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Human Factors and Ergonomics Society Policy Statement on Airline Seating

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HFES Policy Statement: Airline Seating

Overview: Outdated FAA data regarding passengers' size and weight place air passengers at risk with regard to safety, health and comfort. HFES endorses a number of changes to airline seating based on the considerable human factors scientific data relevant to this subject.

Outdated Standards Result in Poor Fit

As highlighted by media reports, the average airline passenger is larger than ever before. Hip-breadth, or the maximum width of the hips when sitting, has increased roughly 3 percent per decade between 1968 and 2012[1]. Unsurprisingly, this also trends with a historic increase in Body Mass Index[2], a rough measure of an individual's body fat. FAA recommendations regarding adequate seat space size have not changed since 1994[3]. Although those dimensions were specific to flight attendants' seats, it is the most relevant. Those guidelines recommended an allowance of 17.7 inches to accommodate shoulder width. However, shoulder width measurements published by the United States Army[4] in 2014 found that 97.6 percent of males and 50 percent of females have shoulder breadths (bideltoid) greater than 17.7 inches. Seat widths that are less than this amount can lead to encroachment on adjacent passenger space, creating discomfort and possible injury[5,6]. See Figure 1 as an example of male shoulder breadth accommodation.

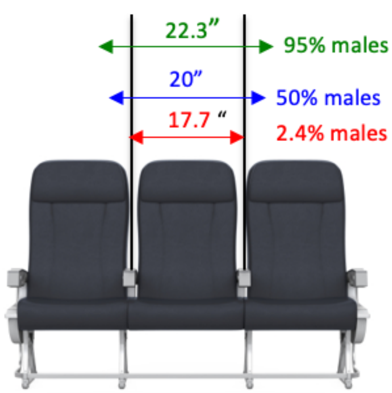

Figure 1. Percent males' shoulder-breadths accommodated in a single seat

Similarly outdated are standards related to passenger seat belts. Seat belts are required to be designed for a maximum passenger weight of 170 pounds[7,8], however about 70 percent of males and 42 percent of females weigh more than 170 pounds[9]. This mismatch with the anthropometry of U.S. passengers suggests that a significant number of passengers are inadequately protected.

Recommendation 1: ***The FAA should update its standards to account for widespread physical changes of the average passenger. This should reflect requiring seat widths and seat belts that accommodate 95 percent of the general population.***

Poor Design Contributes to Injury

The FAA also established a recommendation of at least a 35" strike radius to avoid head strike injuries[3]. This measurement is referenced as an imaginary line rising perpendicularly from a point at the intersection of the seat and seatback to the top of the passenger's head. A too-short strike radius increases the risk of injury during common in-flight and on-the-ground scenarios, including turbulence, braking while taxiing and landings. The average seat pitch distance between economy cabin seats of 32.1 inches[1] may place the seat located forward of the passenger within his or her strike radius.

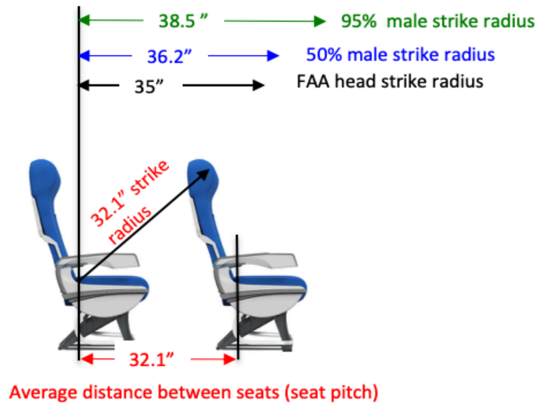

Figure 2. The average distance between seats places the majority of passengers at risk for head strikes.

About 99 percent of males' and 88 percent of females' seated height is greater than 32.1 inches[4], placing them at risk of head strike injuries, as shown in Figure 2.

The need to protect passengers from head strike injuries has been discussed for at least 50 years[10]and the need to protect against serious head injury is specifically called out in the Code of Federal Regulations[7]. As an option, a study of fatalities in a 1987 air crash suggested that about 21 percent of fatalities might have been prevented with better passenger restraint systems[11].

