TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AM -75-13		

4. Title and Subtitle	5. Report Date
FUNCTIONAL STRENGTH OF COMMERCIAL-AIRLINE STEWARDESSES	November 1975
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Herbert M. Reynolds, PhD, and Mackie A. Allgood, MS	
9. Performing Organization Name and Address FAA Civil Aeromedical Institute P.O. Box 25082 Oklahoma City, Oklahoma 73125	10. Work Unit No. 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591	13. Type of Report and Period Covered OAM Report 14. Sponsoring Agency Code

15. Supplementary Notes

Research leading to preparation of this report was performed under Project AM-B-73-PRS-48.

16. Abstract

Data from 13 body measurements and 4 strength tests on 152 female flight attendants are reported herein. The stewardesses are taller ($\bar{x}$ = 165.8 cm) and lighter ($\bar{x}$ = 54.6 kg) than the corresponding age in the civilian population. The strength tests are reported as the average plateau, maximum force, and pound-second force for a two-handed push (110 cm from floor), leg lift (25 cm from floor), back lift (50 cm from floor), and arm lift (100 cm from floor). There are no comparable data in the literature; thus, these data can provide a general guideline as to the maximum strength capabilities of the on-line airline stewardess.

17. Key Words	18. Distribution Statement
Aviation Medicine, Anthropometry, Civil Aviation, Stewardess, Human Factors	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		\$3.00 PC \$ .95 MF

Form DOT F 1700.7 (8-69)

Acknowledgements

The authors gratefully acknowledge Mr. Dean Dahlin and Mr. Bill Barry of Braniff Airways, Inc., for their cooperation in permitting the use of the Braniff stewardess facility at Love Field, Dallas. More important, however, the authors thank the stewardesses who volunteered to participate in the study; without their utmost cooperation, the data could not have been collected.

FUNCTIONAL STRENGTH OF COMMERCIAL-AIRLINE STEWARDESSES

Introduction.

On every commercial flight, members of the flightcrew, which consists of pilots, flight engineers, and flight attendants, have workspaces defined by their assigned duties. Within these workspaces, they must function efficiently and quickly, since the safety of the passengers, plane, and cargo depends on the execution of their skills. The pilot and flight engineer, who are responsible for the operation of the aircraft, have been studied in great detail from abdominal girth[1] to zygotic selection.[2] The female flight attendants, whose safety responsibilities exist primarily in the passenger cabin, have been described in less detail. In fact, engineering design data have come from studies of populations unlike the present-day stewardess population. For example, one of the prime sources of data has been an anthropometric study of WAF's,[3] who were shorter and heavier than stewardesses, and, although comparative data are missing, probably stronger. Thus, design criteria based on the WAF population could create difficult situations for stewardesses.

Federal Aviation Regulations (FAR) prescribe three major responsibilities that are generally accomplished by the stewardesses on board the aircraft. First, they disseminate information to the passengers during takeoff, in-flight, and landing operations (FAR 121.571 and FAR 121.573). Second, they are responsible for food and beverage service control during takeoff and landing (FAR 121.577) and the use and abuse of alcoholic beverages during flight (FAR 121.575). Third, they are responsible for specific, assigned duty stations during emergency operations (FAR 121.397 and FAR 121.417). In the performance of the third duty, they are responsible for the safe and rapid evacuation of passengers under emergency conditions. Since, in most aircraft accidents, the pilots and flight engineers usually are injured on impact or are busy performing emergency shutdown procedures, the stewardesses are the only members of the flightcrew in the passenger cabin. Therefore, it is important that they not only survive the accident, but also be capable of executing the prescribed emergency evacuation procedures.[4] Thus it is necessary to provide the design engineer with appropriate data to make the stewardess-machine interface compatible with their duty requirements.

A previous study, "Anthropometry of Airline Stewardesses" by Snow, Reynolds, and Allgood,[5] was directed toward defining the anthropometric dimensions of stewardesses. The present study will present data on some of the static forces that on-line stewardesses can apply within their workspace environment.

These strength data are unique in that they have been taken from a well-defined population and are directed toward defining work capability within a specific work environment. Most prior studies have measured the strength of females in educational institutions.[6,7,8] Few studies of female strength have attempted to deal with the actual work environment,[9,10,11] and these have been directed toward specific tasks.

Methods.

