The Impact of Pilot Seat Design on Aviation Safety

Eman Mohamed Salem **Toka Mahrous Fahmy** **Bassam Samir Al-Romeedy**

Faculty of Tourism and Hotels, Tourism Studies Department, Sadat City University

Abstract

The basic aim of this study is to highlight the physical, anthropometric, and biomechanical considerations that should be taken into account in the design of the pilot seat. It also investigates the vital role of the pilot seat design in improving aviation safety. EgyptAir pilots (417 in total) were given a questionnaire survey. The study results found out that the design of the pilot seat affects pilot comfort and safety and, in turn, affects aviation safety. As well, the results concluded that pilot seat design affects positively aviation safety and its three dimensions. The study makes contribution by providing designers with the pilots' feedback, complaints, and suggestions related to the seat design with all its components with the aim of dealing with any design-related issues and handling any pilot-related side effects. This ultimate goal is to improve the seat design and enhance pilot comfort and flight safety.

Keywords: Pilot seat, design, aviation, safety, physicality, anthropometrics, biomechanics

Introduction

As mentioned by Lulić et al. (2004), there are several guidelines and recommendations for aircraft designers to follow in order to ensure functional pilot accommodation. The cockpit layout design requirements must be established in the early stages of the design process. The cockpit and numerous mechanical systems are designed based on assumed pilot postures and capabilities. Moreover, Lusted et al. (1994) illustrated that during middle- and long-range flights, pilots in flight complained of discomfort and low-back pain. These complaints may cause a pilot to lose concentration, thus jeopardizing the safety of a fight. Therefore, pilot seats with a variety of adjustment options were created to ensure seating comfort. Parameters which strongly impact pilots' comfort in sitting derive partly from anthropometric and partly from biomechanical considerations.

Furthermore, Ilić et al. (2014) clarified that Vibrations in an aircraft's pilot seat have a negative impact on the pilot's mental and physical state, as well as increasing fatigue in the human body. As a result, it is critical to work continuously to improve pilot comfort and reduce vibration that affects the pilot seat. As explained by Zhang et al. (1996), in the work environment, humans' satisfaction, performance, and safety are enhanced by the comfort of seats, as a result of the long time spent by humans sitting on them carrying out the required tasks.

In Pheasant and Haslegrave's (1996) viewpoint, the interaction of the user, seat, and the task, combined together, determines the comfort of the pilot seat. Vink (2005) added that not only to look comfortable, but also to provide pilots with the feeling of being comfortable, the pilot seat must be designed. Well-designed seats must help pilots to feel comfortable immediately after sitting and continue to feel comfortable during the flight time. Based on the above, this study aims to:

1. Explore the dimensions of ergonomically-designed pilot seat.
2. Investigate the aspects of aviation safety.
3. Find out the impact of pilot seat design on aviation safety.

Literature review

Getting to the core of it all, Andrade (2013) shed light on the fact that due to the long-time humans spend sitting, the comfort of seats is no longer a luxury in the everyday life. Although seats’ comfort is hard to define and difficult to measure, a number of measures, both objective and subjective, were used to evaluate the seats’ comfort level. Parsons (2000) described the objective ones as being quantifiable. In other words, they do not require the explanation of humans to assess discomfort. The most common objective measures are pressure distribution analyses, motion analyses, and postural angle analyses' physicality of the seat". The most common subjective measurements used to measure the pilots’ satisfaction are questionnaires, rating-scales, interviews, and body-map ratings "personal impression".

Playing the same tune, Andrade (2013) stated that for enhancing the safety, satisfaction, and performance of pilots in the work environment, a swelling solicitude in the sound design of seats' comfort brightened up. Lower back pain, musculoskeletal disorders, and susceptibility to fatigue are all direct negative results of the duration pilots spend sitting in poorly designed and uncomfortable seats combined with inappropriate postures. This makes it necessary to look for well-designed seats with lower biochemical problems, less fatigue, and higher suitability levels for pilots. Hence, there has been increased concern about the proper seat design to enhance safety, performance, and pilots’ satisfaction in the workplace. Myers (2010) demonstrated that both ergonomics and aesthetics seem to mesh in the pilots’ seat design.

As mentioned by Corlett (2006), for the purpose of evaluating the proper design of seats, optimal sitting posture is essential. Mimicking an erect posture, when humans standing, upright position is considered the ideal. The advantages of this posture include: allaying pressure around the human body's mid-section, and dolling out pressure equally throughout the human body's muscles.

Contrary to what was previously stated by Corlett (2006), Andrade (2013) and Claus et al. (2009) illustrated that sitting upright posture increases lower spine tension and can be optimum for long periods of time. Furthermore, Cohen (1998) indicated that for the applications of seat ergonomics, pilots were asked to provide feedback on either the comfort or the discomfort of seats. The feedback depends on pointing out physically-hurt regions of pilots' bodies after long flights. In conjunction with the pilots' feedback, objective measures are required to be used for comfortable seats of pilots to be redesigned.

According to Goossens et al. (2000); Mohler (2001); Andrade (2013); and Shubham and Devendra (2017), in seats which are uncomfortably and poorly designed, the combination of incorrect sitting posture and the sitting' period of time results in high-susceptible fatigue, pain in the lower back, and disorders in musculoskeletal. It is conspicuous that there is a requirement for providing best-designed seats that suit the target operators while reducing biochemical issues and fatigue. During the flight, pilots' performance can be decreased and the flight safety concerns can be raised as a result of the humans' physical discomfort.

