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Research Article

The Passengers' Comfort Improvement by Sitting Activity and Posture Analysis in Civil Aircraft Cabin

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Comfort is becoming an important issue that airlines use to differentiate themselves in a competitive market. Activity and posture, as an integrating external manifestation when passengers interact with the complex cabin system, could be used as an effective way to study passenger comfort. This study aims to analyze the passengers' comfort perception based on activity and posture analysis performed by passengers on the flight. By recording and reconstructing the activities performed by passengers in a 2-hour simulated flight, the typical activities and the corresponding postures were identified through the video analysis software system MVTA. The passengers remained the greater part of the time performing the activity of sleeping and resting (34.3%), followed by using small electrical devices (32.7%) and reading (16.1%). The main postures in these activities were encoded and displayed in the elliptic structural diagram based on the variations in head, back, arms, and legs. The difficulties and constraints resulted from the seat and cabin were summarized by a questionnaire. Based on the analysis results, the suggestions about seat design, activity guidance, and arrangement were offered from the perspective of supportability, adjustability, affordance, and aesthetics, which would be applied in improving the passengers' comfort and innovations in cabin and seat.

1. Introduction

With the increase in air travel, passengers are paying more attention to their comfort experience during flights. Comfort is becoming an important issue that airlines use to differentiate themselves in a competitive market [1]. Passengers are required to sit in the seat and are not allowed to wander around the cabin. Their comfort is affected by various aspects of the whole cabin system, including the cabin environment, facilities, services, and physiological and psychological factors of passengers. It has been verified the difficulty to identify and analyze these many factors.

Activity and posture, as an integrating external manifestation when passengers interact with the complex cabin system, could be used as an effective way to study passenger comfort. The analysis of activity and posture can reveal the difficulties and reactions of passengers when dealing with their sitting situations. Passengers would change their activities and postures when they feel discomfort during flight. The duration and frequency of changes in activities and postures reflect the passengers' needs and comfort level.

However, there are few studies that make use of activities and postures analysis method to analyze the relationship between postures, activities, and comfort perception of passengers in flight. Most of the studies focus on the special tasks in the ground vehicles, such as driving activity in vehicles, sitting activity in bus and train, and typing activity in an office environment.

Rossi et al. [2] stated that passengers' activities would vary depending on flight duration, and they analyzed the activities of using electronic devices in commercial flights and domestic environment. Brenner [3] stated that after continuous sitting for 1.5 hours, a passenger's discomfort could be effectively relieved through a short rest. Richards et al. [4] stated that "passenger may immerse in a certain activity too excessively to perceive the discomfort". Research findings show that when eating and drinking, passengers will feel less discomfort, and a complete meal will be better than just having a drink or snack. Lewis [5] indicated that using virtual devices could distract passengers' attention from their feelings of discomfort and could have a positive effect on their comfort experience. Popovic et al. [6] discussed how activities mediate people's experiences in the airport by observational field studies to impact on airport design to facilitate passenger flow through airport precincts. Lijmbach et al. [7] contrasted the differences between elderly and young passengers by analyzing video recordings of the in and egress in seat rows. Ciaccia and Sznelwar [8] assessed dynamically a passengers' discomfort by measuring the interface pressure between the occupant and the seat during the performance of resting and reading of a typical flight. Tan et al. [9] evaluated the seat comfort by analyzing sleeping posture of passengers on long haul.

These studies have laid the foundation for our research. This research focuses on the activities and the corresponding postures of passengers during the flight. They were observed and recorded (by using video recordings and photographs) during simulated flight. They have some freedom of choosing how to sit more comfortably and how to adjust their sitting postures within the limitations of the available seating options in the surrounding environment of the cabin. Analyzing the activities and postures performed by passengers within the flight context will extend the understanding and the anticipation about passengers' needs in flight, which will enable the creation of new ways of thinking about the design of seat and cabin and improving the comfort feeling of passengers.

Thus, this study aims to

Identify the activity duration and analyze which typical activities a passenger would perform

How they carry out these activities, which corresponding postures are related to these activities, and the difficulties and constraints resulted from the seat and cabin

Formulate an effective method to be applied to bring contributions to the improvement of passengers' comfort and innovations in cabin and seat

2. Methods

The method applied to this study is to record and analyze the passengers' activities through video observation, which enables researchers to capture dynamic events occurring fluidly in time [10]. This method is commonly adopted to identify the problems and requirements of users.

2.1. Experimental Environment and Apparatus. The experiment was conducted in an aircraft simulator at the Northwestern Polytechnical University, which is part of a Boeing 8737–300, as shown in Figure 1. There are 30 seats in the simulator and the configuration of the seat is 3–3. The seats have an inclination of 3° in order to simulate the state of stationary cruising flight. The dimensions of the seat are 17 (width) × 17.5 (depth of the cushion) × 18 (height) inches. The first row is fixed, while the pitch of the remaining rows could be adjusted manually. The current seat pitch is 31 inches. The in-flight entertainment (IFE) employs the TV overhead. The controlled temperature was 26 ± 2°C, the relative humidity was approximately 40%. But the vibration, noise, and pressure were different from the real flight environment.

