Research on Test of Anti-G Suits Airbag Pressure

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Abstract. In order to solve the problem of overloading, the common international practice is to use anti-load equipment (anti-load suits). This article focuses on the role of capsule anti-Dutch suit pressure on pilots. Considering the actual situation of overload, if the absolute value of overload is too large and the applied pressure is too small, it will lead to imperfect overload and cause flight safety hazard. Conversely, if the absolute value of overload is too small and the pressure exerted on it will lead to blood circulation disorder Serious or even tissue necrosis occurs. Therefore, it is of great value to study the numerical relationship between cystic pressure and body pressure. In this paper, the relationship between capsule anti-static clothing pressure and body pressure is explored by experimental method. Wearable body surface pressure measurement device is designed based on the membrane pressure sensor. The research shows that: (1) there is a correlation between capsule pressure and body pressure, the absolute value of the body pressure can be estimated by the capsule pressure; (2) The corresponding relationship between the capsule pressure and the body pressure of different parts is different, The corresponding relationship between gauge pressure is also a certain difference.

Keywords: Anti-G suits · Pressure · Pilot · Pressure test experiment

1 Introduction

With the development of modern aviation, the flight capability of high-performance fighter jets has been greatly improved [1]. Overload, fast growth of overload and long overload time have become their important features. Pilots will experience significant acceleration during flight and in the event of overload, centrifugal force applied from the head to the foot forces the blood to the lower body [2, 3]. If the pilot's muscular structure does not adjust well, There will be gray-shaded, black-and-visual issues of great visual impact on the flight [1]. In order to deal with this kind of problem, scientists invented anti-Dutch pilot clothing as early as World War II, and later evolved into a compensatory service [4]. The principle of compensatory service worn by pilots was to pressurize the human lower extremities and abdomen through clothing, To maintain the effective circulation of the body's head blood volume and reduce the adverse effects of

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overload on the human cardiovascular system in order to achieve its anti-Dutch effect [5, 6]. However, there are still many problems with pilots compensating clothes: (1) many connections, complex structures and troubles in testing; (2) susceptible to wearing apparel, and poor real-time data testing [7, 8]; (3) There exists accuracy problem in testing. Therefore, on the basis of the previous studies, we improved the body surface pressure test of pilot compensation service [9]. We use RFP membrane pressure sensor, through the establishment of the test circuit system to obtain the resistance of the sensor changes, so as to obtain in the actual test wearing a compensatory pilot wearing the body surface pressure size. The wearable garment stress testing equipment we developed not only improves accuracy, but also makes testing easier than ever before.

2 Methods

In this study, RFP membrane pressure sensor was used to five parts (left and right thighs, left and right lower leg, abdomen) balloon pressure measurement and calibration to get more accurate pressure and pressure changes in the data, and thus for the future design of the pilot's clothing to do Make a little contribution.

2.1 Measuring Principle

RFP film pressure sensor consists of two thin polyester film, the inner surface of the two films contains conductors and semiconductors. The basic principle of the test is that by applying pressure to the surface of the RFP film, the resistance of the semiconductor decreases as the pressure increases, so different pressures will correspond to different resistances. In this way, by establishing a circuit sensor resistance system, you can know RFP membrane pressure sensor suffered the size of the pressure. When the sensor is used to test the pilot's 5 positions by the balloon pressure value, as long as you know the resistance of the pressure sensor, you can get different parts of the pilot suffered pressure and pressure changes.

2.2 Measurement Methods

a. The pressure sensor has been sewn five stress test strap tied to the thigh (left and right), leg (left and right) and abdomen, and connected with multi-channel pressure obtaining instrument. At the same time the pressure acquisition instrument is access to the computer, and open the appropriate software on the computer, record the static pressure data.
b. Increasing the access to gas, continuous recording of dynamic pressure data, but also record changes in the input pressure value.
c. The pressure data collected by the system should correspond with pressure values recorded respectively.
d. Experimental measurement device is shown in Fig. 1.