Pilot Seat Design Considerations

Andrade (2013) indicated that, for investing in both comfort for pilots and safety for flights, it is necessary to learn the way to avoid the discomfort of seats and biochemical problems by keeping an eye on the behaviors of sitting pilots, the cockpits' systems interfaces, the comfort surveys, and the experiments conducted with the purpose of identifying the appropriate design and measure of seats.

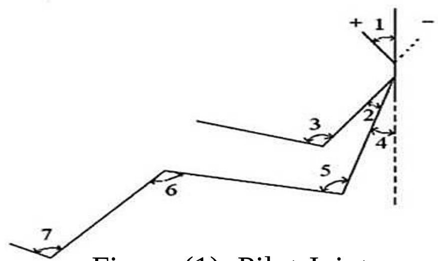

Figure (1): Pilot Joints
Source: (Rune et al., 2008)

As denoted by Rune et al (2008), the design of the pilot's seat must take into consideration the comfort of the different joints, shown in figure (1), of the pilot's body such as knee and anklebone in order to avoid any unnecessary or harmful impact on the pilot that may create a feeling of discomfort or fatigue. The right posture of the pilot ensures easy reach of the controls like the rudder and the stick. As numerated by Andrade (2013), the eleven fundamental requirements that must be met for ensuring the seats' comfort and safety are as shown in figure (2). Physiological, pathological, and anatomical reasons of lower back pain and discomfort are those which these requirements depend on. They are: Foot space probability, enabling position changes; armrests; height of seat pan; lower back support; prolonged flat spine; support of shoulder; curvature of seat pan; backrest incorporation; angle among the thigh and trunk; adjustability of seat tilt; and decreased space amidst the thigh and trunk that can result in the damage of the 4th and 5th discs, resulting in discomfort for those prolonged-sitting humans or operators.

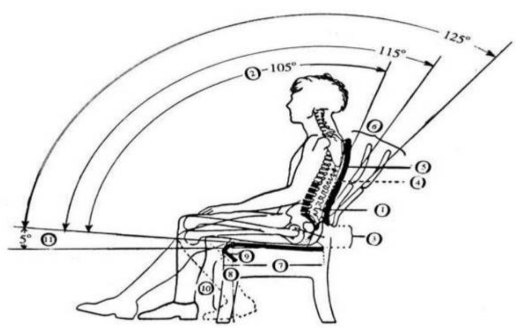

Figure (2): Seat Design Criteria
Source: Andrade (2013)

Moreover, in (1999), Harrison et al. stipulated that the seat design criteria should include: headrests; lumbar support; ease of mobility; armrests; seat height and inclination (adjustments). adjustments should be simple and provide the pilots with numerous options; and a curved seat pan to promote comfort and reduce sitting stress. pilots in an aircraft cockpit, for example, should be able to sit for up to four hours without discomfort or deterioration in work performance. All in all, Andrade (2013) and Gupta et al. (2018) hit the point when they came to the conclusion that seats are essential for the overall performance in the workplace in order to promote comfort and safety. Therefore, optimizing comfort in appropriate seat design, ergonomics, anthropometrics, aesthetics, biomechanics, and proper subjective and objective measurements are required. Concerning the design of the pilot seat backrest in the cockpit, to completely eradicate the shear forces between both of the human skin and the seat cushion and to consider the ergonomic design requirements, a biomechanical model shows that when a backrest is used, the seat must be inclined backwards at the site of the ischial tuberosities (Goossens, 2000).

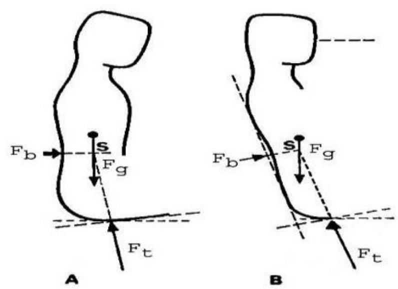

Figure (3): Seat Backrest Design Considerations
Source: (Goossens, 2000)

The left-hand figure (A) depicts a free body diagram of the mass of the human arms, head and trunk (upper body). The lines of action of the force from the backrest (F_b), the weight force of the upper body (F_g), and the force on the ischial tuberosities (F_t) all intersect at one point in a state of static equilibrium (sitting still) (S). As a result, when a backrest is used, the reaction force on the ischial tuberosities (F_t) cannot be vertical but must have a slight inclination. The right-hand figure (B) shows that as the upper body is tilted backward, the inclination of the support force (F_t) increases because its line of action must pass through (S) (Goossens, 2000). Stressing the same point of view, Sanders and McCormick (1987) made seat contour recommendations. Because of the shape of the human spine, contoured seats, for example, are used to distribute weight in the lower regions of the body. As a result, an aggressive or flat contoured seat should be avoided for the majority of seats. Regarding lumber support, for the pelvis to be prevented from tilting backward during sitting, a support force at the level of the posterior superior the iliac spine is required. This lumbar support aims to avoid lumbar kyphosis by supporting the lumber spine to adopt a slight lordotic curvature. The following symbols and letters represent various parts of the figure below (Goossens, 2000):

o Width between armrests	**a** Seat height	**I** Armrest width
f Column cut out width	**h** Backrest height	**j** Backrest width
m Armrest length	**k** Armrest height	**b** Seat depth
ß Backrest inclination	**c** Seat depth effective	**e** Seat width effective
g Lumber support height	**i** Free space pelvis	**ǯ** Armrest inclination
ά Seat inclination at ischial tuberosities		**d** Thigh Support Length

