DOT/FAA/AM-91/6

Office of Aviation Medicine
Washington, D.C. 20591

Donning Times and Flotation Characteristics of Infant Life Preservers: Four Representative Types

Gordon E. Funkhouser
Gregory W. Fairlie

Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, Oklahoma 73125

April 1991

Final Report

U.S. Department
of Transportation
**Federal Aviation
Administration**

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-91/6		

4. Title and Subtitle	5. Report Date
DONNING TIMES AND FLOTATION CHARACTERISTICS OF INFANT LIFE PRESERVERS: FOUR REPRESENTATIVE TYPES	April 1991
	6. Performing Organization Code
	8. Performing Organization Report No.

7. Author(s)	
Gordon E. Funkhouser and Gregory W. Fairlie	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
FAA Civil Aeromedical Institute P.O. Box 25082 Oklahoma City, OK 73125	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Office of Aviation Medicine Federal Aviation Administration 800 Independence Avenue, S.W. Washington, D.C. 20591	14. Sponsoring Agency Code

15. Supplementary Notes

Work was performed under Task AM-B-90-PRS-83.

16. Abstract

Four currently available representative types of infant life preservers were tested to assess the donning times and flotation characteristics for infant subjects (6 months to 2 years old). Two of the four devices tested were fixed-foam recreational devices and two were inflatable, dual-chambered devices that met TSO C-13d requirements. The parent received video-taped donning instructions prior to the timed donning trials. Donning times were recorded from the time the unwrapped device was handed to the parent until the last connection or adjustment was made. The device that was most quickly donned was an inflatable type with a vest attached to the top of the upper chamber (median donning time was 28.8 seconds). This infant life preserver also exhibited good body support with the head well above the water. The two fixed-foam devices were designed to have approximately one-third of the buoyancy of the two inflatable types and relied on assistance from an adult to maintain the infant in a safe flotation attitude. It appears that the fixed-foam infant life preservers would provide more thermal protection than the inflatable life preservers.

17. Key Words	18. Distribution Statement
Infant Life Preservers Infant Flotation Devices Donning Times Flotation Characteristics	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	12	

ACKNOWLEDGMENT

We greatly appreciate the dedicated efforts of Mr. Mark George, Mr. David Dyer, Mr. Ellis Young, and Mr. Gregg Winters of the Protection and Survival Laboratory, Dr. Earl Folk of the Data Analysis Staff, and Mr. Bruce Wilcox, Jr. of the Aviation Physiology Lab.

DONNING TIMES AND FLOTATION CHARACTERISTICS OF INFANT FLOTATION DEVICES: FOUR REPRESENTATIVE TYPES

INTRODUCTION

Renewed interest by the FAA in infant life preservers (ILP) results from the proposed issuance of Technical Standard Order (TSO) C-13f (1) and recommendation A-85-48 of the National Transportation Safety Board (2). TSO C-13f defines flotation attitude of infant-small child life preservers and A-85-48 recommends changes to TSO C-13 to provide specific minimum performance standards for infant flotation devices. A survey of currently available ILPs suggests that these requirements might not be attainable, a situation that would lead to necessary redesign and recertification of infant life preservers for use aboard commercial aircraft. Preliminary assessments of two FAA- approved ILPs were conducted; these ILPs were compared with two commercially available recreational lifejackets for donning time and flotation characteristics.

