

EVALUATION OF VARIOUS LIGHTWEIGHT ARMCHAIRS IN TERMS OF ERGONOMICS

Mehmet Yuksel, Yusuf Ziya Erdil, Ali Kasal, Mehmet Acar

Mugla Sıtkı Kocman University, Mugla, Turkey

e-mail: myuksel@mu.edu.tr, alikasal@mu.edu.tr; erdil@mu.edu.tr; macar@mu.edu.tr

ABSTRACT

This study aimed to evaluate comfort level of the lightweight armchairs based on user's feedback. For this purpose, 5 different lightweight armchairs were selected and a total of 30 healthy adult volunteers (15 males and 15 female) joined to the study. A survey composed of 10 questions based on three times interval that consist of 5, 15, and 30 minutes was applied to the volunteers. The survey concentrated to obtain subject's feedbacks related to their body reactions while they are sitting on the armchairs by five point Likert Scale. Results were analysed statistically and according to the results, some of design criteria such as backrest form, armrest height, sitting depth, and sitting height significantly affected the comfort feeling while sitting on sample armchairs. As a conclusion, it can be said that comfort in use can be increased by consideration of ergonomic criteria in design process.

Key words: Armchair, furniture ergonomics, furniture design, comfort.

1. INTRODUCTION

The way in which human beings earn their lives by working individually and have their lives reshaped has changed in time. Over the time, the necessity of living in collective form, the formation of settlement centres and the development of the industry have offered people a new way of life. There are various social areas where people live together. People feel the need to sit down while waiting for a visit or to rest temporarily. For this, they need seating elements. There are seating members used in theatres, hotel lobbies, plants, libraries, shopping centres, restaurants, business meetings, waiting rooms, homes etc. The more the seat supports the limbs in the sitting, the better the comfort level. Having a backrest, armrest support, with or without upholstery, and lumbar support are the factors that are effective in resting. For instance, a sitting element that supports the body's limbs well while sitting will

offer much better comfort than a sitting element with only a sitting surface and backrest support.

Today, seating furniture has become an important part of our living areas, working and social environments, schools, vehicles etc. Thus, it should be well designed since it is in every place of our lives. It is an irrefutable truth that it is directly related with mental and body health of people; therefore, has important effect on productivity and economy (Hasturk, 2013).

There are variety of body disturbances that limit people's daily activities, such as back pain, lumbar, and neck pain etc. These are all directly associated with design of seating furniture. The previous studies have indicated that many of people have such such pain and discomfort because of the furniture not being designed correctly (Gultekin, 2004; Winkel and Jorgensen, 1986).

Armchairs used for temporary seating are needed in order to sit while working in the spaces where people are living in and shared

with living spaces. Eckelman and Erdil (2001) categorized the seating furniture according to their load capacity in service. They defined the seating furniture as light, moderate, and heavy use.

Light seat types are commonly used armchair models to sit in relatively short periods of time. The general characteristics of light use armchairs characteristically comprised of short backrest height, less backrest inclination angle and armrest height, less seating width and depth and low seating height, with compared to moderate and heavy use type armchairs. Thus, it serves less comfortable sitting to users and generally it is suitable to use for short-term sitting rather than for long-term sitting. Discomfort has been assumed to be imposed by the physical limitation of the subject's environment or cramped position. Basically, the perception of discomfort is caused by physical constraint, stiffness or reduced mobility (Christiansen, 1997; Monette and Weiss-Lambrou, 1999; Shackel et al., 1969). The comfort level of seats should be increased to have an optimum muscle activation for furniture occupants. Therefore, the compatibility between furniture user's anthropometric data and furniture dimensions should be provided. Short sitting comfort on the armchair and the quality of life of the furniture users are extremely important. Therefore, in order to increase the level of comfort in lightweight seats, it is necessary to make related improvements in the dimensional parameters of furniture.

