Research on Influencing Factors of Pressure Comfort of Medical Compression Hosiery for Varices

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Abstract: In this paper, influencing factors of pressure comfort of the medical compression hosiery for varices is studied using EEG evaluation method in the aspects of human body and garment and it is concluded that garment pressure comfort is correlated to the length of garment and body movement: medical compression socks apply greater pressure on the legs of the subjects than medical compression stockings, providing more comfort; the constriction of medical compression hosieries is greater when the subject is sitting than that when the subject is standing, along with greater comfort. However, movements with greater curvature will result in excessive garment pressure on local parts of the legs and decreased comfort.

Medical compression hosiery for varices is the most effective and convenient cure to the varicose vein of lower limbs, a common vascular disease. This hosiery can help the venous blood flow back to the heart, altering the traditional treatments of stripping the varicose superficial veins and high ligation or compression bandaging with elastic bandage. With a special process, the medical compression hosiery for varices can produce certain gradient pressure from bottom to top on lower limbs. Varied pressure differences transmit the pressure through muscle tissues to veins to resist high pressure of veins, help venous blood flow back and improve the venous congestion so as to treat varicose veins. Essentially, the medical compression hosiery for varices applies different pressures on the legs, so constriction and comfort are produced concurrently. Researches on pressure comfort of the medical compression hosiery for varices and development of compression hosieries with treatment effect and comfort have drawn the attention of many scholars.

EEG-based garment pressure comfort evaluation as an objective method to evaluate the comfort is widely accepted in the academia. The garment pressure comfort is mainly transmitted to the higher nervous center of the human brain through the human body's visual and tactile organs. This information can be expressed as the electrical activity of brain cells. With potential of this electrical activity as the vertical axis and the time characteristic as the horizontal axis, the graph of correlation between the potentials and times recorded is the EEG signal[1]. The α wave is the activity in the EEG that has the same pattern, the same cycle and recurs, that is, the EEG rhythm, which is one of characteristic indexes to measure EEG activity and whose strength is correlated to garment pressure[2]. The spectrum energy change of the α wave in the EEG signal can reflect the pressure comfort. When the α wave is suppressed by the pressure of the garment, it will cause discomfort. Liu Yunjuan[3] combined EEG and ERP and discovered pressure of garment can suppress α wave and cause discomfort for body. Different movements can also affect the spectrum energy change of α wave, demonstrating α wave strength of EEG is correlated to subjective mental reaction, constriction and comfort under a certain garment pressure. In this task, α wave under different garment pressures are studied based on EEG technology to further explore the main factors that affect the comfort of the medical compression hosiery for varices.

1. Experiment Conditions

In this task, medical compression hosieries for varices with pressure grade of level I (18mmHg~21mmHg) that comply with standard *FZ/T 73031-2009 Pressure Socks* are selected. The most used socks (as shown in Fig. 1) and stockings (as shown in Fig. 2) are used for experimental

exploration.

Figure 1 Medical compression socks for varices

Figure 2 Medical compression stockings for varices

2. Eeg-Based Pressure Comfort Test

With EEG technology, the EEG signals of 3 subjects who wore medical compression socks and stockings in different postures were acquired using MindAngel EEG Acquisition System.

2.1 Pre-Acquisition of Eeg

First, a segment of EEG was acquired beforehand to determine if experimental equipment works normally in accordance with EEG theory in the following aspects:

① EEG data are presented in 8 channels

② EEG waves change when the subject closes and opens his/her eyes, rolls his/her eyes and speaks.

③ EEG waves change when the subject performs the design movements such as sitting and standing.

2.2 Test on Impact of Length on Garment Pressure Comfort

After three subjects sat or stood for four hours, one subject put on medical compression socks and stockings respectively. EEG change of such subject was tested (in two separate experiments), with data acquired and recorded for comparative analysis. Then the elongation of medical compression socks and stockings were measured on main measuring parts (B ankle/C thickest part of calf/D below the knee) using forces of 5N and 10N.