MATERIALS AND METHODS

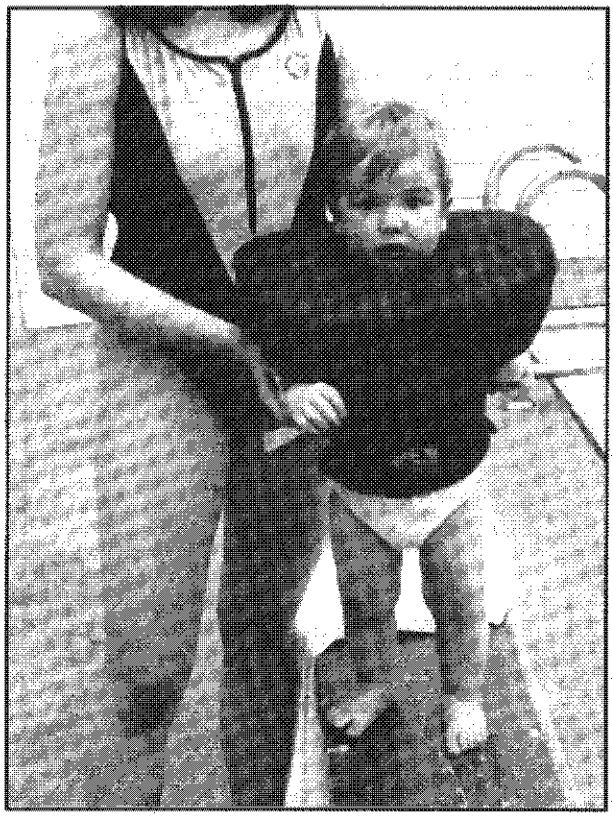
Materials:

Four ILPs were tested. Two were fixed-foam recreational life preservers (type II, U.S. Coast Guard approved) and two inflatable life preservers that met the requirements of TSO C-13d. These devices were considered to be representative of currently available infant life preservers.

ILP #1 was a vest type with both the zipper and the waist belt attachment in the back. A polyvinyl chloride foam-filled ring was attached to the vest which surrounded the neck. Total minimum buoyancy was 7 pounds (Figure 1).

ILP #2, another foam-filled ILP, was also a vest type but had the zipper and waist strap attachment in front. It also had a crotch strap, a tie at the neck, and a flat foam-filled neck collar. It, too, had a minimum

