

DETERMINATION OF CENTERS OF GRAVITY OF INFANTS

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At the present time infants and small children are not adequately protected against crash decelerations, both in aircraft and automotive transportation. In addition, in the event of an aircraft ditching, this young group of the population is provided no personal flotation equipment.

Perhaps the main reason for the long delay in developing protective equipment for children in the age group of 1 month to 3 years by the design engineers was the lack of basic anthropometric data concerning body measurements and locations

of body c.g. (center of gravity) for this group. A previous report¹ published by the author has been used as a basis for numerous restraint devices for children 5 to 18 years of age, and it is hoped that the data presented here may serve the same purpose for infants up to 3 years of age.

I. PROCEDURE

Arrangements were made with several nurseries for making body measurements and determining the location of body c.g. on the portable equip-

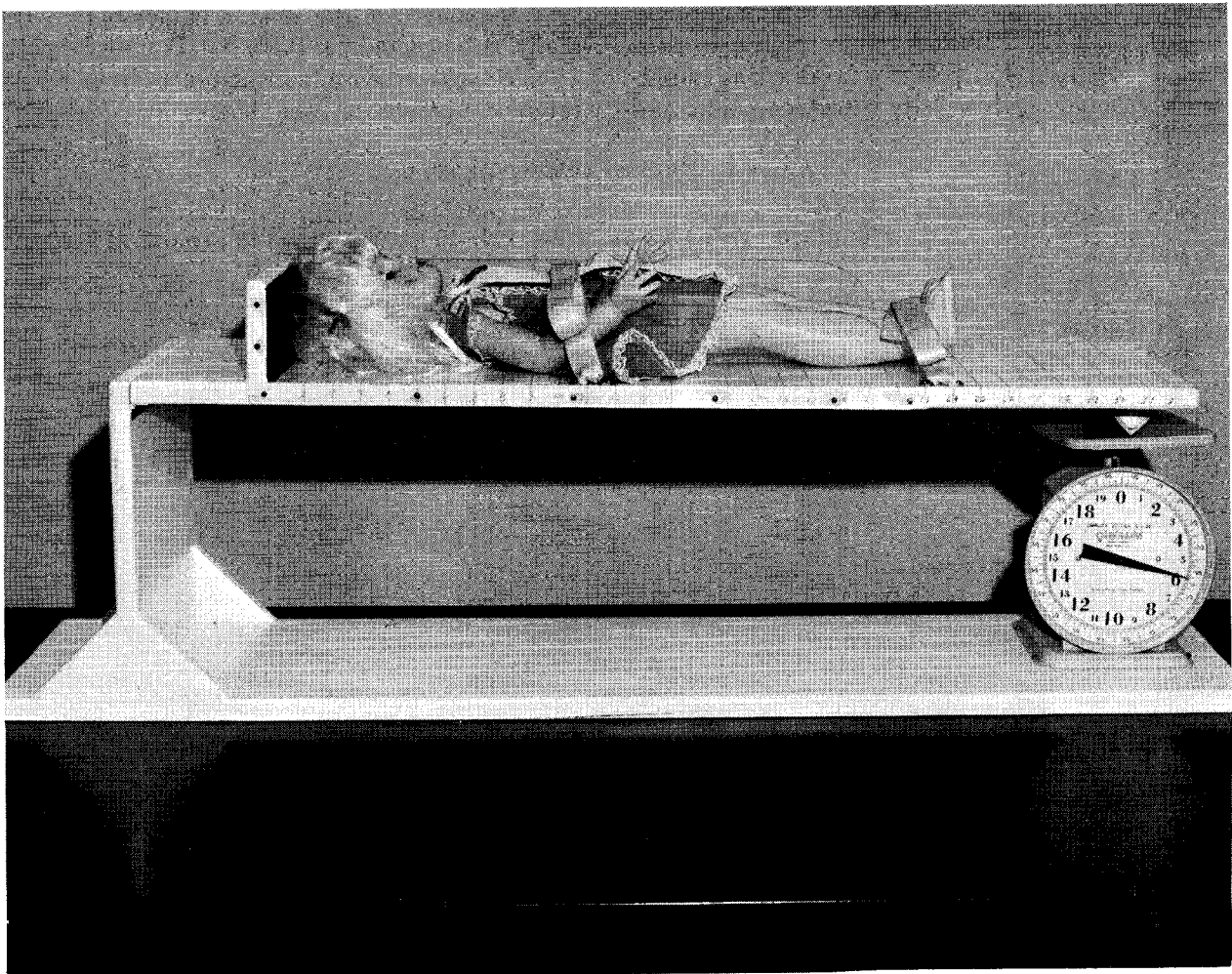


FIGURE 1. Infant c.g. balancing equipment.

ment shown in Figure 1. This equipment consists of a horizontal board with one end resting on a spring scale and the other pivoted on a hinge. While the spring scales are marked "not legal for trade," they were calibrated by weights and found sufficiently accurate for this study. The subject's head was placed against the padded board (5 inches from the fulcrum) and the location of the body c.g. from the top of the head determined from the formula:

$$\frac{36 \text{ (Scale Reading)}}{\text{Body Weight}} - 5 = \text{c.g. from top of head}$$

Where 36 inches = distance from fulcrum to the center of the scale.

