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Seat Configuration, Passenger Variables Affect Aircraft Type III Exit Egress Speed

The U.S. Federal Aviation Administration Civil Aeromedical Institute determined that test subjects' egress time through aircraft Type III exits was affected by their age, weight and gender, although height was not a significant factor. The width of the passageway leading to the exit, and seat encroachment on the exit, also affected overall evacuation times.

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Aviation Writer

Passengers' age, girth, gender and "evacuation experience" can influence how quickly they are able to escape from aircraft through Type III overwing emergency exits, a study of test evacuations has found. The study concluded that existing research protocols that require an age/gender mix in evacuation-certification demonstrations for Type III exits are valid.

The two-part report by the U.S. Federal Aviation Administration (FAA) Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma, U.S., also said that "narrow passageways and/or large encroachments of the seat into the area of the exit opening delay egress significantly."

U.S. Federal Aviation Regulations (FARs) Part 25.807 defines a Type III exit as "a rectangular opening of not less than 20 inches [51 centimeters] wide by 36 inches [91 centimeters] high, with corner radii not greater than one-third the width of the exit, and with a step-up inside the airplane of not more than 20 inches. If the exit is located over the wing, the step-down outside the airplane may not exceed 27 inches [69 centimeters]." Type III overwing emergency exits are required in transport-category airplanes with 60 or more passenger seats.

The related CAMI reports — *Aircraft Evacuations Through Type-III Exits I: Effects of Seat Placement at the Exit* and *Aircraft Evacuations Through Type-III Exits II: Effects of Individual Subject Differences* — reported on recent research to determine the optimum cabin passageway width and seat placement near Type III exits, to ease evacuation of transport aircraft. "Passageway width" in the report refers to the distance between the seat assemblies, from the aircraft's center aisle to the Type-III overwing emergency exit hatch.

The Part I report, which analyzed seat configurations near exits, concluded that "the placement of seat assemblies at the Type-III exit has significant effects on passenger egress ... ." (The researchers distinguished between evacuation, applicable to passengers as a group, and egress, applicable to individual passengers.) Besides its finding that egress is significantly delayed by narrow passageways and/or large encroachments, the report also suggested that "relative to younger subjects, older subjects were found to have a general increase in egress times at all seat placement configurations ... ." Nevertheless, that time difference "did not appear to worsen as the access route to the exit was made more restrictive," researchers said.

The Part II report examined the influence of individual characteristics, such as age, gender and girth, on the speed of egress. The study concluded that "egress through the Type-III exit opening requires significant agility, and ... individual subject attributes play as big a part in effective egress as does aircraft configuration."

Among the factors found to delay egress times were advanced age, increased weight and girth, and gender. Women tended to be slower than men in using the exits. Another important factor was "egress experience" — that is, whether an individual had had prior experience or instructions in using a Type III exit. The study found that "older subjects were able to devise a better strategy than the first one they had used" to pass through the exit in a second trial evacuation.

"In all, these results show that while many passengers have attributes and limitations that could prevent them from evacuating through a Type III exit effectively, there are solutions involving both the aircraft and the passengers that could promote the chances of survival in an emergency," the Part II report concludes.

The FAA asked CAMI to conduct the follow-up study after the Air Transport Association of America (ATA) and several U.S. air carriers petitioned the FAA to allow exceptions to the administration's 1992 rule — based on previous research and studies of actual evacuations — setting a minimum width of aircraft passageways near Type III exits.

That final rule, published on May 4, 1992, required that the passageways leading from the nearest aisle to a single Type III overwing exit be a minimum width of 20 inches, with the seat assembly aft of the exit opening positioned with the front edge of its seat cushion located no more than five inches (12.7 centimeters) forward of the aft boundary of the Type III exit opening.

"Individual subject attributes play as big a part in effective egress as does aircraft configuration."

Because of that rule, "manufacturers and air carriers would generally be required to widen the existing passageways on their aircraft by moving the seat assemblies both forward and aft of the exit opening to provide the necessary passageway width and seat assembly required," the report said. But the ATA and some individual air carriers petitioned the FAA to be allowed to deviate from the rule, suggesting that a narrower passageway width might provide a safety level equivalent to the 20-inch width. The FAA, in turn, asked CAMI to conduct the study described here to provide data that could be used in evaluating requests for deviations.