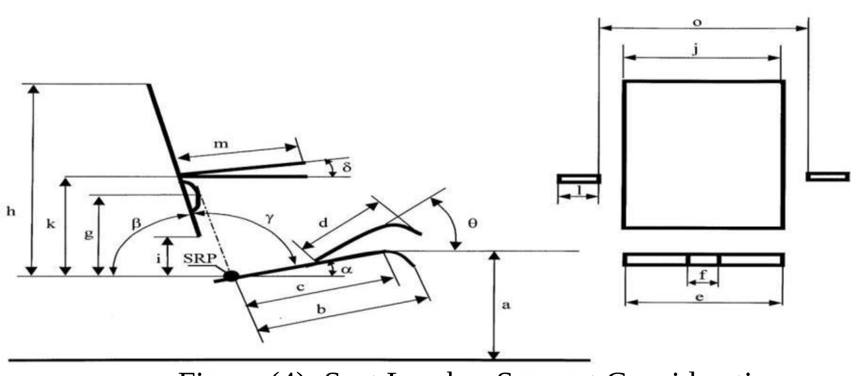

Figure (4): Seat Lumber Support Considerations
Source: (Goossens, 2000)

Based on the above, we propose the following hypotheses:

H1: Pilots' seat design affects positively aviation safety.
H1/1: Pilots’ seat design affects positively organizational safety norms.
H1/2: Pilots’ seat design affects positively work environment hard and soft safety norms.
H1/3: Pilots’ seat design affects positively pilots' performance safety norms.

Methodology

A research study, according to De Vos et al. (2005) and Al-Romeedy (2019a), is a method used to collect the necessary evidence to answer the research questions. The quantitative nature of this study was dependent on survey methodology. According to Creswell (2003), quantitative research is used to develop knowledge in areas such as cause and effect thinking, reducing variables to specific variables, questions, hypotheses, and theory testing. According to Muijs (2004) and Cheia (2010), the quantitative method is a scientific one that uses numerical data through the use of statistical methods to explain social phenomena through the description, analysis, and evaluation of these mentioned phenomena, as well as making predictions about them.

Questionnaire Design

In this study, the questionnaire was divided into three sections as follows: The First Section: It was concerned with the demographic information about the respondents. This section consisted of four questions about gender, age, years of experience, and current position in the airline. The Second Section: This section is divided into two subsections as follows: Subsection (A)revolves around the pilots’ seat design. It aims at finding out if it, through the seat design, has a role in causing the pilots’ feeling of comfort or discomfort and in turn if it affects flight safety. The statements went around multiple dimensions concerning the seat design, including seat adjustability, seat size, seat height, seat cushions, seat backrest, seat position, seat shape, seat armrest, and seat belt. These dimensions were measured by utilizing sixteen statements derived from Andrade (2013). This section depended on (1-5) Likert Scale degrees of agreement, where (1) means ‘Strongly Disagree’, (2) means ‘Disagree’, (3) means ‘Neutral’, (4) means ‘Agree’, and (5) means ‘Strongly Agree’.
Subsection (B) is concerned with the evaluation of the effects of the overall pilots’ seat design on the pilots’ body, every part of the body. An image, adopted from Andrade (2013), was utilized to illustrate the parts of the pilot’s body. Pilots were asked to circle each area’s feeling, comfort or discomfort, resulting from the design. The Third Section: It is concerned with the evaluation of aviation safety. The fifty four statements in this section were retrieved from safety evaluation surveys carried out by ATSB (2004); IWH (2016); Weightman (2017); and Britton (2018). It contained three dimensions, organizational safety norms with twenty-nine statements, work environment hard and soft safety norms with fourteen statements, and pilots’ performance safety norms with eleven statements. In this subsection, a (1-5) Likert scale degrees of agreement was used from (1) means ‘Strongly Disagree’ to (5) means ‘Strongly Agree’.

Population and Sampling

As illustrated by Al-Romeedy and Ozbek (2022) and Veal (2006), every member of the population, in the technique of the random sampling, has an equal chance of being chosen for the sample.

As a result, in this study, the technique of a Simple Random sample was selected. According to data shown in table (1), a cluster sample of Egypt Air airline was chosen for investigation. The number of pilots in the mentioned airline was obtained by contacting the key person in the Integrated Operations Control Center (IOCC) in (2022). The pilots' number in the sample size was determined according to the "Table for Determining Sample Size from a Given Population" (Israel, 2009).

Table 1: The Sample Size of the Study

Airline	
EgyptAir	
N. Of Captain Pilots	525
N. Of Co-Pilots	408
N. Of Distributed Forms	417
N. Of Received Forms	369
N. Of Usable Forms	314
Response Rate	75.3%

In EgyptAir, there were 525Captain Pilots and 408 Co-Pilots. The questionnaire forms were distributed to (417) pilots. A total number of (369) forms were received representing a response rate of (88.5%). Out of these received forms, only (314) were deemed usable. The primary factor of unusable forms was incomplete surveys.