Measurement Technique. The measurement team consisted of one anthropologist, two laboratory assistants, and one photographer. All measurements were taken at two stations in one room of the Braniff stewardess "ready" area at Love Field, Dallas, Texas.* The personal data and 13

* The sample population of this study was limited by economic and time factors. Nevertheless, it is believed that these subjects are representative of stewardesses from all domestic airlines. The reader is referred to the comparison in Appendix B of this report and to the discussion in Reference 5 for further information.

anthropometric dimensions were taken at the first station. Photographs and four measurements of strength were taken during the strength tests given at the second station.

Anthropometry. The anthropometric measurements were taken by one laboratory assistant and recorded by the other. The techniques used were described in a previous paper[5] and did not differ in this study.

To make the strength tests representative of on-line aircraft situations, the stewardesses wore their flight uniforms, which limited the number and type of anthropometric measurements taken. In addition, the number of measurements was restricted because many of the stewardesses were measured in the "ready" area while en route to their flights. Thus, time was a factor that had to be considered in the experimental design. As a result, the amount of time spent with each stewardess was minimized and consisted of one interview in which personal data, 13 anthropometric measurements, and 4 strength measurements were obtained.

Strength Measurements. Traditionally, studies of strength have described measures of force that can be applied across one joint. The present study reports data on four functional measures of strength involving complex body movements across several joints. Thus, the results are greatly dependent on the body leverage system employed by stewardesses, which is in turn confounded by the relationship between their anthropometric dimensions and the spatial location of the testing device. The strength tests in this study were devised primarily to provide the design engineer with data on the maximal static forces that stewardesses could employ at various work levels in commercial aircraft. The sites of isometric strength measurement were a leg lift (25 cm from floor), a back lift (50 cm from floor), an arm lift (100 cm from floor), and a push (110 cm from floor). The heights at which these measurments were made were determined by the senior author, who made measurements in several aircraft to determine common working heights for stewardesses.

During the test procedure, photographs of 103 subjects were taken for analysis of body position relative to performance for the leg lift and push test. The remaining two strength tests (back and arm lifts) were simple to perform and the results were not confounded by position.

Figure 1 illustrates the test device. The force generated by the stewardesses was reacted by a lever system (located under the floor of the test device) loading a GSE type FT–164 force transducer with a range of 0 to 2,000 pounds but calibrated in terms of actual force application to the push or lift bars. The data are reported in pounds force exerted by the stewardess.

The data from the load cell were recorded through a signal conditioner (Endevco Model 4470 with 4476.2 amplified bridge signal conditioner) onto an oscillograph recorder (Consolidated Electrodynamics Corporation oscillograph recorder type 5–124). The data were analyzed manually and then processed on an IBM 360/67 computer through the MIDAS program at the University of Michigan. Definitions of all data taken from the strength measures are given, with examples, in Appendix A.

Results.

Sample Population. Data describing the flight status, racial characteristics, language capabilities, educational accomplishment, martial status, and place of birth of the test subjects are presented in Appendix B.

Anthropometry. Table 1 presents the anthropometric summary statistics with comparative data from stewardess trainess,[5] United States Public Health Survey (18- to 24-year-old females),[14 15] and Air Force women.[16] For the anthropometric dimensions presented here, the two stewardess samples—on-line and trainee—have relatively small differences in comparison to either the Public Health Service survey or the WAF survey. There are methodological problems in comparing anthropometric data not collected by the same measurement team using the same instruments, but, in general, the four studies appear to be similar in measurement definition and technique.

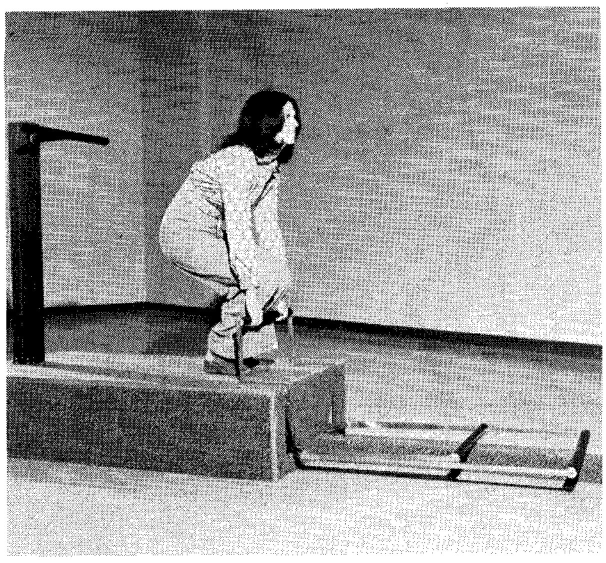

FIGURE 1a.