For the reconstruction of subjects' activities and postures, a Multimedia Video Task Analysis System (MVTA) was employed to record the activities and postures performed by the participants during the experiments, which is used for motion-time ergonomic analysis based on videos. The cameras were set up to record the subjects' activities from four different perspectives.

2.2. Subjects. 27 volunteers with no body pain history and no health problem were recruited from Northwestern Polytechnical University in form of network recruitment. The age of them ranged from 22 to 47 years. And they represent a broad range of body sizes. The gender ratio of male to female was about 2 to 1. Participants were carefully selected in order to obtain a representative sample of the expected passenger population, in terms of diversity in age and anthropometry (stature and weight). Finally, 18 subjects including 12 males and 6 females were chosen to participate in this experiment. The sample spanned a broad range of the population (in terms of percentiles). In terms of standing height, the samples ranged from 5th percentile female to 95th percentile male according to GB/T5703-1999 [11]. In terms of body mass, the sample ranged from 20th percentile female to 90th percentile male according to GB/T5703-1999 [11]. The basic demographic data (age, gender, stature, body mass, and body mass index) and corresponding descriptive statistics values (mean and standard deviation) are shown in Table 1 concretely.

2.3. Experimental Protocol. The participants were observed by using video recordings and photographs during simulated flight. The experimental protocol was explained verbally to subjects, and the signed informed consent was obtained. After measuring the statures and weights of subjects, they were instructed to sit comfortably on the seat and had freedom of choosing their activities and postures within the limitations of the available seat conditions in the cabin. The experiment was conducted in the aircraft simulator and lasted for 2 hours. The video camera recorded the activities and postures adopted by the subjects throughout the tests. After the recording of the flight, a comfort questionnaire was completed to evaluate the subjects' comfort experiences in the context of their performed activities and in relation to seat design aspects. On an 11-point scale (10, high; 0, low), the subjects were asked about the following questions:

Their overall comfort experiences

Their seat comfort experiences when they performed activities

Figure 1: The experimental environment in simulated cabin.

Table 1: Demographic and anthropometric characteristics of subjects.

Subjects	Gender	Age	Statures (cm)	Body mass (kg)	BMI
1	Male	24	175	70	22.86
2	Female	26	168	54	19.13
3	Male	23	172	61	20.62
4	Male	24	169	59	20.66
5	Female	24	163	44	16.56
6	Male	25	177	73	23.3
7	Male	23	175	90	29.38
8	Male	28	178	82.3	25.98
9	Female	25	157	48	18.75
10	Female	24	168	54.6	19.26
11	Female	23	160	53	20.7
12	Female	24	168	54	19.13
13	Male	39	169	74	25.9
14	Male	34	178	79	24.9
15	Male	22	168	65	23.0
16	Male	24	185	70	20.4
17	Male	28	167	62	22.2
18	Male	30	172	64	21.6
Mean and STD	—	26.11 ± 4.38	170.67 ± 6.54	64.27 ± 12.35	21.91 ± 3.16

Their comfort experiences on seat parts such as headrest, backrest, armrest, and seating space when they performed their activities

In addition to the suggestions of participants, they were asked how to improve their comfort experiences and which adjustments of seat parts they preferred to support their activities.

After the experiment ended, they received a gift as rewards.

Finally, MVTA software was used for data analysis, which enables to analyze the video and identify the postures adopted by subjects along the action course.

The whole experimental protocol is shown as Figure 2.

3. Results

The sitting activities and postures of 18 subjects were recorded to estimate the characteristics of sitting postures in relation to their activities. Concerning the data obtained through the videos, the passenger's activities were reconstructed using the software MVTA.

From the process of reconstructing, it is verified that the typical activities performed by the participants were noted with different colors along the performance sequence. The quantitative analysis of the recording could be offered. The total duration and proportion of each activity was calculated. The posture data derived from the video recording were subsequently recorded along the action course. The postures adopted by participants in different activities were described in elliptic structural diagrams. In order to display and classify the related postures, the rapid coding technique was chosen [12]. Each posture was represented by a set of four figures, which, respectively, represent the position of the head, back, arms, and legs. The denotation of the positions is listed in Table 2.