Data Collection

Data was collected using a questionnaire form to test the study's hypotheses. After collecting the contact information of the investigated airline and adjusting the first draft of the questionnaire following the pilot study, the final questionnaire was distributed. The researcher contacted the Integrated Operation Control Center (IOCC) in EgyptAir to get their permission to make repeatable visits to distribute the questionnaire form to its pilots. The questionnaire was also designed electronically on Google forms and distributed via social media. Dusek et al. (2015) highlighted the importance of social media in the collection of required data from the research population which is dispersed throughout large geographical areas and is not easy to reach, along with facilitating the distribution of questionnaires to the sample of the search. The questionnaire forms were distributed from January10, 2022 to August 01, 2022.

Data Analysis

In this study, Likert scale was used to measure the respondents' answers. The data analysis in this study was performed through two steps. Both the descriptive and inferential tests were used to address the research questions and hypotheses for the study. Firstly, descriptive analyses were performed to investigate the frequency distribution of responses to the relevant questions, Std. deviation and mean. To get the findings of these analyses, the statistical package for social science (SPSS V. 24) and (AMOS V. 24) for Windows were used. Secondly, exploratory research examines causality, and is able to reveal relationships between two or more variables (Veal, 2006; Gaafar et al., 2021). Tests used to expose the possible significance of these relationships are as follows: reliability test; descriptive statistics; and path analysis.

Results and Data Analysis

Reliability Test

A high Cronbach's Alpha value reflects the reliability of scale and indicates cohesiveness among scale items. According to Nunnally (1978), Zaki and Al-Romeedy (2019), and Al-Romeedy (2019b), a high Cronbach's Alpha is an indirect indicator of convergent validity. However, the validity needed to be confirmed by CFA. Table (2) indicates values of Cronbach's Alpha for all constructs. Based on the data presented in the table, there is sufficient evidence to suggest that the reliability of the constructs was acceptable, given that the Cronbach's Alpha valueis >0.60 (Nunnally, 1978).

Table 2: Reliability Levels of Instrument – Cronbach's Alpha

	Cronbach's Alpha	No. of items
A- Pilots' SeatDesign (PSD)	.814	16
B- Aviation Safety (AS)	.892	54
Organizational safety norms (OS)	.887	29
Work environment hard and soft safety norms (HS)	.791	14
Pilots' performance safety norms (PP)	.802	11

As shown in table (2), it is concluded from this finding that the scale has high levels of internal consistency and is therefore considered to be very reliable, where Cronbach's Alpha values are >0.732. This leads to the conclusion that all the constructs and variables used in this study are built on well-established instruments with high reliability scores, and the internal consistency of each construct is substantiated to be very good.

Construct Validity

The figures presented in Table (3) say that composite reliability for all items went beyond the desired threshold of .70 (Elbaz et al., 2022; Al-Romeedy, 2019c). They also show that AVE for pilots' Seat design Instrument surpassed the suggested value (0.50). One more finding is that the factor loading for all items of pilots' seat design instrument is higher than 0.5.

Table 3: Results Summary for Construct Validity of pilots' seat design Instrument

Constructs	Factor loading	Composite reliability	AVE
SP1	.805	0.871	0.753
SP2	.913		
SP3	.842		
SP4	.800		
SP5	.845		
SP6	.867		
SP7	.888		
SP8	.714		
SP9	.767		
SP10	.869		
SP11	.911		
SP12	.901		
SP13	.878		

SP14	.814		
SP15	.837		
SP16	.855		

Demographic and other work-related information

Sample characteristics in this study comprise four main items. Table (4) presents the results which were obtained after analyzing demographic variables. The frequency and percentage for each variable are listed in accordance with the survey categories in the table.

Table 4: Demographic and work-related information

Demographic and Work-Related Information		Freq.	%
Gender	Male	310	98.7%
	Female	4	1.3%
Current Position	Captain pilot	180	57.3%
	Co-Pilot	134	42.7%
Age	20-29 years	32	10.2%
	30-39 years	81	25.8%
	40- 49 years	105	33.4%
	50 and Over	96	30.6%
Years of Experience	0-09 years	66	21%
	10-19 years	106	33.8%
	20-29 years	78	24.8%
	30 and Over	64	20.4%

Concerning the respondents' gender; there are just four females representing (1.3%). The majority of pilots are males, representing (98.7%) with a total number of 310 pilots. Concerning the respondents' position; "captain pilot" represents more than 50% of the total sample of 180 (57.3%), and "co-pilot" represents (42.7%) with a total number of 134 pilots. Concerning the respondents' age; (40 to 49 years) represents (33.4%) with a total number of 105 pilots, (50 years and over) represents (30.6%) with a total number of 96 pilots, (30 to 39 years) represents (25.8%) with a total number of 81, and (20 to 29 years) numbering 32 (10.2%). Concerning the respondents' working experience; a total number of 106 pilots (33.8%) have work experience between (10 to 19 years) followed by 78 (24.8%) pilots who have (20 to 29 years) then 66 (21%) pilots who have(0 to 9 years), and at the end come pilots with (30 years and over) with a total number of 64 (20.4%).

