Testing Methods and Effect of Clothing Pressure on Human Body

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Abstract

This paper starting from a brief description on the current clothing pressure numerical test methods, introduces the steps and problems of the finite element simulation on pressure, summarizes the research progress of the influence of clothing pressure on human physiology by four aspects. The further research have be considered; the study should be conducted as the following two aspects, the one is mathematical model of clothing pressure and human physiology, the other is the combination of forecast simulation system and apparel pattern design system.

Keywords: clothing pressure; human physiology; pressure testing; finite element; comfort

Introduction

Clothing comfort can be divided into four independent factors, sports comfortable, thermal comfort, tactile comfort, pressure comfort [1]. In recent years, people are paying more attention to clothing pressure comfort; the human psychological and physiological changes caused by the clothing pressure have been studied gradually. Suitable clothing pressure can protect the body from damage during exercise; it can also improve the efficiency of movement. Excessive clothing pressure will lead to internal displacement deformation, respiratory impairment, tired easily, and the other negative effects. But now the researches of comfort are more about the subjective feeling of people and the objective performance of fabric; there is not a standard scale to illustrate the influence degree of clothing pressure on human body. In view of the comfort is the feeling of a person who wearing the apparel, so the study should be starting with the objective evaluation of human physiological indexes, to connect the subjective feeling.

1. Clothing Pressure Test and Computational Simulation

1.1 Clothing Pressure Test

The numeric of clothing pressure can be obtained by many kinds of methods, the theoretical calculation, simulation, direct tests, indirect tests. Direct test method is more available now because of its operation is convenient [2].

Pressure test systems which have been developed based on the fluid pressure or tensile strain of special materials. In the fluid pressure test system, we can place the parts which have filled with gas on the measured positions, read the scale difference of the fluid and the corresponding pressure value. The tensile strain test system is based on deformation of the sensor what the pressure between clothing and the body act on. Deformation of the sensor will cause the changes of voltage, resistance and radiation quantity [3]. Sensor sensitivity, thickness and the size of the reaction and material have crucial influence on accuracy of test. Thickness of the piezoresistive type Flexiforce sensor is very thin and high sensitivity, and it suitable to test the pressure of almost all curvature points on the human body. The recent development of pressure testing system combining test system and the computer, using the powerful data processing function of it that can continuous record the date, implement the dynamic clothing pressure test [4].

Indirect test methods divided into simulation and theoretical calculation. Simulation method using some materials which are shaping easy to make the body parts models according to the human body size. The most materials are plaster and resins.

With the continuous development of dummy, the elastic performance of materials is more and more close to the human body. They are usually under testing in the environment that human hard to adapt to. But, under ordinary conditions, these two kinds of methods are seldom used due to the complexity of model making and accuracy. Kirk [5] had calculated the pressure by fabric tensile stress and the radius of curvature of the body. The elongation of fabric at warp and weft can be converted to tension. Radius of curvature can be measured with relevant ruler. But the experimental error is easy to occur because of manual measuring precision. Considering there are a lot of limitations on the pressure sensor test, Yejin Lee [6] had printed the pattern of round and square on the apparel, check the changes when people wearing the apparel. He had accurate estimated stress direction and the radius of curvature by three dimensional imaging, calculates and verifies the clothing pressure. Although it has a lot of steps, the accuracy of this method is very high, and can be used as a supplement to direct test method.

1.2 The Finite Element Method to Predict and Simulation

Finite element analysis can simulate the stress and strain of entity model which build by Reverse engineering technology. Reverse engineering technology mainly includes data acquisition, data processing and model reconstruction [7]. These data is imported into the CAD software to reconstruct the entity model after collection, and import the model into the CAE software to build the finite element model. We should mesh it, set material parameters, input boundary conditions and load, solving and take the post-processing [8]. Data acquisition has a crucial effect on model accuracy. In the most, we use the Optical scan and the CT scan. The Optical scan using range finder with multiple source to measure experiment object; the coordinates of the corresponding points collected according to the interval of the position by light and optical axis angle, to obtain point cloud data [9]. The principle of CT scan is use of the scanned images according to the signal strength of different density to extract the contour data. The data obtained from CT scans is more accurate than other methods, but the thinner the thickness is the more human intake of X-ray [10].

In 2008, Mirjalili [11] was using the ANSYS software to analysis and forecast the pressure of elastic clothing. Maximum error of predictive values relative with the experimental data is 7%, this can valid the feasibility of the finite element method to predict pressure.

In 2011, Yinglei Lin [12] was build a nonlinear elastic material model and a male standing leg model which include kneecap, tibia and fibula, skin and soft tissue. Using Solid Works software to generate profile curve, entity model is set up, the skin entity model minus the skeleton entity model for soft tissue model. The paper had forecast the pressure distribution and validation, predictive value in accordance with the test values highly; put forward the finite element method can also be used to predict the deformation of elastic clothing. At the same time, Rui DAN [13] established finite element model in cross section of the position medial malleolus up 6 cm. It concluded the bone position and the body surface curvature has influence to the stress and displacement. Through the change of four areas of the section, combined with the comfort evaluation, provides reference for the design of the sock-tops.