3.1. Activities. During the experiment, it has been verified that participants have performed activities such as sleeping and resting, reading, using small electrical devices, watching video in flight, eating or drinking, and talking with others. The most observed activities are listed in Table 3, which is an overview of the recorded activities during the flight. The

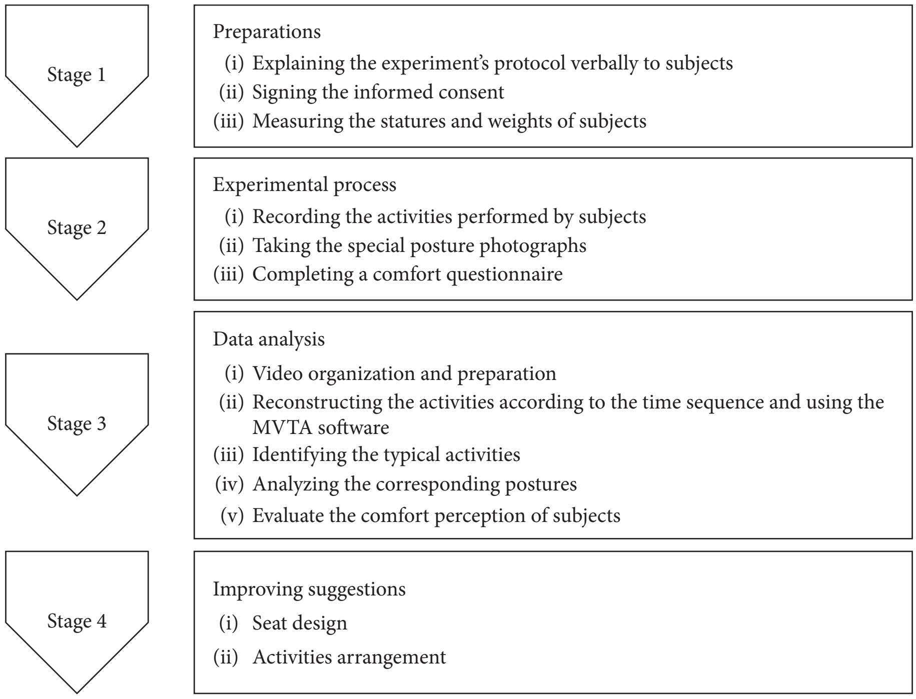


Figure 2: The experimental protocol.

Table 2: Denotation of coding.

Body parts	Description	No.
Head	Free of support	1
	Against headrest	2
	Supported by hands	3
Back	Free from backrest	1
	Leaning against backrest	2
	Against backrest	3
Arms	Free from armrest	1
	Upon armrest	2
	Only elbow	3
Legs	Feet on the floor	1
	Legs or feet crossed	2
	Other	3

three main activities were identified. Participants remained the greatest part of the time performing the activity of sleeping and resting (34.3%), followed by using small electrical devices (32.7%) and reading (16.1%).

3.2. The Postures in Activities. Associated with four main activities, the corresponding postures were analyzed in a descriptive way. The top distinct postures that were mostly observed were encoded and analyzed based on the variations in head, back, arms, and legs. In relation to the postures adopted by passengers in different activities, the elliptic structural diagram was used to display them directly.

There are more postures observed in the activities. Table 4 shows an overview of the most observed postures in the whole flight according to the percentages. The most frequently observed postures: 2311 (29.7%), head against headrest, back against backrest, arms free from armrest, and legs free with feet on the floor; 1332 (17.4%), head free of support, back against backrest, only elbow against armrest, and legs crossed; and 2321 (13.3%), head against support, back against backrest, arms upon armrests, and legs free with feet on the floor.

The relationship between postures and activities are displayed in Figure 3, which showed the most observed postures in four activities. The lightest shading represents the sleeping and resting, the lighter shading indicates using the small electric devices, the darker shading presents reading, and the darkest indicates watching. Some postures appear in a higher proportion in activities of sleeping and resting and watching video, respectively, and lower in activities of using small electric devices and reading, such as postures 2311, 2321, 2222, and 2312. Postures 1332 and 1311 are the contrary. This is a typical phenomenon.

3.2.1. The Postures in Sleeping and Resting. For all the activities observed on the flight, 34.3% of participants choose to sleep and rest. However, due to the limitation of available seating space and resources (armrests, footrest, and adjustability of backrest), the activity and postures of participants are restricted. They can only stretch their bodies as far as possible within the seat adjustment range.

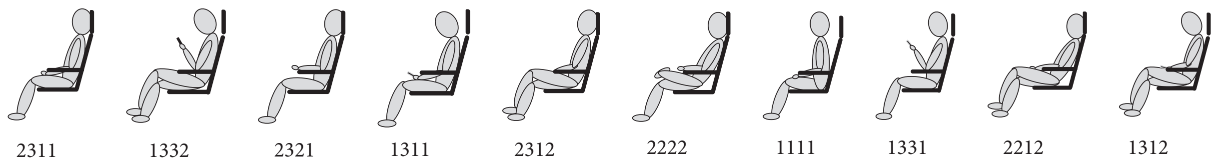
The ellipses were used to replace the parts of a passenger's body, which makes the posture and angle of each part of passenger's body clearer. The top postures observed in sleeping and resting are displayed in Figure 4.