Descriptive Statistics

1- **Pilots' Seat Design**

A- **Seat Design Dimensions**

Table 5: Mean Value and Standard Deviation (SD) of Seating Posture

No.	Seating Posture	Mean	SD	T	Sig.	Rank
1	Seat is readily adjustable	4.2800	.8815	10.267	.000	3
2	The seat size affects the pilots' comfort.	4.3200	1.0190	9.160	.000	1
3	The seat is easy to get in and out of.	3.9400	1.2190	5.452	.000	10

4	The seat height affects the legs comfort.	3.8800	1.3797	4.510	.000	13
5	Seat cushion affects the pilots' buttocks.	4.1400	1.1430	7.052	.000	6
6	Seat backrest affects the pilots' backbone.	4.1800	1.172	7.115	.000	4
7	The seat backrest curve affects the pilots' shoulders.	4.0600	1.0382	7.219	.000	9
8	The seat backrest length affects the pilots' backbone.	4.1200	1.1890	6.660	.000	7
9	The seat backrest width affects the pilots' comfort.	4.1400	1.11067	7.283	.000	5
10	The seat backrest firmness affects the pilots' comfort.	4.1000	1.1473	6.779	.000	8
11	The head backrest firmness affects pilots' neck.	3.9000	1.2494	5.093	.000	12
12	Seat design causes the pilots' lumbar stiffness.	3.9400	1.1322	5.870	.000	11
13	The position of the seat armrests affects the pilots' comfort.	3.7400	1.4258	3.670	.000	15
14	The shape of the seat armrests affects the pilots' comfort.	3.8400	1.2512	4.747	.000	14
15	The stiffness of the seat armrests affects the pilots' forearm.	3.6400	1.1738	3.855	.000	16
16	The seatbelt position is easy to reach	4.2800	.8580	10.548	.000	2
Pilots' Seat Design		**4.0313**	**.7786**	**9.366**	**.000**	

Concerning the study sample's responses to the design of the seat variable statements, Table (5), demonstrates that the total mean of the responses reached (4.0313) with a standard deviation of (.7786). This mean indicates that the respondents agreed that the design of the seat ensures pilots' comfort. The mean for this variable ranged between (3.6400) and (4.3200). Item No. (2): "The seat size affects the pilots' comfort" came in the first place, with a mean of (4.3200), which is higher than the general mean of (4.0313) and a standard deviation of (1.0190). This showed that respondents strongly agreed that the size of seats in the cockpit affects the pilots' feeling of comfort. Statement No. (15): "The stiffness of the seat armrests affects the pilots' forearm" ranked last, with a mean of (3.6400), which is lower than the general mean of (4.0313), with a standard deviation of (1.1738). This indicated that respondents agreed that the stiffness of the seat armrests affects the pilots' forearm. Minimal dispersion in the responses of the study sample about the seat design variable is clearly mirrored in the table. This reflects the convergence of the sample members' attitudes towards the importance of the seat design. The convergence in the values of the mean is also shown. It can be concluded from the statistical significance values related to the calculated (t) values that there is vast agreement among the study sample members about the statements of this variable, given that the statistical significance of all levels was below the level of the significance (0.05).

B- Seat Design and the Human Body

Table 6: Results Summary of Pilot Seat Design and the Human Body.

No.	Human Body Parts	Comfort	Percentage %	Discomfort	Percentage %
	Body Posture (Front)				
1-	Shoulder	125	39.8%	189	60.2%
2-	Chest	301	95.9%	13	4.1%
3-	Upper Arm	314	100%	-	-
4-	Abdomen	298	94.9%	16	5.1%
5-	Forearm	314	100%	-	-

6-	Basin	304	96.8%	10	3.2%
7-	Hand	300	98.7%	4	1.3%
8-	Thigh	302	96.2%	12	3.8%
9-	Leg	266	84.7%	48	15.3%
10-	Foot	282	89.8%	32	10.2%
	Body Posture (Back)				
1-	Head	235	74.8%	79	25.2%
2-	Cervical	157	50%	157	50%
3-	Back	110	35%	204	65%
4-	Upper Arm	300	98.7%	4	1.3%
5-	Waist	61	19.4%	253	80.6%
6-	Forearm	314	100%	-	-
7-	Buttock	78	24.9%	236	75.1%
8-	Thigh	251	79.9%	63	20.1%
9-	Leg	266	84.7%	48	15.3%

Regarding the results of Body Posture illustrated in Table (6), it is clear that Waist Discomfort ranked first with (80.6%). Then, Buttock Discomfort came to rank second with (75.1%). Back Discomfort occupied the third place with (65%). Shoulder discomfort came in the fourth place with (60.2%). Considering Cervical discomfort, opinions about comfort and discomfort were equal with (50%). Back Upper Arm Discomfort represented (1.3%). Forearm and Front Upper Arm came to be free from discomfort feeling: zero discomfort feeling. Head feeling of discomfort was (25.2%). Thigh Discomfort showed a percentage of (20.1% Back) and (3.8% Front). Leg Discomfort represented (15.3%). The abdomen recorded a discomfort percentage of (5.1%), followed by the chest with (4.1%).