Figure 1. Front and rear views of ILP #1 with subject #16



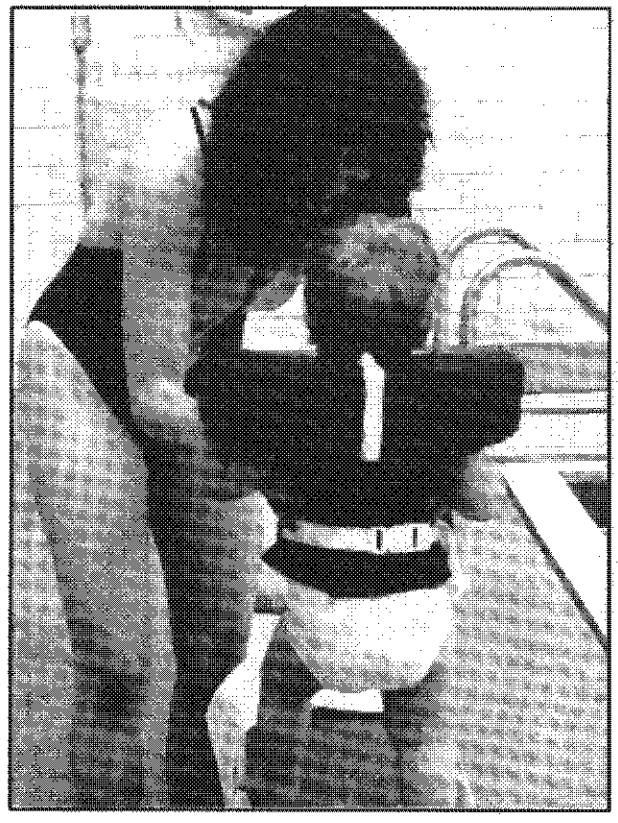
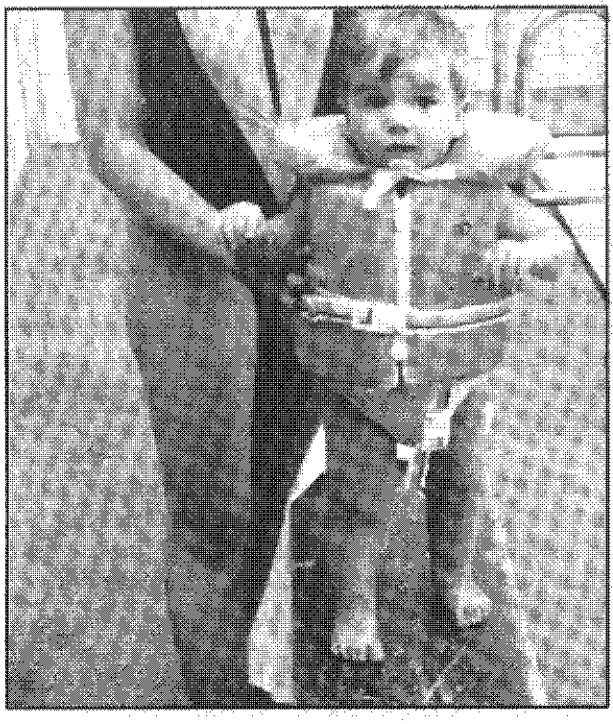
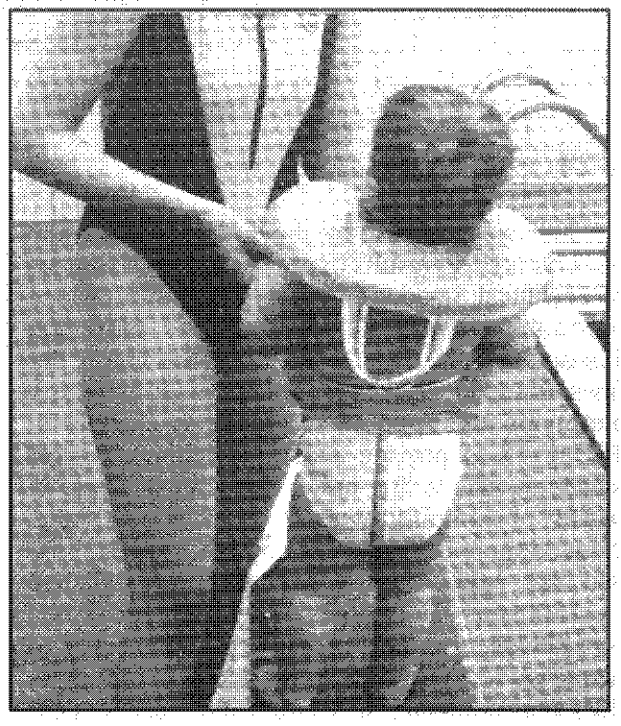


Figure 2. Front and rear views of ILP #2 with subject #16

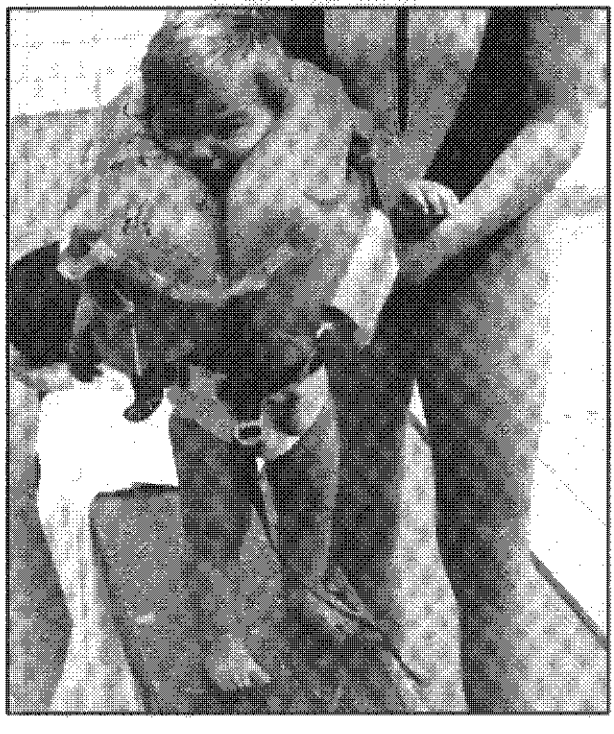




buoyancy of 7 pounds (Figure 2). (The manufacturer's information label attached to ILP #2 advised: "A child is difficult to float in a safe position because of the distribution of body weight and a childs tendency to attempt to climb out of the water. An approved device will keep a child afloat, but not always in a face up position.")

