CORRELATION ANALYSIS BETWEEN PASSENGERS' ANTHROPOMETRY AND SEAT TRAY TABLE HEIGHT FOR IN-FLIGHT ACTIVITY COMFORT

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Abstract: During flight, passengers' comfort can be linked to their self-state, cabin design environment and also their in-flight activities. It is noted that the common passengers' in-flight activities while seated such as eating, writing and using a laptop greatly involve the use of seat tray table. Consequently, from design ergonomics point of view, it is crucial for the seat tray table to be of appropriate height to enable the passengers to use it with comfortable sitting posture. However, due to the different anthropometry measurements, different passengers may require different tray table height to comfortably conduct their in-flight activities. In line with this notion, an experiment is conducted using an aircraft cabin mock-up that is located at Aerospace Design Simulation Laboratory, Universiti Putra Malaysia, Malaysia. For this experiment, 38 participants were asked to sit inside the cabin mock-up and conduct two common in-flight seated activities: eating and using a laptop, which involves the use of the seat tray table. The height of seat tray table is adjusted until the participants felt adequately comfortable to perform each activity. The collected data is later analyzed using statistical software package, MINITAB. On the whole, based on the findings from statistical correlation analysis, it can be concluded that the comfortable seat tray table height for both in-flight activities is correlated with the passengers' anthropometric measurements. The top associated sitting anthropometric measurements for the eating activity are found to be crown buttock height, buttock knee length, eye height, elbow height and shoulder height. On the other hand, for using a laptop, the top parameters are forward grip reach, abdominal depth, crown buttock height, buttock heel length and popliteal height. Based on this finding, these anthropometry parameters should be taken into consideration while designing the seat tray table, especially in deciding its proper height.

Keywords: seat tray table; flight comfort; statistical analysis; aircraft cabin; in-flight activities

1. Introduction

These days, comfort has been a big consideration for many people in choosing their transportation options, especially when it comes to using public transportation. In line with this, comfort is also among the key factors that can influence the selection of flight services among aircraft passengers [1]. However, comfort itself is a rather complex subject as it is influenced by both objective ergonomics requirement and also subjective human perception. There are several different approaches to comfort evaluation by various researchers. Initially, there is the notion that comfort occurs in the absence of discomfort, hence comfort assessment can be focused only on two states: "discomfort present" and "discomfort absent" [2]. However, several researchers then further define comfort and discomfort as two extreme opposite ends of a continuum with a neutral point in between them [3]. This means that there are different levels of comfort (or discomfort) that could be experienced by the person in response to their surroundings.

Meanwhile, recent studies have also extended the assessment of comfort to include considerations from various aspects including physical, social, situational, physiological, psychological and environmental [4]. This allows a deeper and more thorough evaluation of comfort experience as more factors that can influence the comfort levels are taken into account. In general context of aircraft passengers, their level of comfort can thus be affected by their own state of self, their performed activities and the surrounding environment provided by the aircraft cabin design.

To date, most studies on aircraft cabin comfort have been more focused on the effects of reduced seat pitch, especially since many discomfort complaints from passengers are linked to the small available legroom at their seat. Flight comfort has been shown to greatly decrease for passengers with larger body dimensions when the seat pitch is reduced [5]. Similarly, another study has demonstrated great influence of anthropometric measurements with seat pitch on the perceived passengers' comfort [6]. Nonetheless, these previous studies are commonly conducted without considering the context of passengers' activity. It is believed that, depending on activities the passengers are performing, their comfort level would be different with the same cabin design environment. For instance, the comfort level of aircraft passengers when using their smartphone in seated position has been shown to be affected by the height of the seat armrests [7], which might not be the case in other activities. Extending on this notion, since many other common in-flight activities as shown in Figure 1 involve the use of seat tray table, passengers' comfort while performing these activities might also be influenced by the height of the tray table. An indication of such probable relationship between comfort and height of seat tray table has been demonstrated in a study on the influence of tray table height on the neck posture of aircraft passengers [8]. It is strongly believed that this situation occurs due to different anthropometry measurements of the passengers.

