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Research of Body Pressure Distribution Change with the Use of BackJoy and Satisfaction of Human Sensibility

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Objective: The aim of this study is to investigate the effect of BackJoy on how it effectively reduces the physical load generated in a posture in which the user sits, increases user's comfort and satisfaction, and maintains the correct posture.

Background: Because of development of science and economic development, most office workers and students spend about 75% of their working time in chairs. However most of them have a poor posture.

Method: This experiment conducted measurement using a pressure mat and surveyed to evaluate fatigue level, satisfaction and comfort of sit. The study is experimented 20 male and 14 female participants. The participants carried out four different types of tasks and each task took 20 minutes long.

Results: In the case of experiment results before and after the use of BackJoy, average pressure, contact area and pressure per unit area appear to prove that using BackJoy is more effective.

Conclusion: Through this study, the BackJoy's effects for the maintenance of good posture and loads that occur in the body are reduced. In the future study, there are some researches needed for various verifications using an EMG sensor that shows loads of vertebrae and we need to analyze each group of the participants by dividing them.

Application: The evaluation method used in this study can be applied to evaluating ergonomic chairs.

Keywords: BackJoy, Sitting Posture, Body Pressure Distribution, Satisfaction, Comfort

1. Introduction

Although, most office workers sit about 75% of their working time in chairs in everyday life, they have maintained improper working posture, given that only 31% of them maintained balance to left and right directions and only 25% to forward and backward directions out of their total sitting time in chairs, respectively (Park, 2011).

Although, sitting time in chair increased, most office workers did not maintain proper working posture. For this reason, studies on the posture, when users sit chairs, are actively conducted recently through body pressure distribution measuremen and experiments using EMG sensors. Mergl (2005) and Zenk (2006) studied what effects the chair users have on physical fatigue and mental comfort through body pressure

distribution measurement. Choi (2013) classified driver's seat body pressure distribution-based sitting strategies, and Park (2012) measured body pressure distribution, analyzed workers' posture in the case of VDT work and evaluated discomforts. Park (2013) conducted a study on the warning function, when a user takes improper posture by installing sensors on the seat board and back board of an office chair. Kim (2011) was studied that the chest supported chair's effects for the maintenance of good posture. From the studies conducted thus far, studies on body pressure and comfort were carried out on the basis of car seats or office chairs. However, most users do not have the seats or chairs studied and designed ergonomically in a car or the office. To supplement such a demerit, the BackJoy that can be conveniently carried anywhere, anytime to simply maintain proper posture has been studied.

This study investigated and analyzed R&D on various chairs development to maintain proper posture in students' learning activities or office worker's working, and conducted research on how much BackJoy can effectively reduce physical load occurring from user's sitting posture, and enhance satisfaction and comfort, and on whether BackJoy has an effect on maintaining proper posture by measuring body pressure and using a questionnaire survey technique.

2. Method

2.1 Subject

This study selected 34 male and female collegians without muscular skeletal disease around the waist (Male: average height - 174.67cm, average weight - 73.1kg / Female: average height - 162.21cm, average weight - 54.4kg) as the subjects of this study. The males and females were divided into three groups so that a variety of people could be recruited from the height aspect in selecting the experiment participants (Table 1) (Size Korea Home Page, 2013).

Table 1. Group classification

Gender	Group			Total
Male	Under 169.5cm	169.5cm ~ 176.7cm	Exceeding 176.7cm	20
	5	8	7	
Female	Under 157.5cm	157.5cm ~ 161.5cm	Exceeding 161.5cm	14
	4	5	5	

2.2 Equipment used

To study body pressure distribution change according to the use of BackJoy (with BackJoy and without BackJoy), the pressure mat was set on the chair used in a general lecture room and on BackJoy. For the pressure mat, a square mat installed with Xsensor's 36x36 sensor was used for measurement, and the measured data were analyzed using Xsensor's X3 Pro v6.0 software (Table 2). The collected data were analyzed on whether statistical significance existed with regard to before and after the use of BackJoy using the SPSS 18.0 program.