5 inches = distance subtracted for distance from fulcrum to top of head.

The horizontal platform was marked at 1-inch increments from the headboard to facilitate reading body measurements with reference to the top of the head. Distances were projected to the scaled platform by pressing a drafting right-angle triangle against body reference points and

taking readings at the point of contact of the right angle.

Sex, race, age in months, weight, stature, scale reading, distance from top of head to the uppermost point of the crotch determined by firm pressure applied with the triangle, and the distance from top of head to the mid-point of the top of the shoulder were recorded for each child at the nursery. Later the investigators calculated trunk length and distances of the c.g. from the top of the head, from the crotch, from the feet, and from the shoulders. In addition, the distance of the c.g. from the feet was calculated in terms of percent of stature. Attempts were made to study 150 crying, wiggling infants, but 15 had to be eliminated as it was impossible to calm them down enough to obtain accurate readings.

II. RESULTS

A summary of the data accumulated in this study is presented in Table I. It may be noted from studying the c.g. measurements from various reference points on the bodies (top of head,

TABLE I. Summary of infant c.g. data.

N	4♂+6♀=10	17♂+17♀=34	17♂+ 12♀=29	21♂+12♀=33	5♂+8♀=13	8♂+8♀=16
Age in Months	0 - 6	6 - 12	12 - 18	18 - 24	24 - 30	30 - 36
<i>Weight (pounds)</i>						
Mean	15.1	19.4	23.5	25.4	27.9	29.9
Standard deviation	4.0	2.3	2.7	3.3	2.2	1.8
<i>Stature (inches)</i>						
Mean	24.9	28.2	31.2	33.1	35.6	36.9
Standard deviation	2.4	1.5	1.8	2.3	1.2	1.0
<i>Top of head to crotch (inches)</i>						
Mean	17.1	18.9	20.2	20.8	21.7	22.1
Standard deviation	1.3	.8	1.1	1.0	.9	.6
<i>Top of head to shoulder (inches)</i>						
Mean	5.7	6.2	6.7	6.9	7.2	7.5
Standard deviation	.3	.5	.5	.4	.3	.4
<i>C. G. from top of head (inches)</i>						
Mean	11.1	12.5	13.8	14.7	15.5	15.8
Standard deviation	1.3	.9	1.3	1.2	1.1	.5
<i>C. G. from crotch (inches)</i>						
Mean	6.0	6.3	6.3	6.0	6.2	6.4
Standard deviation	.7	.8	.7	.9	.7	.6
<i>C. G. from Feet (inches)</i>						
Mean	13.8	15.7	17.4	18.4	20.1	21.1
Standard deviation	1.4	1.4	1.1	1.7	.6	.9
<i>C. G. from shoulder (inches)</i>						
Mean	5.3	6.3	7.2	7.8	8.3	8.3
Standard deviation	1.1	.9	1.1	1.1	1.2	.5
<i>C. G. from feet - % of stature</i>						
Mean	55.5	55.6	55.8	55.5	56.6	57.3
Standard deviation	2.3	2.9	2.6	2.9	1.7	1.5

crotch, feet, shoulders) of the different age groups that one measurement remains more or less constant with growth; i.e., height of c.g. above the crotch. This measurement of 6 ± 0.7 inches for a zero to 6-month-old infant and 6.4 ± 0.6 inches for a 30 to 36-month-old child is surprisingly close to that measured on the adult male of 5.9 ± 0.9 inches.²

In addition, it may be noted that the height of the c.g. from the feet in terms of percent of body stature remains fairly close and varies less than 2 percent (55.55 to 57.30) in the first 3 years of life. This agrees with Weinbach's study³ in which he found a mean height of c.g. for children 1.4 to 3.5 years of age in percent of body stature to be 54.7.