The top two postures in sleeping and resting were Posture 2311 (head against headrest, back against backrest, arms free from armrest, and legs free with feet on the floor)

Table 3: The most recorded activities during the flight.

Activities	Sleeping and resting	Using small electrical devices	Reading	Watching	Eating/drinking	Talking
%	34.3	32.7	16.1	9.4	5.2	2.3

Table 4: An overview of the most observed postures in the whole flight.

Postures	2311	1332	2321	1311	2312	2222	1111	1331	2212	1312
										
%	29.7	17.4	13.3	12.6	10.2	7.7	4.2	3.2	1.1	0.5

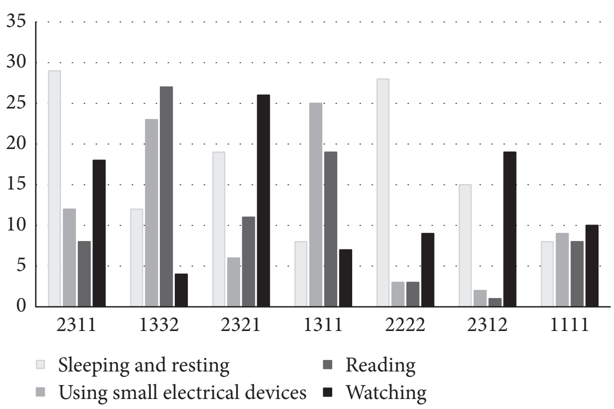


Figure 3: An overview of the most observed postures in four activities.

and 2222 (head supported by hands, back leaning against backrest, arms upon armrest, and legs crossed), which, respectively, were observed with 32% and 26%. Participants adjusted their postures according to their comfort feeling. Considering the space needs of rear participants, in these two postures, the backrest of the seat was not adjusted to a larger angle, which does not cause too much interference to the participants in the back row. Participants put their elbows on the armrest and support their heads with their hands and their legs crossed in the second posture (3331). Long-term support will cause wrist and elbow discomfort. The first posture is more common, and the body stretches as far as possible, without any overlapping. Some participants have their backs leaning against the backrest of the seat.

3.2.2. The Postures in Using Electrical Devices. With the development of the communication industry and technology, participants are allowed to use the small electronic devices during flight. More and more passengers will use the smartphones to watch videos or perform other entertainment activities during the flight. In this experiment, 32.7% of participants used the small electrical devices. The common postures are displayed in Figure 5.

Passengers generally used forward-leaning postures when using electrical devices. Compared with sleeping or resting, using electrical devices will obviously cause more discomfort in the neck and arms of participants. There are not too many differences between the proportions of different postures using electrical devices. The postures of participants changed very frequently when they used smartphones. At first, they will put the smartphones on the legs and their heads were down. Their legs were crossed or naturally flat on the ground (1311 and 1312). In these postures, their necks were easily uncomfortable because they kept their heads down for a long time. And then they changed their postures into other ones, such as 1331 and 1332, to alleviate the head and neck discomfort. The smartphones were lifted with hands by participants and the head and the back were against the headrest and backrest. The arms are suspended, which would lead to fatigue in the arms. They would put the smartphones on the table to alleviate the discomfort of arms or support the arms with the armrests (1121 and 3131). The participants preferred to increase the angle of the backrest so that they could lean on the backrests more comfortable (2232 and 2211).

All postures did not last long time. The participants changed their postures frequently until their adjustment achieved a relatively short time balance. They wanted to support their arms and body.

The top two postures in using electrical devices were Posture 1311 (head free of support, back against backrest, arms free of armrests, and legs free with feet on the floor) and 1332 (head free of support, back against backrest, only elbow against armrest, and legs crossed), which, respectively, were observed with 18.4% and 17.5%.

3.2.3. The Postures in Reading. 16.1% of participants would spend time on reading books or magazines during flight. The common postures are shown in Figure 6. The postures of reading books are basically the same as those of using smartphones. Because both of them are looking at the things in their hands, so this paper did not make a separate analysis of reading books postures. The difference between reading and using a smartphone is that reading is mostly performed

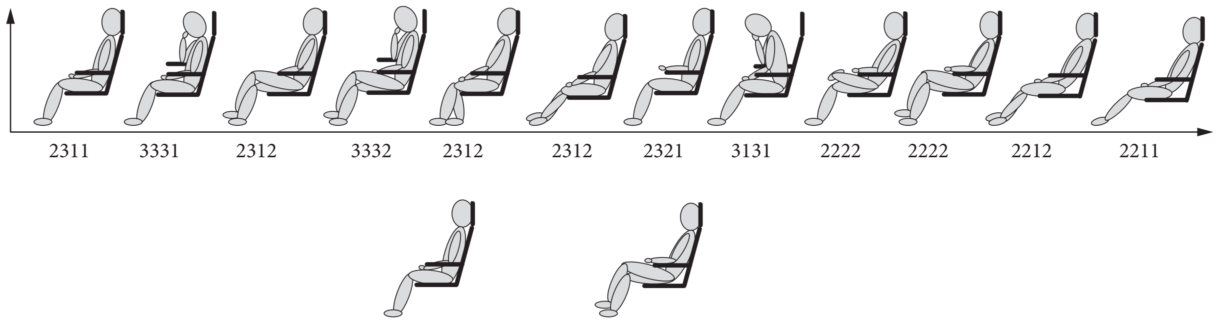


Figure 4: The elliptic structural diagram in sleeping and resting.