2.3 Experimental design

To measure the change in body pressure distribution, according to the use of BackJoy (with BackJoy and without BackJoy), experiments before and after the use of BackJoy were conducted. To measure change, when task is performed, and when task is not performed, the experiments were carried out by classifying tasks into four types (Table 3).

Table 2. Equipment used in the experiment

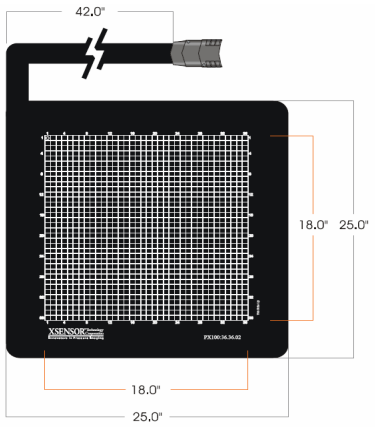
Experiment equipment	Pictures
BackJoy (BackJoy SitSmart, BackJoy Co.)	
Pressure mat (X3 100 36x3, Xsensor Co.)	

Table 3. Task classification

Step 1	Without BackJoy / 20 minutes to sit quietly
Step 2	Without BakcJoy / 20 minutes performing computer tasks
Step 3	With BakcJoy / 20 minutes to sit quietly
Step 4	With BackJoy / 20 minutes performing computer tasks

The experiment was carried out with 3-step procedure (preparation, implementation and questionnaire steps) (Figure 1). In the preparation step, pre-education was conducted so that the subjects could accurately recognize the purpose and procedure of the experiment, and their basic information and size (height, weight, chest size, and hip circumference) was measured, after preparing for subject's experiment consent. In the experiment performance step, experiments were conducted on the four types of tasks, and body pressure distribution by task was measured using the pressure mat. Each task continued 20 minutes, and 30 minutes of sufficient rest was provided between each task to minimize load that can occur from the experiment participant's body. In the task performing work, the subjects could conduct the same work by searching the Internet and wrapping up, based on one keyword. In the last survey step, a survey was conducted on the basis of the questions designed beforehand, and interviews were carried out for emotional part so as to reflect the experiment participants' opinions.