Smardzewski, J. (2013) studied on axenic springs for seating to test and determine their resistance to cyclic as well as prolonged static loads. The results of his investigations made it possible to conclude that the designed spring had stiffness characteristics similar to the compression characteristics of polyurethane foams. Cyclic and prolonged static loads had no significant influence on

changes in spring height so their impact on the comfort of seating was insignificant.

Yuksel et al (2017) mentioned that structural properties of furniture have significant effects on user's comfort. They investigated upholstery thickness on comfort level and they determined that there is a linear relationship between upholstered thickness and sitting comfort level.

Schackel et al (1969) studied the determination of comfort level based on a survey that they applied to 20 volunteers. They analysed effect of armchairs on 15 different body points of the volunteers by 11 different scaling stage. As a result of the study, they determine that there is no statistical significance of gender factor while time factor has significant effect on seating comfort level.

Kilinc (2015) evaluated the ergonomic suitability of 18 chairs with different ergonomic characteristics in various sizes and backrest inclination angles with both survey and human-oriented product development software; also, compared the consistency of the data obtained from the questionnaires with the data obtained from the software. As a result, he stated that increasing the backrest inclination angle from 90° to 105° reduces the reaction forces between L5 and sacrum, which has an important role in the comfort of the sitting action, by 50%.

Vos et al (2006) mentioned that the discomfort occurred between body and seating interface, primarily caused by physical characteristics of the furniture rather than user's effects and postural behaviours.

It has been realized that there is very limited research related to furniture user's comfort level in the literature. Therefore, in this study, it was aimed to investigate comfort level of different light use single seat armchairs based on users' feedback and determine effects of important factor on comfort feelings.

2. EXPERIMENTAL METHODS

This study involved evaluation of the ergonomic suitability of light use single seat armchairs by application of a survey. The study consisted of 5 different armchairs that

were obtained commercially from a manufacturer. 30 volunteers participated (15 females, 15 males aged between 25–50 years old) who self-reported to have no serious health conditions. The armchairs used in this study are shown in Figure 1.



Figure 1: The armchair models used in this study

The dimensions and some ergonomics properties of each armchair are shown in Table 1.

Table 1: Dimensions and some properties of the armchair used in this study

Armchair dimensions	Number of the armchair model				
	Model 1	Model 2	Model 3	Model 4	Model 5
Seat width (cm)	47	46	50	45	40
Seat depth (cm)	44	49	46	47	50
Seat height (cm)	45	42	46	43	42.5
Back rest angle (°)	103	102	102.5	108	104
Arm rest height (cm)	21.5	16	20	17	17
Lumbar support	No support	No support	No support	No support	No support
Backrest height (cm)	82	81	81	84	81

In the first part of the study, 60 different static anthropometric measurements were obtained from the participants by using a specially designed anthropometric armchair and

an anthropometry set. These data were then used to make comparisons between armchair and human dimensions. An armchair sample is shown in Figure 2.