In 2013, Gongbing SU [14] used CT images to build a three-dimensional model with 8 mm layer spacing. Import the point cloud data into Pro/Engineer, fitting curve and curved surface. He respectively analyzed the range of stress, strain and deformation of the sock in four different sizes. The conclusion provided the reference for the research of pressure comfort.

2. Effect of Clothing Pressure on Human Physiology

2.1 Integumentary System

Each part of human body has different sensitive degree of clothing pressure, as well as to withstand the maximum pressure value. Jia WANG [15] did an experiment, the research objects are ankle and calf of three healthy female college students. She used a blood pressure cuff on lower limb to simulate clothing pressure and take a continuous measurement of pressure and the skin blood flow with AMI body clothing comfort physical quantity test system. In compression state, peripheral blood flow of the skin will be blocked. The influence degree of the ankle pressure on peripheral blood flow is more than the calf pressure. In certain pressure range, the skin blood flow is increases; when pressure exceeds a certain critical value, it will gradually decrease. Through analysis and study of the results, presumably, clothing pressure mainly influence nerve regulation, humoral regulation, as well as the deformation of the blood vessels to change the microcirculation, thus affecting the skin blood flow.

Tadaki [16] points out the reduce amount of sweat rate which affected by pressure on armpit is proportional to strength and area of pressure. Between 5.88 to 19.6 KPA, Pressure size, compression area affect reduce of sweating rate. Sawako Tanaka [17] found that even if the pressure on the skin is very small, but sweating rate reduction is also considerable because of its large compression area.

2.2 Circulatory System

Zhiming WU [18] had test heart rate, blood pressure and clothing pressure on the neck of 15 young women in wearing knitting high-necked unlined upper garment different clothes. The research shows that heart rate and blood pressure is associated with pressure. When pressure exceeds 1.2 KPA, the physiological indicators in the neck appeared the downward trend, the influence of clothing pressure on the systolic blood pressure is more than the diastolic blood pressure. If clothing pressure overshoot, it has a negative effect on the human body blood pressure recovery after movement.

Daifang XU [19] use of polyamide and polyurethane blended fabrics which the composition of polyurethane is increases gradually to make 6 kinds of one-piece swimsuits in different size. She tested the heart rate, diastolic blood pressure, systolic blood pressure and clothing pressure when the object in a swimsuit. When the clothing pressure on the breast is lower than 1.15 KPA, the changes of heart rate is not obvious; When it is between 1.15 to 1.59 KPA, heart rate increased obviously; When it is above 1.59 KPA, heart rate increases slowly, the trend is more gentle. Diastolic pressure is decline significantly during or after movement when clothing pressure above 0.37 KPA on the waist. Systolic blood pressure decreased significantly when clothing pressure is above 0.57 KPA on the abdomen.

2.3 Respiratory System

Zhaorong GUO [20] was using Power lab system to test the body physiological indexes when the person dressing in chest waist and abdomen one bunch of clothing. The research found that the clothing pressure between 4 KPA and 6.6 KPA, the respiration rate are raised.

Weina CHANG [21] had record the oxygen uptake, amount of exhaled carbon dioxide, ventilation and heat of the person who dressing in clothes with different levels of elasticity. The experimental results show that the clothing pressure has no significant impact on the respiratory physiology data. This conclusion is different from previous research results. It is assumed that the error caused by the instrument, heat loss, and in short time.

2.4 Other Physiological Systems

Clothing pressure can affect the secretion of hormones which enhance human immunity and vitality; this will lead to the change of immune system. In addition, the secretion speed and concentration of saliva will significantly reduce if the body under pressure for a long time. Reduce the secretion of saliva will affect the working efficiency of the digestive system and cause food is not easy to be digested [22].

Through some study, Lihua XIE [23] found that the pressure can delay the scar hyperplasia, to not left serious burn scar. The principle is the elastic clothing continued pressure to the human body can promote orderly rearrangement of collagen fibers. Lizhuo WANG [24] had a similar study. He proved the conclusion of an Australia clothing researcher. He advised women who had breast surgery to wearing a specially designed bra which have appropriate brassiere pressure and promote the cure of breast wound and abate symptoms.

3. The Further Research

3.1 The Establishment of Calculation Model

The purpose of study the relationship between the clothing pressure and human physiology is to optimize the clothing design, improve clothing comfort. Pressure changes cause of the change of human physiological, impact on security dress and motor function. Build pressure and physical calculation equations to adjust the pressure, reach for the best condition of human activities.