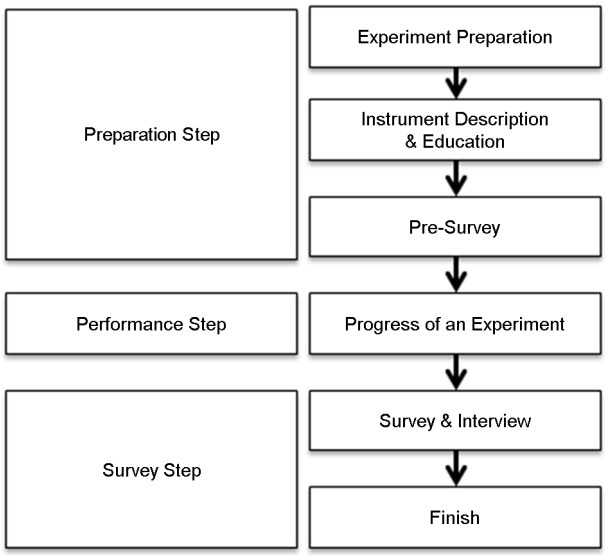


Figure 1. Experiment process

3. Results

3.1 Body pressure distribution

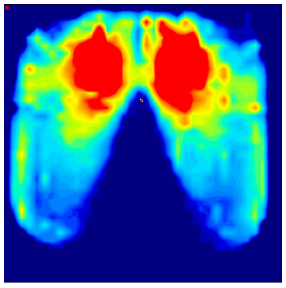
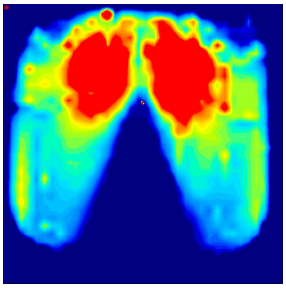
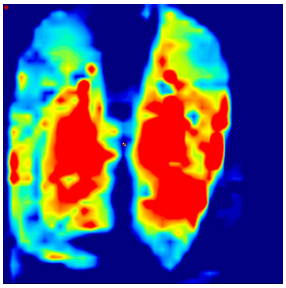
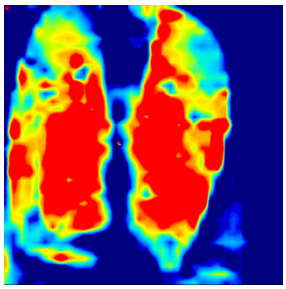
This study comparatively evaluated through statistical verification on the cases of working and not working before and after the use of BackJoy, and also verified significance. Body pressure distribution measurement can be used for the evaluation of user's discomfort or fatigue level (Na, 2000): when high average pressure is measured, it is known that proper posture is not maintained (Oh, 2012). This study checked what body pressure value was demonstrated on average through the average pressure (g/cm^2) value in the experiment. Also, this study calculated the area, where hips contact through the contract area (cm^2) value, and computed total load, in addition to average value through the Est. load (N) value computed from the multiplication of the hip contact area by average pressure value so as to use it for fatigue level evaluation.

For comparative evaluation, this study compared the initial and last values in terms of the use of BackJoy (with BackJoy and without BackJoy), and checked in which case smaller change occurred. And then, this study checked in which case smaller average value was shown through average value comparison using the data, according to the use of BackJoy (with BackJoy and without BackJoy). Through these two comparisons, this study checked how much more effective it is to use BackJoy (Table 4). Also, an analysis was conducted to find out which had bigger effect in terms of the use of BackJoy (with BackJoy and without BackJoy) by classifying into the cases of performing task and non-performing task.

For average pressure, looking at average change before and after the use of BackJoy, the average pressure was 69.84g/cm^2 before using BackJoy, but it fell to 66.03g/cm^2 after using BackJoy. Looking at change while maintaining sitting posture, the average change was 3.63g/cm^2 before using BackJoy, but it was 2.88g/cm^2 after using BackJoy. In the significance test through ANOVA analysis, significant difference was exhibited on the results before and after the use of BackJoy ($F(1,135)=6.253$, $p<0.05$) (Table 5).

Regarding the contact area, the average contact area fell from 1268.72cm^2 before using BackJoy to 1216.75cm^2 after using BackJoy. Looking at the change while maintaining sitting posture, the average contact area was 190.06cm^2 before using BackJoy, but it was reduced to 29.06cm^2 after using BackJoy. In the significance test through the ANOVA analysis, there was significant difference on

Table 4. Average body pressure distribution for each task

Task	During the experiment, average body pressure distribution (A sample of the experimenter 1)
Step 1 Without BackJoy 20 minutes to sit quietly	
Step 2 Without BakcJoy 20 minutes performing computer tasks	
Step 3 With BakcJoy 20 minutes to sit quietly	
Step 4 With BackJoy 20 minutes performing computer tasks	

the results before and after the use of BackJoy ($F(1,135)=6.99$, $p<0.01$) (Table 5).

In the case of Est. load, it dropped from 871.55N on average before using BackJoy to 793.74N after using BackJoy. Looking into the change while maintaining sitting posture, the average change was 63.86N before using BackJoy, but it was demonstrated as 52.74N after using BackJoy. The significance test through the ANOVA analysis, there was significant difference before and after the use of BackJoy ($F(1,135)=8.98$, $p<0.01$) (Table 5).