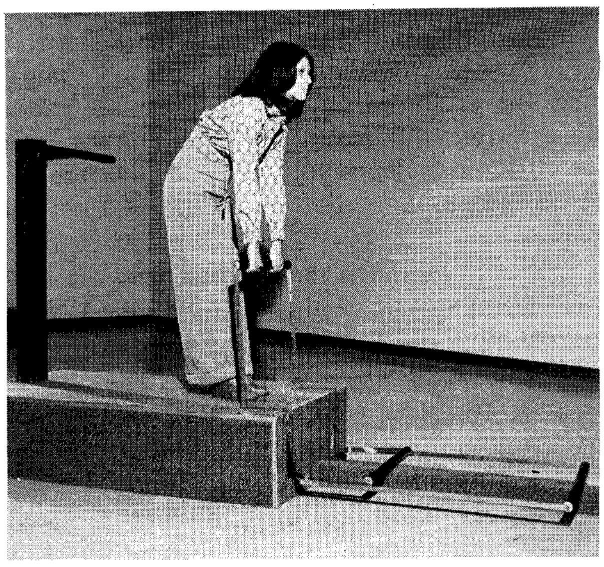

FIGURE 1b.

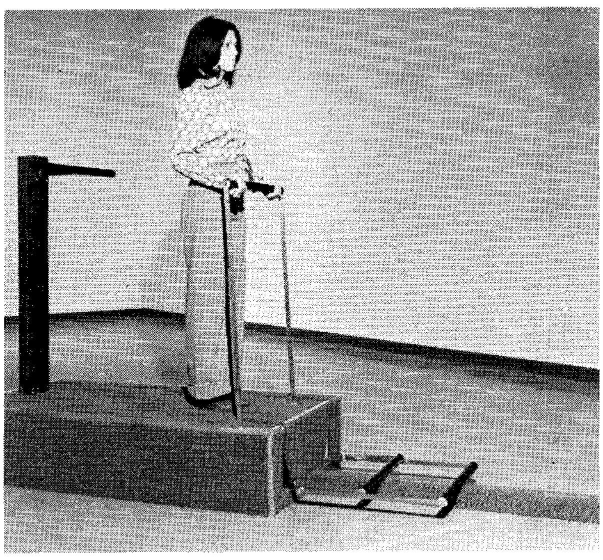

FIGURE 1c.

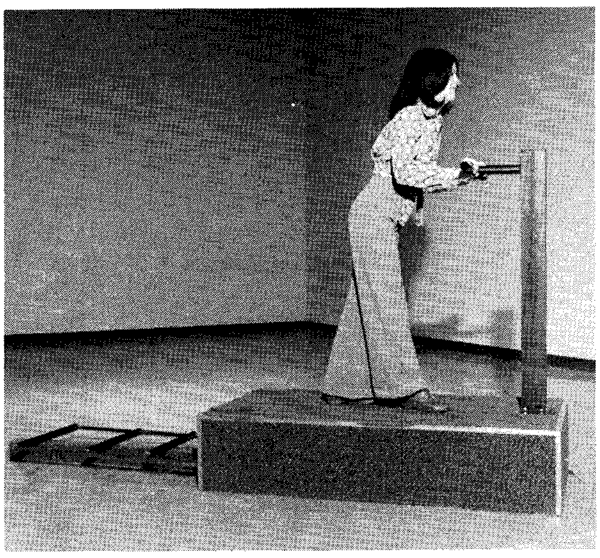

FIGURE 1d.

FIGURE 1. Test apparatus arranged for: (a) 25 cm lift height; (b) 50 cm lift height; (c) 100 cm lift height; and (d) 110 cm push height.

These anthropometric data describe a stewardess sample that is tall and lightweight as compared to the female population at large. The stewardesses' average height is 3.7 cum and 4.2 cm taller and their average weight is 3.3 kg and 5.7 kg lighter than the Public Health Service and WAF samples, respectively. Furthermore, the stewardesses have relatively less fat as measured at the triceps skinfold and apparently less total soft tissue when circumferences are compared.

In general, the average airline stewardess does not appear to have the body build of the average American female.

Strength. The data reported herein measured voluntary strength of each subject for four tests: push, leg lift, back lift, and arm lift. To minimize the effects of motivation, the instructions for each test were phrased in terms applicable to the flight attendant's job. In addition, the sequence of strength tests was changed for each subject.

1. Push. In the isometric push test, the subject pushed against an aluminum cylinder located 110 cm from the floor (see Figure 2). The floor of the test device was covered with flame-resistant carpeting used in FAA aircraft so that the reaction between feet and floor would approximate airplane conditions.