Two Subject Groups Chosen

The CAMI researchers chose two groups of 37 subjects. The groups were roughly matched in size, weight and gender. The primary grouping factor was age. In Group One, subjects ranged in age from 18 to 40; Group Two subjects were between 40 and 62 years old. (Each group included one or more 40-year-olds.)

To try to equalize the subjects' experience with transport aircraft and their prior knowledge about emergency evacuations, the subjects were allowed to learn how to climb through the Type III exit at the beginning of their group's participation in the testing.

In what researchers called "a counterbalanced research design," the subjects approached the exit using five different passageway widths: six inches (15.2 centimeters), 10 inches (25.4 centimeters), 13 inches (33.0 centimeters), 15 inches (38.1 centimeters) and 20 inches.

Varying Seat Encroachments Tested

Also tested were three seat-encroachment distances: five inches, or "minimum"; 10 inches, or "midpoint"; and 15 inches, or "maximum." The "seat encroachment" measurement refers to the distance that the aft seat assembly's cushions are positioned forward of the aft boundary of the Type III exit opening.

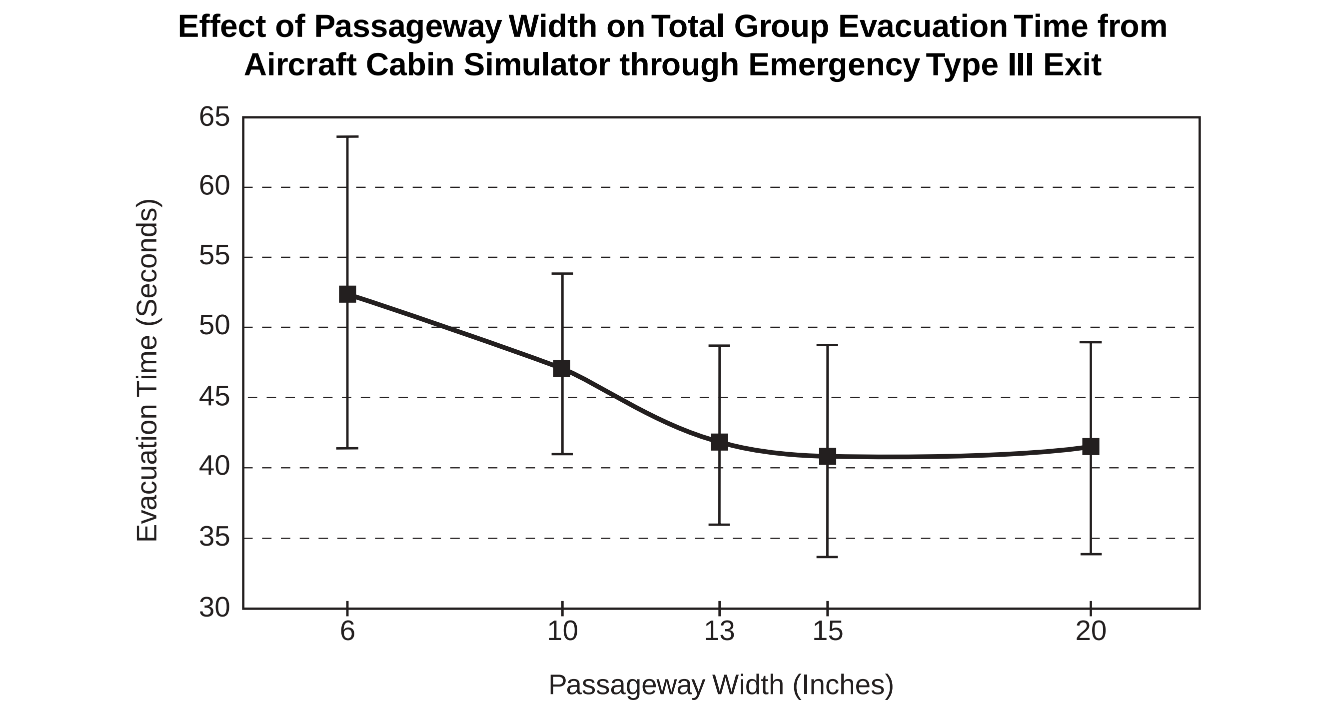
Each group completed 30 videotaped, simulated emergency evacuations — two trials each for the 15 possible combinations of passageway width and encroachment — using a Type III overwing exit.