ILP #3 was an inflatable with two inflation chambers. The device was donned by placing it over the head of the wearer. It was secured by a waist strap and a crotch strap that attached in the front (Figure 3).

Figure 3. Front and rear views of ILP #3 with subject #16



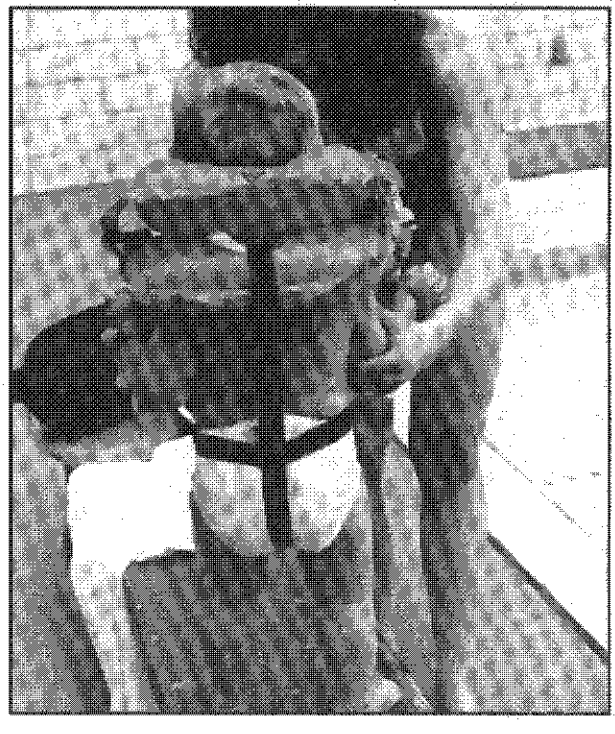


Figure 4. Front and rear views of ILP #4 with subject #16

ILP #4, the other inflatable, also had two inflation chambers, but was held in place under the arms of the wearer by an attached vest which had three buckles in the back (Figure 4).

Methods

Donning: Donning trials were conducted with 22 infants and their parents; 17 of these subject pairs also tested ILP flotation characteristics. Subject demographics are given in Table 1. ILP donning tests were arranged in a Latin Square design, because of the number of subjects used and to minimize the possible effects of learning, fatigue, and experimental bias. Tests were conducted in the CAMI Evacuation Simulator.

Each test was conducted with the infant on the lap of the parent, who was seated in the center of a typical triple coach seat with "passengers" seated on both sides. A triple coach seat positioned in front of the subjects had a pitch of 32 inches, which resulted in an 11-inch knee space for the parent. A video presentation of donning techniques was shown before each test.

Video recordings of the donning test activity were made using two video cameras. One camera was placed on the aisle side to record the side view and the other camera was placed directly in front of the subject. The seat-back cushion in front of the subject was replaced with 1/4-inch clear Plexiglas to allow camera access to the subject. A timer on the side camera was used for data reduction.

Flotation Characteristics: The four infant life preservers were tested for flotation in the CAMI Survival Tank. Video cameras were placed on two sides of the subjects above the water and one camera was placed at one of the observation windows below the surface of the water to record the underwater activity. The parents placed the infants in a supine position and a prone position on the surface of the water and allowed them to float freely. The video recordings were used to evaluate the flotation characteristics of the infant life preservers.