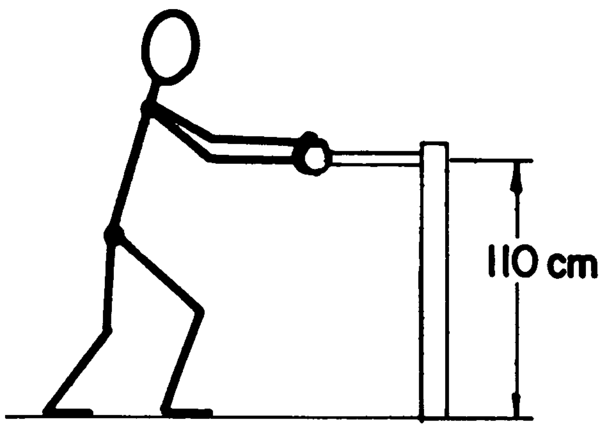

FIGURE 2. Schematic of position for two-handed forward push.

TABLE 1. Summary Statistics (Mean and Standard Deviation) for On-line Stewardess Sample with Comparative Data from Stewardess Trainee, USPHS, and WAF Samples*

	STEWARDESS (ON-LINE)	STEWARDESS (TRAINEE)	USPHS SAMPLE (18-24 YRS.)	WAF SAMPLE
No.	152	423	534	1905
Age	25.0	22.1	21.0	23.4 (6.45)
MEASUREMENTS				
Height	165.8 (5.19)	166.3 (4.85)	162.1	162.1 (6.00)
Weight	54.6	52.9	58.6	57.9 (7.52)
Suprasternale Height	133.4 (4.49)	134.6 (4.34)	--	132.0 (5.30)
Iliospinale Height	93.0 (3.82)	92.3 (3.40)	--	--
Shoulder Breadth	39.6 (1.44)	40.6 (1.56)	--	42.0 (2.31)
Bicristal Breadth	26.7 (0.13)	27.3 (1.40)	--	--
Knee Breadth	8.8 (0.32)	8.9 (0.38)	--	8.1 (0.45)
Elbow Breadth	6.2 (0.27)	6.1 (0.31)	--	6.1 (0.30)
Upper Arm Circumference (Relaxed)	23.9 (1.41)	23.3 (1.35)	25.9	25.6 (2.29)
Lower Arm Circumference (Flexed)	23.9 (1.41)	--	--	25.0 (1.52)
Calf Circumference	33.2 (1.68)	32.2 (1.63)	--	34.1 (2.25)
Anterior Thigh Skinfold	2.4 (0.56)	2.0 (0.45)	--	--
Triceps Skinfold	1.4 (0.40)	1.4 (0.33)	1.8	1.9 (0.54)

*Weight is in kilograms; all other measurements are in centimeters.

Each of the flight attendants was asked to push on the test device as if it were a Type I door exit with an emergency evacuation in process. The subject was asked to imagine that the door was jammed and a strong wind was blowing outside. Thus, the typical force curve should have had a peak at the beginning of the test followed by a plateau for the remaining 5 seconds (see Appendix A). As shown in Table 2, approximately 80 percent (122) of the flight attendants generated a peak.

TABLE 2. Summary Statistics for the Push

Strength Measures	No.	$\bar{x}$	SD	Min.	Max.
Average Plateau (lb)	152	66.7	17.82	30.0	128.0
Maximum Peak Force (lb)	122	97.1	25.68	50.3	177.5
Time to peak (sec)	122	0.42	1.32	0.05	9.4
Pulse (lb.-sec)	152	65.6	16.29	27.8	124.3

The two-handed forward push is described by Kroemer[17] as Experiment I in a series of push tests conducted by the Air Force. The present study measured the push force exerted by the stewardesses at 66.3 percent of their mean statute. The subjects had an average 24° body angle from the vertical (approximated from photographs as the included angle between vertical and an axis drawn between shoulder and ankle joints of the load-bearing leg). This angle had a positive correlation ($r=0.306$) with pulse.[18] The feet were separated in the midsagittal plane by an average distance of 14.6 inches (approximated from photographs). Sixty percent of the subjects placed the right foot in front of the left foot, thereby pushing primarily from the left foot.

2. Leg Lift. Measurement of the force exerted by the legs was made by having each subject isometrically lift a bar 25 cm from the floor of the test device (see Figure 3). The subject was instructed to squat, grasp the bar with her arms extended, keep her head up, and lift the bar with her legs by pushing against the floor. It was obvious during the data collection that this test was physically the most difficult task to perform.