<u>Recommendation 2</u>: The FAA should mandate a minimum seat pitch to accommodate the seated height of 95 percent of the general population (38.5”). Alternatively, 3 or 4-point restraints should be provided, as is done in some aircraft for premium cabins.

A second area of concern is the lack of proper lumbar support in airline seats resulting in significant neck and back discomfort[12] , particularly on extended flights and for taller people[13]. Further, shorter people report discomfort associated with lack of foot rests[13].

<u>Recommendation 3</u>: The FAA guidelines should specify the inclusion of foot rests and adjustable lumbar supports to reduce neck and back strains and injuries[14]

Emergency Evacuation Considerations

A crucial part of any airplane design should be the ability for passengers to safely and expediently evacuate an airplane in the event of an emergency. Currently, planes with more than 44 seats must be able to be completely evacuated within 90 seconds in emergency conditions[15]. Total time to evacuate a transport aircraft has been shown to vary from 48 seconds for low density (30 passengers) to 124 seconds for high density (70 passengers)[16]. Egress time is also affected by the size of the door and whether it opened inward or outward. Of the factors that inhibit a safe and timely evacuation, passenger waist size has significant impact on people's ability to get out of the egress door. The greatest individual evacuation time to pass through an over wing exit is observed from individuals whose waist circumference is 41 inches or greater[16]. Approximately 19 percent of all males and about 5 percent of females in the United States have waist circumferences greater than 41 inches[4]. Although FAA[17] specifies the age and gender composition of the passengers it uses to establish its “90 second” exit standard, it does not require waist size be taken into account.

<u>Recommendation 4:</u> FAA policy on emergency evacuations should include consideration for variation in waist size in addition to age and gender.

Additional Health Threats

Less comfortable seats may also be more dangerous. Cramped seating spaces and limited movement are implicated as a "very significant risk"[18-25] for the development of serious, life-threatening conditions such as Deep Vein Thrombosis (DVT) which can lead to Pulmonary Embolisms (PE). While research based on examinations of passengers could not measure active cases of PE's, more than ten percent of tested passengers on long duration flights were found to show markers associated with PE's[25]. These threats are present in any period of long duration restricted movement and may be exacerbated by current airline seat dimensions.

***Recommendation 5*: When updating seat dimension standards, the FAA should take into consideration possible adverse health effects of airline seats and review whether larger seating spaces should be mandated for long-duration flights.**

***Recommendation 6*: The FAA, internally as well as through the National Academies and the National Institutes of Health, should determine whether the body of research regarding airline seat dimensions is sufficient to draw a full range of recommendations. If there is not sufficient research available, the FAA should request additional research on this topic.**

References

1. Molenbroek, J. F. M., Albin, T. J., & Vink, P. (2017). Thirty years of anthropometric changes relevant to the width and depth of transportation seating spaces, present and future. *Applied ergonomics*, *65*, 130-138.
2. Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., ... & Farzadfar, F. (2011). National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9· 1 million participants. *The Lancet*, *377*(9765), 557-567.
3. AC 25.785-1B https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%2025.785-1B.pdf Downloaded November 26, 2018
4. Gordon, C. C., Blackwell, C. L., Bradtmiller, B., Parham, J. L., Barrientos, P., Paquette, S. P., ... & Mucher, M. (2014). *2012 Anthropometric survey of US Army personnel: Methods and summary statistics* (No. NATICK/TR-15/007). ARMY NATICK SOLDIER RESEARCH DEVELOPMENT AND ENGINEERING CENTER MA.
5. Le, P., Rose, J., Knapik, G., & Marras, W. S. (2014). Objective classification of vehicle seat discomfort. Ergonomics, 57(4), 536-544.
6. Quigley, C., Southall, D., Freer, M., Moody, A., & Porter, J. M. (2001). Anthropometric study to update minimum aircraft seating standards. UK: Loughborough University.
7. 14 CFR 25.562
   https://www.govinfo.gov/content/pkg/CFR-2002-title14-vol1/pdf/CFR-2002-title14-vol1-sec25-562.pdf
   downloaded January 12, 2019
8. 14 CFR 25.785 - Seats, berths, safety belts, and harnesses Downloaded March 3, 2019
   https://www.govinfo.gov/content/pkg/CFR-2011-title14-vol1/pdf/CFR-2011-title14-vol1-sec25-785.pdf
9. Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NCHS). National Health and Nutrition Examination Survey Data. Hyattsville, MD: U.S. Department of Health