Table 5. Analysis of the difference between before and after the use of BackJoy

Classification		Mean			Std. Deviation			F	Sig.
		Initial	Final	Total	Initial	Final	Total		
Average pressure (g/cm^2)	Without BackJoy	68.56	72.19	69.84	0.84	0.82	8.41	6.253	0.01*
	With BackJoy	65.17	68.05	66.03	2.71	2.75	9.31		
Contact area (cm^2)	Without BackJoy	1256.922	1446.98	1268.72	6.68	176.44	108.36	6.99	0.01*
	With BackJoy	1210.21	1239.27	1216.75	13.88	11.22	120.53		
Est. Load (N)	Without BackJoy	848.67	912.53	871.55	17.31	22.91	155.33	8.98	0.00***
	With BackJoy	775.31	828.05	793.74	83.43	93.19	147.41		

An analysis was carried to identify the effects in the cases of using and not using BackJoy (with BackJoy and without BackJoy) by dividing into the cases of performing work and not-performing work.

In the case of average pressure, it fell by about 5.09g/cm^2 from 69.23g/cm^2 before the use of BackJoy to 64.14g/cm^2 after the use of BackJoy, when work was not performed. But, average pressure dropped by about 6.62g/cm^2 from 70.46g/cm^2 before the use of BackJoy to 63.84g/cm^2 after the use of BackJoy, when work was performed. In case of contact area, it fell by 54.84cm^2 from 1259.71cm^2 before the use of BackJoy to 1204.87cm^2 after the use of BackJoy, when work was not performed. However, contract area dropped more by 7.55cm^2 from 1271.78cm^2 to 1209.39cm^2, when work was performed. For Est. load, it fell by 95.11N from 857.42N to 762.31N, when work was not performed. However, Est. load dropped more by about 31N from 885.69N to 759.58N, when work was performed (Table 6) (Table 7).

Table 6. When work was not performed: Analysis of the difference before and after the use of BackJoy

Classify		Mean	Std. Deviation	F	Sig.
Average pressure (g/cm^2)	Without BackJoy	69.23	8.53	5.67	0.02*
	With BackJoy	64.14	9.06		
Contact area (cm^2)	Without BackJoy	1259.71	103.18	3.86	0.05
	With BackJoy	1204.87	125.90		
Est. Load (N)	Without BackJoy	857.42	150.63	7.51	0.01*
	With BackJoy	762.31	135.20		

Table 7. When work was performed: Analysis of the difference before and after the use of BackJoy

Classify		Mean	Std. Deviation	F	Sig.
Average pressure (g/cm^2)	Without BackJoy	70.46	8.36	10.21	0.02*
	With BackJoy	63.84	8.69		
Contact area (cm^2)	Without BackJoy	1271.78	105.76	4.63	0.03*
	With BackJoy	1209.39	131.89		

Table 7. When work was performed: Analysis of the difference before and after the use of BackJoy (Continued)

Classify		Mean	Std. Deviation	F	Sig.
Est. Load (N)	Without BackJoy	885.69	160.89	12.36	0.00***
	With BackJoy	759.58	133.62		

3.2 Sensitivity evaluation

In the evaluation of one's own usual posture score, the mean value was 3.35 (Std=0.157). Subjects with less than mediocre (4 points) were 61.8% (total number of subjects: 34, subjects with less than 4 points: 21). However, one's own usual posture score, after the use of BackJoy, was 5.05 on average (Std-0.197), and those who with less than mediocre were 11.7% (total number of subjects: 34, subjects with less than 4 points: 6). Among the experiment participants who thought their own poster score was bad with less than 4 points, 85% (18 subjects) of them were changed to mediocre or higher ($F(1,66)=45.571$, $p<0.01$), after the use of BackJoy. Three subjects, who gave score less than 4 points, even after the use of BackJoy, evaluated their usual sitting posture as 2 points. They showed interview result that they evaluated their sitting postures after the use of BackJoy as not good, because it was hard to maintain waist straight, since their usual posture was so bad (Table 8).

