, disc herniation's and their medical treatments were studied scientifically and with this knowledge decisions were made for continuing with the research and prototyping. After acquiring the medical background, different materials and medical devices were listed in a product breakdown structure for testing purpose. Finally the best-performing elements were determined and applied in the prototype.

2.1. Materials Back Belt

The aim of the final prototype was to develop a product which fulfil two main properties: stabilization of the back and comfort ability. The patients have to perceive the belt as a comfortable support for their back during the use of the product.

Therefore selections of materials were made to develop a strong and flexible product. The main properties of the chosen materials are flexibility, breathability, antistatic, hydrophilic and pleasant to the skin. For the first and second layer a cotton twill material is used because this material is strong, breathable, antistatic and pleasant to the skin. Because of its properties the material is used in the inner surface of the medical back belt where it is directly applied onto the skin. The third layer is a non woven polyester filling which gives extra stability and comfort ability. As fourth layer cotton drell material is used because of its outstanding strong and flexible properties. This material is often used in orthopaedic devices like orthopaedic corsets and temporary trunk orthosis because it can support and stabilize the parts of the body where it is applied. In the medical back belt it is applied in both sides of the product so that a straight posture can be realized. Furthermore PES tricot is used for more support and flexibility. Because of the combination of these four different materials the stabilization and comfort ability can be realized and make sure that the patient have a straight posture during the usage.

The construction of the back belt and material that is used, is shown in figure 2 and table 1.

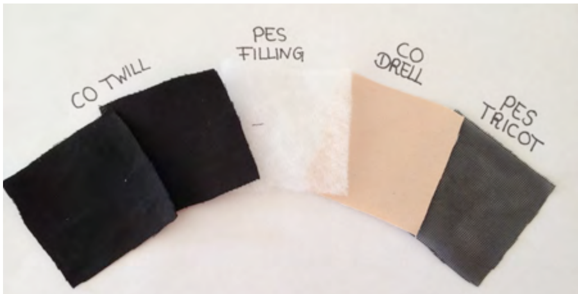

Figure 2: Material applied in prototype

CO twill
CO twill
PES filling
CO drell
PES tricot

Table 1: Construction of material in medical back belt

The medical back belt is 160 cm long and 40 cm wide. The outer surface consists out of five different components; on the left hand side is the hook and loop fastener with cotton drell and polyester tricot next to it. In the centre the cotton twill material is used and in the right side of the belt cotton drell material and polyester tricot is applied. The fifth component on the right hand side is the cotton twill material with the integrated NMES device. The construction of the outer surface is shown in figure 3.

The inner surface of the medical back belt consists out of cotton twill because it is directly applied onto the skin. In the centre of the inner surface the orthopaedic pad with the textile electrodes is attached and on the right hand sight the hook and loop fastener is used to close the medical back belt. The construction of the inner surface is shown in figure 4.

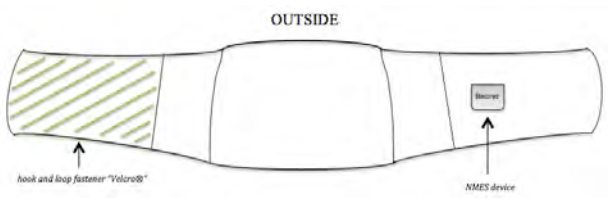

Figure 3: Outer surface of the medical back belt

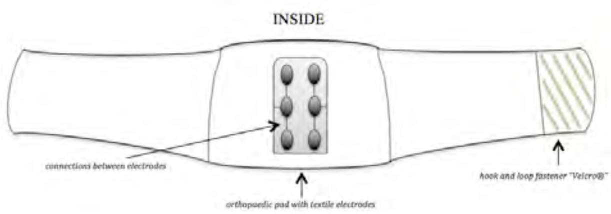

Figure 4: Inner surface of the medical back belt

2.2. Materials neuromuscular electrical stimulation

The neuromuscular electrical stimulation consists out of two main elements: the NMES device and the textile electrodes.

While testing and selecting the NMES device it was clear that the NMES device has to be able to transmit the electrical impulses to the textile electrodes so that the therapy could be as effectively and comfortable as possible. With the NMES therapy the muscles can be stimulated and it is used to achieve a muscle growth. During the research three different NMES devices are tested and the Beurer EM 35 with the best testing results are applied into the prototype. The NMES device “Beurer EM 35” is shown in figure 5. [3]

Furthermore a range of conductive yarns and techniques were tested to get usable and comfortable textile electrodes. Bekaert Bekinox VN12/2, Shieldex silver plated nylon 234/34 4 ply and Shieldex silver plated nylon 117/17 2ply were purchased and tested for conductivity and resistance. Techniques like weaving, knitting and embroidering are applied to find the best way to develop good performing textile electrodes, which can transfer the impulses to the back muscles and do not irritate the skin. Finally it was obvious that the best textile electrodes are developed by using the embroidery technique in combination with the Shieldex silver plated nylon 117/17 2ply yarn, that is shown in figure 6. [4]

