

Research Article

Method and Device for Determining Comfort in Seating Groups and Comparison of Subjective and Objective Evaluations

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Abstract

Seating groups, designed to support various human activities such relaxation, calming and relieving tiredness, are one of the most important products that directly affect the quality of life. Resulting from the product diversity and development of technology, human expectations from products have increased. Comfort, aesthetics and ergonomics have gained importance in selection criteria at this phase. However, the perception of comfort varies according to body mass index, tiredness level and psychology of the person. This variety poses a major problem in standardizing comfort. The furniture industry needs an understandable comfort scale that can appeal to the majority of the society. This study focuses on two issues: a checklist based on the parameters determined to evaluate the comfort of seating groups by determining the comfort parameters, and the development of a mathematical modeling method of comfort based on the feedback obtained from the users about the products. In order to determine the comfort criteria, comfort studies made in various areas and products have been examined, and a machine that applies pressure to the back and seating points of the seating groups in accordance with the ergonomic structure of the people, records the reaction force obtained from the product according to the applied pressure in the data memory and converts it into a graphic. The designed machine processes the mathematical formula to be created with the variables of position, force and time to reach the force, within the data it receives, and ensures a comfort

value in the products. As a result, the comfort standard in seating groups has been determined by the mathematical modeling method and will be made into a quality standard by using the method determined in new product designs.

Keywords: Furniture, Seating Group, Comfort, Mathematical Modeling, Comfort Test, Comfort Standard

1. Introduction

Many people spend a significant portion of their time seating nowadays, and people's desire for comfort in seating is constantly increasing. Comfort become prominent in numerous products those with physical touch with the end user, such as the seating group. Inkum et al. (2020) indicates that approximately 50% of people complain of back pain caused by poorly designed sofas and chairs. This issue, which is extremely important for human health, especially for seating groups, should be seriously considered. According to Kasal et al. (2015), the fact that compliance with comfort and ergonomics criteria, along with aesthetic and durability factors in the design of a seating group, will directly influence human health makes these factors even more considerable.

Failure to perform comprehensive analysis for the comfort aspect of design in seating groups causes to be negative feedback from the end user. Most of the studies rely on a subjective sensation, such as a questionnaire or checklist, and qualitative data obtained by analyzing feels to measure seating comfort. Anthropometric and objective studies have also been carried out albeit few in number. Swardzewski (2013) examined the effect of springs on seating comfort. It determined the resistance of the springs to the load and it was determined that there was no change in the spring height after prolonged seating because of stiffness property and thus the impact on comfort was not significant. In order to evaluate the comfort of the classroom furniture, anthropometric measurements were taken from 225 university students and comparing with the existent classroom furniture, Kahya (2018) observed that the existing classroom furniture was exceedingly suitable for the anthropometric characteristics of the students.

Zhang et al. (1996) studied 42 office worker participant and various descriptors to identify factors associated with seating comfort and discomfort. In order to investigate the polydimensional nature of comfort, comfort descriptors were requested from office workers and verified by a questionnaire study, which is a subjective measurement method. Naddeo et al. (2018) emphasized that there are three fundamental elements that make up the perception of comfort, these are human posture, pressure and load distribution in the contact area. Experimental tests were conducted using a school chair on the effects of three main factors on comfort. As a result of the study, it was determined that there was a positive correlation between anthropometric variables (subjects' height,

age and weight) and pressure variables (peak pressure and average pressure). There is a negative correlation between contact area and peak pressure, as one increases, the other decreases. Volpe et al. (2012) proposed an approach to simplify and shorten the furniture design process based on parametric CAD models and FE simulation. It render possible to test products virtually without prototype production.

Bahrampour et al. (2019) used a subjective evaluation method with 6 different seat depths on 36 university students in order to determine the optimum depth in the school chair. At the end of the test period of 90 minutes, it was concluded that the feeling of discomfort decreased and the seat depth of 40.2 cm was more comfortable. Itfekhar et al. (2019) conducted a survey on 100 participants on the seat using pneumatic cylinders to provide comfort. It was concluded that people between the ages of 20 and 30 like high pressure, while people between the ages of 30 and 50 like low pressure.