Table 8. Posture scores before and after the use of BackJoy

Classification		Mean	Std. Deviation	F	Sig.
Total score	Without BackJoy	3.35	0.16	10.22	0.01***
	With BackJoy	5.05	0.20		

In the evaluation of comfort on the hips, thighs and the part below knees before and after the use of BackJoy, the scores after the use of BackJoy were higher than those before the use of BackJoy. One's own evaluation on the comfort of hips and upper part of thighs was 3.64 points, but it went up to 4.58 points after the use of BackJoy ($F(1,66)=11.56$, $p<0.05$). For the comfort of the part below knees, the usual mean comfort score was 3.65, but it went up to 4.59 after the use of BackJoy ($F(1,66)=4.86$, $p<0.05$) (Table 9).

Table 9. Comfort evaluation before and after the use of BackJoy

Classification		Mean	Std. Deviation	F	Sig.
Hips, Thighs	Without BackJoy	3.64	0.92	11.56	0.01*
	With BackJoy	4.58	1.15		
Below the knees	Without BackJoy	3.65	1.12	4.86	0.31*
	With BackJoy	4.59	1.16		

In the additional interview, when 73% (25 people) of the experiment participants used BackJoy, they showed an opinion that using BackJoy was more comfortable than sitting in an ordinary chair in the waist straightening posture. Also, there was an opinion that a feeling of converging hips was good, and an opinion that BackJoy was helpful to maintaining proper posture, because it was difficult to take twisting legs, when they used BackJoy.

4. Conclusion

This paper carried out a study to verify how much BackJoy can reduce physical load occurring from user's sitting posture, raise satisfaction and comfort, and how much effect of BackJoy had on the maintaining proper posture through body pressure distribution measurement and a questionnaire survey technique.

Through experiments, this study checked how much body pressure was indicated on average through average pressure values. Through contact area values, the area that hip contact was calculated, and mean and total loads (N) were computed through Est. load values by multiplying the area value by average pressure value to use them for fatigue level evaluation. This study also compared the initial and last values in the cases of using and not using BackJoy (with BackJoy and without BackJoy) and checked in which case change was smaller. And then, this study also confirmed in which case smaller mean value was demonstrated through average value data comparison, according to the use and non-use of BackJoy. Through these two comparisons, how much more effective it was to use BackJoy was confirmed. By dividing the cases of performing and non-performing work, an analysis was carried out to identify which case had more effect in terms of the use and non-use of BackJoy.

This study compared the initial value before the use of BackJoy and final value after the use of BackJoy by dividing into the cases of using and not using BackJoy. In all evaluation of average pressure, contact area and load to each area, smaller changes were shown, when BackJoy was used. In the average of data, while using BackJoy, smaller average values were demonstrated in the case of using BackJoy than the case of not using BackJoy. Consequently, when a user was sitting in a chair, the case using BackJoy was effective to reduce the load that may occur physically, compared to the case of not using BackJoy. In the comparison of average pressure, contact area and load to each area according to performing and not performing task, the change values were bigger in the case of using BackJoy. Through this, this study confirmed that the use of BackJoy was more effective (Tables 5 to 7).

In the questionnaire survey results, the experiment participants evaluated the corrected posture by using BackJoy was better than their usual sitting posture. The experiment participants, who evaluated their own sitting posture low in the cases of using and non using BackJoy, said they gave low score, because lots of load occurred to maintain waist straight, even after the use of BackJoy, given that their usual sitting posture was so bad. In the comfort evaluation of hips, thighs and the part below knees in the cases of using and not using BackJoy, the scores of the experiment participants were higher in the case of using BackJoy (Tables 8 and 9). In the additional interviews, there were opinions that they received help in straightening waist and their hips were converged and that they also got help in maintaining proper posture, because twisting legs was not easy using BackJoy.

This study verified the effects of BackJoy, through which users can correct their sitting posture, based on the simple use method and convenient potable attribute of BackJoy, via body pressure distribution measurement and a questionnaire survey. In the future study, verification into more diverse directions is presumed to be necessary by carrying out research via experiments on the load occurring to user's waist through the effects of BackJoy, according to user's weight, by attaching EMG sensors.

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