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I. Introduction.

A factor in the proper fitting and design of shoulder harnesses is the angle of the shoulder slope. Shoulder straps of relatively inflexible or coarse material, if not fitted correctly, will tend to concentrate the load toward one edge, thereby increasing discomfort and the probability of functional interference resulting from the compression of underlying soft parts, particularly nerves and blood vessels that supply the arm. Pain, congestion, and mild paralysis of the affected extremity can result from such compression and can materially impair pilot performance by increasing fatigue and stress and, in emergency situations, might critically affect strength for operating controls.

A survey of the literature fails to disclose data on the normal value of shoulder-slope angles. The present study was undertaken to provide such information for use in shoulder-harness design.

II. Materials and Methods.

The materials for the present study were a random sample of 55 from a series of some 500 somatotype photographs of male Air Traffic Service trainees collected by the Anthropology Laboratory of the Protection and Survival Laboratories of the Civil Aeromedical Research Institute. Details of the composition of the overall collection are described elsewhere.[1] Here is will suffice to note that it corresponds closely in age, stature, weight, and other anthropometric variables to the sample composing the Air Force Anthropometric Survey of Male Flying Personnel conducted in 1950.[2] All subjects had recently passed a physical examination essentially equivalent to that given annually to commercial airline pilots. Therefore, both the overall collection and the subsample used in the present study probably provide an adequate representation of the male pilot population. The mean age of the sample was 27.9 years; the weight, 161.8 pounds; and the stature, 69.56 inches.

The measurements were taken from 5- ×7-inch negatives of the posterior view of each subject in the standard somatotype pose: standing normally erect, with head in the eye-ear horizontal and the arms held laterally with the fingers extended and the hands about 6 to 8 inches from the sides. Care was taken in posing the subject to see that the shoulders were in a relaxed and natural position.

The shoulder profile of each subject, enlarged to approximately normal body size, was projected upon tracing paper, and the silhouette was traced on the paper. Care was taken to alternate the presentation of the negatives so that any systematic errors in projection technique would be compensatory.

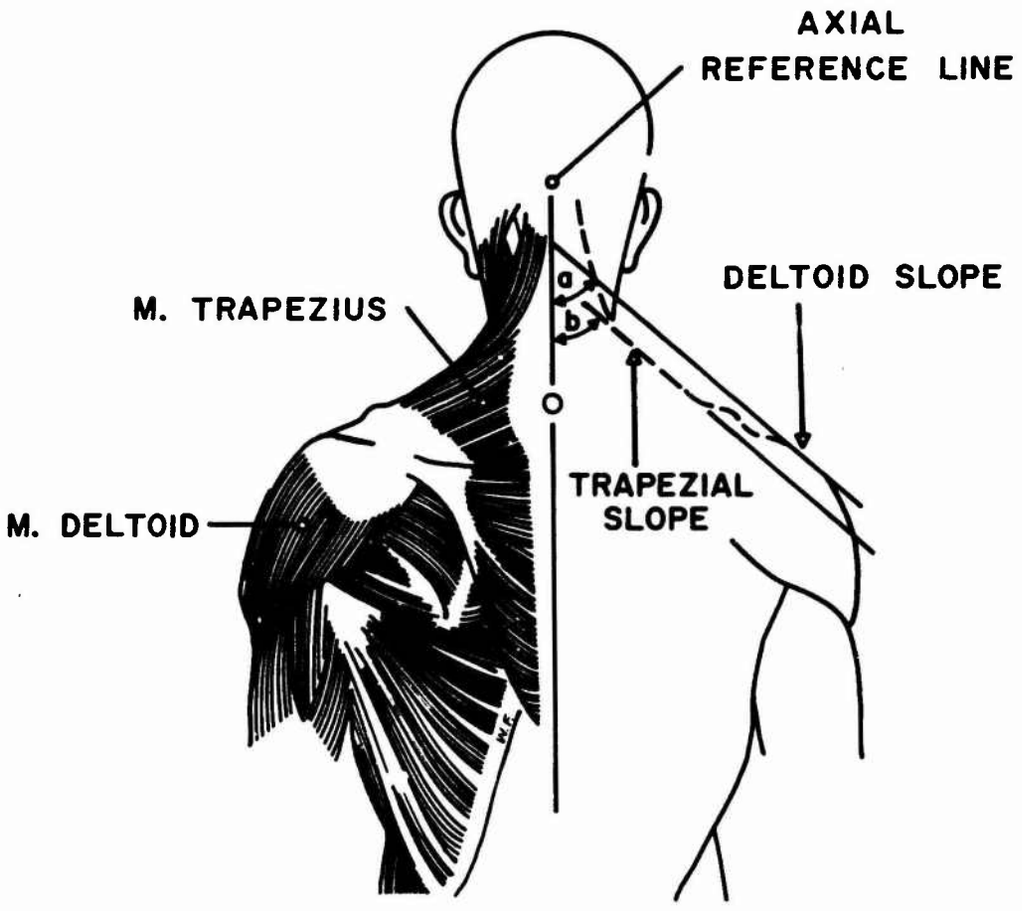
III. Definition of Measurement.