2.3 Test on Impact of Movement on Garment Pressure Comfort

In this experiment, the common postures of people with varicose veins, namely sitting and

standing are selected as the test movements. The subjects put on the same kind of medical compression hosieries after standing and sitting for a long while (4h) (in two separate experiments) and their EEG signals were acquired for comparative analysis.

2.4 Test on Impact of Leg Circumference Change on Garment Pressure Comfort

Leg circumference of the subject not wearing the medical compression hosiery was first measured. Due to action and distribution of force, the supporting pressure is the maximum at the ankle and gradually decreases from bottom to the top of the leg. The pressure is decreased to 70%-90% of maximum pressure value at mid-calf and to 25%-45% of maximum pressure value at the thigh. Therefore, pressure values on four parts, including B ankle, C mid-calf, D part below the knee and G base of thigh were measured in this experiment. Then circumferences of BCDG four parts were measured for subjects wearing the medical compression hosiery for the purpose of comparison, and their EEG signals were acquired simultaneously.

3. Test Results and Discussion

3.1 Analysis of Impact of Length on Garment Pressure Comfort

By comparing EEG signal patterns of subjects wearing medical compression socks and stockings understanding status and analysing EEGs acquired in the experiments, we found: the α wave of the subject wearing medical compression socks is more stable than that of the subject wearing medical compression stockings, that is, pressure comfort of medical compression socks is better than that of medical compression stockings.

By measuring the elongation of the same hosiery in B (ankle), C (mid-calf), D (below the knee) and G (base of thigh) parts, as shown in Fig. 3, we concluded that elongation of the hosiery gradually increases from bottom to top of the leg, that is, elasticity modulus decreases and pressure drops.

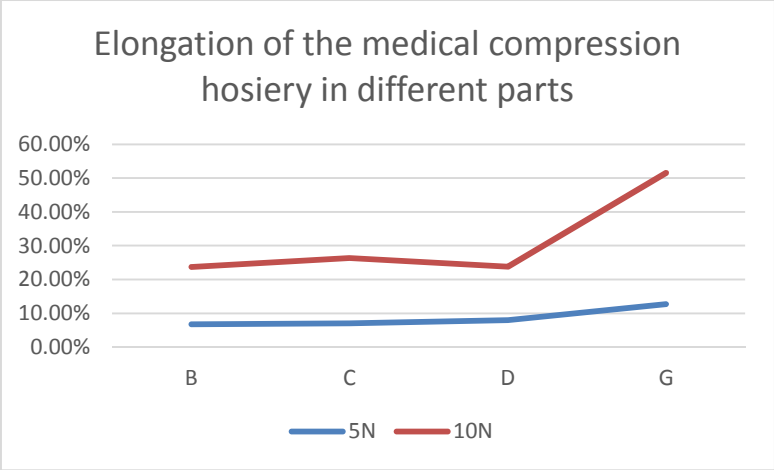

Figure 3 Elongation of the medical compression hosiery for varices shows an overall increase trend

Due to gradient pressure design, the medical compression hosiery for varices has action and distribution of force. The supporting pressure is the maximum at ankle and gradually decreases from bottom to the top of the leg. The gradient decrease of pressure can help venous blood of lower limbs flow back, thus effectively relieving or mitigating pressure on veins and venous valves. Hosieries of different lengths apply different forces on the same part. Pressure distribution of socks is more intensive while that of stockings is more dispersed so they have different garment pressures on the same part of leg. Therefore, based on the test results of comparing EEG changes of one subject wearing medical compression socks and stockings and measuring the elongation of these two types of medical compression hosiery on main measuring parts, it is concluded that length of the medical compression hosiery is one of the main factors that affect its pressure comfort. Medical compression socks apply greater pressure on legs of subject than the stockings, thus providing more

comfort.

3.2 Analysis of Impact of Movement on Garment Pressure Comport

By comparing EEG signal patterns of subjects wearing medical compression hosieries under sitting and standing status and analyzing EEG signals acquired in the experiments, we found: the α wave of EEG signal of the seated subject is suppressed compared with that of the standing subject, that is, subjects wearing medical compression hosieries feel greater constriction and comfort under the sitting status than under the standing status.