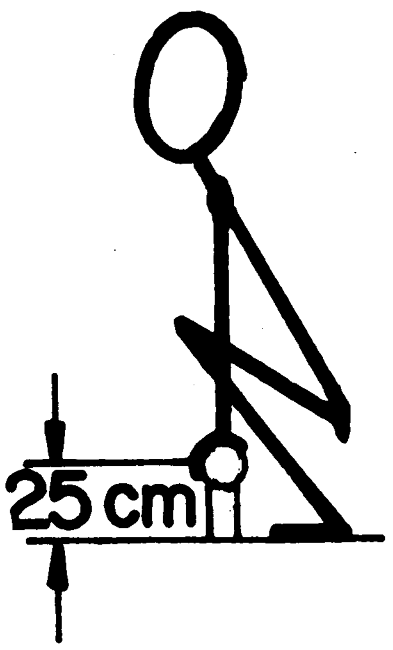

FIGURE 3. Schematic for position of leg lift.

Table 3 reports the summary statistics for the leg lift. The wide range in the data reflects both motivation and physical coordination factors.

As in the push test, photographs were taken during the leg lift test. Analysis of the photographs indicates that many subjects tended to lower their heads and raise their buttocks during the test. The most frequent positional problems occurred at the feet (48.8%) and trunk (45.9%). In general, the subjects tended to position their feet away from the bar and elevate their buttocks, which tended to increase the angle of the trunk from vertical. It is interesting to note that the correlation between trunk angle and pulse ($r=0.429$, $\alpha<.05$) was positive and significant.

These data indicate that there is a behavioral tendency to lift loads primarily with the back musculature rather than the legs. This observation opposes traditional views on load lifting, but recent data[17] support these observations.

TABLE 3. Summary Statistics for the Leg Lift

Strength Measures	No.	$\bar{x}$	SD	Min.	Max.
Average Plateau (lb)	149	111.4	33.85	47.3	213.1
Maximum Force (lb)	150	130.9	35.44	55.0	253.0
Pulse (lb-sec)	149	103.7	30.38	46.2	200.2

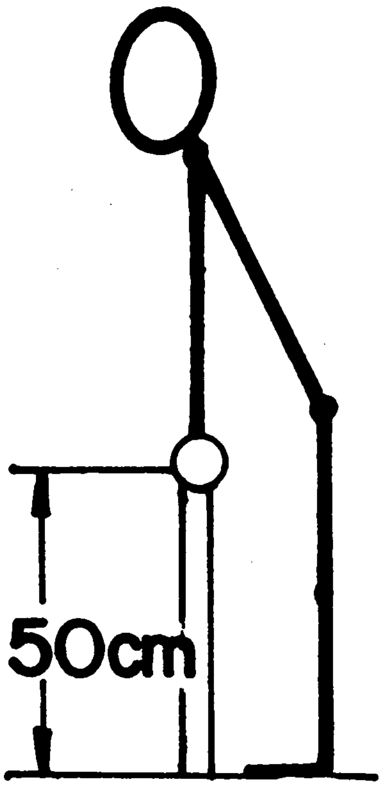

FIGURE 4. Schematic of position for back lift.

3. Back lift. The back lift was measured by having the subject lift a bar 50 cm from the floor (see Figure 4) by using primarily the muscles in her back. The subject was instructed to bend at the waist with her arms and legs fully extended, grasp the bar with her hands, and lift it with her back. The task was simple to perform, but 9.2 percent (14) of the subjects did not participate due to back problems arising either from relatively recent injuries or from congenital conditions for which they were under the care of a physician.

Table 4 reports the summary statistics for the back lift. These data also have a large range, which probably reflects the extent to which motivation as well as other sociocultural variables affect the subjects' performance.

TABLE 4. Summary Statistics for the Back Lift.

Strength Measures	No.	$\bar{x}$	SD	Min.	Max.
Average Plateau (lb)	138	144.7	43.85	62.7	257.3
Maximum Force (lb)	138	163.3	47.89	63.8	285.3
Pulse (lb-sec)	138	129.1	39.19	64.2	219.2

There were no photographs taken of this test, but observations made during the test procedure indicate that none of the subjects had difficulty in following the instructions.

4. Arm lift. The arm lift was measured by having the subject stand erect and isometrically lift a bar 100 cm from the floor (see Figure 5). None of the subjects had any difficulty with this strength test, and all subjects participated.