Fig. 1. Measuring equipment

2.3 Calibration Methods and Data Processing

Calibration Method

Calibrate the sensor with a press for every 50 g of boost (Figs. 2 and 3). Set the data measured by the sensor to y and press to x, and establish the linear relationship between x and y. Design programming experiment software According to its linear relationship (piezoelectric sensors have been calibrated by the manufacturer and provide the calibration data).

Fig. 2. Sensor calibration press

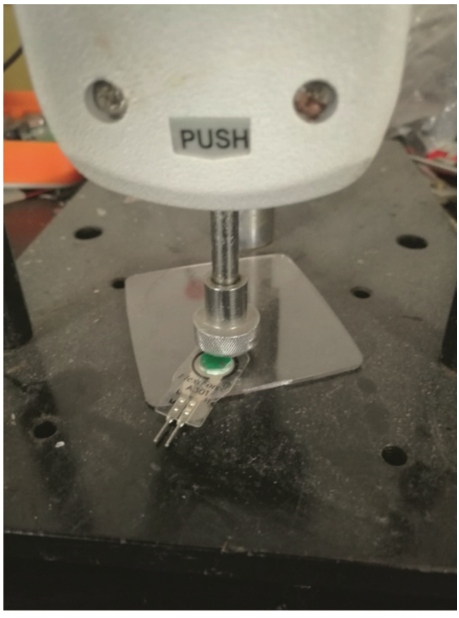

Fig. 3. Press calibration RFP film sensor

Data Processing
The data obtained from continuous testing is stored in Excel format with good notes. Calculate the slope and error when the pressure is rising by using the Excel to calculate the average of the fifteen measured data from the five sites. Assuming that the change of the data obtained by the pressure tester is y, the variation of the pressure unit of the gas introduced is x, and the linear relationship between y and x is established by using Excel to obtain the relationship between the actual compensated pressure and the body surface pressure. To prevent pilots in the high-speed overload dizziness situation to provide effective help.

2.4 Significance

Through the improvement of the sensor, to achieve more accurate and more convenient compensation service pressure measurement. The improved sensor can directly touch the skin, reducing the impact of dress on the experiment; RFP film pressure sensor consists of two thin polyester film, the inner surface of the two films laying conductor and semiconductor. Compensatory service Internal piezoelectric sensors on both sides of the layer to add a thin layer of elastomers, effectively help to absorb the error introduced by the force distribution, improve test accuracy; the use of multi-channel pressure sensors, each sensor corresponds to a channel, the data more accurate, more operational Convenience.

3 Results and Discussion

3.1 Detailed Description of the Research Process

In this study, we tested and recorded a total of 4 pilots pressure values at different press with compensated clothes, and also recorded the actual value of the gas pressure. The data collected by the pressure harvester is compared with the air pressure of the actual gas, and the relationship between them is found out.

3.2 Research Findings and Conclusions

This study mainly focuses on two points: (1) there is a correlation between capsule pressure and body pressure, the absolute value of the body pressure can be estimated by the capsule pressure, the effect of different body pressures on the blood circulation is different So as to dynamically update the capsule pressure according to the need of the flight so as to ensure the life safety of the pilot in the overload state; (2) The corresponding relationship between the capsule pressure and the body pressure of different parts is different, The corresponding relationship between gauge pressure is also a certain difference, so pilots should be obtained during training phase capsule pressure - body pressure “conversion table”, so as to pilots play an effective protective effect.

For the purpose of this study, we measured the surface pressure of pilot wearing a pressurized service pilot by using a piezoelectric sensor. We selected a total of 4

candidates for the entire experiment. Due to the operation and the software itself Some problems led to the deletion of the experimental data of the first candidate. However, when we still got the better data among the remaining three candidates, Fig. 4 shows that after we use Excel records, we process and analyze the data The actual pressure and various parts of the linear relationship between the measured values.

