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Evaluation and Study on Relationship between Sitting Posture and Work Efficiency

Pei Xuesheng[1,2], Tian Liyingi[2]

[1]*School of Mechatronic Engineering and Automation, Shanghai University, Shanghai, China*
[2] *School of Art and Design Henan University of Science and Technology, Luoyang , China*

Abstract. The relationship between the work efficiency and the sitting posture of the office staff was analyzed by comparing changes in operation time of different tasks at different sitting postures. Combined with the body pressure distribution experiment, the relationship of operation time at different sitting postures was concluded, which provides reference for the study on office chair design and work efficiency improvement.

1 Introduction

Most of the office staff sits during work. Sitting for a long time at work, people always feel fatigue and uncomfortable, and also feel upset mentally. Plus the comfortableness of office chairs, all the factors influence the work efficiency. However, after they change comfortable chairs with appropriate dimensions or change their postures, their work efficiency is improved unexpectedly. The work efficiency improvement due to comfortable chairs proves the statement[1-2] of ergonomics. At the same time, sitting for a long time and poor sitting postures adversely influence the human health, with an intensifying trend. Thus, the design of modern office chairs should not only improve the comfortableness but also consider the influence of the sitting posture on the work efficiency. Furthermore, the design should also sufficiently consider adjustment and correction for the sitting posture and reduce the adverse influence on human health to the maximum extent, so as to meet the human physiological needs. This needs to apply the principle and method of ergonomics and comprehensively consider the sitting posture behavior, the physical and geometric characteristics of chairs and the human-chair interaction relationship[3]. Many researches tried to improve the work efficiency by increasing the chair comfortableness. However, improvement in the comfortableness not necessarily improves the work efficiency. From different sitting postures, to verify the relationship between the sitting posture and the work efficiency, two sitting postures are adopted for testing.

There are three kinds of sitting postures, trunk bending forward, trunk straightening up and trunk bending backward. The requirement for the optimum sitting posture during office work is that the pressure it caused can be distributed in the intervertebral discs of the vertebrae in the most appropriate way and deal load it produced can be distributed in attached muscular tissues[4] in the appropriate and even way. Among these three sitting postures, trunk straightening up is the popularly required “ideal posture” and “healthy posture”. However, the research by W assem Am ir Bashir, a researcher from a Canadian hospital affiliated to the University of Aberta, with the nuclear magnetic resonance (MRD) method for the first time shows that if people sit straight up, their spine and surrounding muscles and ligament will be tensioned, which will cause chronic pain if people keep such sitting posture for a long time. This is also one of the reasons why people feel uncomfortable when sitting on a chair with a backrest at about 90 degrees[5]. When sitting for a long time, people need to adjust their postures and actions frequently, so as to eliminate abnormal pressure to the spine and to seek for the most stable and comfortable posture[6]. Thus, this paper tests the relationship between the sitting posture and the work efficiency by testing the two sitting postures, trunk straightening up and trunk bending backward.

2 Experimental process

2.1 Subjects

Twenty healthy subjects, half males and half females, aged 21-32 (25.2 years old at average), with regular work in the indoor offices, for computer operation and without medical history of spine diseases, were selected.

2.1.1 Formatting the title

The title is set in bold 14-point Arial, flush left, unjustified. The first letter of the title should be capitalised with the rest in lower case. You should leave 35 mm of space above the title and 6mm after the title.

2.1.2 Formatting author names and author affiliations

Author names should be typed in 9-point Arial. The style for the names is First Names then Last Name, with a comma after all but the last two names, which are separated by "and". Do not use academic titles.

Affiliations of authors should be typed in italic 8-point Arial. They should be preceded by a numerical superscript corresponding to the same superscript after the name of the author concerned. Please ensure that affiliations are as full and complete as possible and include the country.

2.2 Experimental design

The experiment adopts the single-factor two-level within-group design, and each subject is tested under these two fixed sitting postures. The most basic method of evaluating the relationship between the sitting posture and the work efficiency is to select suitable office chairs. Considering different heights and weights of the subjects, the chairs with adjustable height and backrest angle were chosen. The next step was to determine the sitting posture, for which the two postures, trunk straightening up and trunk bending backward, were adopted for the three experimental tasks. The last work is to set the work tasks, including typing, reading and calculating. The subjects should operate with all of these two postures and would be subjectively evaluated as to which posture is more comfortable after the test. Furthermore, the body pressure distribution of corresponding sitting postures was measured, and relevant experimental data were sorted for analysis.