The article proposes a test device that enables the evaluation of seating group comfort based on the objective measurement methods used for the development of the comfortable seating group and the feeling of comfort was determined qualitatively by receiving feedback from users with a checklist based on comfort parameters.

2. Materials and Methods

This study includes subjective evaluation including user feedback and objective evaluation including measurements and evaluation with the developed comfort test device. Studies were carried out on 4 different seats shown in Figure 1. The study was also conducted on 40 volunteers (20 men - 20 women) between the ages of 20-35. There are no known diseases. Subjects were asked to sit on the chairs one at a time. The test time was a minimum of 5 minutes for each seat. Comfort assessments of the subjects were made after sitting and touching actions based on perceptual sensations. The subjects were asked to evaluate the sensation in different body parts after the test.



Figure 1: Seats used in the study (Manufacturer: Yataş Group, Turkey)

Anthropometric measurements of the individuals were obtained, and these measurements taken from the seats and people were then compared. Measurements were taken from subjects in sitting and standing positions. An anthropometric device defines all dimensions and weight information shown in Figure 2.

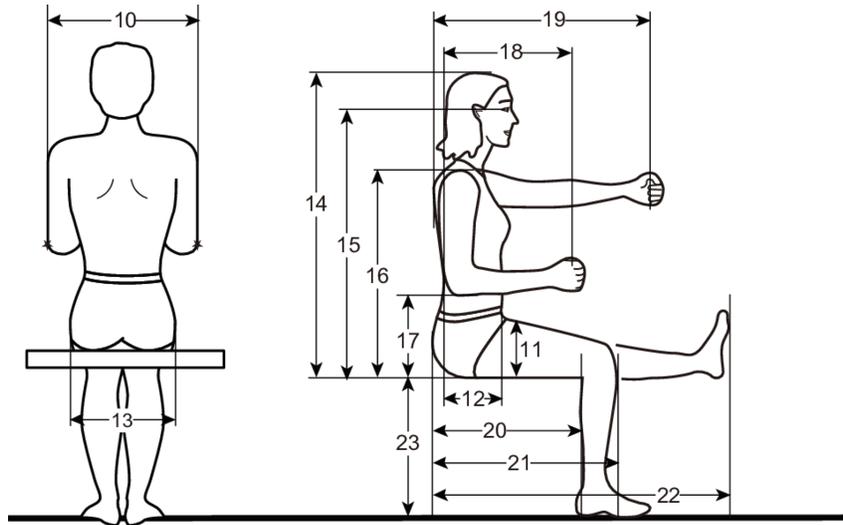


Figure 2: Anthropometric Measures

The dimensions and weights of four different seats to be used for the test are given in Table 1.

Table 1: Specifications of different seats

	Model 1	Model 2	Model 3	Model 4
Height (mm)	910	870	910	920
Width (mm)	800	760	800	710
Depth (mm)	830	850	830	840
Arm Dimensions W*H (mm)	110*645	100*650	110*645	110*600
Weight (kg)	26,6	25	26,6	24,5
Foot / Base Height (mm)	180	200	180	180

Session Dimensions W*D*H (mm)	540*580*435	540*580*450	540*580*435	490*600*460
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Besides the subjective evaluations, a test device was designed, which objectively evaluates the comfort test in seating groups and enables the expression of comfort with quantitative data. With the developed test device, a certain pressure will be applied to the back and front area at the same time during the testing phase of the products, and a certain collapse (displacement) will occur in the components of the seating groups under the resulting force. The pressure-displacement occurring under the applied force will be transferred to a curve and the comfort value of the tested seat will be determined with the comfort intervals defined on the device. The height, length, width and seating widths of the products produced for the test machine design will be determined. According to these dimensions, a device that will apply pressure in accordance with human ergonomics has been designed.

