Identifying Aircraft Passenger Postures and Factors Influencing Body Part Discomfort

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Abstract Aircraft passengers' physical activity levels are often limited during flight for extended periods of time, which can have serious impact on health, comfort, and passenger experience. Passengers are generally advised to walk around the plane and do certain exercises, especially in mid- to long-haul flights, to increase blood flow and reduce discomfort. However, several factors, such as limited personal space and social factors, can make doing these exercises difficult.

In this paper, we introduce sources of discomfort that passengers face in medium to long-haul flights as identified during a simulated flight study. Participant behaviour and postures identified in the study as contributing to participants' reports of discomfort and pain will be described. Twenty-nine participants sat in an aircraft simulated cabin for 180 minutes and periodically performed in-seat exercises. During the trial, they completed a questionnaire every twenty minutes. The questionnaire collected data on demographic information, self-reported discomfort scores for multiple areas of the body, which types of exercises participants performed, and qualitative comments about discomfort. Participants were photographed and video recorded in order to evaluate their postures, movement direction, and other behavioural and physical sources of discomfort. A body mapping analysis was used to identify which parts of the body experienced discomfort in terms of frequency and severity. Body part areas identified as receiving highest scores of discomfort ratings were: back of the neck, back-left shoulder, back-right shoulder, back-left buttock, and back lower back. This work will be used to understand the design of immersive technology intervention for encouraging passengers to engage in physical activity during flights.

Keywords: Passenger Experience**,** Comfort, Body Part Discomfort, Data visualization.

1 Introduction

Due to increasing amounts of air travel, developing new ways to improve passenger comfort in restricted physical spaces is crucial for aircraft manufacturers and airline companies (Vink, 2011). Furthermore, aircraft passenger comfort is an important factor in passenger's acceptance of the transportation system and therefore, their tendency to choose a flight with the airline again (Jacobson, 2007). Comfort level has also been closely associated with passenger health during flight, with constrained cabin seating spaces being linked both to discomfort and negative health outcomes such as deep vein thrombosis (Brundrett, 2001). In order to reduce health risks during flight and to improve comfort, passengers are often advised to walk around the plane and do exercises to increase blood flow (Budd et al., 2011).

Comfort and discomfort have been investigated in several studies in the context of air travel (Ahmadpour, 2017). Vink (2011) defined the concept in relation to three conditions of comfort: DISCOMFORT in which participants experience discomfort; NO DISCOMFORT in which participants experience no discomfort; and COMFORT in which participants experience outstandingly more comfort than expected. There are many factors which might affect passenger comfort and discomfort, including physical, psychological, object, environmental and contextual factors (Menegon et al., 2017). The passenger interaction with the aircraft environment can be associated with high levels of comfort but it can also generate discomfort which is typically associated with pain (Menegon et al., 2016).

Advances in digital technology, such as systems involving virtual reality, offer potential benefits to improving passenger comfort in flight, but in order to design systems that leverage these benefits, a greater understanding of the experience of physical discomfort in flight is needed. Previous work has indicated that virtual and interior spaces may help to evoke the illusion of increased space, and as a result, the level of comfort may increase (Aaltonen et al., 2014). Virtual reality technologies has been used to create environments which distract participants from their main source of discomfort by displacing them from the real-world environment and into a novel context, for instance, a flying carpet ride (D'Cruz et al., 2014).

This paper presents the findings from a study in which participants were asked to perform exercises at regular intervals during a 3-hour flight simulation, with specific focus on which exercises passengers tended to do most, what difficulties they faced while doing these exercises, and reported levels of discomfort in different body areas.

2 Method

In this section, participants, study materials and procedure will be explained.

2.1 Participants

29 participants (18 male, 11 female) from the University of Nottingham community took part in the study. The participants' mean age was 27.58 years and the standard deviation was 8.64. Participants were asked to choose their seat, remain in the same seat for entire study which was three hours representing medium haul flights, complete the questionnaire every twenty minutes and perform in flight exercises periodically. Ethical approval for the study was granted by the University of Nottingham Faculty Of Engineering Ethics Committee.

2.2 Study Materials

The study took place in a controlled laboratory setting. Participants were allowed to choose their seats during the study but they were not permitted to change the selected seat until the end of study.

Six seats were employed for this study. On each row, three seats were available. Configuration of the seats was arranged as shown in figure 1. Two cameras were mounted in the study laboratory to observe the participants. One of them was located on the right and front side of the seats and the other was located on left side to have a complete view of all participants. The researcher carried out limited observations during the study from behind. Based on Kim et al. (2016) the seat pitch for this study was set as a typical seat pitch in economy seats of 31 inches, where seat pitch is the distance between a point on one seat and the same point on the seat in front.