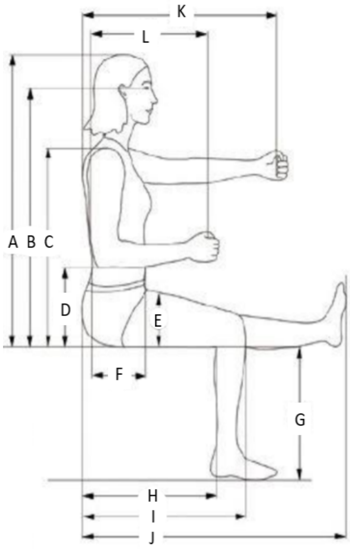
Figure 1: Use of seat tray table for common in-flight activities: (a) eating, (b) using laptop, (c) writing

In this study, an experiment is conducted using aircraft cabin mock-up to establish potential effects of varying seat tray table height on passengers' perceived comfort level while performing two common in-flight activities at their seat: eating and using a laptop. The collected experimental data is statistically analyzed to establish any underlying relationships between the level of perceived comfort during these two in-flight activities and both seat tray table height and several sitting anthropometric measurements of the passengers.

2. Methodology

A total of 38 volunteers have been recruited for the aircraft sitting comfort experiment in this study through promotional ‘call for participants’ postings on various social media platforms such as Facebook and WhatsApp. In order to focus more on the Malaysian public, the selection criteria for the participants include that they must be Malaysian citizen and also should have prior experiences in taking flights with commercial airlines. The experiment is carried out using available aircraft cabin mock-up in Aerospace Design and Simulation Laboratory, Universiti Putra Malaysia. The experimental procedures applied in this study are essentially adapted from previous aircraft comfort studies such as [6] and [9], which have been conducted to study the relationship between seat pitch and anthropometry parameters of aircraft passengers. In this case, the same procedures are adapted to study the effect of the seat tray table height instead of the seat pitch.

Before the experiment session is started for each participant, they are properly briefed with the aim of the study and the planned procedures of the experiment. Their body anthropometry measurements in sitting position are measured. As can be observed in Figure 2, the anthropometry measurements that are taken in this study are all linear measurements and therefore standard conventional measuring tools such as flexible measuring tapes can be used in the measuring process. Once their body anthropometry measurements are collected, the participants are asked to individually sit in the aircraft cabin mock-up. In the first part of the experiment, the participants are asked to eat the prepared foods with the height of the seat tray table is adjusted until they felt at their most comfortable for the eating activity. Similarly, for the second part of the experiment, participants are asked to type a given short paragraph on a laptop and height of the seat tray table is adjusted until they are at their utmost comfort to carry out the activity. The collected comfortable seat tray table’s height data and also anthropometry measurements are then statistically analyzed using the MINITAB software package.



Label	Anthropometric Measurements
A	Crown Buttock Height
B	Eye Height
C	Shoulder Height
D	Elbow Height
E	Thigh Thickness
F	Abdominal Depth
G	Popliteal Height
H	Buttock Popliteal Length
I	Buttock Knee Length
J	Buttock Heel Length
K	Forward Grip Reach
L	Elbow Grip Length

Figure 2: Human anthropometry measurements for sitting position [6]

3. Results & Discussion

Correlation analysis is a standard statistical method that is used to denote the association between two (or more) variables or parameters [10]. In this case, the measures of association or relationship will be in terms of its strength and also direction, which are reflected by the resultant correlation coefficient.

In general, correlation coefficient value of +1 indicates that the two variables or parameters are perfectly interrelated in a positive linear manner whereas a perfectly negative linear relationship is implied when the value of the correlation coefficient is -1.

Table 1 presents the descriptive statistics of the participants' anthropometry measurements based on gender. It can be inferred from the collected anthropometry data in Table 1 that the male participants have comparatively slenderer and taller body-built on average to the female participants. This situation is essentially consistent with the observations made in a few other studies on Malaysian population such as [11] and [12], which indicates that females have averagely larger and shorter body compared to males.

Table 1: Descriptive statistics of sitting anthropometry measurements (in cm)

Anthropometry Parameters	**Males (n = 30)**				**Females (n = 8)**			
	Mean	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**
Crown Buttock Height	84.20	5.46	75.20	96.20	80.51	2.68	76.60	84.60
Eye Height	73.42	4.98	62.50	84.50	69.78	2.89	65.30	73.00
Shoulder Height	55.05	5.31	47.00	66.50	53.96	5.18	45.30	61.10
Elbow Height	19.68	3.85	13.00	28.40	20.86	5.02	13.80	27.60
Thigh Thickness	14.62	2.62	9.30	20.70	15.66	3.59	11.90	22.10
Abdominal Depth	22.96	4.69	16.80	37.40	22.49	5.30	15.90	32.20
Popliteal Height	46.02	2.84	41.00	52.90	44.99	2.01	42.50	48.50
Buttock Popliteal Length	46.67	3.40	39.20	53.70	45.68	2.57	43.40	51.00
Buttock Knee Length	58.08	4.04	50.00	65.20	57.60	3.66	54.40	64.30
Buttock Heel Length	103.31	7.73	88.50	117.10	102.55	7.35	95.30	117.30
Forward Grip Reach	74.48	5.53	60.20	83.70	71.42	5.01	64.80	78.70
Elbow Grip Length	38.15	3.81	30.10	44.60	38.04	3.57	33.90	43.30