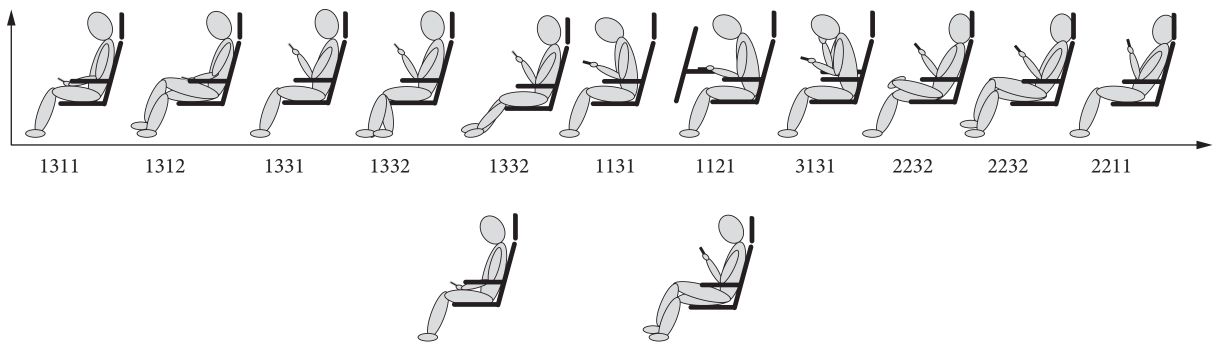


Figure 5: The elliptic structural diagram in using electrical devices.

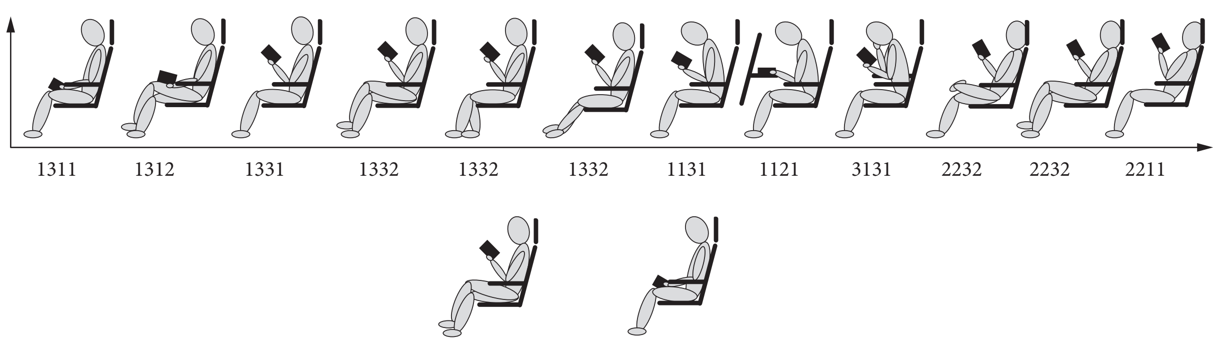


Figure 6: The elliptic structural diagram in reading.

with two hands. The arms were raised higher when using smartphones. There were more movements with more hands when reading. And participants changed their postures more frequently because of the weight of the book. Participants would look for supportable parts, such as armrests, backrests, and tables to relieve fatigue.

The top two postures in reading are Posture 1332 (head free of support, back against backrest, only elbow against armrest, and legs crossed) and 1311 (head free of support, back against backrest, arms free of armrests, and legs free with feet on the floor), which, respectively, were observed with 12.1% and 10.5%.

3.2.4. The Postures in Watching. Watching the video in plane accounted for 9.4%. The common postures are displayed in Figure 7. Participants need to look up and watch the video in flight because the TV is fixed on the top of the cabin. Therefore, there are few changes in head and back. The most frequent postural changes are the arms and legs.

The top two postures in watching are, respectively, Posture 2312 (head against headrest, back against backrest, free from armrest, and legs crossed) and Posture 2321 (head against headrest, back against backrest, arms upon armrest, and legs free with feet on the floor), which, respectively, were observed with 13.4% and 11.2%.