and Human Services, Centers for Disease Control and Prevention, [downloaded 10/28/2017] [https://wwwn.cdc.gov/Nchs/Nhanes/2015-2016/BMX_I.XPT LFigures
10. Yost, C. A., & Oates, R. W. (1969). *Human survival in aircraft emergencies*. STENCEL AERO ENGINEERING CORP ARDEN NC.
11. Lillehei, K. O., & Robinson, M. N. (1994). A critical analysis of the fatal injuries resulting from the Continental flight 1713 airline disaster: evidence in favor of improved passenger restraint systems. *The Journal of trauma*, *37*(5), 826-830.
12. McGill, S. M., & Fenwick, C. M. (2009). Using a pneumatic support to correct sitting posture for prolonged periods: a study using airline seats. Ergonomics, 52(9), 1162-1168.
13. Le, P., Rose, J., Knapik, G., and Marras, W.S. (2014). Objective classification of vehicle seat discomfort. Ergonomics, 57 (4), 536-544.
14. Quigley, C., Southall, D., Freer, M., Moody, A., and Porter, J.M. (2001). Anthropometric study to update minimum aircraft seating standards. UK: Loughborough University.
15. 14 CFR § 25.803 Emergency evacuation. https://www.govinfo.gov/content/pkg/CFR-2017-title14-vol1/pdf/CFR-2017-title14-vol1-sec25-803.pdf
downloaded January 12, 2019
16. McLean, G. A., & Corbett, C. L. (2004). *Access-To-Egress III: repeated measurement of factors that control the emergency evacuation of passengers through the transport airplane type-III overwing exit* (No. DOT-FAA-AM-04-2). FEDERAL AVIATION ADMINISTRATION OKLAHOMA CITY OK CIVIL AEROMEDICAL INST.
17. 14 CFR Appendix J to Part 25, Emergency Evacuation. https://www.gpo.gov/fdsys/pkg/CFR-2016-title14-vol1/pdf/CFR-2016-title14-vol1-part25-appJ.pdf downloaded November 29, 2018
18. Ferrari, E., & Morgan, G. (2004). Travel as a risk factor for venous thromboembolic disease. *European journal of medical research*, *9*(3), 146-149.
19. Ferrari, E., Chevallier, T., Chapelier, A., & Baudouy, M. (1999). Travel as a risk factor for venous thromboembolic disease: a case-control study. *Chest*, *115*(2), 440-444.
20. Forbes, C. D., & Johnston, R. V. (1998). Venous and arterial thrombosis in airline passengers. *Journal of the Royal Society of Medicine* 91, 565-566.
21. Hollingsworth, S. J., & Barker, S. G. E. (2001). "Long Haul" Flight and Deep Vein Thrombosis: A Model to Help Investigate the Benefit of Aspirin and Below-knee Compression Stockings. *European journal of vascular and endovascular surgery*, *22*(5), 456-462.
22. Ball, K. (2003). Deep vein thrombosis and airline travel—The deadly duo. *AORN journal*, *77*(2), 346-358.
23. Galili, Y., & Bass, A. (2002). Long-distance flights and the risk of venous thromboembolism-a real threat or just another flight hysteria? *IMAJ-RAMAT GAN-*, *4*(11), 1020-1022.
24. Belcaro, G., Geroulakos, G., Nicolaides, A. N., Myers, K. A., & Winford, M. (2001). Venous thromboembolism from air travel: the LONFLIT study. *Angiology*, *52*(6), 369-374.
25. Jacobson, B. F., Münster, M., Smith, A., Burnand, K. G., Carter, A., Abdool-Carrim, A. T. O., ... & Calvert-Evers, J. L. (2003). The BEST study-a prospective study to compare business class versus economy class air travel as a cause of thrombosis. *South African Medical Journal*, *93*(7), 522-528.