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Sleeping Posture Analysis of Economy Class Aircraft Seat

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Abstract— **With the rapid development of technology, the comfort of service has become an important issue. Air travels, especially long distance, may cause both physiological and psychological discomfort to passenger. Passenger comfort is clearly a main factor in user's acceptance of transportation systems. Sleeping is one of the common activities during the long haul flight. In this paper, subjective and objective measurement method was described to evaluate the sleeping posture of economy class aircraft seat passenger.**

Index Terms— **aircraft seat, sleeping posture, subjective measurement, objective measurement.**

I. Introduction

Air travel is becoming increasingly more accessible to people both through the availability of cheap flights and because the airlines are now able to cater for individuals of all ages and disabilities. Health problems may arise due to anxiety and unfamiliarity with airport departure procedures prior to flying, whilst during the flight, problems may arise as a result of the food served on board, differences in the environmental conditions inside the cabin (pressure, ventilation, relative humidity, noise and vibration), the risk of cross-infection from fellow passengers, seat position, posture adopted and duration of the flight. These can be further compounded by changes in time zones and meal times, which may continue to affect an individual's health long after arrival at the final destination [1]. Travel by air, especially long distance, is not a natural activity for human. Many people experience some degree of physiological and psychological discomfort and even stress during flying. Excessive stress may cause passenger to become aggressive, over-reaction, and even endanger the passenger's health [2, 3]. A number of health problems can affect flying passengers.

Comfort is an attribute that today's passenger demand more and more. The aircraft passenger comfort depends on different features and the environment during air travel. Seat comfort is a subjective issue because it is the customer who makes the final determination and customer evaluations are based on their opinions having experienced the seat [4]. The aircraft passenger seat has an important role to play in fulfilling the passenger comfort expectations. The seat is one of the important features of the vehicle and is the place where the passenger spends most of time during air travel. The aviation industry is highly competitive and therefore airlines try to maximize the number of seats [5]. Often this results in a very limited amount of seating space for passengers, especially in economy class [6]. In this paper, we described the subjective and objective measurement to analyze the sleeping posture of economy class aircraft seat passenger.

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II. Aircraft Seat

Seat is one of the important elements for the passenger comfort. Different seat aspects have to be seen and taken into account in the comfort model. In charter and economy class the two least satisfactory characteristics are 'seat comfort' and 'leg room' [1].

The Civil Aviation Authority (CAA) is the regulatory body for the safety guidelines for aircraft seat spacing. The guidelines are set with safety, not comfort, in mind and relate to robustness of aircraft seats at the time of a crash and the ease of passenger evacuation in the event of an emergency [1]. There are three kinds of seat position in the aircrafts, such as window, corridor and isolated. For passengers seated in the central position of three or more seat row, the feeling of being surrounded is one of the worst aspects of economy air travel.

InNova [7] was created a seat design called the bubble. The innovation of the design is to relocate the hand baggage to underneath the seat, therefore eliminating the need for overhead bins; this in turns increase the passenger's perception of space by reducing the tunnel effect. B/E Aerospace developed the moving set called ICON seating [8]. The moving seat surface allows the passenger to adopt multiple postures, including back and side sleep. Side support wings on the seat bottom can be adjusted to provide leg support in a side sleep posture. ICON seating allows passenger in full control of comfort and personal space.

Lantal Textiles from Switzerland was developed the pneumatic cushions comfort system for aircraft seat. The new system is replaced conventional foams with air-filled chambers. Passenger can adjust the pneumatic pressure of the seat to suit their personal preferences, from firm when seated upright and medium when relaxing to soft in the fully flat position [9].

III. Relationship of Subjective Measurements to Comfort and Discomfort

Due to the lack of proven analytical metrics, seat manufacturers have opted to rely on subjective evaluations as the main indicator of seat comfort. The seat manufacturers developed elaborative subjective evaluation protocols that involved highly structure questionnaires [10]. The questionnaires direct occupants to assign feelings of discomfort to a specific region of seat. The questionnaires, which typically contain numeric scales (e.g. 1 = very uncomfortable to 10 = very comfortable), produce subjective ratings that are translated into performance requirements/specifications [11]. A properly designed questionnaire is paramount because it affords researchers an instrument from which to establish theories [12].

IV. Relationship of Objective Measurements to Comfort and Discomfort

Comfort measurement of seat is difficult because of such factors as user subjectivity, occupant anthropometry, seat geometry, and amount of time spent sitting [13]. A great deal of research has been performed in recent years to find objective measures for predicting seat comfort perception. Some of the proposed objective measures include vibration, interface pressure, posture and muscle activity. These objective measures are correlated with subjective data to determine the relative effects of each measure related to comfort [14].