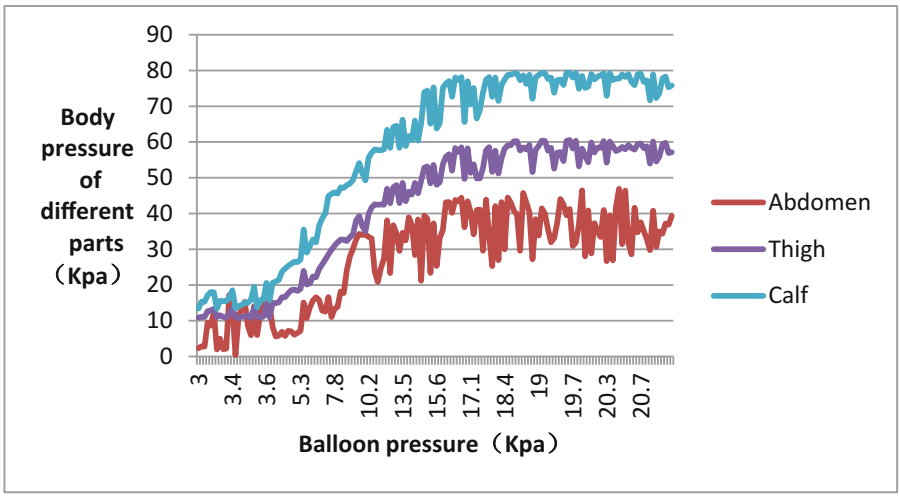

Fig. 4. Subjects' different parts of the body surface pressure changes with the balloon pressure

As can be seen from Fig. 4, the body surface pressure at 5 sites increases with the increase of capsule pressure. When the capsule pressure increases to a certain extent, the body surface pressure tends to be stable and no longer increases. The reason is that muscle has been compressed to the maximum extent, can not be further compressed, in line with the actual changes in human physiology. Comparisons can be found from various parts can be found, the smallest body surface pressure on the abdomen, calf surface pressure of the largest. This is because the abdominal and thigh parts of the larger force and fat content than smaller legs, resulting in a small surface pressure, in line with the actual situation of human physiology.

Figure 5 depicts the body surface pressure at 3 sites of abdomen, thigh, and lower leg at 5 kPa and 10 kPa balloon pressures. In addition, the error bars for each condition are plotted to show the difference between subjects. It can be seen that the difference of body surface pressure in the abdomen of the subjects is higher than that of the thighs and calves. The reason may be that the abdomen has more soft tissues and the differences among subjects are quite different. Fat content is relatively similar.

Figures 6, 7, 8, 9,10, 11, 12,13, 14, 15, 16, 17, 18, 19 and 20 are based on five parts of the body surface pressure and pressure changes in the relationship between the capsule pressure of three subjects, where the abscissa is the balloon pressure x (in Kpa), the vertical axis is the body surface pressure y (in Kpa), fitted straight line can be used to predict different body surface pressure according to balloon pressure in different parts of the subject. In addition to the poor fitting accuracy of Fig. 6, the other plots' R2 value are all

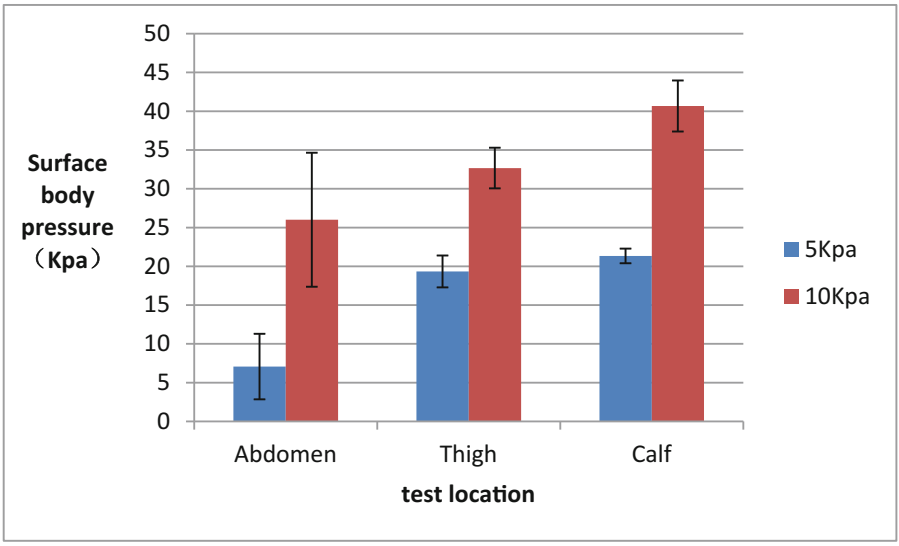

Fig. 5. Different parts and different pressure on the surface of cystic pressure contrast

greater than 0.95, indicating that the fitting accuracy is good and that the surface pressure of different parts of the pilot can be calculated directly from the fitted straight line equation, which will be effective to improve the researcher on the level of anti-Dutch clothing.