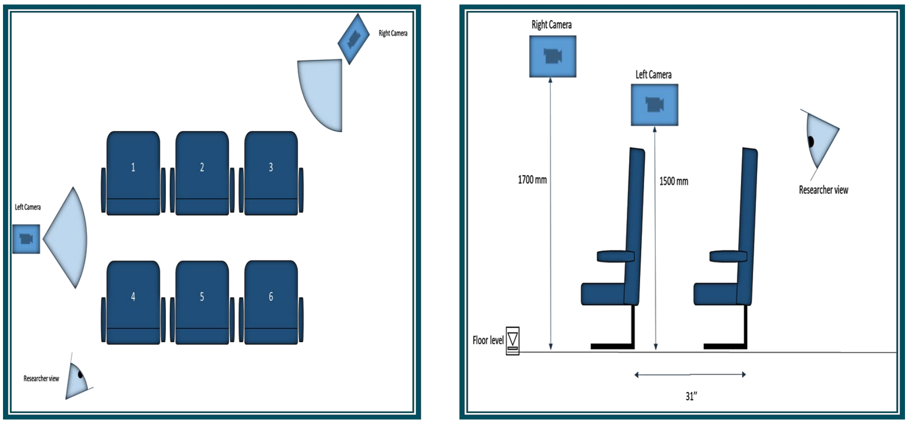

Fig. 1. Plan view and side view

2.3 Procedure

The study took place over the course of three hours, during the majority of which participants remained seated. They were asked to complete the questionnaire at the beginning of the study and every 20 minutes during the 3-hour period. Before the start or at the end of the study, the following anthropometric measurements were taken for each participant: height, lower leg length, upper leg length, shoulder breadth, hip breadth and sitting eye/head height. Height measurements were taken with them wearing their shoes using a stadiometer. All other measurements were taken in a seated position, with them wearing the clothes they arrive in (coat removed) using an anthropometer, board and tape measure. During the study, researchers observed their seated postures and recorded their general activities (e.g. reading, listening to music, sleeping). If they left their seats, a researcher made a note of the time they got up and the time that they return to their seat and what they did while they were away from their seat.

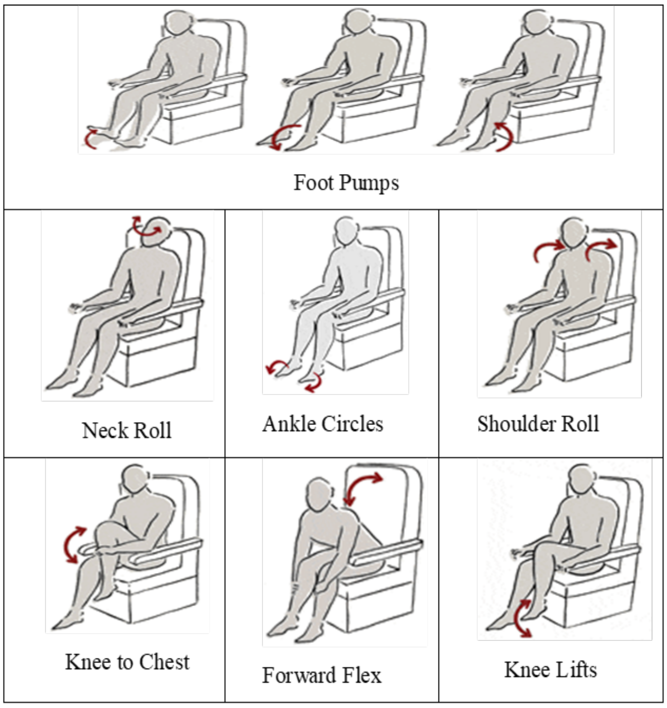

Fig. 2. In-flight exercises (Qantas The Australian Way Magazine, n.d.)

Videos were used to analyse data such as the postures participants adopted during different activities or at different times. Participants were provided with guidance on seated exercises recommended for in-flight use and were asked to select and perform these exercises during the course of the study as many as they like, as shown in Figure 2.

The main data collected during the study were measurement of relevant anthropometric dimensions of participants, user choice of seating position, periodic ratings of comfort and discomfort, frequency of doing in-flight exercises and qualitative feedback on aspects of discomfort.

3 Results

The results of the study will be discussed in the following parts.

3.1 Anthropometric measurement

In order to evaluate the sample's representativeness, data collection involved collecting details of relevant body dimensions in standing and seated positions. Seated measures were taken with the participants sitting on a chair. The participants were measured without their outerwear such as coats and jackets. The main measures included standing height, sitting height, shoulder breadth, hip breadth, upper leg length, lower leg length. Table 1 shows what percentiles the participants represented in alignment with the broader population. As shown in Table 1, the sample was representative of the broader population.