Figure 2: An armchair sample used in this study

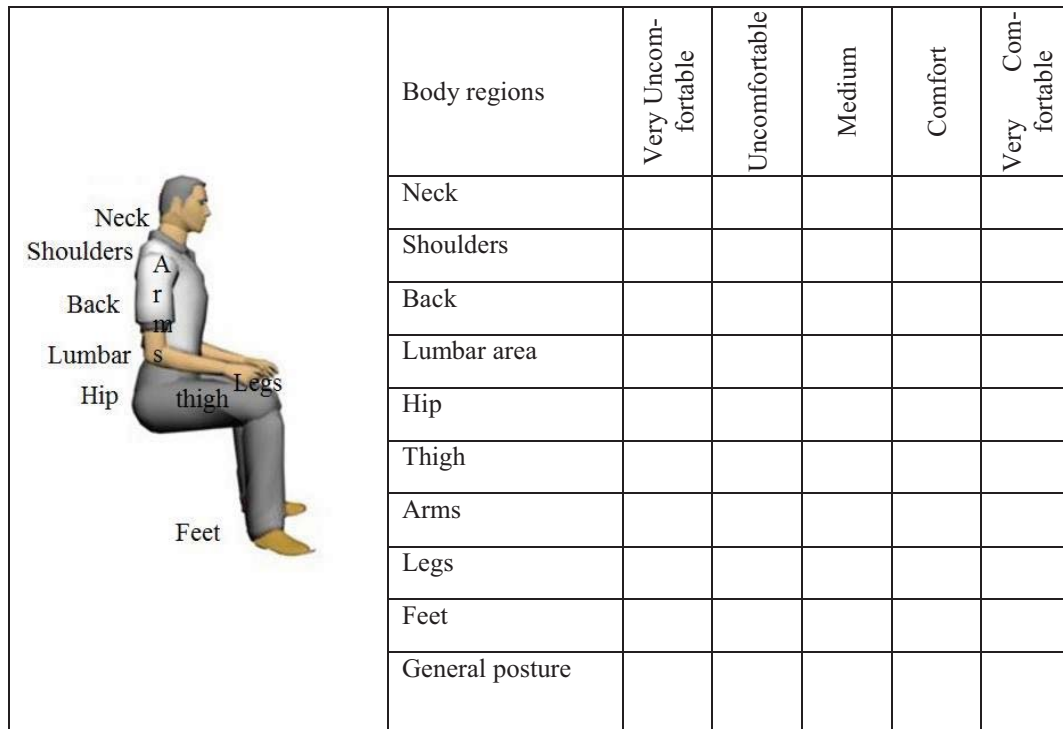
2.1. EVALUATION OF SURVEYS

The experimental design consisted of 30 volunteers (15 females and 15 males), 5 different armchair models and questionnaires that are on the 3 different time intervals (30 volunteers X 5 model armchair X 3 sitting time intervals = 450 questionnaires). Time intervals were 5, 15 and 30 minutes. Volunteers were seated and surveyed at different times for each armchair model. In other words, to obtain reliable data, more than one questionnaire was not administered on the same day. The level of comfort of the volunteers was measured from their perceptive feeling of comfort after the seating action. The volunteers were allowed to sit for the prescribed time and surveyed based on their

feelings about 10 different body areas with a 5-point Likert scale questionnaire. The participants rated comfort between 2 and 10 points from very uncomfortable (2) to very comfortable (10) (Figure 3). The total comfort value distribution was as follows:

Very Uncomfortable	:2 Points
Uncomfortable	:4 Points
Medium	:6 Points
Comfort	:8 Points
Very Comfort	:10 Points

The largest total comfort value was 100 (10 regions x 10 points = 100). Comfort level determination questionnaire set is given in Figure 3.



Body regions	Very Uncomfortable	Uncomfortable	Medium	Comfort	Very Comfortable
Neck					
Shoulders					
Back					
Lumbar area					
Hip					
Thigh					
Arms					
Legs					
Feet					
General posture					

Figure 3: The questionnaire applied in the study (Kasal, 2004)

3. RESULTS AND DISCUSSION

3.1. EVALUATION OF DATA

ANOVA test was conducted to determine the effect of armchair model and time interval as well as their two-way interaction on feeling of comfort. In addition, Duncan test was performed on significant main ef-

fects and interaction to determine homogeneity groups. The results are given separately for male and female volunteers.

3.1.1. Results for Female Participants

In the case of female participants, main effects was significant ($p < 0.05$). The results of the ANOVA test are given in Table 2.

Table 2: Analysis of variance (ANOVA test) results of total comfort values for female volunteers according to the armchair model and time interval factors.

Source	DOF	Sum of	Mean Square	F value	Level of sig.
Corrected Model	14	6092.382	435.170	1.986	0.020*
Intercept	1	941805.551	941805.551	4298.887	0.000*
Armchair Model (A)	4	3471.538	867.884	3.961	0.004*
Time interval (B)	2	1921.342	960.671	4.385	0.014*
Interaction (AB)	8	699.502	87.438	0.399	0.920NS
Error	210	46007.067	219.081		
Total	225	993905.000			

The main effects were found statistically significant while the two-way interaction was

found statistically insignificant. The Duncan test results are given in Table 3.