2- Aviation Safety

The results contained in Table (7) and which refer to the study sample's responses to the pilots seat design in safety variable statements and its dimensions indicate that the total mean of the responses to pilots seat design in safety amounted to (4.3195) with a standard deviation of (.5038), and taking into consideration the standard used in this study and the responses of the sample, this mean signifies that the respondents strongly agreed that Pilots seat design has an impact on Aviation Safety.

Table 7: Results Summary of Aviation Safety

	Mean	SD	Rank
Organizational safety norms	4.2566	.5977	3
Work environment hard and soft safety norms	4.3657	.5056	1
Pilots' performance safety norms	4.3364	.5368	2
Pilots Seat Design	4.3195	.5038	

Model fit

Table (8) presents the values of model fit indicators of the path analysis model for the impact of the seat design on safety. Based on the table, it is clear that the value of chi-square is less than 5, reaching 1.992, therefore the model is accepted. The results show that the value of the (CFI) was 0.990, and this indicates the conformity of the model. As well, the results in the table indicate that the value of the (GFI) was 0.974, which suggests the conformity of the model. As indicated by the table, the value of the (NFI) was 0.979, in conformity with the model. As for the (IFI), which has a value ranging from 0.900 to 1.00, and must be more than 0.90 for the model fit, recorded a value of 0.958, which indicates the conformity of the model. The (TLI) value was 0.980, signifying the conformity of the model. Finally, the results show that the (RMSEA) value was 0.003, which is a value close to zero. This indicates the conformity of the model. In light of all the above-mentioned indicators, it becomes clear that the proposed model fitted the sample data.

Table 8: Model Fit for Path Analysis from Pilots' Seat Design to Aviation Safety

Indicators	Value
χ^2/df	1.992
Comparative Fit Index – CFI	.990
The Goodness of Fit Index – GFI	.974
Normative Fit Index – NFI	.979
Incremental Fit Index – IFI	.958
Tuker – Lewis Index – TLI	.980
Root Mean Square Error of Approximation – RMSEA	.003

Test of hypotheses
Model fit
H1: Pilots' seat design affects positively aviation safety.

Table 9: Pilots' Seat Design to Aviation Safety

Path	Estimate	S.E.	C.R	P Value	Result
Pilots' Seat Design → Aviation Safety	.781	.129	6.054	.000	Supported

Table (9) indicates that the value of the standard estimate from Seating Posture to safety was 0.781, which is significant (p-value <0.05), and this means that the seat design positively affects 78.1% of safety. The standard error was 0.129. The C.R. value was 6.054. So, H1 is supported.

1/1 Pilots' seat design affects positively organizational safety norms.

Table 10: Seat Design to Organizational Safety Norms

Path	Estimate	S.E.	C.R	P Value	Result
Seat Design→ Organizational Safety Norms	.588	.105	5.600	.000	Supported

Table (10) indicates that the value of the standard estimate from the seat design to organizational safety norms was 0.588, which is significant (p-value <0.05), and this means that the seat design positively affects 58.8% of organizational safety norms. The standard error was 0.105. The C.R. value was 5.600. Hence, H1/1 is supported.

1/2 Pilots' seat design affects positively work environment hard and soft safety norms.

Table 11: Pilots' Seat Design to Work Environment Hard and Soft Safety Norms

Path	Estimate	S.E.	C.R	P Value	Result
Seating Posture → Work Environment Hard and Soft Safety Norms	.659	.097	6.794	.000	Supported

Table (11) indicates that the value of the standard estimate from the seat design to work environment hard and soft safety norms was 0.659, which is significant (p-value <0.05), and this means that the seat design positively affects 65.9% of work environment hard and soft safety norms. The standard error was 0.097. The C.R. value was 6.794. Therefore, H2/1 is supported.

1/3Pilots' seat design affects positively pilots' performance safety norms.

Table 12: Pilots' Seat Design to Pilots' Performance Safety Norms

Path	Estimate	S.E.	C.R	P Value	Result
Seating Posture → Pilots' Performance Safety Norms	.801	.152	5.270	.000	Supported

Table (12) indicates that the value of the standard estimate from the seat design to pilots' performance safety norms was 0.801, which is significant (p-value <0.05), and this means that seating posture positively affects 80.1%of pilots' performance safety norms. The standard error was 0.152. The C.R. value was 5.270. Hence, H3/1 is supported.

Results and recommendations

The study presented a number of results as follows:

1. The seating posture in EgyptAir is optimal and seats provide pilots with the required comfort level.
2. The seat design in EgyptAir enhances pilots' performance to operate a safe flight.
3. The seat strongly affects the flight safety.
4. The seat height, size, width, curve, seat belt, cushion, backrest, headrest, and arm rest, are all well designed and allows for pilots' feeling of comfort or zero discomfort. This enhances the comfort and safety of pilots.
5. Pilots' Seat Design affects significantly and positively aviation safety and its dimensions.

Recommendations

The study presented a number of designers-related recommendations such as:

1. Pilot seat must consider the capabilities and limitations to provide pilots with the highest level of comfort and safety.
2. A seat massage should be available to avoid back and neck pain for the pilot in long-time flights.
3. Pilots must report any side effects resultes from the seat design.
4. Pilotsmust hold aperiodecally-performed examinations toensure their physical fitness.
5. Airlines must put into consideration the pilots' complaints.
6. Designers must keep in touch with pilots to get their feedback to improve seat design.