The subjects began each trial sitting in six-abreast seat assemblies, 60 percent of which were situated aft, and 40 percent forward, of the single, starboard Type III exit. The exit was the only route available to leave the aircraft. A buzzer signaled the start of each trial, at which time a researcher removed the Type III exit cover from outside of the aircraft simulator, and the passengers began to evacuate the cabin.

To encourage a high level of performance, researchers sought to establish a "competitive cooperation" among test subjects, who were told that the three group members who had the fastest egress times would receive a bonus payment. Nevertheless, the subjects were instructed not to jump ahead in the egress queue or otherwise interfere with other passengers' efforts. They also were required to sit at different locations at the beginning of every test trial, to counterbalance the effect of their seats' proximity to the exit. Two flight attendants participated in the trials to encourage and direct participants.

The Part I report, which analyzed seat configurations near exits, found that narrow passageways (less than 13 inches wide), as well as "large encroachments of the seat into the area of the exit opening," significantly delayed the evacuation of passengers through the exit.

The results from both Group One and Group Two — the younger and older groups, respectively — showed "increases



At the minimum encroachment for each width. Bars show standard deviations.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 1

in evacuation times related to both narrower passageway widths and larger seat encroachment distances." Figure 1 shows the effect on total group evacuation time of the different passageway widths for Group One and Group Two combined; Figure 2 (page 4) shows the same effect on Group One and Group Two separately.

Although, at every passageway width, Group One's total group evacuation time was faster than the total group evacuation time for Group Two, there was an apparent anomaly. Evacuation times for the two groups showed a relatively small difference at the 10-inch and 13-inch passageway widths (Figure 3, page 4). But the report explained that the reduced agility of older subjects prompted one of the flight attendants to urge the subjects to crawl over the seats to reach the exit, an instruction that the researchers had not planned and that introduced an extraneous factor — "the study had begun to measure 'seat-stepping' time instead of seat placement effects," the report said. But the high evacuation-time differential shown in Figure 3 for the six-inch passageway width was measured before the flight attendant's unexpected instruction.

At the maximum seat encroachment tested (15 inches), the report said, "both subject groups performed more poorly" in evacuations than they had 5-inch and 10-inch seat-encroachment distances, across all passageway widths. No significant difference in total evacuation times for both groups was found at minimum vs. midpoint encroachment distances (Figure 4, page 5).

In summary, the Part I report found that the results from the two groups "suggest that the 13-inch passageway with a midpoint encroachment distance would be the most restrictive configuration allowable to obtain evacuation performance essentially equivalent to that obtained with the 20-inch passageway offset (by) five inches [the minimum encroachment distance]."

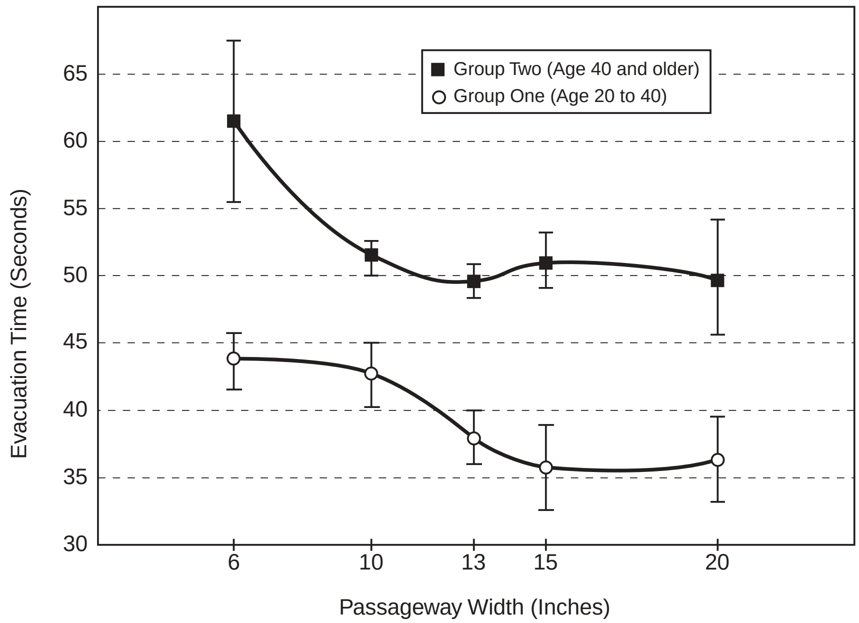
Although the passageway width and seat configuration near Type III exits were important factors in the speed of an evacuation, human factors also played a key role, the researchers found.