Table 3: Duncan test results for Armchair Model main effect for female participants

Armchair Model	N	X	HG
4	45	71.9333	A
2	45	64.0667	B
5	45	63.8000	B
1	45	63.7556	B
3	45	59.9333	B

X: value average HG: Homogeneity group

Test results showed that 4th model armchair showed the highest values (71.93). The other armchairs were in the same homogeneity group. According to Table 3, 4th model

armchair had approximately %12 more comfort than the other model armchairs.

The Duncan test results for time interval effects for female participants are given in Table 4.

Table 4: Effect of time interval on the comfort for female participants

Time interval (min)	X	HG
5	68.5600	A
15	64.0400	AB
30	61.4933	B

X: value average HG: Homogeneity group

According to the results, it was determined that the comfort level at 5 minute time interval was the 11% higher than 30 minutes time interval. Results indicated that the 5 minute time interval comfort level was 68.56; while 15 minutes time interval comfort level (64.04) and 30 minutes time interval (61.49).

3.1.2. Results for Male Participants

In the case of male participants, main effects was significant ($p < 0.05$). The results of the ANOVA test are given in Table 5.

Table 5: ANOVA results of total comfort values for male volunteers according to the armchair model and time interval effects

SOURCE	DOF	Sum of	Mean Square	F value	Level of sig.
Corrected Model	14	7682.916	548.780	2.107	0.013*
Intercept	1	762361.818	762361.818	2926.893	0.000*
Armchair Model (A)	4	937.938	234.484	0.900	0.465NS
Time interval (B)	2	6326.009	3163.004	12.144	0.000*
Interaction (AB)	8	418.969	52.371	0.201	0.920NS
ERROR	210	54698.267	260.468		
Total	225	824743.000			

Armchair models, time interval factors, and their interactions were analysed statistically. The time interval main effect was found to be statistically significant but the

armchair model effect was found insignificant. The Duncan test was applied for time interval main effect (Table 6).

Table 6: Duncan test results for time interval effect results of male volunteers

Time interval (min)	X	HG
5	64.7600	A
15	58.0933	B
30	51.7733	C

X: value average

HG: Homogeneity group

According to Table 6, the highest seating comfort level in armchair models was achieved in the 5 minute time interval. Results indicated that the 5 minute time interval (64.76) comfort level was higher than in the 15 minutes time interval comfort level (58.09); while, in the 30 minutes time interval (51.77) comfort level has given the lowest value. The reason for this could be said that as the sitting time increases, the sitting comfort decreases. In other words, there is an inverse relationship between sitting time and sitting comfort.

4. CONCLUSIONS

In this study, 5 different light use armchairs and 3 different sitting time intervals on the armchair were examined separately for both female and male subjects in terms of comfort. As a result of the study, it was determined that the armchair model and time interval for both female and male volunteers were significantly effective in terms of comfort.

When the averages of the total comfort values obtained in the questioner for female volunteers are compared, the highest value was obtained in the 4th lightweight armchair model and it was determined that it was the most comfortable. Since the backrest angle of this 4th lightweight armchair model is 108 degrees, it supports the back part of the female volunteers who participated in the study well. In a similar study, Kilinc (2015) stated that increasing the backrest inclination angle from 90° to 105° reduces the reaction forces between L5 and the sacrum, which has an im-

portant role in the comfort of sitting. Therefore, muscle activation will be significantly less, which is an important factor in increasing the total comfort value. According to results it can be said that lightweight armchair models can be more suitable for female users.

According to the results obtained from this study it could be concluded that,

- In light use armchair models, as the sitting time increases, the discomfort increases
- Total comfort of female volunteers is higher than male volunteers.

Study also gave the indication that, in future studies, it is important to design a seat in accordance with the anthropometric dimensions of users. Especially, careful consideration should be given to seat height, armrest height, seat width, seating depth, backrest form and angle in the best way will make it easier for furniture designers.