2.3 Experimental facilities and testing environment

The experiment was divided into two parts, i.e. testing of the facial expression analytic system and body pressure distribution, and subjective evaluation of the subjects, which will be introduced as follows:

(1) Facial expression analytic system. Human facial expression provides massive important information for interpersonal communication. As one of the most direct communication methods, facial expression allows us to recognize the emotional state and intension of other people. However, it is extremely challenging to objectively explain the facial expression. The facial expression analytic system (Face ReaderTM) is a unique automatic facial expression analysis tool which allows users to objectively evaluate personal emotion changes. The facial expression analytic system can show whether the emotion are positive or negative while visualizing facial expression into bar charts, pie charts and continuous curve signals. It helps understand the emotional state of users in real time.

(2) The body pressure distribution of human bodies with the two sitting postures was measured with the tekscan device. The tekscan device can measure the pressure value of all points between the human body surfaces and the contact surfaces, and the tekscan pressure distribution measurement system uses the unique patent technology-the flexible film grid-type tactile pressure sensor. Due to the thin thickness of only 0.1mm and the good flexibility, the sensor provides better conditions for measuring pressure between various contact surfaces. Furthermore, pressure on any contact surface can be measured statically or dynamically, and the pressure distribution profile, various data and the pressure peak value can be displayed in real time through visual and vivid two-dimensional and three-dimensional colored images.

2.4 Experimental procedures

2.4.1Experimental preparation

(1) Researchers debugged two cameras, with one directly facing the subjects' faces, centered at nasal tips, so as to collect the subjects' expressions; and with the other one aligning at the sitting posture and operation process of the subjects, so as to verify the feasibility and accuracy of the experiment, and conduct pre-experiment for formal experimental content and do appropriate debugging.

(2) When the subjects arrived at the experimental site, they rested for 2 min before the experimenters explained the experimental purpose, method and requirements, so the subjects can understand the procedures of the whole experimental steps and followed the designed experimental steps during operation.

(3) arranged to take part in the experiment by operating with the postures of sitting upright or sitting back. Before the experiment, each subject informed the operator (responsible for recording videos of the subjects) after they were well prepared, and then started the experiment according to the sequence in the task cards after being told to start.

(4) After finishing operation with the first posture, the subjects reported to the operator and rested for 3 min, and then finished operation at the second posture with the same steps, and such procedures were repeated until the 20 subjects finished the tests.

(5) Body pressure testing. The sitting postures adopted in the experiment include sitting back and sitting upright. The subjects kept these two postures during experiment, and the body pressure distribution diagram of these two postures was obtained by the body pressure distribution testing system. Thus, the body pressure distribution borne by the chairs under these two sitting pressure can be obtained, which helps judge the comfortableness of the chairs.

3 Test results and data analysis

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The experiment collected a lot of experiment video and data. The tekscan device measured body pressure distribution data, and the software of the facial expression analytic system (Face ReaderTM) processed the obtained video so as to get related experimental data[7].

3.1. Body pressure distribution test

The experiment adopts two sitting postures, sitting back and sitting upright, and tests the body pressure distribution of corresponding postures in an elaborate way, as shown in Figures 1 and 2.

From the figures, it can be seen that the maximum pressure value is 200 for each of these two sitting postures. However, the pressure distribution gradient interfaces are different that pressure distribution was concentrated surrounding two points of the ischium for the posture of sitting back, and the area with the maximum pressure value for this posture is bigger than that of the posture of sitting upright, while the leg pressure is smaller; compared with the posture of sitting back, pressure distribution and pressure gradient change of the posture of sitting upright is evener, and pressure distribution of the whole contact surface is relatively even, so people can better keep the same working state for a long time.

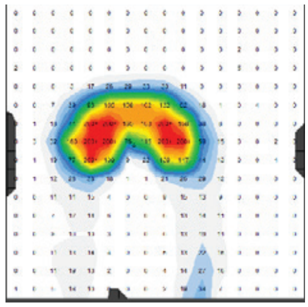

Figure 1. Body pressure distribution state at posture of sitting back.

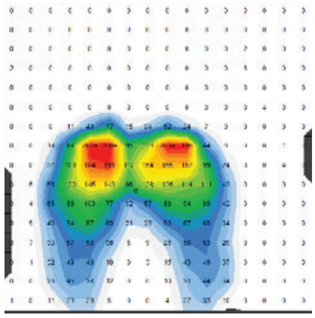

Figure 2. Body pressure distribution state at posture of sitting upright.

3.2 Task completion time statistics

As each subject operated twice during the experiment, they were divided into two parts randomly, with the first 10-person group operating sitting back firstly, while the other 10-person group operating sitting upright firstly. The time used by the subjects at both sitting postures was counted.