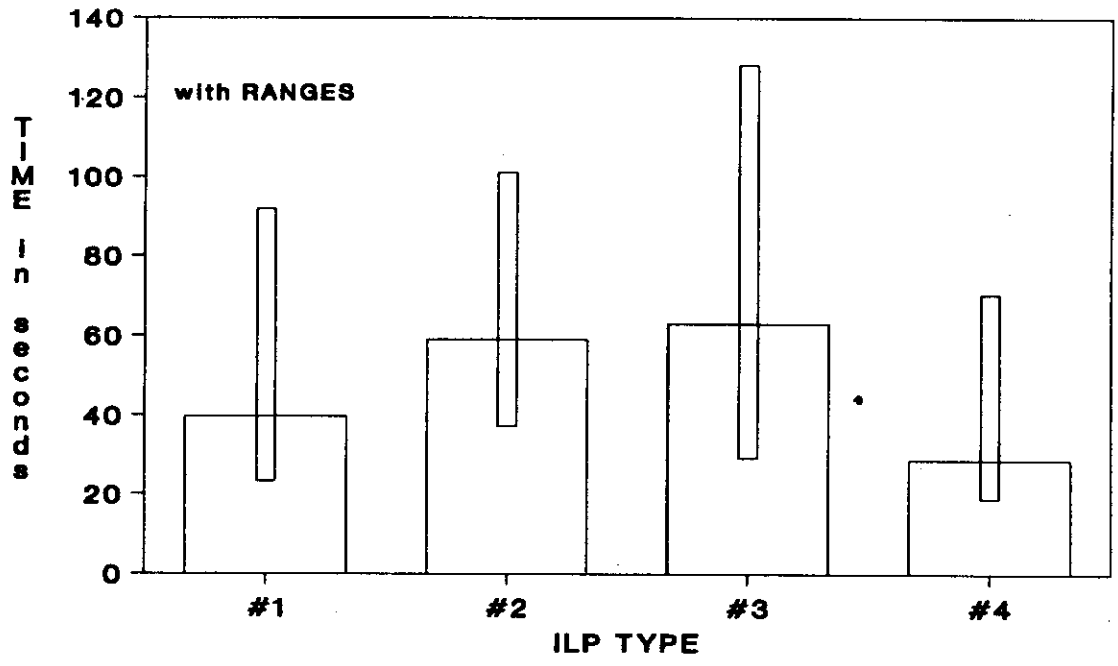
TABLE 1. SUBJECT DEMOGRAPHICS

SUBJECT	SEX	AGE (mo.)	HEIGHT (in.)	HEIGHT PERCENTILE #	WEIGHT (lb.)	WEIGHT PERCENTILE #
1 *	M	11	24	<5	22	50-75
2 *	F	20	32	25-50	25	50-75
3 *	F	22	34	50-75	27	50-75
4 *	M	21	31	<5	25	25-50
5	F	16	30	10-25	24	50-75
6 *	M	12	31	75-90	23	50-75
7 *	M	14	31	50-75	23	25-50
8 *	F	16	22	<5	22	25-50
9	F	15	29	5-10	20	10-25
10	M	17	32	50	20	<5
11*	M	13	31	75	30	>95
12*	F	13	30	50-75	22	50-75
13*	F	21	31	5	24	25-50
14*	F	16	32	75	23	50
15*	M	12	30	50	22	25-50
16*	M	14	30	25	25	50-75
17	M	21	33	25-50	27	50-75
18*	M	16	32	50-75	23	25-50
19*	M	9	28	25-50	25	>95
20*	M	13	30	25-50	23	50
21	M	12	33	>95	24	75
22*	M	14	30	25	23	25-50
MEANS FOR DONNING GROUP		15.4	30.3		23.7	
MEANS FOR WATER GROUP		15.1	29.9		23.9	

* Denotes Water Group.

Percentiles derived from Reference Number 3.

FIGURE 5. MEDIAN DONNING TIMES



RESULTS

ILP Donning Tests:

Donning time was measured from the moment the parent had the unwrapped ILP in hand until the last attachment or adjustment was made. Median donning times with ranges are shown in Figure 5.