Conclusion and Further Research

The study clarified the significant role the seat design plays in enhancing pilot comfort and flight safety. Seat design considerations are vital to developing the seat design to ensure pilot safety. The study was founded on the hypothesis that seat design affects aviation safety. The study targeted EgyptAir pilots as a study population. The study's questionnaire concentrated on pilot seat as the place in which pilots spend most of time and was used to collect data. The study went around one main hypothesis that seat design affects the aviation safety. The study yielded a number of results. Finally, the study made a number of recommendations for cockpit designers. As for further research, it is recommended to study the possibility of developing auto-adjustable seats that scan pilot body through biosensors and adjust themselves automatically.

References

- Al-Romeedy, B. (2019a). Green human resource management in Egyptian travel agencies: constraints of implementation and requirements for success. *Journal of Human Resources in Hospitality & Tourism, 18*(4), 529-548.
- Al-Romeedy, B. (2019b). Strategic Agility as a Competitive Advantage in Airlines - Case Study: Egypt Air. *Journal of the Faculty of Tourism and Hotels-University of Sadat City, 3*(1), 1-15.
- Al-Romeedy, B. (2019c). The role of job rotation in enhancing employee performance in the Egyptian travel agents: the mediating role of organizational behavior. *Tourism Review, 74*(4), 1003-1020.
- Al-Romeedy, B., and Ozbek, O. (2022). The effect of authentic leadership on counterproductive work behaviors in Egyptian and Turkish travel agents: Workplace incivility as a mediator. *African Journal of Hospitality, Tourism and Leisure*, 11(2), 409-425.
- Andrade, Y. (2013). An Ergonomic of Aircraft Pilot Seats. PhDdissertation, Embry-Riddle Aeronautical University.
- Australian Transport Safety Bureau (ATSB). (2004). Aviation Safety Survey: Safety Climate Factors, AVIATION RESEARCH PAPER. Available at: ATSB Aviation Safety Survey - Safety Climate Factors Accessed on December, 2021.
- Britton, T. (2018). 30 Good Questions for Safety Surveys in Aviation SMS. Available at: 30 Good Questions for Safety Surveys in Aviation SMS (asms-pro.com) Accessed on December, 2021.
- Cheia, G. (2010). Research Methods in Tourism, GEOREVIEW: Scientific Annals of Stefan cel Mare University of Suceava, Geography Series19(2). Available at: https://www.researchgate.net/publication/307685405_RESEARCH_METHODS_IN_TOURISM Accessed on January, 2020.
- Claus, A., Hides, J., Moseley, G., and Hodges, P. (2009). Different Ways to Balance the Spine: Subtle Changes in Sagittal Spinal Curves Affect Regional Muscle Activity. *Spine, 34*(6), 208-214.
- Cohen, D. (1998). An Objective Measure of Seat Comfort. *Aviation Space and Environmental Medicine, 69*, 410-414.
- Corlett, E. (2006). Background to Sitting at Work: Research-Based Requirements for the Design of Work Seats. *Ergonomics, 49*(14),1538-1546.
- Creswell, J. (2003). Research design: Qualitative, quantitative, and mixed methods approach (2nd Ed.). Thousand Oaks, CA: Saga Publications.
- De Vos, A., Strydom, H., Fouch, C., and Delport, L. (2005). Research at grassroots for the social science and human service profession (3rd Ed.). Pretoria, S.A: Van Shaik.
- Dusek, G., Yurova, Y., and Ruppel, C. (2015). Using Social Media and Targeted Snowball Sampling to Survey a Hard-to-reach Population: A Case Study. *InternationalJournal of Doctoral Studies, 10*, 279-299.
- Elbaz, A., Soliman, M., Al-Alawi, A., Al-Romeedy, B., and Mekawy, M. (2022). Customer responses to airline companies' service failure and recovery strategies: The

moderating role of service failure habit. *Tourism Review*. https://doi.org/10.1108/TR-03-2022-0108