Table 1. Experimental time statistics

No.	First upright, then back						No.	First back, then upright					
	Sitting upright			Sitting back				Sitting back			Sitting upright		
	Typing	Reading	calculation	Typing	Reading	Calculation		Typing	Reading	Calculation	Typing	Reading	Calculation
1	252	104	124	170	98	52	2	211	131	63	169	118	42
3	254	57	30	210	32	28	5	147	53	25	194	39	26
4	211	190	98	153	179	40	7	242	99	70	213	77	29
6	360	115	81	278	81	29	10	302	141	72	249	94	47
8	221	61	71	138	48	93	12	247	53	45	240	26	35
9	255	121	70	204	103	45	13	179	65	44	151	58	40
11	272	70	141	209	81	34	14	114	81	40	110	65	25
17	231	148	60	186	135	67	15	227	58	44	214	52	34
18	143	87	38	85	97	28	16	193	89	70	170	52	38
19	137	114	49	129	82	47	20	248	124	38	204	114	29
Total time	2336	1067	762	1762	936	463	Total time	2110	894	511	1914	695	345

According to Table 1, whether for the posture of sitting back or sitting upright, all subjects used less time during the second operations. Thus, it can be seen that people's proficiency at work influences the work efficiency.

3.3 Analysis on task time

As the experiment adopts the single-factor two-level within-group design, time consumption of the first testing and the second testing for these two sitting postures was compared, the result of which showed the time consumption was the same. Thus, the time of three tasks at these two sitting postures was compared.

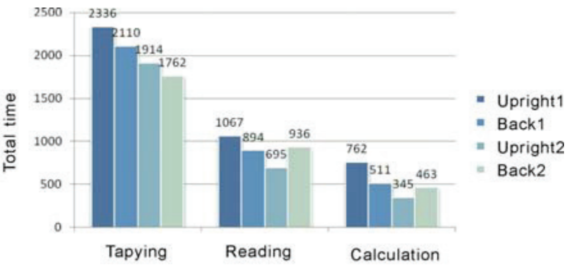

Figure 3. Bar graph of completion time of all tasks at two sitting postures.

From Figure 3, it can be seen that whether the subjects operated with the posture of sitting upright or sitting back, the time consumption of the three tasks for the posture of sitting back for the first time was less than that of the operation at the posture of sitting upright for the first time, indicating that the efficiency of people at the posture of sitting back is higher than that at the posture of sitting upright; while during operation for the second time, the subjects at the posture of sitting back were only faster in typing compared with at posture of sitting upright, while they at the posture of sitting upright were faster in reading and calculating compared with at the posture of sitting back. Through analysis, it is found that the reasons for this phenomenon include that during typing at the posture of sitting back, as the trunks bent backwards, the viewpoint height of eyes was lowered, and the sight distance was farther compared at the posture of sitting upright, so the whole field of view was broadened; in addition, the arm bending angle was bigger, so the movement scope of arms was enlarged and operation was more flexible. While when the subjects operated at the posture of sitting upright, the viewpoint height of eyes was high, and the sight distance was close, the bending angle of arms was smaller, so operation was restricted to a certain extent, and accordingly the subjects at the posture of sitting back was faster in typing. In contrast, during the experiment of "reading and calculating", why the subjects were faster at the posture of sitting upright at the second experiment was decided by the working state of the tasks. Specifically, reading needs a certain proper distance, so compared with reading at the posture of sitting upright, the sight distance of eyes was farther which influences the reading speed, and further influences the work efficiency. This can also be seen from the average values of the three tasks at these two different sitting postures.

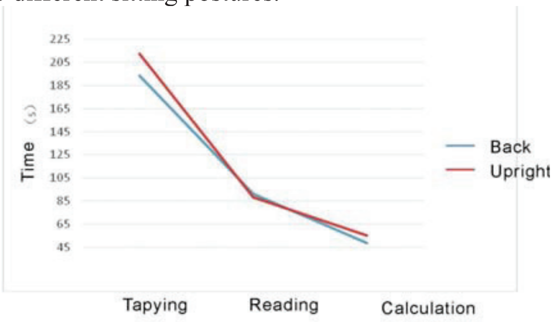

Figure 4. Task completion time at different sitting postures.

From Figure 4, it can be seen that the subjects sitting back were faster in typing and calculating compared with that sitting upright, indicating that they had higher task completion efficiency at the posture of trunk bending backward, but they were slightly slower in reading compared with that at the posture of trunk straightening up. This is decided by the operation characteristics of the tasks. In particular, the reason why the reading time at the posture of trunk bending backward was more than that at the posture of trunk straightening up is that the farther sight distance caused by the sitting posture led to the farther sight distance during reading, which influences the reading speed and further increases the reading time at the posture of trunk bending backward.

3.3 Descriptive statistics test

The facial expression analytic system (Face ReaderTM) recognized the facial expression of the 120 operating videos, and data were analyzed through software identification, from which the following icons were obtained.