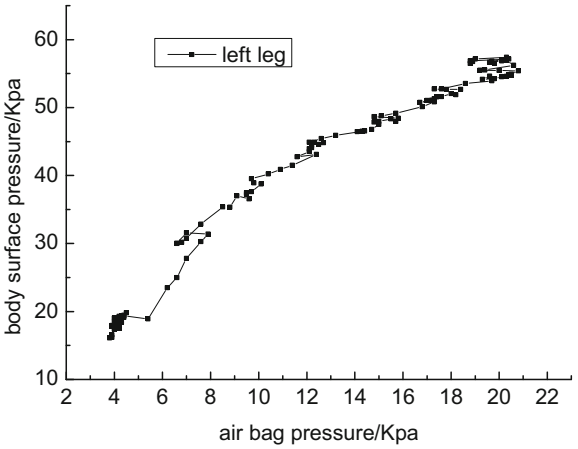

Fig. 6. Left leg body pressure changes with the cyst pressure of subjects 2

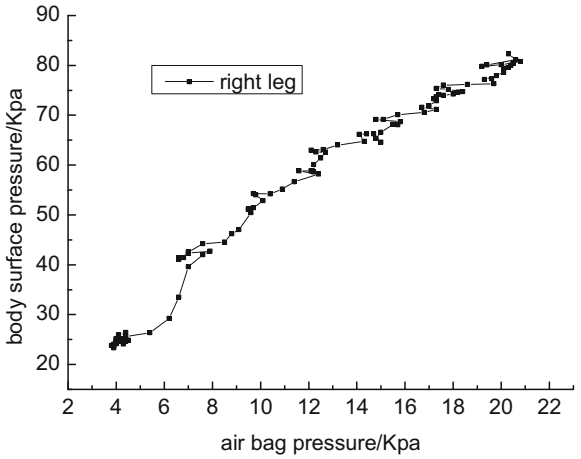

Fig. 7. Right leg body surface pressure changes with the cyst pressure of subjects 2

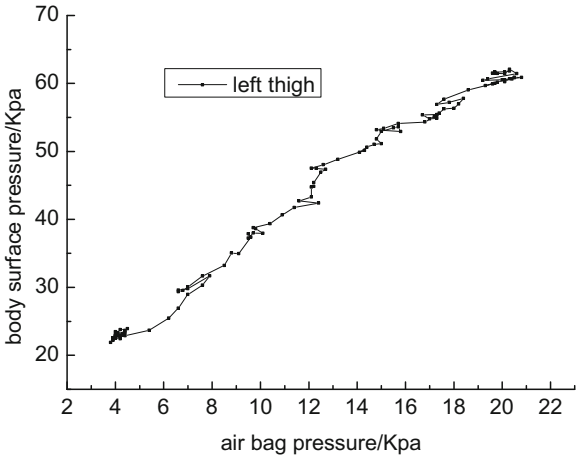

Fig. 8. Left thigh body surface pressure changes with the cyst pressure of subjects 2

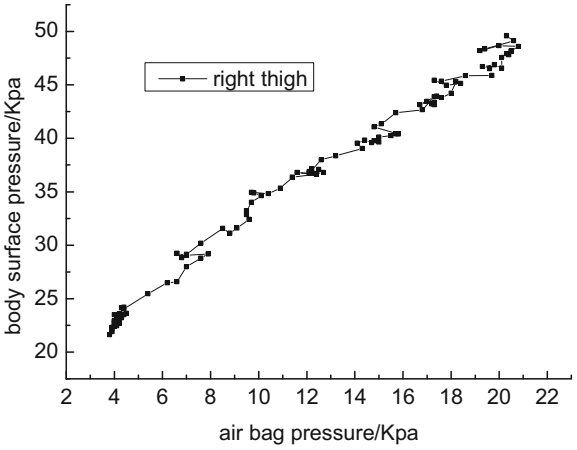

Fig. 9. Right thigh body surface pressure changes with the cyst pressure of subjects 2