- Gaafar, H., Elzek, Y., and Al-Romeedy, B. (2021). The Effect of Green Human Resource Management on Green Organizational Behaviors: Evidence from Egyptian Travel Agencies. *African Journal of Hospitality, Tourism and Leisure, 10*(4), 1339-1356.
- Goossens, R., Snijders, C., and Fransen, T. (2000).Biomechanical Analysis of the Dimensions of Pilot Seats in Civil Aircraft.*Applied Ergonomics, 31*(1), 9-14.
- Gupta, I., Kalra, P., Chawla, P., and Singh, J. (2018). Evaluation of Pilot's Seat Design of Civil Aircraft for Indian Anthropometric Data by using Delmia Human Software. *Procedia Manufacturing, 26*, 70-75.
- Harrison, D., Harrison, S., Croft, A., Harrison, D., and Troyanovich, S. (1999). Sitting Biomechanics part I: Review of the Literature. *Journal of Manipulative and Physiological Therapeutics, 22*(9), 594-609.
- Ilić, Z., Rasuo, B., Jovanović, M., and Jovičić, S. (2014). Impact of pilot seat position on the seat's vibration spectrum on piston propeller aircraft. Available at: (PDF) impact of pilot seat position on the seat's vibration spectrum on piston propeller aircraft (researchgate.net)Accessed on August, 2022.
- Institute for Work and Health. (2016). Workplace Health and Safety Survey. Toronto, Canada: University Ave. Available at: ohs_vulnerability_measure _questionnaire _2016.pdf (iwh.on.ca) Accessed on: December, 2021.
- Israel, D. 2009. Sampling the Evidence of Extension Program Impact. Program Evaluation and Organizational Development, IFAS, University of Florida.
- Lulić, J., Muftić, O., and Sušić, A. (2004). Ergonomical analysis of pilot seat KM-1. Proceedings of 2nd International Ergonomics Conference, Croatia.
- Lusted, M., Healey, S., and Mandrijk, J. (1994). Evaluation of the Seating of Qantas Flight Deck Crew. Applied Ergonomics: the journal of people's relationships with equipment, environments and work systems, Oxford: Elsevier.
- Mohler, S. (2001). Lower Back Pain a Common Complaint, but Precautionary Practices Help Pilots Cope. Human Factors Aviat Med Flight Safety Foundation.
- Muijs, D. (2004). Doing Quantitative Research in Education with SPSS. Sage Publications, London, UK.
- Myers, G. (2010). Social Psychology (10thEd.). New York: McGraw-Hill Humanities/Social Sciences/Languages.
- Nunnally, J. (1978). Psychometric Theory. McGraw-Hill, New York.
- Parsons, C. (2000). Environmental Ergonomics: A Review of Principles, Methods, and Models. *Applied Ergonomics, 31*(6), 581-594.
- Pheasant, S. and Haslegrave, C. (1996). Bodyspace: Anthropometry, Ergonomics and the Design of Work (3rd Ed.). USA: CRC Press.
- Rune, S., Hongjun, X., and Bifeng, S. (2008). Ergonomic Assessment Method for Cockpit Layout of Civil Aircraft X Based on Virtual Design. 26th International Congress of the Aeronautical Sciences.
- Sanders, M. and McCormick, E. (1987). Human Factors in Engineering and Design. (6th Ed.). McGraw-Hill Book Company: New York

- Shubham, M. and Devendra, H. (2017). Design Review of Aircraft Cockpit for Aesthetic and Ergonomic Considerations. *International Journal of Science and Research (IJSR), 6*(2), 39-44.
- Teeselink, G., Siepe, H., and De Pijper, R. (1999). Log Files for Testing Usability, in M. Rauterberg (Ed.), IPO Annual Progress Report 34. Eindhoven: University of Technology.
- Veal, A. (2006). Research Methods for Leisure and Tourism (3rd Ed.). Financial Times/ Prentice rd Hall/Pearson Education: London.
- Vink, P. (2005). Comfort and Design: Principles and Good practice. CRC Press, Boca Raton.
- Weightman, D. (2017). Organizational Safety Perception Survey. PMA COMPANIES. Available at: MN - State Wide Report - Exec Summary_tcm36-322251.pdf Accessed on December, 2021.
- Zaki, H. and Al-Romeedy (2019). The Effect of High-Performance Work Practices on the Creative Performance and Talented Employee Retention: The Mediating Role of Job Embeddedness. *Journal of the Faculty of Tourism and Hotels, Alexandria University, 16*(1), 48-68.
- Zhang, L., Helander, M., and Drury, C. (1996). Identifying Factors of Comfort and Discomfort in Sitting. *The Journal of the Human Factors and Ergonomics, 38*, 377-389.

أثر تصميم مقعد الطيار على السلامة الجوية

إيمان محمد سالم　　　تقى محروس فهمي　　　بسام سمير الرميدي

الملخص العربي:

الهدف الأساسي من هذه الدراسة هو تسليط الضوء على الاعتبارات الجسدية، والأنثروبومترية، والميكانيكية الحيوية التي يجب أن تؤخذ في الاعتبار عند تصميم مقعد الطيار. كما يسلط الضوء على الدور الحيوي لتصميم مقعد الطيار في تحسين سلامة الطيران من خلال تعزيز شعور الطيار بالراحة والأمان ومراعاة قدرات الطيارين والقيود عند تصميم المقعد. تم توزيع 417 استمارة علي طياري مصر للطيران. ووجدت نتائج الدراسة أن تصميم مقعد الطيار يؤثر على راحة الطيار وسلامته ويؤثر بدوره على سلامة الطيران. كما توصلت الدراسة إلى التأثير الإيجابي لتصميم مقعد الطيار علي السلامة الجوية. تساهم الدراسة من خلال تزويد المصممين بملاحظات الطيارين والشكاوى والاقتراحات المتعلقة بتصميم المقعد بجميع مكوناته بهدف التعامل مع أي مشكلات متعلقة بالتصميم والتعامل مع أي آثار جانبية متعلقة بالطيار. هذا الهدف النهائي هو تحسين تصميم المقعد وتعزيز راحة الطيار وسلامة الطيران .

الكلمات الدالة: مقعد طيار، تصميم، الطيران، السلامة، الجسدية، القياسات بشرية، الميكانيكا الحيوية