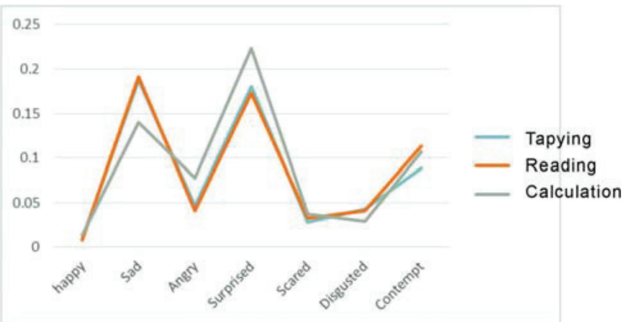

Figure 5. Emotional intensity for different tasks at the posture of sitting upright.

From Figure 5, it can be seen that the positive emotion brought by sitting upright and sitting back during calculating was surprisingly higher than that during typing and reading, indicating that different work contents can result in emotional fluctuations. Specifically, dull work with repetitive reduces people's working enthusiasm, while challenging work is more apt to cause emotional changes, and further can arouse people's working enthusiasm.

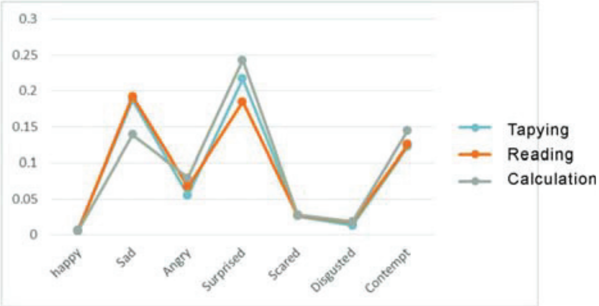

Figure 6. Emotional intensity for different tasks at the posture of sitting back.

From Figure 6, it can be seen that the positive emotional valence brought by sitting upright and sitting back during calculating was bigger than that during typing and reading, indicating that calculating gave people more positive emotional experience. However, the positive emotion caused by calculating at the beginning was truly less than that caused by reading and typing, the reason for which is that the difficult work suppresses people's working emotion at the beginning, but once approaching completion, the positive emotion will increase sharply, thus bringing the sense of joy for people.

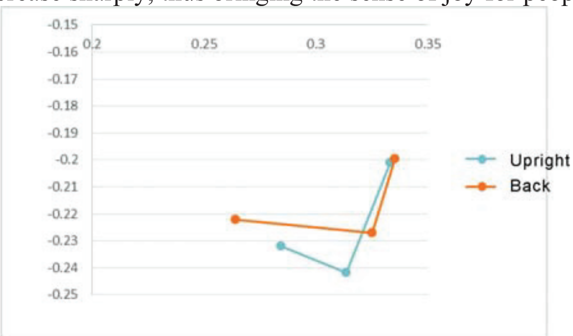

Figure 7. Positive emotion aroused by all tasks at different sitting postures.

From Figure 7, it can be seen that in the three tasks, the emotional arousal value of the posture of sitting back is the largest, indicating that the posture of sitting back causes more positive emotional experience compared with the posture of sitting upright, the reason for which is that when sitting back, the normal waists are in the curve shape of lying on side in a relax state. In this state, the gaps between the spines is normal, pressure on the intervertebral discs is tiny and even, causing hardly any thrust to the ligament, so people feel most comfortable and relaxed. Thus, in the posture of sitting back, the positive emotion is higher than that in the posture of sitting upright.

4 Shortcoming

Due to limitation in experimental task setting and random difference of the subjects, in spite of some deviation in the experimental task, the whole experimental design also has some shortcomings: (1) due to limitations of self-designed conditions of the testing personnel, there is difference which leads to deviation in the result of task completion data; (2) the operating time of each tester should be extended, the reason for which is that the less than half an hour of experimental operation time does not allow a good understanding of the difference in the work efficiency at different sitting postures during long-time work; and (3) the body pressure testing only extracted pressure distribution in the static state, rather than adopting the dynamic records.

5 Conclusion

(1) Starting from three viewpoints, the work efficiency related to the sitting posture, the office chairs and different work contents, this paper designs the experiment exploring the relationship between different sitting postures of the office staff and the work efficiency.

(2) According to the experiment, there are many factors which influence the work efficiency, including not only work contents but also the working proficiency and the operating characteristics of the work contents. The relevant data and factors obtained can help for desk and chair design in later days.

(3) Through comparison of these two sitting postures, it can be seen that for work within 10 min, the posture of sitting back can better arouse the enthusiasm of people and is favorable for the work mainly relying on arms. While for work with more than 10 min, the advantages of the posture of sitting back are only limited to the work mainly relying on arms, and the efficiency of working at the posture of sitting upright is higher for the other two tasks, which indicates that for long-time operation, it' s more appropriate to choose the posture of sitting upright for the work with requirements for the sight distance.

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