As shown, ILP #4 was most quickly donned with a median time of 28.8 seconds (range 19.0 seconds to 70.5 seconds), followed next by ILP #1 with a median donning time of 39.6 seconds (range 23.3 seconds to 91.8 seconds). ILP #2 was third at 59.1 seconds (range 37.3 seconds to 101.1 seconds). ILP #3 was slowest with a median donning time of 63.1 seconds (range 29.2 seconds to 128.1 seconds).

The simplified designs of ILPs #1 and #4 allowed faster donning than for the more confusing ILPs #2 and #3 ($p < 0.05$). For all percentiles of the donning time distribution, ILP #4 had a shorter donning time than ILP #1; however, the difference was not statistically significant at the 0.05 level. The Kolmogorov-Smironoff two sample non-parametric test was used to test for differences in donning times (4).

The percentage donned for each ILP is plotted against time in seconds and presented in Figures 6 through 9.

FIGURE 6. PERCENT DONNING, ILP #1

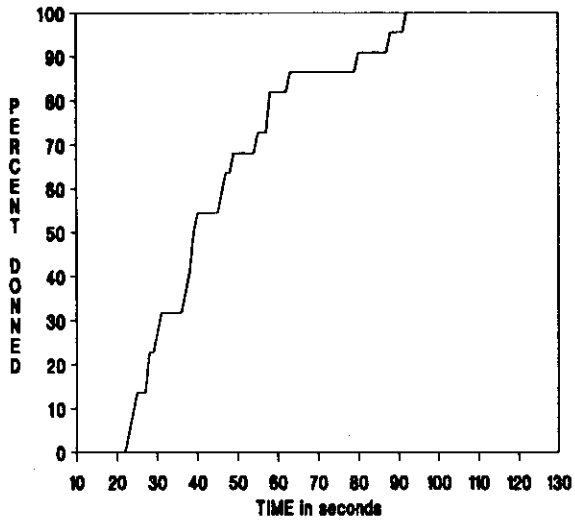


FIGURE 7. PERCENT DONNING, ILP #2

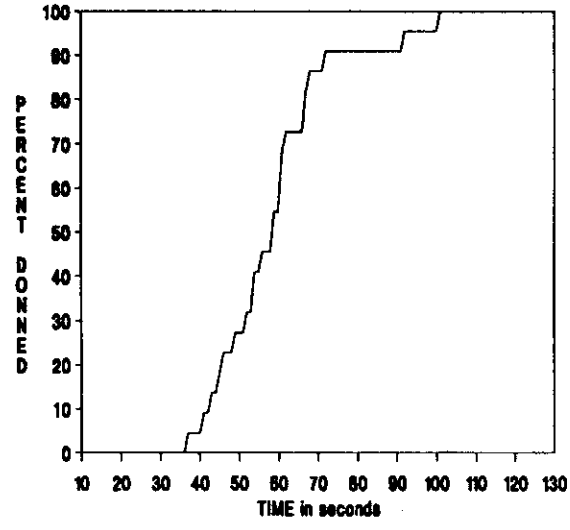


FIGURE 8. PERCENT DONNING, ILP #3

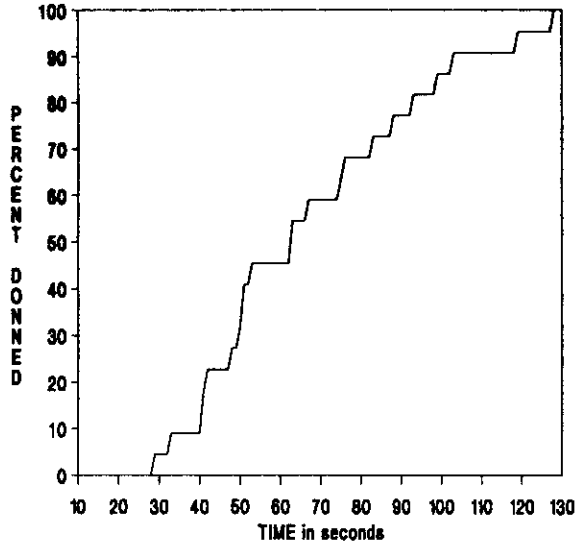


FIGURE 9. PERCENT DONNING, ILP #4

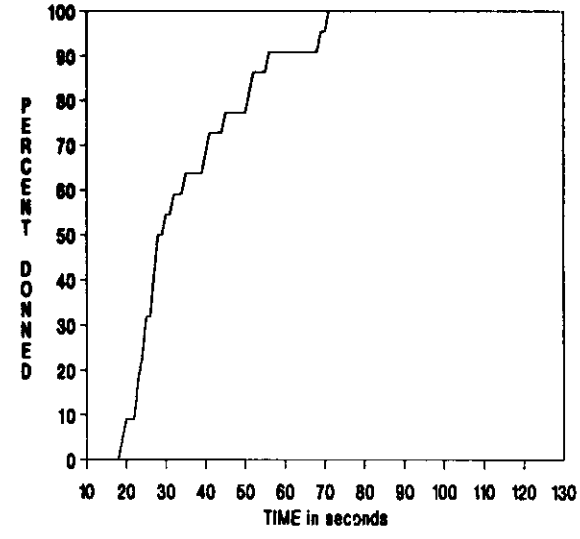