The seat industry strongly encourages research in the field of objective comfort assessment, especially dedicated to the seat and the related postures [15, 16]. The posture is one of the important issues to be considered in the seat design process [17] regarding not only the car and the user [18, 19] but also the experimental conditions. The instruments that used in the posture measurement are camera, optoelectronic system (ELITE), driving posture monitoring system, digital signal processing, ultrasonic device (Zebris), 3D motion analysis (Vicon), and motion measurement system (Qualisys).

V. Sleeping Posture Analysis

Two analyses were conducted to study the sleeping posture during long haul travel.

A. *Observation on Sleeping Posture*

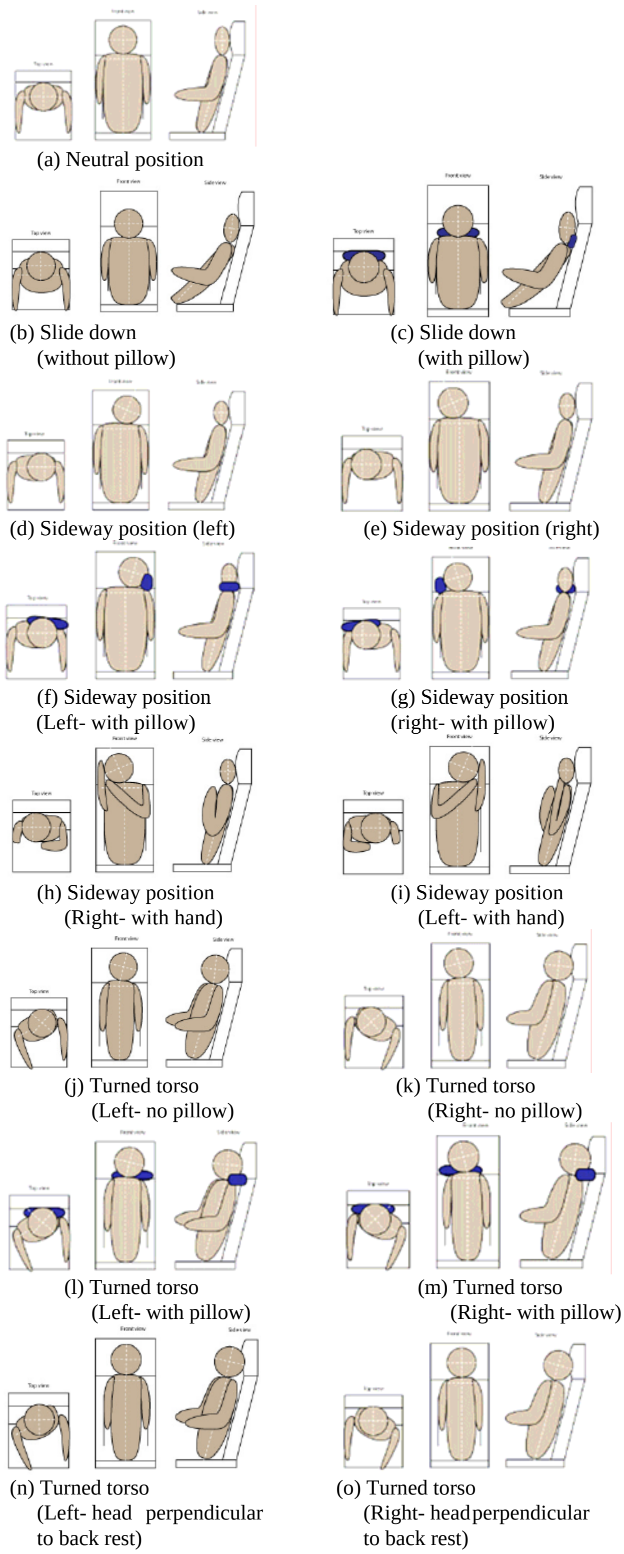
The main purpose of the observation is to find out the sleeping posture and sleeping behavior of passenger during long distance travel. The observation is conducted in a long haul flight from Amsterdam, the Netherlands to Kuala Lumpur, Malaysia. The duration of the trip was 12 hours.

The researcher documented the activity of the passengers in his visual range. There were 15 subjects, 8 female and 7 male selected in the observation. . The age of subjects was between 19 to 62 years old. The average age was 28 years old.

Based on the observation results, 7 different sleeping positions identified. Observation in a long haul flight established a ground protocol on sleeping behavior of economy class passenger in a sitting position.