Age Caused Greatest Individual Variations

The Part II report noted that, of the individual subject variables tested, age had the greatest effect on individual egress time (Figure 5, page 6), followed by weight (Figure 6, page 6) and gender (Figure 7, page 7). Height was found to have no significant bearing on egress time.

The Part II report noted that increases in the age and weight of passengers "were associated with nearly linear increases in

Effect of Passageway Width on Total Group Evacuation Time from Aircraft Cabin Simulator through Emergency Type III Exit, by Group

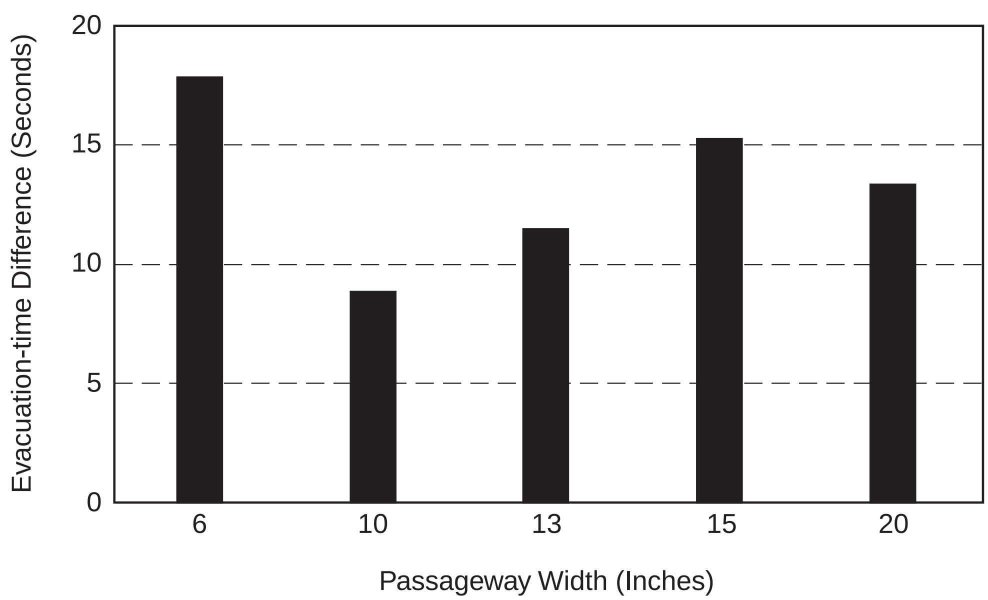


At the minimum encroachment for each width. Bars show standard deviations.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 2

Average Evacuation-time Difference Between Group One and Group Two from Aircraft Cabin Simulator through Emergency Type III Exit



At the minimum encroachment for each width.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 3