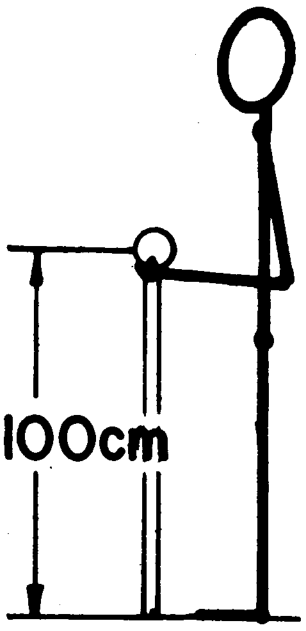

FIGURE 5. Schematic of position for arm lift.

Table 5 reports the summary statistics for the arm lift. It is interesting to note, however, that the range and standard deviation are again large.

TABLE 5. Summary Statistics for the Arm Lift

Strength Measures	No.	$\bar{x}$	SD	Min.	Max.
Average Plateau (lb)	152	78.8	21.95	31.4	165.7
Maximum Force (lb)	152	90.3	24.13	24.7	172.2
Pulse (lb-sec)	152	74.6	21.07	28.7	154.9

Conclusions.

Obviously, strength test results reflect the extent to which subjects are motivated, either by themselves or the environment in which the tests are conducted. Most of the subjects in the present study were experienced flight attendants (average service time of 44.1 months) who understood the utility of the project. Thus, the maximum values in the present study should reflect maximum *voluntary* force exertions for the corresponding working heights and positions. However, these values do not define the maximum forces that could be exerted by flight attendants under stress. There appears to be a psychological and/or physiological stop for strength tests that prohibits muscle exertion to the point of self-injury.[18, 19]

The present study attempted to measure not the maximum force exerted under stress, but typical loads at various levels in the aircraft that the flight attendants could be expected to handle. The minimum values tend to have less significance, since they reflect motivation rather than maximum voluntary strength of a subject. In conclusion, these data should provide the design engineer with general guidelines on the strength capabilities of stewardesses.

APPENDIX A

STRENGTH DATA REDUCTION

Force generated by the subjects was measured directly from an oscillograph recording. Figures A–1 and A–2 are examples of typical recordings of the push test and of the arm, back, and leg lift tests, respectively.

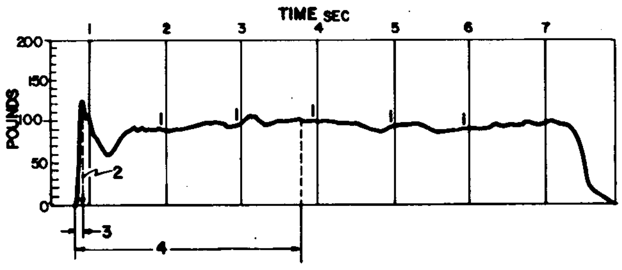

FIGURE A–1. Typical force-time curve tracing of push test.

Push

1—Average plateau. The height of the tracing was measured at the intersection of the curve and timing mark for 5 seconds and averaged in pounds force (lb).

2—Maximum strength. The height of the first peak in the recording was measured in pounds force (lb).

3—Time to maximum strength. The time to produce the first peak in the recording was measured within 50 milliseconds (sec).

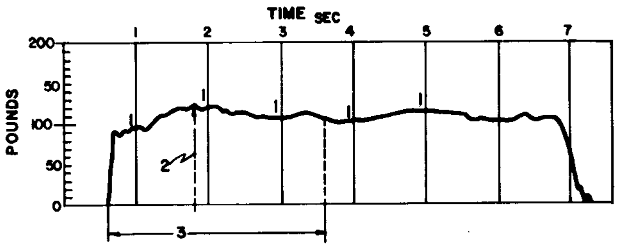

FIGURE A–2. Typical force-time curve of the arm, back, and leg lift tests.

4—Pulse. The area under the curve for the first 3 seconds was measured and averaged for 1 second (lb-sec).

Leg, Back, and Arm Lifts

1—Average plateau. The height of the tracing was measured at the intersection of the curve and timing mark for 5 seconds and averaged in pounds force (lb).

2—Maximum force. The maximum height of the tracing was measured in pounds force (lb).

3—Pulse. The area under the curve for the first 3 seconds was measured and averaged for 1 second (lb-sec).

APPENDIX B

SAMPLE POPULATION DATA

The subjects in this study were paid, volunteer stewardesses from one airline, Braniff International, which was selected because its age, height, and weight entrance requirements for stewardesses in 1971 (Table B–1) were characteristic of the majority of domestic airlines.[12] Furthermore, the actual range of values in the present study for age, height, and weight encompassed all of the domestic carrier requirements for stewardesses.