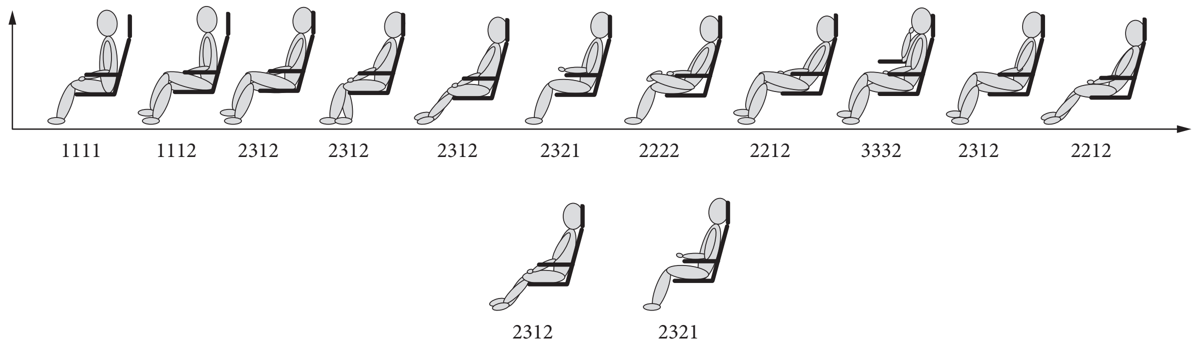


Figure 7: The elliptic structural diagram in watching.

3.3. Survey. At the end of the experiment, the subjects were asked to answer a questionnaire. By summarizing the questions from the survey, it is verified that the difficulties reported by the participants related to the available space are displayed by the adopted postures. The difficulties in all activities and the average comfort scores are listed in Table 5.

78.6% of participants considered sleeping and resting were one of the most difficult activities in flight. The average comfort score in this activity is 3.3 points, which is the lowest in all activities. The main constraints in this activity are mainly about the supportability and restricted space of seats, such as the inclination of the seat is too little, participants did not have enough space to move their legs and change the arm position, and they had difficulties in supporting their bodies and arms when sleeping and resting. They reflected that when they slept or had a rest, long periods of sitting and leaning on the backrest will lead to discomfort in the shoulder and back of the participants. Because there is no side support in headrest and backrest, it is easy for participants to lose their balance in a relaxed state during sleeping or resting. And then it will lead to physical discomfort of neck and head and psychological insecurity of participants, even affecting the participants sitting next to them. The second question is lack of leg space. When participants slept or had a rest, they like to stretch their legs straight. However, because of the restricted space, it is difficult to make their legs reach under the front seat. They had to cross their legs in different ways, which can be shown in Figure 5. The armrest is another part which was complained most in the survey. Because the height of the armrest cannot be adjusted, the participants with different percentages will have various discomforts when using the armrest. And because the armrest is too narrow and too hard, it cannot meet the requirements of both sides of the participants at the same time, resulting in unhappiness among participants. The armrest could not offer a good support for arms when sleeping and resting.

67.9% and 46.4% of participants reported difficulties in using small electrical devices and reading, respectively. The average comfort scores for these two activities are, respectively, 4.6 and 4.9 points. Some participants complained that there was no fixed place for mobile phones and no charging ports in the seats when using smartphones. Some ones reflected the light switch was too high and the light is not bright enough. The armrests were the most complained about in these two activities. They are too hard and narrow. According to Figures 6 and 7, when participants were using smartphones or reading, they had to lift the smartphones or books with one hand. The elbow was the only part in contact with the armrest, which will lead to the discomfort of the elbow and fatigue of arms. Participants had no enough space to move their arms, and their necks lack support, which would lead to fatigue in the arms and neck. However, reading got the highest comfort score, 7.9 points, among all the activities. Proper activities will distract the passenger's attention from discomfort perception. Richards et al. [4] stated that "passenger may immerse in a certain activity too excessively to perceive the discomfort," which can give some suggestions for improving the participants' comfort experiences in actual flight.

Only 14.3% of participants thought it was difficult to watch videos in flight, which was the lowest. And the average comfort score in this activity was 5.1 points, which was the third highest score. Some participants said the TV hanged too far to see clearly, there was no choice about the TV programs, and the backrest could not be adjusted to super place. Correspondingly, they wanted more choice about TV programs and more seat space.

21.4% of participants reflected eating and drinking had difficulties. The average comfort score was 6.8 points. The main question was lacking of space. And some participants hoped they could use electronic equipment when eating and have more choice about food and drinks.

Only 7% of participants thought that talking had difficulties. The average comfort score was 7.5 points, which was the second highest score because in this experiment there were few subjects performing this activity.

These data are shown in Figure 8.

4. Discussion

According to the results of activity analysis and survey, the seat design and the limited space in the cabin are important factors that restrict the activities of passengers, which affect the comfort perception of passengers. People wanted more movement space and possibilities to perform their activities. Sitting was a dynamic task. Postural changes and the specific postures were related to the discomfort feeling. A more reasonable seat design, cabin layout, and activity arrangement can effectively improve passenger discomfort.

Table 5: The main results summarized in the survey.