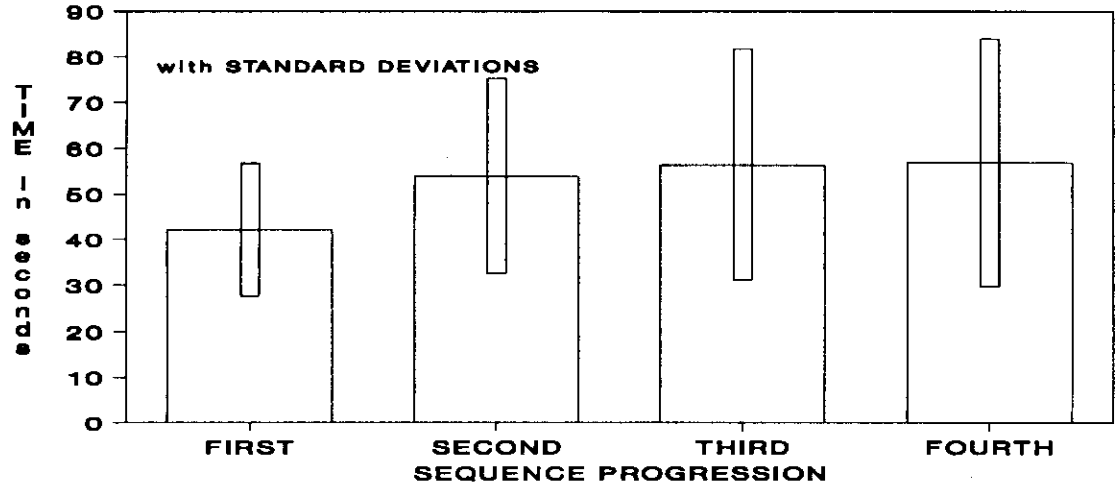


FIGURE 10. MEAN SEQUENTIAL DONNING TIMES



The Friedman two-way analysis of variance using ranks (4) was used to test the significance of order in the donning of the devices (Figure 10). The effect of order did not yield a significant difference even though there was an 11.6-second difference between the first and second average donning times. A consideration should be that ILPs 1 and 4 were both so much better than the other two that order was an insignificant factor.

Flotation Characteristics Tests:

Some infants, when they were placed in the prone position with ILP #1 were unable to keep their faces out of the water while the life preserver rolled them to the supine position. Those who were rotated from the prone position to the supine position (without rolling to the side) did keep their faces out of the water. When the infants were untethered and unsupported, they tended to come to rest in the supine position.

The other fixed-foam ILP, #2, demonstrated much of the same characteristics as ILP #1. The exception was much less head support. In the free-floating, supine position, the back of the head was well into the water with little or no support from the foam-filled collar.