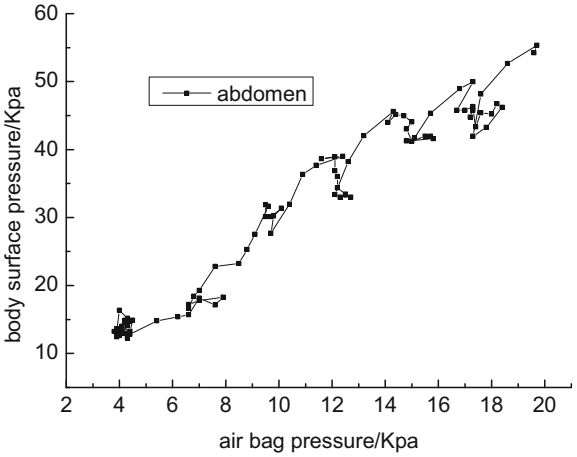

Fig. 10. Abdomen body surface pressure changes with the cyst pressure of subjects 2

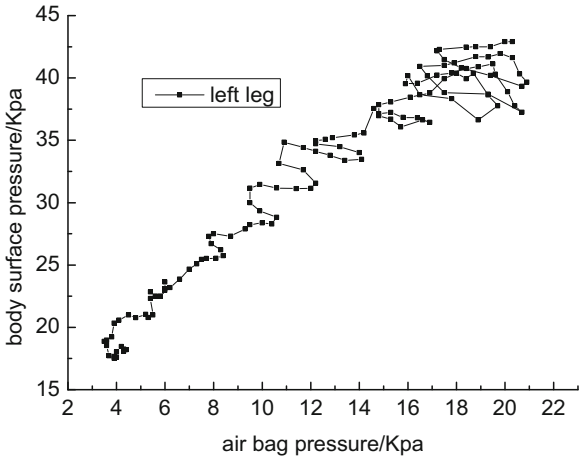

Fig. 11. Left leg surface pressure changes with the cyst pressure of subjects 3

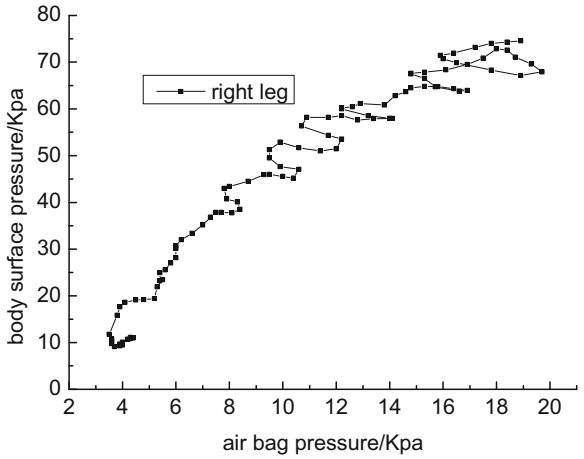

Fig. 12. Right leg surface pressure changes with the cyst pressure of subjects 3

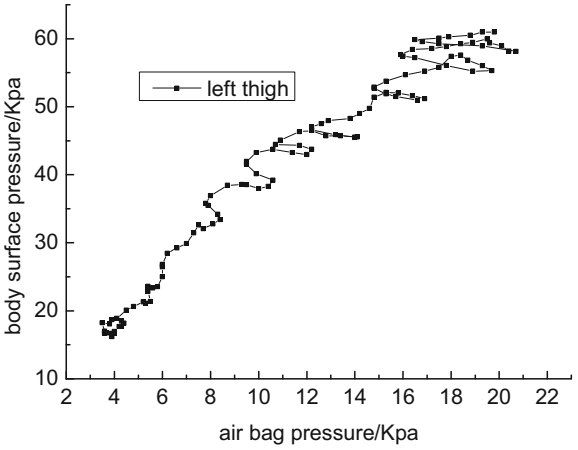

Fig. 13. Left thigh surface pressure changes with the cyst pressure of subjects 3