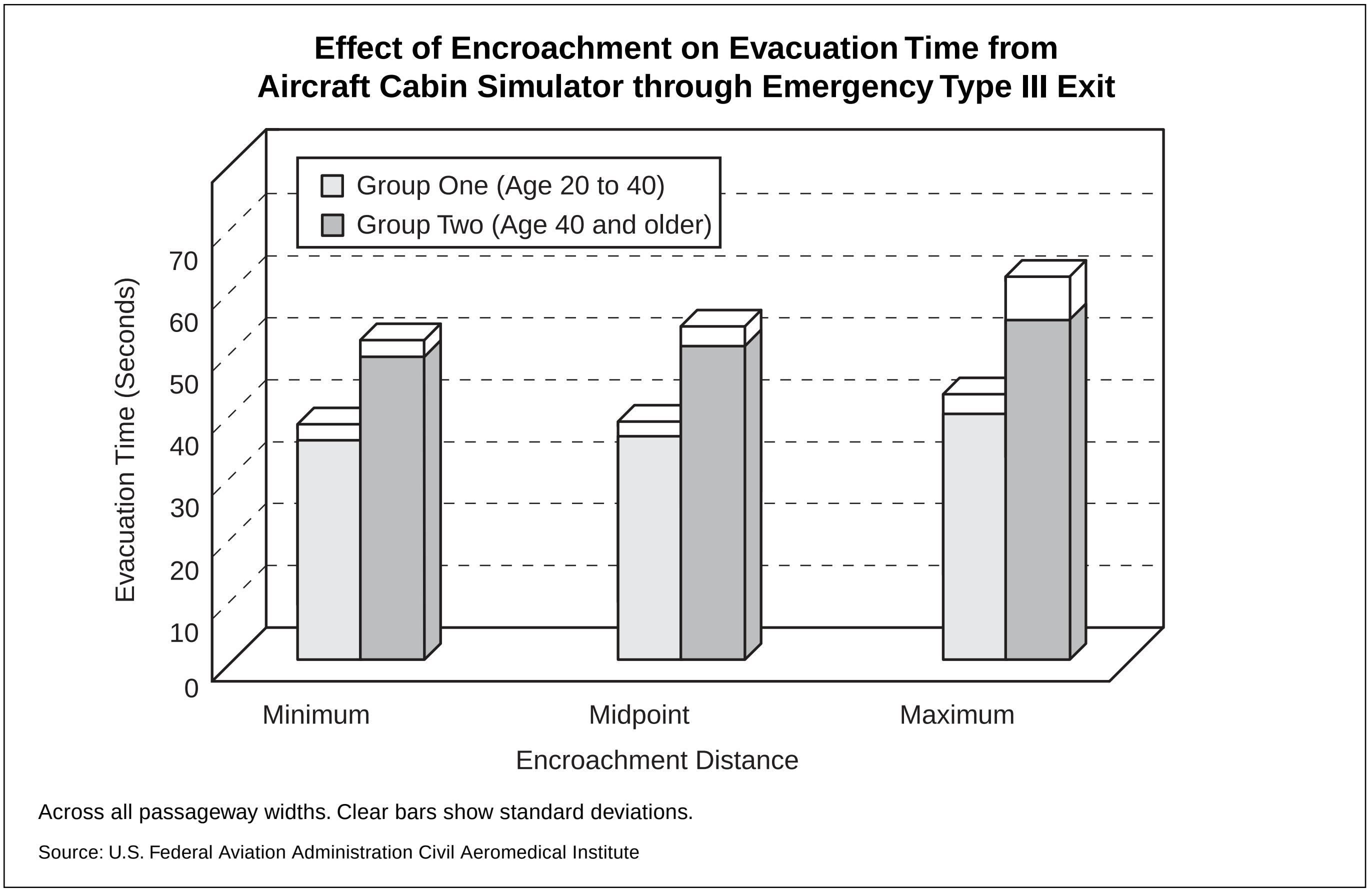


Figure 4

subject egress times" and that a passenger's gender "also proved to be an important variable in determining speed of egress, as females were much slower than males."

In general, the Part II report concluded, "these effects appear to result from the decrements in agility produced as humans become older, heavier and wider … ."

But the researchers found that "the effects of seat assembly placement and age were merely additive, without systematic interactions." In other words, the experiment offered no reason to believe that reducing the egress "workspace" delayed the older group any more than it delayed the younger group. CAMI researchers speculated that this finding resulted partly from the "egress experience" gained by participants in the first tests, although this was considered doubtful because both the younger and older groups had "an equivalent learning opportunity."

Learning Affected Results

But learning did play a part in some experimental results, according to the report. When subjects were grouped by 10-year age intervals (rather than in terms of Group One and Group Two), researchers reported, "50-year and older subjects performed comparatively more slowly at the six-inch and 10-inch passageways on trial 1 ... ."

Nevertheless, the study found, those same over-50 participants "improved their performances significantly on trial 2 ... .