The protocol of sitting position while sleeping is based on four general sitting positions and one open sitting position. The sitting position while sleeping protocol as follows (Fig. 1):

1. Neutral position
2. Slid down on seat in neutral position
   - With pillow
   - Without pillow
3. Head in tilted position (left and right)
   - With pillow (between shoulder and head)
   - Without pillow
   - Supported with hand (between shoulder and head)
4. Torso sitting position
   - With pillow (head in diagonal with backrest)
   - Without pillow (head in diagonal with backrest)
   - Head resting on head rest (head perpendicular with backrest)



(a) Neutral position
(b) Slide down (without pillow)
(c) Slide down (with pillow)
(d) Sideway position (left)
(e) Sideway position (right)
(f) Sideway position (Left- with pillow)
(g) Sideway position (right- with pillow)
(h) Sideway position (Right- with hand)
(i) Sideway position (Left- with hand)
(j) Turned torso (Left- no pillow)
(k) Turned torso (Right- no pillow)
(l) Turned torso (Left- with pillow)
(m) Turned torso (Right- with pillow)
(n) Turned torso (Left- head perpendicular to back rest)
(o) Turned torso (Right- head perpendicular to back rest)

Fig. 1. The sitting position while sleeping protocol

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B. Objective Measurement on Sitting Posture While Sleeping

The purpose of the objective measurement is to measure and validate the sitting position while sleeping protocol that based on observation method. The objective measurement was conducted in an innovative aircraft cabin simulator (Fig. 2).

Fig. 2. Aircraft cabin simulator

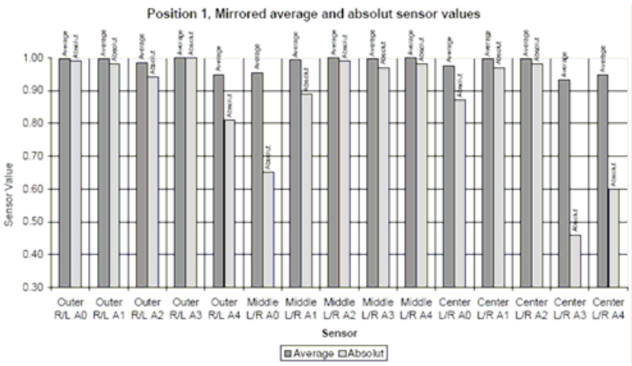
The experiment was conducted for each individual separately. Before the experiment, the participant was briefed with the experiment procedure and regulation. The participant was sat in the prepared seat, interpreted the 10 sitting positions from the protocol for 30 seconds. The measurement was started when the participant confirmed in the correct sitting position. Each position was measured with Max and microcontroller. Force sensitive resistor (FSR) was used for the posture measurement. Fig. 3 shows the preparation of the sensors on seat head rest area.

Fig. 3. FSR sensors on head rest area

Twelve participants, 4 female and 8 male, participated in the experiment. The age range of participant was between 22 to 25 years old, with an average of 24 years old. Their average height is 1.82 m.

From the experiment, the sensor outputs corresponded with the sitting posture protocol (Fig. 4 and Fig. 5).

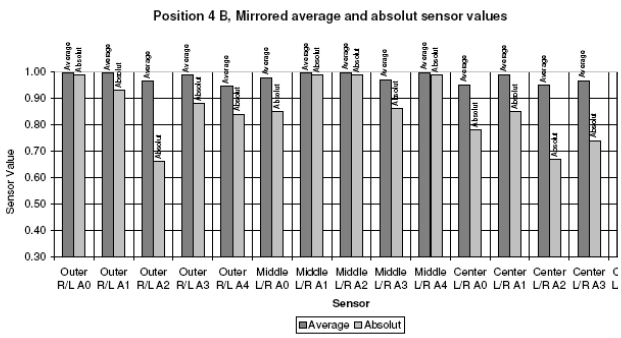
(a)



(b)

Fig. 4. Position 1, neutral sitting position (a) a participant in position 1 (b) sensor output

(a)



(b)

Fig. 5. Position 4B- sitting position in turned torso position with a pillow (a) sensor output (b) a participant in position P4B

The sitting position with P4C-turned torso, with head facing the seat in front was the most comfortable sitting position for participants. The sitting position with P3C- head tilted with hand supporting between neck and head was criticized by many participants. For P5- freedom for personal sleeping preferences, it is the most preferable sleeping position among the participants. During the experiment, most of participants turned their torso slightly up to perpendicular towards the backrest as well as leaning to their side of their face (with or without pillow) against the headrest.

VI. Conclusion

In this paper, we have described the subjective and objective measurement techniques used to measure sitting posture while sleeping of the economy class aircraft seat. The developed posture measurement method is used to detect the posture change of aircraft passenger. 12 participants involved in the experiment to validate the protocol with the sensor platform. For subjective measurements, observation method is used to determine the sitting posture while sleeping. The protocol enables the ongoing research to quantify the sitting posture, predict the sitting pattern and make the comparison. It is recommend that objective and subjective measurement should be correlated together for better understanding of comfort and discomfort in order to design comfortable economy class aircraft seat.

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