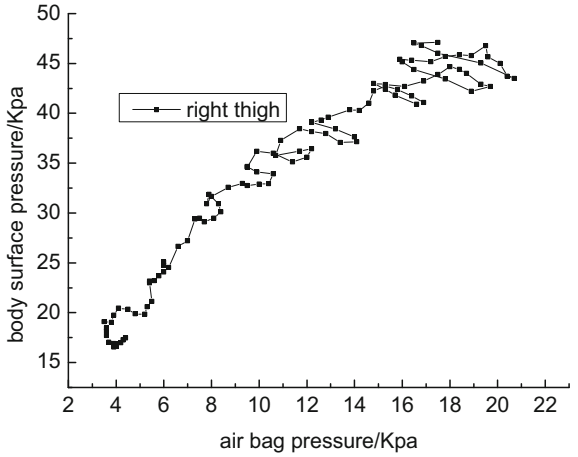

Fig. 14. Right thigh surface pressure changes with the cyst pressure of subjects 3

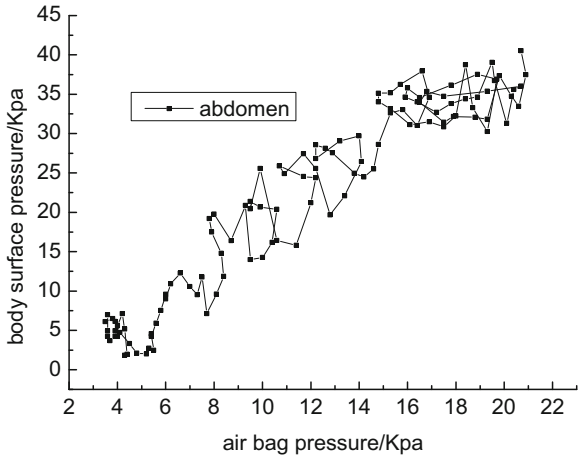

Fig. 15. Abdomen surface pressure changes with the cyst pressure of subjects 3

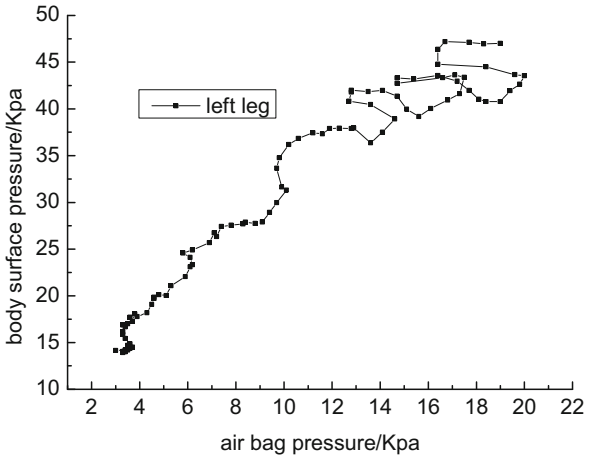

Fig. 16. Left leg surface pressure changes with the cyst pressure of subjects 4

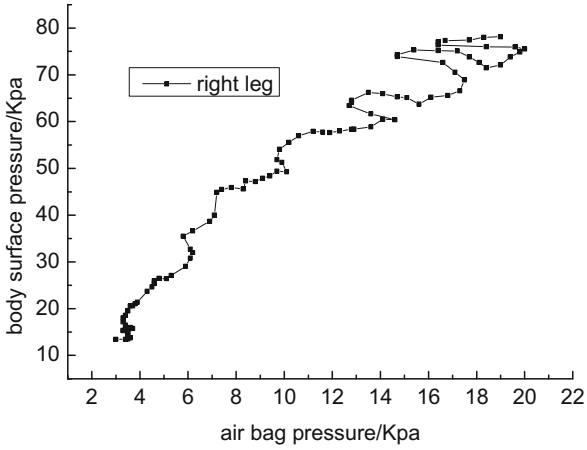

Fig. 17. Right leg body surface pressure changes with the cyst pressure of subjects 4