Inflatable ILP #3 showed good head support and self-righting characteristics. Even with the crotch strap in place and adjusted, the flotation chambers tended to move up and restrict head movement and visibility. Some infants seemed anxious about being placed in this situation.

The other inflatable ILP, #4, because of the location of the inflation chambers under the armpits, appeared to provide a greater distance from the water to the nose and mouth than the other ILPs. It also showed good righting characteristics and head support. As with the others, turning (or rolling to the side) from the prone position increased the likelihood of getting water in the face.

DISCUSSION

It is imperative that the results of these tests be evaluated with the knowledge of the wide variability among the subjects and the nearly perfect environmental conditions. Infants between the ages of 6 months and 2 years display dramatic developmental differences. It is during this period that they develop their own unique personalities, learn to communicate orally, learn to walk, start toilet training, lose baby fat, cut teeth, etc. So, it is not surprising that during the donning tests and the water tests, some were quite submissive while others were equally resistant to the manipulations of the parents. Some cried, some giggled, and more than one had a bowel movement during the tests. Parental response to their infants during the tests seemed to be influenced by the mood of the infants. The level of motivation of the parents to the tests also varied considerably.

The environment presented the best possible situation for these activities. The water temperature was 90 degrees F with no waves or wind. The air temperature of the simulator that was used for the donning tests was 72 + 2 degrees F. Ample time was

taken to let the subjects adjust to the test environment. The infant life preservers were inflated orally because inflation with CO2 cylinders is a terrifying experience for infants.

An earlier donning study (5) with adults showed that vest-style life preservers were more quickly donned than the ones currently used on commercial air carriers. In this study, the trend was somewhat obscured by the confusing straps and buckles on some life preservers. Perhaps the color-coding of the straps and buckles and the words "WAIST" and "CROTCH" printed on the straps would facilitate the donning of ILPs #2 and #3. Crotch straps do help to hold the life preservers in place, but the need for one was obviated by the design of ILP #4 where the inflation chambers were located under the arms of the infant. ILPs #1 and #2 were loosely held in place by the armholes, and the crotch strap on ILP #2 did seem to help hold the life preserver in place. The crotch strap on ILP #3 was necessary to keep the infant from pushing the uninflated chambers from around its neck and head.

In the water, ILP #1 and especially ILP #2 needed more buoyancy to support the head out of the water. Perhaps an inflatable ring to replace the collars of these two devices would offer more buoyancy with more support to the head. Maintaining the foam in the vest portion of these devices would be desirable for thermal protection. Flotation characteristics of ILPs #3 and #4 were very good but afforded very little thermal protection. The vest portion of ILP #4 could be modified to include thermal insulation. The restricted head movement encountered with ILP #3 was distressing to most of the infants. This, however, does not diminish the function of the ILP.

As an aside, during the first pilot test of the study, a mother placed ILP #3 on her 22-month-old daughter and orally inflated both chambers. The daughter immediately reached back, stuck her fingers in the oral inflation tubes and opened the valves, causing partial deflation of the chambers.

SUMMARY AND CONCLUSIONS

These tests show that under ideal conditions, ILP #4 was the most quickly donned, followed by ILP #1 and ILP #2, with ILP #3 being the slowest to be donned. Further work should be done to simplify the manipulation of the straps and buckles. This should include color-coding the straps and buckles and printing the words "WAIST" and "CROTCH" on the straps.

In the water, ILPs #1 and #2 tended to let the infants' faces go under water when they self-righted from the prone position. ILP #3 exhibited good flotation characteristics but restricted head movement. Good flotation characteristics, very little restriction of movement, and good support of the head well above the water were found with ILP #4. Future in-water studies should include testing these and other life preservers with children 2 to 5 years of age. Additionally, infant flotation cots should be evaluated for new-born infants to 6 months of age.

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☆U.S. GOVERNMENT PRINTING OFFICE: 1991 - 561-020/20993