Table 2. Anthropometric data representing 5th and 95th percentile values obtained from the participant sample, compared with respective population values in centimetres (Norris. et al., 1998)

		Male				*Female*			
		5% sample	*5% population*	*95% sample*	*95% population*	*5% sample*	*5% population*	*95 % sample*	*95% population*
Standing Height		169.925	164.69	187.865	186.65	155. 75	152.78	178.35	173.73
Sitting Height		54.26	85.45	91.30	97.19	75.75	79.53	88.00	91.02
Shoulder Breadth		41.91	47.740	53.345	62.06	36.5	41.47	43.90	52.84
Upper leg length	Buttock to front of knee	53.28	56.90	64.145	66.47	50.00	54.21	61.00	63.98
	Buttock to back of knee	42.895	54.55	52.625	45.81	42	44.00	50.75	52.77
Lower leg Length	Popliteal height	52.685	39.46	61.63	47.63	51. 50	35.13	59.55	42.94
	Top of knee height	41.17	51.44	47.235	61.57	43.00	47.40	54.00	56.02
Hip Breath		32.75	30.97	44.445	37.65	32.8	30.78	42.4	38.15

3.1 Most frequent exercises

The number of times each exercise was performed during the study by all the participants is shown in Figure 3; this was collected via the routine questionnaire. Analysis revealed that the most frequent in-flight exercises were foot pumps and neck roll manoeuvres.

Participants indicated in open-ended responses that lack of physical space prevented them from doing several of the exercises. As Figure 3 demonstrates, participants more frequently did the exercises which required less physical space. Comparison to anthropometric measurements indicated that especially tall participants and those who were sitting in the middle seat may have also performed these space-constrained exercises more frequently.

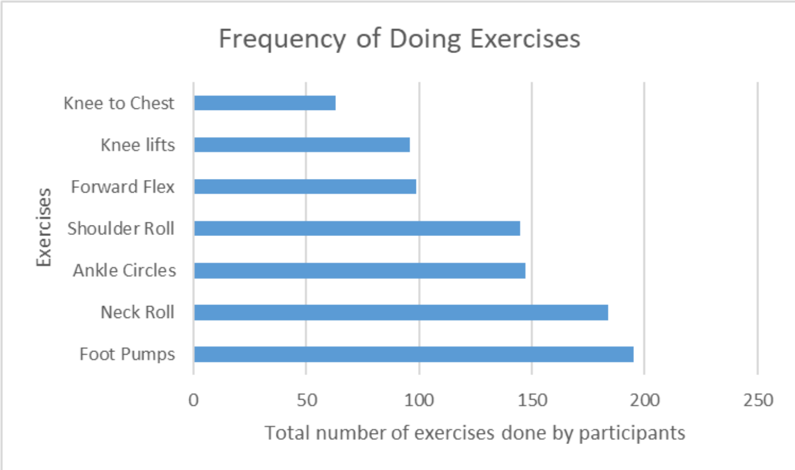

Fig. 3. Most frequent exercises

3.2 Participants' overall levels of comfort

Ratings were collected at 20 minutes intervals during the study, using the following question: How satisfied are you with your current level of comfort? Participants were asked to rate this on a 1-9 scale where 1 was extremely dissatisfied and 9 was extremely satisfied. Mean recorded comfort rating over time is illustrated in Figure 4.

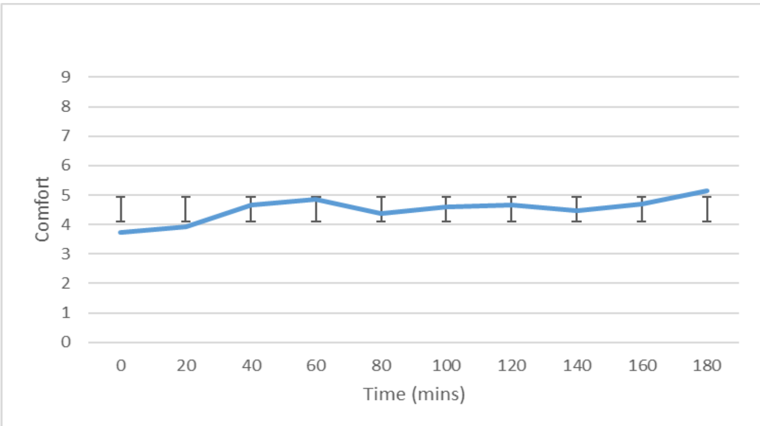

Fig. 4. Participants' mean comfort rating (error bars = 1SD)

3.3 Body Map Analysis

Participants were asked to indicate their discomfort in different body parts every twenty minutes. During the study, each participant gave the rating of 0 to 9 in which 1 referred to slight discomfort, 9 referred to extreme discomfort, and 0 indicated that the participant did not experience discomfort in that body part. Representation of the data was made using a heat map visualization method (Fisher & Marean, 2017).