ACKNOWLEDGEMENTS

This study was supported by Scientific and Technical Research Council of Turkey (TUBITAK) with the project number; 116O937. Preliminary Data of This Study were verbally presented at the IX International Scientific and Technical Conference, 2018 Sofia, Bulgaria.

REFERENCES

- CHRISTIANSEN, K. 1997. Subjective assessment of sitting comfort. *Coll. Antropol.* 21, pp. 387–395.
- ECKELMAN, C. A., ERDIL, Y. A. 2001. Performance Test Method for Intensive Use Chairs-FNEW, A Description of the Test Method with Drawings, FNR 176, pp. 83–269: 20.

- GÜLTEKİN, T. 2004. Ankara'da Yaşayan Erişkin Bireylerin Vücut Bileşimi Değerleri, PhD Thesis, Ankara University, Institute of Social Science.
- HASTÜRK, E.Y. 2013. Statik Antropometrik Verilerle Ergonomik Oturma Mobilyası Tasarımı, Thesis, Ankara University, Institute of Social Science.
- KASAL, Ö. 2004. Çizim mekanlarında insan-eylem donatı elemanı ilişkileri üzerine bir araştırma, Master Thesis, Gazi University, Institute of Natural Science.
- KILINÇ, H. 2015. Çeşitli Tiplerdeki Ahşap Ev Sandalyelerinin Ergonomik Açısından Uygunluğunun İnsan Odaklı Ürün Geliştirme Yazılımı İle Analiz Edilmesi, Muğla Sıtkı Koçman Üniversitesi, Fen Bilimler Enstitüsü, Yüksek Lisans Tezi.
- MONETTE R, M., WEISS-LAMBROU, D.J. 1999. In search of a better understanding of wheelchair sitting comfort and discomfort. Proc. RESNA Annu. Conf. pp. 218–220.
- SHACKEL, B., CHIDSEY, K., D., SHIPLEY, P. 1969. The Assessment of Chair Comfort, In: *Sitting Posture*, Ed. by E. Grandjean, Taylor & Francis, London, pp. 155–192.
- SHACKEL, B., CHIDSEY, K.D., SHIPLEY, P. 1969. The assessment of chair comfort. *Ergonomics* 12, pp. 269–306.
- SMARDZEWSKI, J. 2013. Auxetic springs for seating, *Turkish Journal of Agriculture and Forestry*, 37, pp. 369–376.
- VOS, G.A., CONGLETON, J.J., MOORE, J.S., AMENDOLA, A.A., RINGER, L. 2006. Postural Versus Chair Design Impacts upon Interface Pressure, *Applied Ergonomics*, 37, pp. 619–628.
- WINKEL, J., JORGENSEN, K. 1986. Evaluation of foot swelling and lower-limb temperatures in relation to leg activity during long-term seated office work. *Ergonomic* 29, 313–328.
- YÜKSEL, M., KASAL, A., ACAR, M., ÖZCAN, C., EFE, H., ERDİL, Y.Z. 2017. Determination of load distribution on a seating surface by using pressure mat for different upholstery thickness, IV. International Furniture Congress, 19-21 October, Düzce, Turkey.



UNIVERSITY OF FORESTRY

FACULTY OF FOREST INDUSTRY



INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN

1/2020

INNO vol. IX Sofia

ISSN 1314-6149
e-ISSN 2367-6663

Indexed with and included in CABI

INNOVATION IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN

Science Journal
Vol. 09/p. 1–78
Sofia 1/2020

ISSN 1314-6149
e-ISSN 2367-6663

Edition of
FACULTY OF FOREST INDUSTRY – UNIVERSITY OF FORESTRY – SOFIA

The Scientific Journal is indexed with and included in CABI.