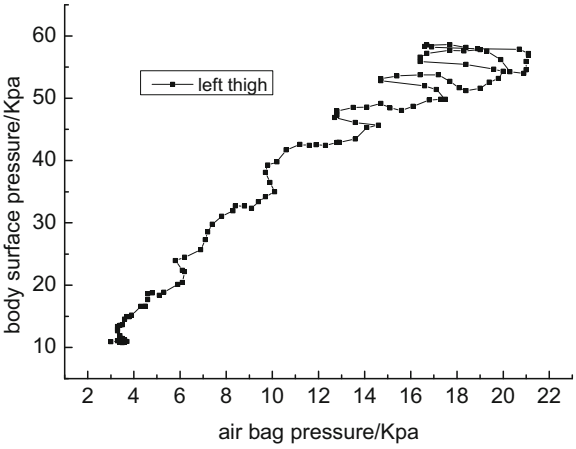

Fig. 18. Left thigh body surface pressure changes with the cyst pressure of subjects 4

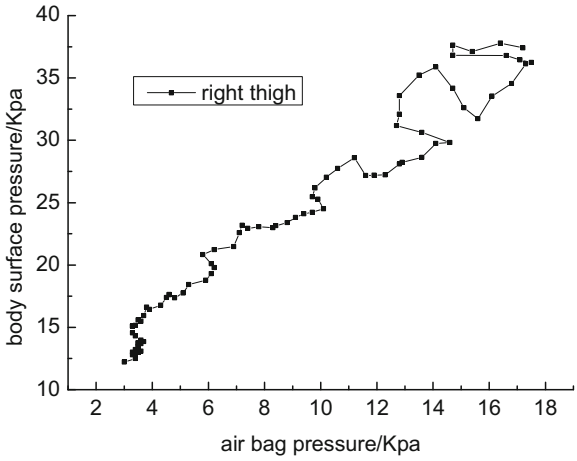

Fig. 19. Right thigh body surface pressure changes with the cyst pressure of subjects 4

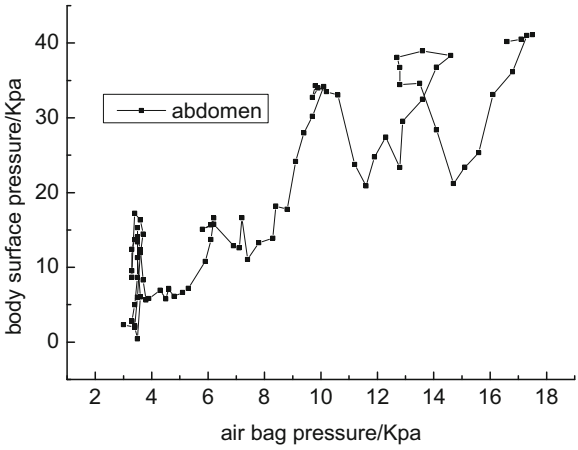

Fig. 20. Abdomen body surface pressure changes with the cyst pressure of subjects 4

3.3 Discussion of the Existing and New Problems

a. Due to the discrepancy between the experimental equipment and the expectation, we were unable to confirm whether the pressure catcher and the pneumatic pump could be unified at the same time. So we discussed with professor and finally learned that the increase of the pressure pump is set by air pressure of mask. The ultimate mask pressure is controlled by the pilot's breathing rate, and it will be based on a certain proportion of the relationship between the decision to pay the overall service pressure value. Therefore, we finally use the mobile phone to continuously record the data on the screen of the computer to compensate for the pressure changes, to facilitate our follow-up work on the data.

b. During the experiment, all the data of the first test failed to be fully recorded because of the storage function of the Lab view software itself. When we found out the problem, we found a way to deal with it and remedy it with Professor. And we also came up with the corresponding measures according to the existing problems in advance if similar software problems could be dealt with in the future.

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