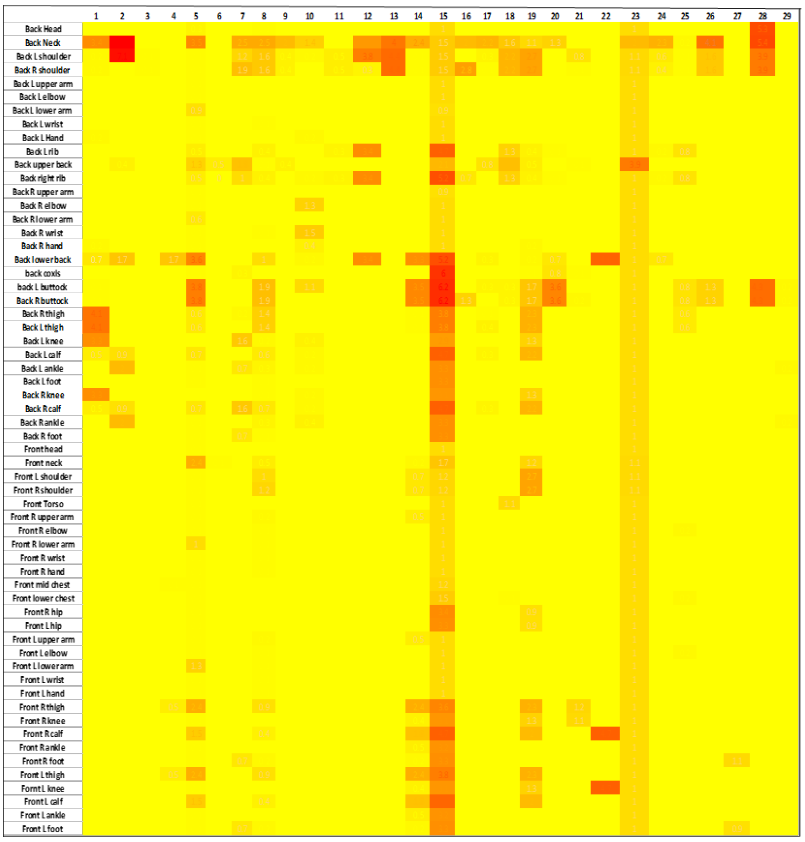

Fig. 5. Overall Heat Map visualization

Figure 5 shows the data for all participant self-reported discomfort ratings over the three hour period, calculated by the mean rating per participant and body part. In this heat map, the colour key is indicated with yellow as 0, the lowest rating and red as 9, the highest rating in the heat map. It can be interpreted from the overall heat map that the darker colour is mostly located on the back part side of the body, such as the back of the neck, the back-left shoulder, the back-right shoulder, the back-left buttock, the back-right buttock and the lower back.

The heat map analysis indicates that although there were individual differences in participant experiences during the study, several body parts were commonly associated with discomfort. After analysing the data the six body parts that were associated with discomfort were identified. These body parts discomfort consist of the back of the neck, the back-left shoulder, the back-right shoulder, the back-left buttock, the back-right buttock and the lower back.

4 Discussion

In this study, we aimed to explore the association among passengers' comfort levels, the body parts affected by discomfort during a simulated medium haul flight, and the range of exercises which passengers performed. Passengers most frequently performed exercises which were easy to achieve in the confined space, and subjective feedback indicated that reasons for not engaging in movement included limited space and embarrassment, a finding that aligns with previous research (Aaltonen et al., 2014). Among the recommended inflight exercises, foot pumps, neck rolls, ankle circles and shoulder rolls were the most frequently chosen, likely because they did not need much space. As the exercises that participants chose to perform reflects the range of motion available to them in the cabin seat environment, these findings can be used to indicate the spatial envelope available for comfort- and health-promoting activities during flight. This is envisioned to be of particular use in the design of interventions, such as virtual reality applications, where exploiting the alignment between the physical and virtual world can be used to influence sensory perception (Tennent et al., 2019).

The exploratory nature of this work provided insight into the physical experience of discomfort during medium haul flights while identifying the range of movements frequently selected by passengers. The body mapping analysis indicated that, although experience varied widely across individuals, discomfort reports were frequently associated with the back of the neck, the left and right shoulders, the lower back, and the left and right buttock. As such, this suggests an opportunity for interventions to support passengers in improving their comfort in these specific areas. Building upon this work, future research will explore participants' behavioural patterns and postures associated with discomfort during the study.

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