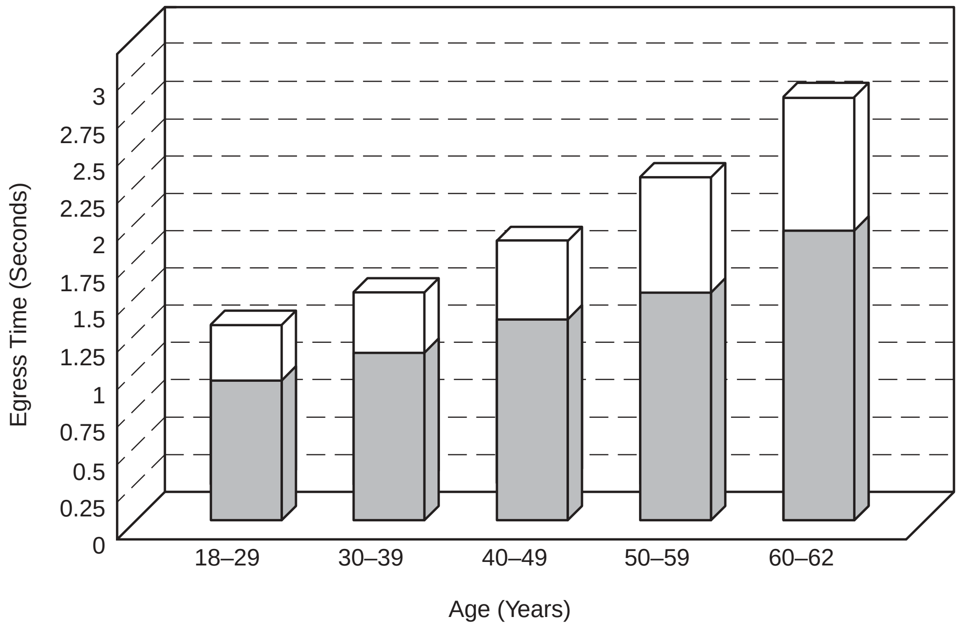
"This indicates that a more specialized effect of egress experience had been established, whereby the older subjects were able to devise a better strategy than the first one they had used," the report said. In contrast to the older groups, the 49-and-younger groups "performed essentially alike on both trials at the minimum encroachment distance," researchers found.

The report suggests several implications of the CAMI test results for U.S. federal aviation regulatory actions. Researchers say the test results:

- Reaffirmed "as valid" the FAA's requirements for an age/gender mix in testing (as specified in FARs Part 25, Appendix J, which relates to the Part 25.803 emergency-evacuation certification demonstration in Type III-exit egress);

- Suggested that "other passenger attributes might be included in such test requirements where the likelihood

Effect of Age on Individual Egress Time* from Aircraft Cabin Simulator through Emergency Type III Exit

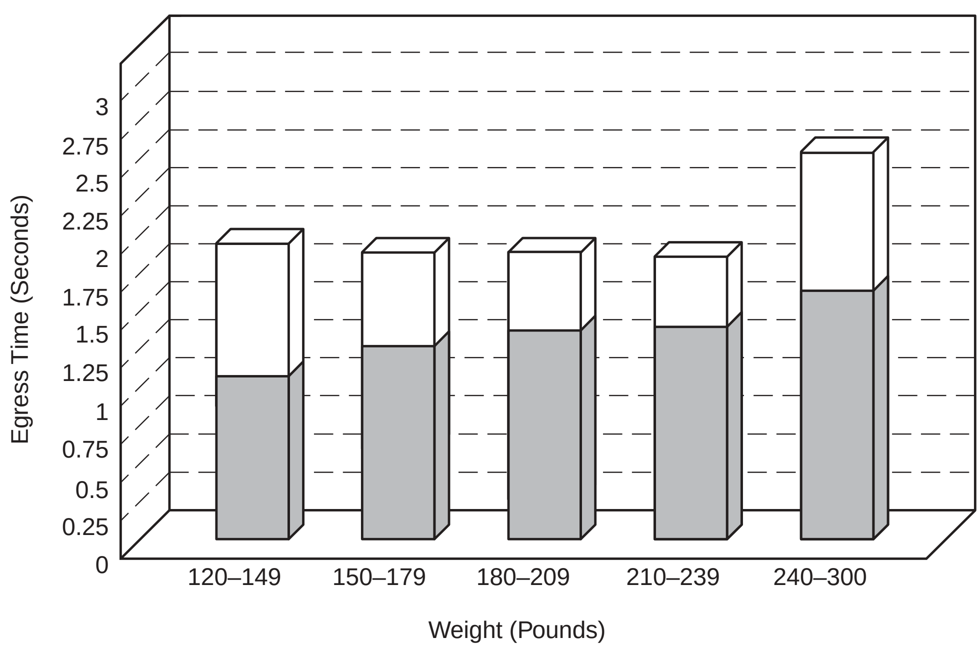


* After subject had reached Type III exit. Clear bars show standard deviation.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 5