SCIENTIFIC EDITORIAL BOARD

Alfred Teischinger, PhD (Austria)	Hülya Kalaycioğlu, PhD (Turkey)
Alexander Petutschning, PhD (Austria)	Ladislav Dzurenda, PhD (Slovakia)
Anna Danihelová, PhD (Slovakia)	Marius Barbu, PhD (Romania)
Asia Marinova, PhD (Bulgaria)	Nencho Deliiski, DSc (Bulgaria)
Bojidar Dinkov, PhD (Bulgaria)	Neno Tritchov, PhD (Bulgaria)
Danijela Domljan, PhD (Croatia)	Panayot Panayotov, PhD (Bulgaria)
Derya Ustaömer, PhD (Turkey)	Pavlo Bekhta, PhD (Ukraine)
George Mantanis, PhD (Greece)	Silvana Prekrat, PhD (Croatia)
Ivica Grbac, PhD (Croatia)	Štefan Barčík, PhD (Slovakia)
Ivo Valchev, PhD (Bulgaria)	Valentin Shalaev, PhD (Russia)
Ján Holécý, PhD (Slovakia)	Vasiliki Kamperidou (Greece)
Ján Sedliačik, PhD (Slovakia)	Vesselin Brezin, PhD (Bulgaria)
Julia Mihajlova, PhD (Bulgaria)	Vladimir Koljozov, PhD (Macedonia)
Hubert Paluš, PhD (Slovakia)	Zhivko Gochev, PhD (Bulgaria)

EDITORIAL BOARD

N. Trichkov, PhD – Editor in Chief	V. Savov, PhD
D. Angelova, PhD – Co-editor	P. Vichev, PhD
N. Minkovski, PhD	

Cover Design: DESISLAVA ANGELOVA

Printed by: INTEL ENTRANCE

Publisher address: UNIVERSITY OF FORESTRY – FACULTY OF FOREST INDUSTRY

Kliment Ohridski Bul., 10, Sofia, 1797, BULGARIA

<http://inno.ltu.bg>

<http://www.scjournal-inno.com/>

CONTENTS

A METHODOLOGICAL APPROACH FOR NUMERICAL ANALYSIS OF UPHOLSTERED SOFA WITH FINITE ELEMENT METHOD (FEM)	7
Tolga Kuşkun, Ali Kasal, Ersan Güray, Recep Birgül, Yusuf Ziya Erdil	
INFLUENCE OF THE APPLIED PRESSURE ON FINGER JOINED END-TO-END WOOD.....	16
Todor Petkov, Vladimir Mihailov	
MATHEMATICAL DESCRIPTION OF THE CHANGE IN THE ATMOSPHERIC TEMPERATURE DURING DAYS AND NIGHTS	21
Nencho Deliiski, Neno Trichkov, Natalia Tumbarkova	
COMPUTATION OF THE AVERAGE MASS THERMAL CONDUCTIVITY OF OAK FURNITURE ELEMENTS SUBJECTED TO CONVECTIVE HEATING BEFORE LACQUERING	29
Nencho Deliiski, Neno Trichkov, Dimitar Angelski, Ladislav Dzurenda, Zhivko Gochev, Natalia Tumbarkova	
INFLUENCE OF UV RADIATION ON COLOR STABILITY OF NATURAL AND THERMALLY TREATED MAPLE WOOD WITH SATURATED WATER STEAM	36
Ladislav Dzurenda, Michal Dudiak, Adrián Banski	
PHYSICAL AND MECHANICAL PROPERTIES OF COMBINED WOOD-BASED PANELS WITH PARTICIPATION OF PARTICLES FROM VINE STICKS IN CORE LAYER	42
Rosen Grigorov, Julia Mihajlova, Viktor Savov	
ENGINEERING OF SELECTED PROPERTIES OF LIGHT MEDIUM DENSITY FIBREBOARDS PRODUCED FROM HARDWOOD TREE SPECIES	53
Viktor Savov	
EVALUATION OF VARIOUS LIGHTWEIGHT ARMCHAIRS IN TERMS OF ERGONOMICS	60
Mehmet Yuksel, Yusuf Ziya Erdil, Ali Kasal, Mehmet Acar	
AUTOMATION OF TECHNOLOGICAL OPERATIONS IN THE MANUFACTURE OF WOODEN TOYS.....	68
Izabela Radkova, Zornica Petrova	
SCIENTIFIC JOURNAL „INNOVATIONS IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN“	75