Before the sofa or armchair will be placed in the appropriate position of the comfort evaluation tester, the seating test part will quickly decrease to the contact load in the downward direction until it contacts the armchair. After the contact, it will be moved up again at a much lower speed, and the point where the contact is broken (the position where the load is zero) will be accepted as the zero position. While applying the pressure to be applied downward until the set load amount is reached, the counter-reaction load information and the advance position information will be displayed graphically. Afterwards, the back test point will be reached to the entered angle value. In the same logic as the sitting test, the back will complete the test point movement. A value limit condition in the range of 40 - 200 kg has been accepted for vertical movement. A value limit condition in the range of 20 - 80 kg has been accepted for horizontal movement.

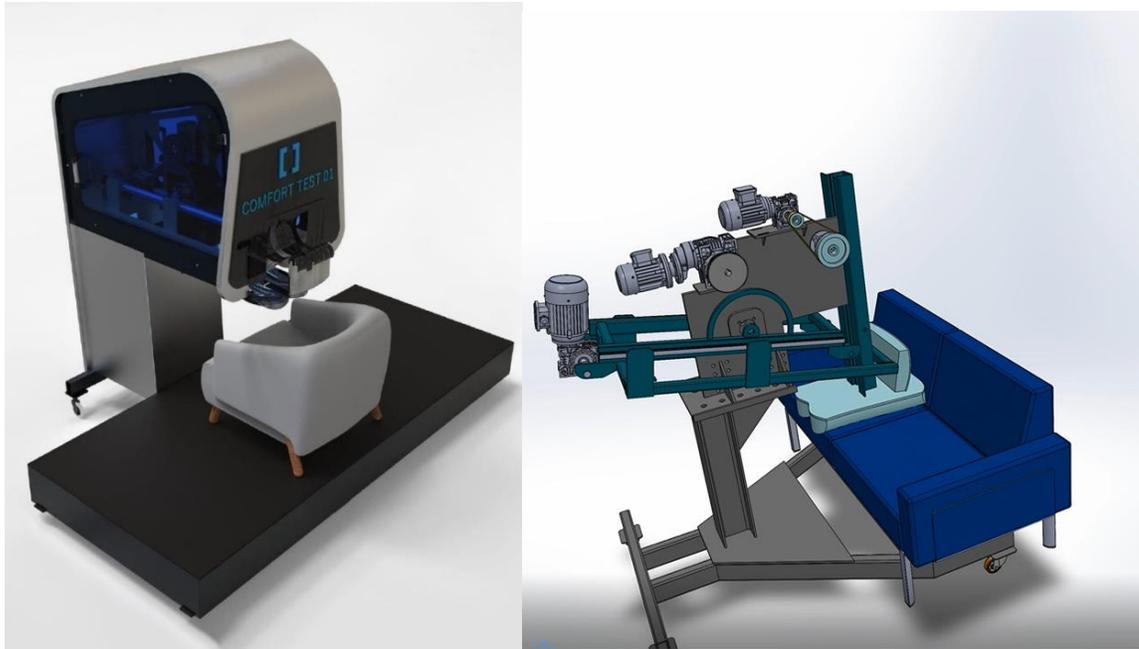


Figure 3: Test Device

3. Results

Table 2: Anthropometric measurements

In the anthropometric design of the furniture, many measurements were made from the body size of the users, such as shoulder distance, knee height, hip-knee distance, and height etc. When the measurements taken and the seat design in four different models were compared, it was observed that the dimensions were compatible with each other. In addition, even if the results are that the seat length can be shortened for short people or lengthened for tall people, these are exceptional cases.