Effect of Weight on Individual Egress Time* from Aircraft Cabin Simulator through Emergency Type III Exit

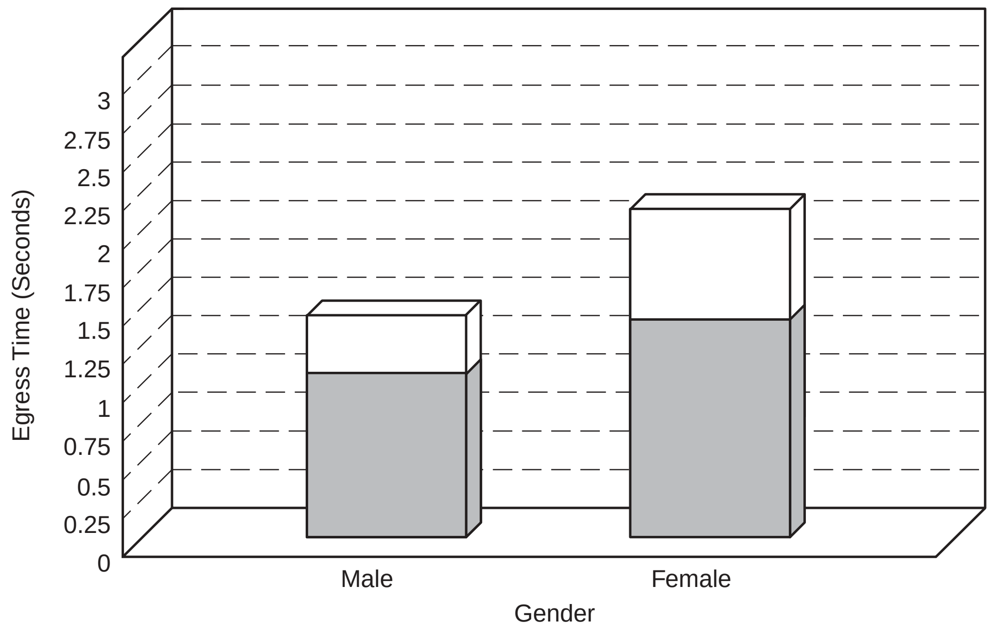


* After subject had reached Type III exit. Clear bars show standard deviation.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute

Figure 6

Effect of Gender on Individual Egress Time* from Aircraft Cabin Simulator through Emergency Type III Exit



* After subject had reached Type III exit. Clear bars show standard deviation.

Source: U.S. Federal Aviation Administration Civil Aeromedical Institute.

Figure 7

of significant interactions of such attributes with aircraft equipment and/or configurations could influence specific test results"; and,

- Should affect future research, because "the design of evacuation studies should benefit from knowledge about the ability of subject experience and/or multiple egress trials to alter the results."

In conducting future research involving aircraft seating configurations, the report suggested, experts should keep in mind that "prior experience with aircraft evacuations can reduce the error associated with the *human factors* element always attendant in studies where humans are employed as research subjects.

"However, other questions, where operational issues are the focus, are generally not amenable to protocols involving such experience, and in either case the results can suffer" from an inability to generalize the results without a full evaluation of the available data.♦

Editorial Note: This article was adapted from two related reports: *Aircraft Evacuations Through Type-III Exits I: Effects of Seat Placement at the Exit*, Report no. DOT/FAA/AM-95/22, July 1995, written by G.A. McLean, Mark H. George, C.B. Chittum, and Gordon E. Funkhouser of the U.S. Federal Aviation Administration (FAA) Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma, U.S.; and *Aircraft Evacuations Through Type-III Exits II: Effects of Individual Subject Differences*, Report no. DOT/FAA/AM-95/25, August 1995, written by McLean and George of CAMI. Both the first report (13 pages) and the second report (25 pages) include photos, charts and references.

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