The subjects were measured in the Braniff stewardess ready area at Love Field, Dallas, Texas, either just before entry on flight duty or immediately after release from flight duty. There was no attempt to control the immediate flight status of the attendants, as the research effort was directed toward evaluating the effective functional strength of stewardesses on duty rather than the maximum laboratory strength.

The experimental design considered sampling bias to be unavoidable, since the subjects were volunteers and it was believed that the measurement program would appeal to experienced stewardesses. The age and experience distributions discussed later confirm this sampling bias.

Flight Status. Twenty-eight subjects, or 18.4 percent of the total sample, were trainees who had completed 4 of the 8 weeks prescribed training. The remaining 124 subjects, or 81.6 percent of the total sample, were airline stewardesses who had collectively accumulated 5,474 months of duty for a mean length of service of 44.1 months.

The remaining discussion and all data consider trainees together with the on-line stewardesses. The differences between means for the two groups in a representative series of anthropometrical and strength variables (age, height, weight, shoulder breadth, upper arm circumference—flexed, average plateau—push, average plateau—25–cm lift, average plateau—60–cm lift) were tested by the student "t" test for unpaired observations in normally distributed data, and only age was significantly lower ($\alpha < .01$) for the trainees.

Race. The sample was predominantly (97.4%) Caucasian with three Negroes and one American Indian.

Language. There were 12 foreign languages spoken, with Spanish, French, and German being the most common. Twenty-five (16.5%) of the stewardesses spoke two languages (including English) and six (3.9%) spoke three languages (including English). The remaining 121 (79.6%) stewardesses spoke only English.

Education. Eighteen (11.8%) of the stewardesses had had no formal education beyond high school, while 8 (6.5%) had attended only vocational school (model, fashion merchandising, business, etc.). The majority, 126 (82.9%), had attended college, including four (2.6%) who had

TABLE B-1. Comparison of Age, Height, and Weight Minimum-Maximum Requirements Between Braniff/All Domestic Airlines and the Present Study

Selection Variables	MINIMUM REQUIREMENT				MAXIMUM REQUIREMENT			
	All Domestic Airlines		Present Study		All Domestic Airlines		Present Study	
	Requirement	% Airlines Represented by Requirement	Measured	% Airlines with Minimum > Measured	Requirement	% Airlines Represented by Requirement	Measured	% Airlines with Maximum < Measured
Age (yr)	19.5	40	19.6	100	None	37.5	46.3	100
Height (in)	62	75	60.8	100	69	52.5	70.7	100
Weight (lb)	100-105	51	91	100	131-135	21.2	146	100

also attended vocational school. Table B–2 reports the level of college education that had been attained at the time of measurement.

TABLE B-2. Level of Education Completed for 126 College Attendees in the Present Sample

Classification	No.	% Cumulative Of College Attendees
Freshman	31	24.6
Sophomore	47	61.9
Junior	17	75.4
Senior	3	77.8
Bachelor's degree	25	97.6
Graduate school	3	100.0

By considering those attending vocational school to have had 1 year of post-high-school education and those attending graduate school to have had 5 years, the average number of years of post-high-school education in the sample is about 2 years.

Marital Status. Ninety-nine stewardesses (65.1%) were single and had never been married, 41 stewardesses (27.0%) were married, and 12 stewardesses (7.9%) were divorced or widowed. One trainee, who was divorced, had one child.

Place of Birth. Since Braniff International is largely a Texas-based airline, the West South Central census region was the best represented—Arkansas, 1; Louisiana, 2; Oklahoma, 7; and Texas, 33. The remaining census regions were relatively well-represented (see Table B–3) except the Middle Atlantic region (N.Y., N.J., Pa.), for which there was a difference of 15.2 percent between the native-born stewardess sample and the 1950 census population distribution[13] (the census closest to the year of birth of the majority of the stewardesses in this sample).

TABLE B-3. Place of Birth of the Present Sample Compared With the 1950 Census Distribution

CENSUS REGION	No.	Present Sample	Census 1950	Difference from census
New England (Maine, N.H., Mass., R.I., Conn.)	6	4.1	6.2	- 2.1
Middle Atlantic (N.Y., N.J., Pa.)	7	4.8	20.0	-15.2
East North Central (Ohio, Ind., Ill., Mich., Wis.)	21	14.4	14.1	+ 0.3
West North Central (Minn., Ia., Mo., N. Dak., S. Dak., Neb., Kan.)	30	20.5	20.2	+ 0.3
South Atlantic (Del., Md., D.C., Va., W. Va., N.C., S.C., Ga., Fla.)	7	4.8	7.6	- 2.8
East South Central (Ky., Tenn., Ala., Miss.)	8	5.5	9.3	- 3.8
West South Central (Ark., La., Okla., Tex.)	43	29.4	9.6	+19.8
Mountain (Mont., Idaho, Wyo., Colo., N. Mex., Ariz., Utah, Nev.)	9	6.2	3.4	+ 2.8
Pacific (Wash., Oreg., Calif., Alaska, Hawaii)	15	10.3	9.6	+ 0.7
Subtotal	146	100.0	100.0	
Foreign (Belgium, Canada, Chile, Germany, and Panama)	6			
Total	152			