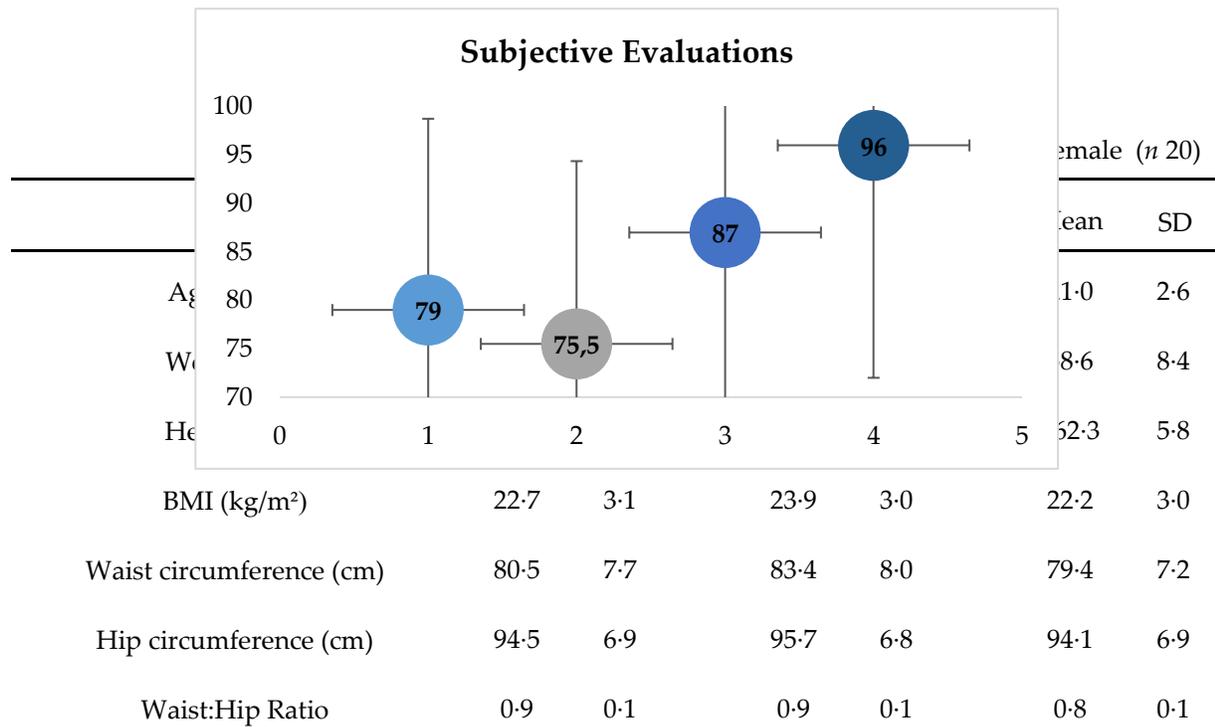


Figure 4: Subjective evaluations result

Figure 4 shows the subjective evaluation results. Some questions directed to people; how comfortable is your hip and upper leg area, how comfortable is your back area, how comfortable is your waist area, how did you find the general spine support of the seat, how do you evaluate the comfort of the seat, is in the form. All results have been compiled and the above conclusions have been reached.

The pressure values applied to the back and seating area during the test are shown in Figure 5 with the data obtained from the device and the force time graph. The mathematical model of comfort is processed on the test device and the graphic values

that should be in the seat are shown with a curve. These values are optimum values. The test device determines comfort value ranges over a hundred value as a result of the test.