Activities	Difficulties percent	Average value	Difficulties	Suggestions
The overall comfort experiences	—	6.4	Lack of space Lack of adjustment Lack of support of arms	—
Sleeping and resting	78.6%	3.3	There is no enough support for head, arms, and body Legs cannot straighten out Influencing neighboring participants Lack of space Lack of privacy protection	Need a better headrest and backrest Need more leg space It is better to have a wider seat It is better to have wider and softer armrests It is better to adjust the backrest to a bigger angle
Using small devices	67.9%	4.6	There is no fixed place for mobile phones in the seats No charging ports Arms and necks are very tired	It is better to fix the smartphone in the seat back It is better to charge the phone easily
Reading	46.4%	4.9	The light is not good Arms and necks are very tired Armrest is too hard and narrow There is no enough leg space	Lower the lighting switch and have a brighter light It is better to have wider and softer armrests It is better to have a more appropriate feet support
Watching	14.3%	5.1	The TV hangs too far to see clearly There is no choice about the TV program The backrest could not be adjusted to super place	It is better to have a separate TV in every row Have more choice about the program Have more leg space
Eating and drinking	21.4%	6.8	Lack of space Cannot use electronic equipment when eating	Have more space Have more choice about food and drinks
Talking	7%	7.5	The armrests are not convenient when talking Side chatting is uncomfortable	It is better if the seat could rotate The armrests could be taken in

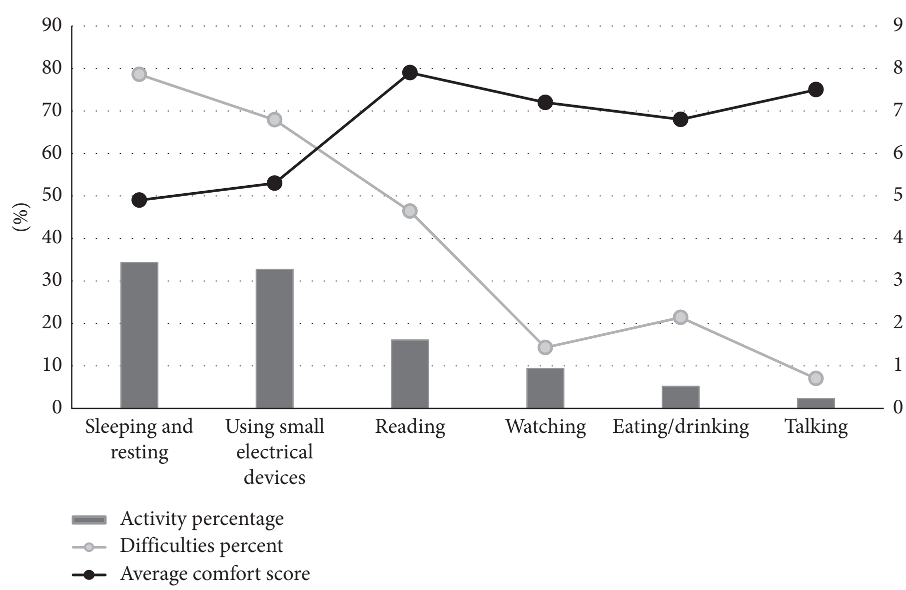


Figure 8: Data of activities in cabin.

4.1. The Suggestions for the Design of Cabin Seat. Through the analysis of passengers' activities and common sitting postures in flight, the real needs of passengers can be reflected and inducted. The reconstruction of passengers' sequence activities can reflect the changes of passengers' comfort and discomfort feeling. The seat design can be improved according to the behavioral needs of sitting postures. Summarizing questionnaire and activity analysis, we can concretely summarize the following design points that need to be improved. Considering the physical and psychological demands of passengers, some improvements of seat design can be summarized as follows.

4.1.1. Supportability. Comfortable and reasonable support of the seat is a necessary condition to ensure passengers' physiological health. Passengers have to keep sitting in a relatively restricted posture for a long period, which may cause the discomfort or pain in neck, shoulders, back, elbows, knees, etc. The existing seat design has achieved the basic support function, taking into account the curve of the human spine. Concerning the postures adopted by the passengers, it has been noticed that most of them look for some support (for the head, back, arms, and legs). On the basis of survey and activity analysis, it is necessary to have some supporting and privacy protection functions of headrest and backrest. When sleeping and resting, it is easy to produce unbalance in a relaxed state, which may cause psychological discomfort or insecurity and impact the passengers in the next seat. The side support with proper height and thickness is a good try, which could protect passengers from head injuries during sleeping and resting. The armrest is also an important factor in supportability. Because the width of the armrest is too narrow, it is the most frequently mentioned by passengers in the survey. When a passenger uses an armrest, the other next to him is bound to be affected. Sharing a narrower armrest prevents adjacent passengers from using it at the same time. Inadvertent contact can also make unfamiliar passengers uncomfortable when they perform the different activities. Therefore, it is better to design wider or individual armrests.