3.2 Link to the Design and Manufacture System

Clothing pressure for the human body is mainly determined by fabric performance and clothing sizes. Input fabric performance parameters in the modeling system, set up the size of clothing to control pressure distribution. After pressure simulation, it will be link to the design system to produce the patterns. It can guide the clothing design and production.

4. Conclusions

Pressure comfort is the important indicator to evaluating the comfort of clothing. Appropriate pressure has important significance for human body. Two methods have been proposed in this paper. The further researches we will make are modeling and simulation.

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References

Songhe REN. Study on pressure comfort of clothing [J]. Hebei textiles, 2011, (2):43-45.

Xingyuan DUAN. Study on test ways of clothing pressure [J]. Knitting industry, 2006,(11): 53- 55.

Liming CUI, Fengyang LI, et al. Present situation of clothing pressure measurement [J]. Journal of Jilin Teachers Institute of Engineering and Technology (Natural Sciences Edition), 2007, 23(3): 8- 10.

Mengzhen HUA, Jin LI. A study on a new test ways of clothing pressure [J]. Shandong textile technology, 2006, (5):38- 41.

WM Kirk, JR, et al. Fundamental relationship of fabric extensibility to anthropometric requirements and garment performance [J]. Textile Research Journal, 1966, 36:37-47.

Yejin Lee, Kyunghi Hong. Development of indirect method for clothing pressure measurement using three-dimensional imaging [J].Textile Research Journal, 2013, 83(15):1594-1605.

Siyuan CHENG, Shaowang XIE. Reverse engineering and application of Geomagic Studio [D]. Beijing: Tsinghua university press, 2010.

Yongtao BAO. The Finite Element Modeling and Application of the 95th Percentile Chinese Human Head [D]. Tianjin: Tianjin university of science and technology, 2010.

Hongqin DAI. Clothing ergonomics [D]. Suzhou: Suzhou university press, 2011.

Xiaochun HU, Songqin GUO, et al. Research on the3-dimensional finite element modeling of human foot-skeleton based on CT images [J]. JOURNALOF HEFEI UNIVERSITYOF TECHNOLOGY, 2005, 28(9): 1188- 1191.

S A Mirjalili, M Rafeeyan, et al. The Analytical Study of Garment Pressure on the Human Body Using Finite Elements [J]. FIBRES&TEXTILES in Eastern Europe, 2008, 16(3): 69-73.

Yinglei Lin, Kai-Fi Choi, et al. Finite element modeling of male leg and sportswear: contact pressure and clothing deformation [J].Textile Research Journal, 2011, 81(14): 1470-1476.

Rui DAN, Xuerong FAN, et al. Study on standard curve of lower leg cross section at top of men's socks [J]. Journal of Textile Research, 2012, 33(3): 119-123.

Gongbing SU, Haiying CHEN, et al. Building of finite element model of lower limbs and analysis of socks' comfort [J].Journal of Tianjin polytechnic university , 2013, 32(6): 32- 35.

Jia WANG. Study of the Influence of Garment Pressure on Human Physiological Comfort— Effect on the Skin Blood Flow of Pressure Exerted on Lower Limbs [J]. Suzhou: suzhou university, 2008.

TADAKI E, KUMAZAW A, et al. Hemihidrosis due to skin pressure with particular ramarks on the intensity and area of the pressure sti-mini [J]. Jpn J Physiol, 1981 (31): 259-267.

TANAKA S, MDORIKAWA T, et al. Effects of pressure exerted on the skin by elastic cord on the core temperature, body weight loss and salivary secretion rate at 35℃ [J]. Eur J App 1 Physiol, 2006 (96): 471-476.

Zhimin WU, Min ZHAO, et al. Carotid sinus physiology as affected by clothing pressure on human neck [J]. Journal of Textile Research, 2011, 32(5): 98-106.

Daifang XU, Dongyun LIU, et al. Analysis of Physiological Response by Pressure Developed by Female Swimsuit [J]. Journal of Beijing Institute of Clothing Technology, 2012, 32(1):1-8.

Zhaorong GUO, Jun XU. The test experiment of corset on human physiological effects [J]. Journal of Xi'an Polytechnic University, 2012, 26(2): 168-173.

Weina CHANG. The Clothing Comfort Based on the Pulmonary Function Analyser [J]. Textile science and technology progress, 2010, 35(6):71-73.

Tamura T., Koshiba T., et al. Effect of clothing pressure on the autonomic and the central nervous system [J]. Proceeding of the 23rd Symposium on Human-environment System, Sapporo, Japan, 1999: 132-135.

Lihua XIE, gang YAN, et al. the application of Homemade tight children suit in pediatric hyperplastic burn scar [J]. 2007, (1): 119-120.

Lizhuo WANG, Dongsheng CHEN. Study of pressure comfort of brassiere [J]. Journal of Textile Research, 2008, 29 (4): 134-138