This is because under the same constriction condition, the greater the curvature of body part, the bigger the garment pressure, as shown in Fig. 4. Some parts of human body may deform and displace during the movement, which will change the curvature of such part and thus result in the change of garment pressure[4]-[7]. The curvature of knees when the subject is seated is greater than that under the standing status, so the knees are under bigger garment pressure after the subject puts on the medical compression hosiery.

As a result, the movement of the subject when he/she is wearing the medical compression hosiery is one of the main factors that affect the pressure comfort. The movement with bigger curvature will result in bigger garment pressure on certain part of leg and less comfort [8].

3.3 Analysis of Impact of Leg Circumference Change on Garment Pressure Comfort

Under normal circumstances, it's commonly believed that the leg circumference will be smaller when it's under pressure of the medical compression hosiery. The change of leg circumference of the subject under excessive sitting or standing status was measured and the results are shown in Fig.4. The leg circumference changed little and the circumferences of some parts even increased when the subject put on the medical compression hosiery. This is because except for garment pressure on legs, the thickness of the hosiery changes with the elongation. Smaller elongation results in greater thickness while greater elongation results in smaller thickness. Thus, the leg circumference changes little before and after the subject puts on the medical compression hosiery and may have the probability of increase.

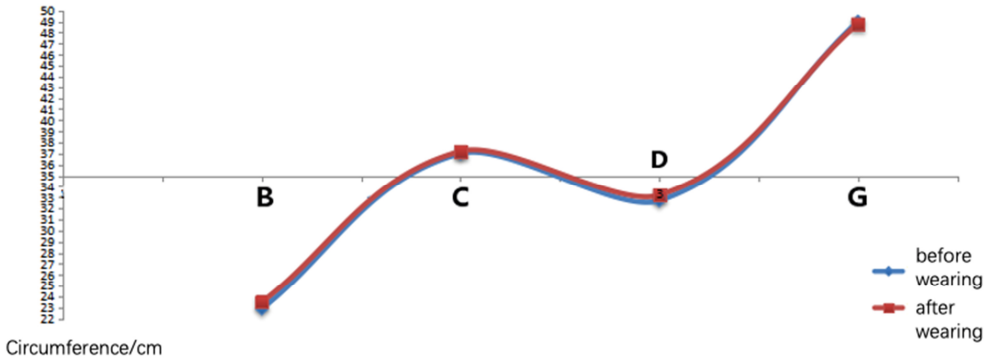

Figure 4 Curve of leg circumference change before and after the subject puts on medical compression stockings

EEG signals show no evident pattern when three subjects wear the same type of medical compression hosieries in the same state [9, 10]. Observation results indicate that compared with the EEG signals of the other two subjects, the α wave of the first subject is significantly suppressed, while the other two subjects are also slightly suppressed to different degrees in spite of stable α waves. It can be only concluded that pressure comfort of legs is improved with the medical compression hosiery. As fabric thickness and elasticity on different parts can also affect the measurement results of leg circumference, the correlation between circumference change and pressure comfort cannot be identified so we believe that change of the leg circumference is not an influencing factor of pressure comfort.

4. Conclusion

In this task, the medical compression hosiery for varices is taken as the object of the research, constriction and comfort of garment under different lengths, movements and leg circumferences are studied and comprehensive evaluation research is conducted using EEG technology. It is concluded that:

Under experiment conditions, length of the medical compression hosiery and body movement are major factors that affect pressure comfort of the medical compression hosiery. For medical compression hosieries of different lengths, α wave of EEG signal of the subject wearing medical compression socks is more stable than that of the subject wearing medical compression stockings, that is, the pressure comfort of medical compression socks is better. During different movements of subjects wearing the medical compression hosiery, the α wave of EEG signal of seated subjects is suppressed compared with that of the standing subjects, that is, subjects wearing medical compression hosieries feel greater constriction and comfort under the sitting status than under the standing status.

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