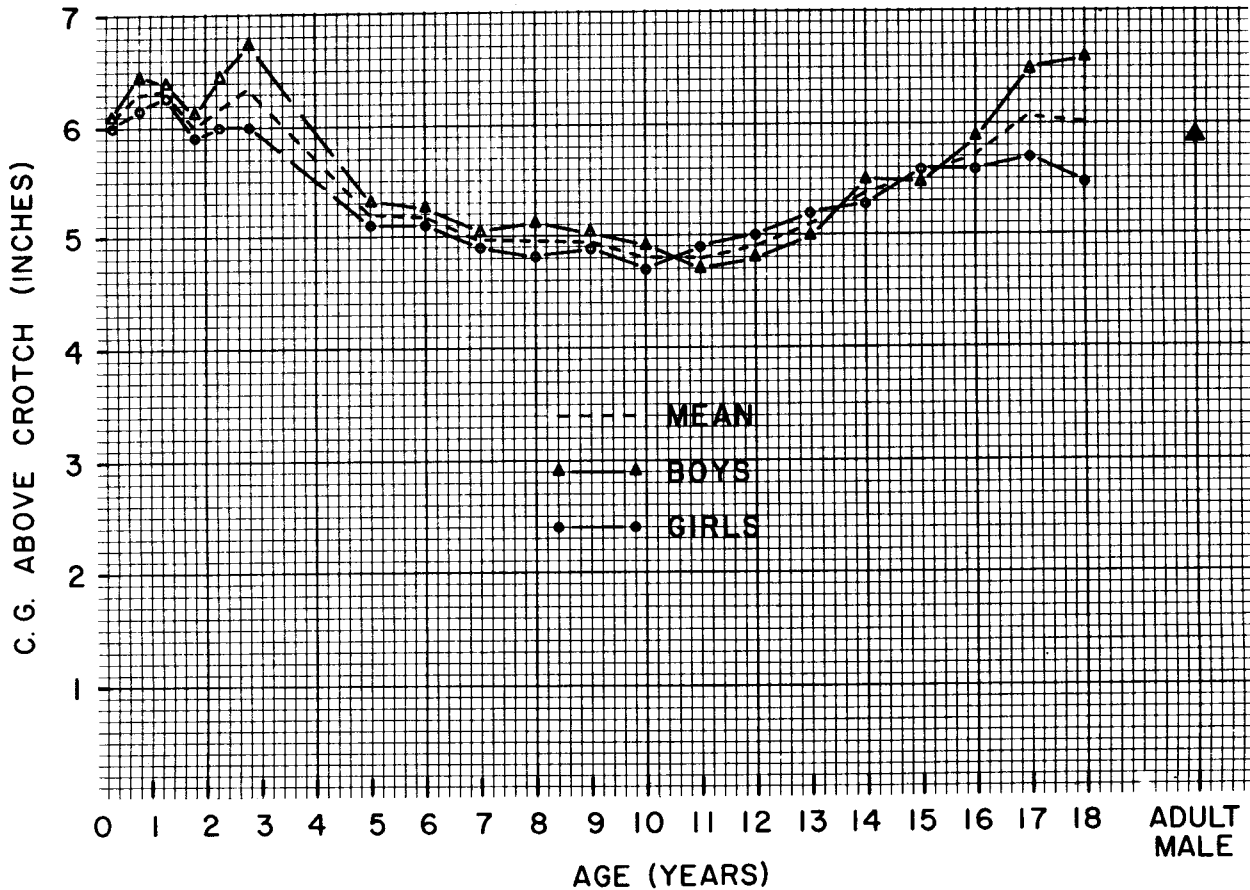


FIGURE 2. Means of c.g. of children standing.

Figure 2 combines the data in this report with those from the author's previous studies of body c.g. positions in children (5 to 18 years) and the adult male to present a nearly complete guide for determining the location of the body c.g. (as measured from the crotch) in the standing position. For the first 2 years the c.g. of the body is in excess of 6 inches above the crotch. From ages 5 to 13 this measurement has decreased and remains at about 5 inches. By the time a person reaches 17 or 18 it has returned to remain at its original measurement of about 6 inches.

III. CONCLUSIONS

While the location of the body c.g. as referenced from the crotch in the standing position remains fairly constant at 6 inches throughout life, it does not follow that all age groups can be equally well restrained against crash impact forces with the same restraint equipment. Six inches in an infant with a 9-inch trunk places the c.g. high in the chest, just below the armpits. At 1 year of age, the trunk has increased in length to 12 or 13 inches and the c.g. is located

at about the tip of the sternum. Between the ages of 1 and 3 years, the trunk increases in length to between 14 and 16 inches and the c.g. is located in the soft abdominal viscera. Not

until the child reaches his fifth or sixth year has the c.g. dropped sufficiently and the pelvis developed enough in size to allow the seat belt to be used as a safe and effective restraint device.

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