The textile electrodes are placed onto an orthopaedic patch because this element can make sure that the electrodes won’t slip out of their position. [5] This aspect is very important because the electrodes are placed directly onto the muscles so that they can effectively stimulate them. There are six textile electrodes placed onto the orthopaedic pad and connected with each other to make sure that the electricity can flow through each of the electrodes. The orthopaedic pad is placed in the lumbar region of the back and the textile electrodes are attached onto the back muscles. The “musculus erector spinae” in the lower back will be simulated by direct muscle stimulation because the electrodes are directly placed onto the muscles. The area in-between the plus and minus electrodes is precisely calculated because the textile electrodes must not be placed onto the backbone. The backbone has to be protected because the spinal cord passes through the vertebrae’s of the backbone and must not be damaged at any time. The orthopaedic pad with the textile electrodes is shown in figure 8.

Figure 5: NMES device

Figure 6: Embroidery of textiles electrodes

Figure 7: Orthopaedic pad with textile electrodes

The NMES device is connected to the electrodes by soldering and stitching and transmits an electrical impulse to the textile electrodes. The three electrodes on the left side of the pad and the three electrodes on the right side of the pad are connected with each other. A line of embroidered Shieldex silver plated nylon 117/17 2ply yarn in between the three electrodes makes sure that every electrode will get the impulses that are transmitted from the NMES device. At the back of the orthopaedic pad the electrodes are connected to wires that are interconnected to the NMES device by soldering and stitching. Furthermore the orthopaedic pad is fixed by a hook and loop fastener to the medical back belt to make sure that it won't slip out of their position. The electrical wires are placed in between the first and second layer of the medical back belt and run parallel to the NMES device. At the back of the NMES device the wires are connected by soldering them onto a snap fastener.
The front and back of orthopaedic pad and the construction of the connections between the textile electrodes and the NMES device are shown in figure 8.

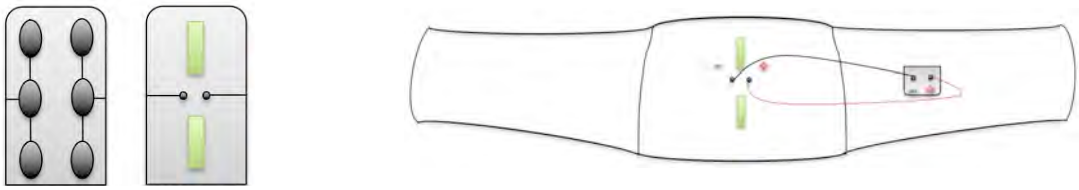

Figure 8: Front of orthopaedic pad with textile electrodes / back of the orthopaedic pad with connections to NMES device / connections of the NMES device and the textile electrodes

3. Results and Conclusions

The prototype was tested by a group of participating orthopaedic patients during a period of four weeks. They tested the product two times a week on flexibility, comfort ability and effectiveness. Different intensities and settings are tested during the four weeks so that the best intensity and setting could be identified for further usage. The medical back belt with integrated neuromuscular electrical stimulation is shown in figure 9.
During and after every testing section the participating orthopaedic patients wrote down their perceptions and if there were any special distinctions. In the end they had to answer some questions like if they wanted to use the medical back belt for a longer period, did they felt any effects in the back during and after the electrical stimulation and if the medical back belt stabilize the back and make a straight posture possible.
Finally a number of important results came out of the tests. All the participants indicated that the medical back belt stabilizes the back and feels pleasant during the electrical stimulation. It became clear that the electrical stimulation is comfortable if the intensity is not too high. The impulses shouldn't be to sharp; otherwise the therapy would be very unpleasant.
Furthermore the tests have shown that the neuromuscular electrical stimulation has the opportunity to prickle the muscles so that they will not get weaker.
The tests have shown that Shieldex silver plated nylon 2ply can be applied directly onto the skin. Usually electrodes are used in combination with liquid or gel to make them more conductive and to occur any irritations or wounds. The applied textile electrodes were used without any liquid or gel and the tests have shown that the textile electrodes didn't have any negative influences on the skin. The electrical impulse can easily

Figure 9: Medical back belt with integrated neuromuscular electrical stimulation

be transmitted and electrodes have the possibility to prickle the muscles while conducting electricity. To conclude, a lumbar back belt was made with the function to stabilize the back and make a straight posture possible and the muscles in the back can be stimulated by the integrated neuromuscular electrical stimulation.

4. Acknowledgement

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