In the meantime, Table 2 presents the descriptive statistics of the recorded comfortable height of the seat tray height during the conducted experiment for participants in both in-flight activities of eating and also using a laptop. Moreover, statistical paired *t*-test is conducted using MINITAB to test whether there is significant difference in comfortable seat tray table's height between the two activities. For this test case, the null hypothesis is that the required comfortable height of the seat tray table during eating activity is similar or less than that while using a laptop. With 95% confidence level, the resultant *p*-value of 0.031 as shown in Table 2 implies that the null hypothesis could be rejected. This means that there is notable difference between the comfortable seat tray table's height for both activities for each person. In this case, comfortable seat tray table's height for eating activity could be taken to be relatively higher than that for using the laptop for each participant.

Table 2: Descriptive statistics of seat tray table height

Activity	**Comfortable Seat Tray Table Height (in cm)**				***p*-value of the paired *t*-test**
	Mean	**SD**	**Min.**	**Max.**	
Eating	74.15	3.33	65.60	81.40	0.031
Using a Laptop	73.00	3.41	65.60	81.40	

Moreover, the results of correlation analysis for the comfortable seat tray table height during eating and using a laptop with the anthropometry measurements are presented in Table 3. It can be observed that there seems to be negative correlation between the anthropometry measurements and comfortable height of the seat tray table for both activities, with exception of the only positive correlation between popliteal height and seat tray table's height while using a laptop. A negative correlation signifies that as a person's anthropometry measurement increases, the comfortable seat tray table's height also becomes lower. The reverse is true for positive correlation. In terms of magnitude of their association, top five sitting anthropometry parameters with the eating activity are crown buttock height, buttock knee length, eye height, elbow height and shoulder height. On the other hand, for using a laptop, the top parameters include forward grip reach, abdominal depth, crown buttock height, buttock heel length and popliteal height. It can be observed that most of these parameters are related to the upper body of the passengers, which makes sense since the motion of the considered activities involves that part of the human body than the lower part, especially since they are in sitting position. These anthropometry parameters should therefore be appropriately considered when designing the height of the seat tray table.

Table 3: Correlation analysis results

Anthropometry Parameters	**Correlation Coefficient with Comfortable Seat Tray Table Height**	
	Eating	**Using a Laptop**
Crown Buttock Height	– 0.440	– 0.132
Eye Height	– 0.357	– 0.058
Shoulder Height	– 0.278	– 0.060
Elbow Height	– 0.302	– 0.019
Thigh Thickness	– 0.212	– 0.100
Abdominal Depth	– 0.205	– 0.199
Popliteal Height	– 0.010	+ 0.128
Buttock Popliteal Length	– 0.219	– 0.035
Buttock Knee Length	– 0.415	– 0.061
Buttock Heel Length	– 0.206	– 0.131
Forward Grip Reach	– 0.276	– 0.267
Elbow Grip Length	– 0.138	– 0.018

4. Conclusion

The comfort level of aircraft passengers is also influenced by their comfort in performing in-flight activities, which mostly involves the usage of available tray table at their seat. In order to provide proper comfort level for the passengers, the height of the seat tray table should also be appropriate. From the findings of this study, it is taken that the comfortable height of the seat tray table can notably differ for different in-flight activities as demonstrated for eating and using a laptop. Furthermore, it has also been highlighted in this study that there is association between the comfortable seat tray table's height and a few sitting anthropometry parameters of the aircraft passengers. All in all, it can therefore be concluded that the comfortable seat tray table's height may vary between in-flight activities and also between each aircraft passenger due to their different body anthropometry measurements. A few essential parameters of the human anthropometry have also been identified in this study, which should be considered in the design and also setting of appropriate seat tray table height. Furthermore, this supposition leads to the proposal of a possible new seat tray table design with adjustable height to better suit the needs of aircraft passengers, which will be further explored in the next step of this study.

Acknowledgement

The authors acknowledge funding for this research from Ministry of Higher Education Malaysia through their Fundamental Research Grant Scheme: FRGS/1/2018/TK09/UPM/2/1 (Vot: 5540074).

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