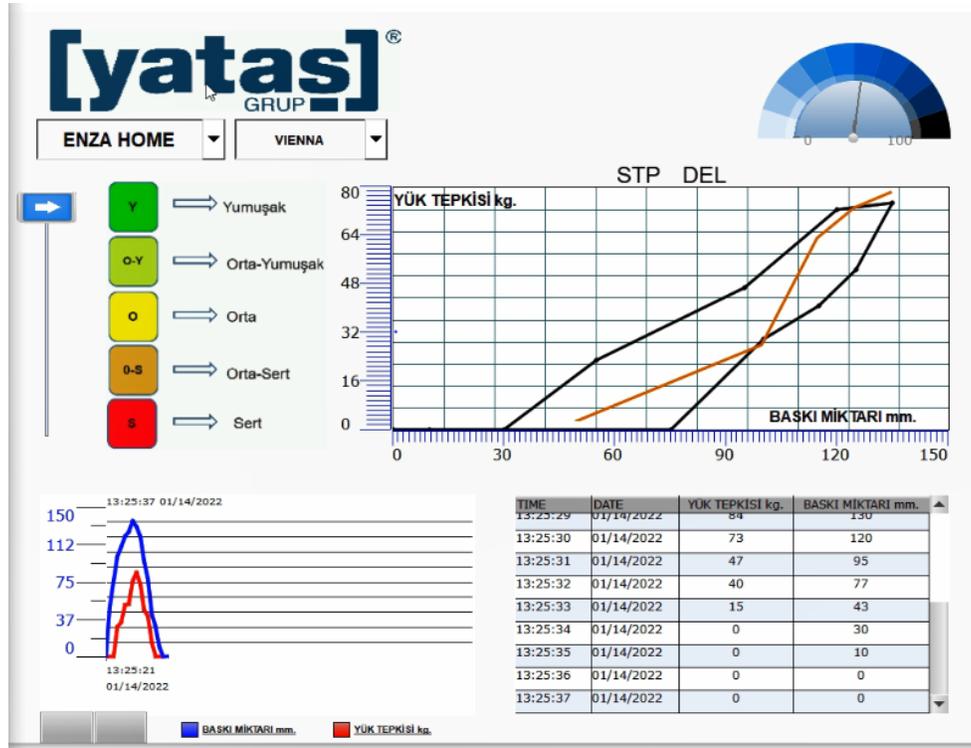


Figure 5: Data obtained from the test device

Figure 6 shows the comparison of survey results and test device results. In other words, it is a comparison chart of subjective evaluation of individuals and quantitative measurements that are not based on individuality provided by the comfort tester. Comfort levels were close for all seats, with the highest level of comfort in Model 4. When the obtained results are evaluated, the model 2 has the lowest comfort level with 78%. Model 1 has a comfort value of 81,5%, which is very close to model 2, and model 3 has a comfort value of 88%.

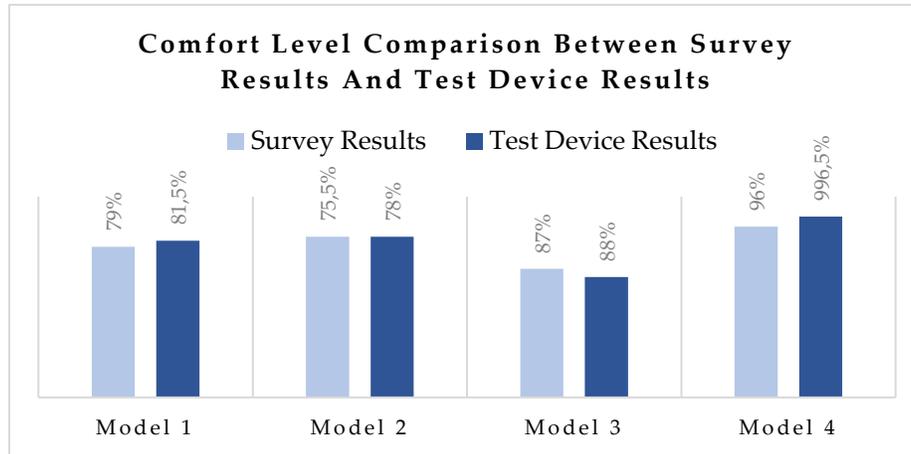


Figure 6: Comparison of survey and test results

When the factors affecting comfort are examined, the variety of materials used in the seat interlayers, that is, in comfort providers, changes the comfort value, rather than the seat dimensions. There are many important comfort determinants such as sponge densities, interlayer filling material, wood or metal frame, etc.

4. Discussion and Conclusion

As a conclusion, a test device was designed, which objectively evaluates the comfort test in seating groups and expresses the comfort expression with quantitative data. The aim is to perform the interpretation process on the basis of products for the definition of unexplained comfort in seating groups. With the developed test device, a certain pressure will be applied to the back and seating area at the same time while the products are in the testing phase. Under the resulting force, a certain collapse (displacement) will occur in the components of the seating groups. The pressure-displacement occurring under the applied force will be transferred to a curve and will be transferred as a test result via a screen on the device. A new device is provided that can accurately evaluate the comfort of the seating group, solving the problem of low accuracy of the seat comfort predicted by the material properties. Objective measurements and subjective evaluations were compared and the measurement method was confirmed.

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