4.1.2. Adjustability. Adjustability is one of the most mentioned questions by passengers in the survey, which is related to the inclination angle of the headrest, backrest, armrest and seat surface, light, IFE, etc. Adjustability addresses the individual differences in comfort needs of different passengers performing different activities. For example, when sleeping and resting, the headrest, backrest, and footrest should be adjustable. Passengers are allowed to change them to satisfy their needs. But it is better not to affect the rear passengers. If passengers want to communicate with others or keep themselves isolated and protect their privacy, the corresponding design or products should be offered. For example, individual armrests and seats that can be moved back and forth independently.

The light and IFE should be adjustable when passengers are reading or watching. They could choose their preferred lighting intensity or video programs.

4.1.3. Affordance. The seat and other products should be easy to operate and not cause any harm when passengers carry out different activities or adopt different postures. The design of them should have good ergonomic features and accessibility. For example, the seat inclination angle, lighting intensity, and IFE adjustment buttons should be placed in the right place for passengers to operate. And they would be invited to use these buttons. There are adequate charging interfaces for small electrical devices and access to phones and the Internet.

4.1.4. Aesthetics. It would intensify the passenger comfort experience if the aircraft cabin was clean and tidy and the flight facilities were featured to make them have the aesthetic enjoyment and a good association [13]. Beautiful seat design, including the materials, stiffness, colors, weight, price, maintainability of the seat, uniform and harmonious cabin color matching, clean and tidy cabin, and good services would effectively improve passengers' comfort perception.

4.2. The Suggestions for the Design of Cabin Activities. Proper movement will distract the passenger's attention from discomfort perception. After continuous sitting for 1.5 hours, the passenger's discomfort could be relieved effectively through short rest [3]. The regular change of posture, standing, and walking have a positive effect on discomfort resulting from prolonged sitting [14]. This is because timely walking can promote the leg blood circulation and prevent the blockages and thrombosis, thus to relieve effectively discomfort. Therefore, it is necessary to design and arrange the rational activities from boarding to disembarking to improve the comfort feeling of passengers.

Aircraft cabin is a highly restricted space, and passengers are not allowed to leave their seats freely and perform random activities. Passengers feel discomfort in a long sitting, and they have to change their postures and activities frequently, which can be shown in the previous activity analysis. It is passive. The aim of the specific activity arrangement is to guide and motivate passengers at a particular moment to actively perform some particular activity, which could lead passengers to change a fixed posture in order to improve their comfort perception. For example, it is a common way to arrange for passengers to drink and eat at a certain time. A proper reminder to go to the bathroom is also a way to encourage passengers to leave their seats.

The application of new virtual reality technology and new devices is another good way to improve the passengers' comfort feeling, such as wearable devices and virtual reality glasses. New experiences brought about by new technologies and new interactive ways would effectively enhance the comfort perception. So, these activities by using new devices or experiencing new games and videos would be helpful.

The activity design in aircraft cabin is from boarding to disembarking a complete design throughout the whole flight process. The complete activity design in the future will be conducted, including activity type, activity arrangement, exact time arrangement, duration arrangement, and application of specific devices.

5. Conclusions

The research provided a method to analyze the activities and postures performed by passengers in flight and their comfort experience. The main activities in flight were sleeping and resting, using the small electrical devices, and reading. The corresponding postures related to their respective activities were displayed in the elliptic structural diagram, which described the characteristics of each posture more clearly. The most common activities on flight reflect the demands of passengers. While the most common postures in activities reflect the comfort level of the cabin seat and the degree to whether the activities are successfully performed.

In order to translate these analysis results into improving the passengers' comfort, the suggestions of seat and activity design are provided. The analytical method of activities and postures can be applied into seat design and cabin layout in real flight context. Seat pitch, leg room, and seat width should be increased in many economy class airline seats [15]. However, it is not a viable solution to improve passengers' comfort by making the seats larger and increasing the seat pitch cabin and leg space in the economy class because it means less seats and higher costs in the airplane. The demands are for more flexible and comfortable seating possibilities. Other ways could be considered to enhance the passengers' comfort, such as the supportability, adjustability, affordance, and aesthetics of the seat. The reasonable activity guidance and arrangement would motivate passengers to perform certain activities in a certain time and change a fixed posture in order to improve their comfort perception. Seat design and activities arrangement could compensate the discomfort caused by seat pitch and legroom. All these needs are interdependent and may be complementary or conflicting. How to achieve a balanced state in the cabin system is the key problem. By adapting the seat and activity design to provide more flexible and comfortable activities and postures, would improve the comfort experiences of passengers and offer a competitive advantage in the aviation industry.

However, there are still some limitations in this study. The sample size of the subjects in this experiment is small and there is no diversity in age. It is just for the short-haul flight. The different flight type should be considered. And more specific design method should be studied in the future.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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