REFERENCES

1. Churchill, E., J. T. McConville, L. Laubach, and R. M. White: Anthropometry of U.S. Army Aviators —1970. U.S. Army Natick Laboratories, Technical Report No. 72–52–CE, Series C & PLSEL–95, 1971.
2. Snyder, R. G.: The Sex Ratio of Offspring of High Performance Military Aircraft Pilots, HUMAN BIOLOGY, 33(1): 1–10, 1961.
3. Daniels, G. S., H. C. Meyers, and S. H. Worrall: Anthropometry of WAF Basic Trainees. Technical Report No. 53–12, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, 1953.
4. Snow, C. C., J. J. Carroll, and M. A. Allgood: Survival in Emergency Escape from Passenger Aircraft. FAA Office of Aviation Medicine Report No. AM–70–16, 1970.
5. Snow, C. C., H. M. Reynolds, and M. A. Allgood: Anthropometry of Airline Stewardesses. FAA Office of Aviation Medicine Report No. AM–75–2, 1975.
6. Clarke, H. H., and R. A. Munroe: *Test Manual: Oregon Cable Tension Strength Test Batteries for Boys and Girls from Fourth Grade Through College,* Eugene, Oregon, Microcord Publications in Health, Physical Education, and Recreation, 1970.
7. Haynes, E. M.: The Relationship Between Certain Anthropometric Measurements and Certain Tests of Strength and Motor Ability Among College Women. Unpublished Masters thesis, Florida State University, 1962.
8. Darwick, D.: Maximal Work Capacity as Related to Strength, Body Composition, and Physical Activity in Young Women. Unpublished Masters thesis, Michigan State University, 1964.
9. Karim, B. B.: A Study of Female Pilot Control Force Capabilities for General Aviation Aircraft. Unpublished Masters thesis, University of Oklahoma, 1971.
10. McFadden, E. B., and J. J. Swearingen: Forces That May Be Exerted by Man in the Operation of Aircraft Door Handles, HUMAN FACTORS, 1(1):16–22, 1958.
11. McFadden, E. B., J. J. Swearingen, and C. D. Wheelwright: The Magnitude and Direction of Forces Man can Exert in Operating Aircraft Emergency Exits, HUMAN FACTORS, 1(4):16–27, 1959.
12. Morton, A. C.: The 1970–71 Airline Guide to Stewardess Careers, *International Stewardess News,* Hialeah, Florida, 1970.
13. U.S. Bureau of the Census. *U.S. Census of Population,* Vol. I, 1950.
14. Stoudt, H. W., A. Daman, and R. McFarland: *Weight, Height, and Selected Body Dimensions of Adults, 1960–1967.* National Center for Health Statistics, Series 11, Number 8. United States Public Health Service, U.S. Dept. of HEW, 1965.
15. Stoudt, H., A. Daman, R. McFarland, and J. Roberts: *Skinfolds, Body Girths, Bicranial Diameter, and Selected Antrropometric Indices of Adults, 1960–1962.* National Center for Health Statistics, Series 11, Number 35, 1970.
16. Clauser, C. E., P. E. Tucker, J. T. McConville, E. Churchill, L. L. Laubach, and J. A. Rearden: Anthropometry of Air Force Women, Report No. AMRL–TR–70–5, Wright-Patterson Air Force Base, Ohio, 1972.
17. Kroemer, K. H. E.: Push Forces Exerted in Sixty-Five Common Working Positions. Report No. AMRL–TR–68–143, Wright-Patterson Air Force Base, Ohio, 1969.
18. Kroemer, K. H. E.: Human Strength: Terminology, Measurement and Interpretation of Data. HUMAN FACTORS, 12(3):297–313, 1970.
19. Ikai, M., and A. H. Steinhaus: Some Factors Modifying the Expression of Human Strength. J. APPL. PHYSIOL., 16:157–163, 1961.
20. Roush, E. S.: Strength and Endurance in the Waking and Hypnotic States. J. APPL. PHYSIOL., 3:404–410, 1951.