The profile of the shoulder is determined by the contour of the underlying soft parts, the skeletal structure and, particularly, by two muscles, the deltoid and the trapezius (Figure).

In the present study, the angle of shoulder slope was defined as the angle between a line tangent to the shoulder and the axial reference line (a perpendicular connecting the midpoint of the gluteal furrow with the center of the spine of the seventh cervical vertebra).

This angle might, however, vary somewhat according to whether the trapezial or deltoid segments, or both, were used to determine the line of shoulder inclination. Therefore, on the right shoulder, the angles determined by both of the latter segments were measured so that statistical comparisons of the two techniques could be made. On the left shoulder, only the angle of the trapezial segment was determined.

In all cases, the measurements were made by extending the slope line to its junction with the vertical axis and recording the angle to 0.5° with a drafting machine.



Posterior shoulder profiles showing trapezial (a) and deltoid (b) angles of slope.

IV. Results.

In the Table are presented the statistical results of the present study. Values recorded range from 52° to 88° in this comparatively small sample of 55, with means in the neighborhood of 67° and standard deviations of 5.0°.

Student's t tests were used to compare the means of the deltoid and trapezial slope angles of the right shoulder. The results were not significant ($t = 0.83$, $0.6 > p > 0.5$ with 108 df). However, an F test of the differences between the standard deviations of the two techniques revealed

Table. Shoulder Slope Angles of 55 ATC Trainees

Measurement	$\bar{X} \pm SE_{\bar{x}}$	$S \pm SE_s$	$V \pm SE_V$	Range	N
	degrees	degrees	%	degrees	
R Shoulder (deltoid segment)	65.6 ±0.8	5.8 ±0.6	8.8 ±0.9	52.0 – 80.5	55
R Shoulder (trapezial segment)	66.4 ±0.6	4.6 ±0.4	7.0 ±0.7	55.5 – 88.0	55
L Shoulder (trapezial segment)	68.5 ±0.7	5.2 ±0.5	7.7 ±0.7	59.0 – 80.5	55
R+L Shoulder (trapezial segment)	67.5 ±0.7	5.0 ±0.5	7.4 ±0.7	55.5 – 88.0	55

a difference of borderline significance ($F = 1.55$, $0.10 > p > 0.05$ with 54×54 df), indicating that the deltoid slope is slightly more variable.

The means of the right and left trapezial slopes were also compared, and the difference was significant at the 0.5 probability level ($t = 2.19$, $0.5 > p > 0.02$, 108 df).

V. Discussion.

The present study reveals no significant differences in the means, between the angles of the trapezial and deltoid segments of the shoulder profile; however, the smaller standard deviation of the trapezial segment angle indicates that it is slightly less variable and hence would be the preferable measurement for use in future studies.

The statistically significant differences between the means of the right and left trapezial angles are of some anatomical interest. Hypertrophy of the trapezius, as an examination of physical culturists will reveal, results in a more acute trapezial angle. The slight unilateral hypertrophy associated with handedness should also have the same result; i.e., in right-handed persons, the right trapezial angle should be slightly smaller than the left. In the present sample, handedness was not recorded, but we may assume it conforms reasonably well with the findings of previous workers,[3] in which left-handedness occurs with a frequency of 8.6% in American males. That being the case, we would expect a slightly larger trapezial angle in a predominantly right-handed sample, as does, in fact, occur in the present series.

From a practical standpoint, such a small difference in the right and left trapezial angles is not critical, and the weighted mean of the two sides (67.5°) can be considered adequate for the design of shoulder harness.

VI. Conclusions.

A. No significant differences exist between the deltoid and trapezial angles of shoulder slope as herein defined and measured.

B. A statistically significant differences exists between the right and left trapezial angle and is probably associated with handedness. From the practical standpoint, the difference between right and left trapezial angles is negligible from the standpoint of shoulder-harness design.

C. The mean shoulder-slope angle (measured from the vertical body axis) of normal males, based on the weighted means of the right and left trapezial segments of 55 ATC trainees, is 67.5° with a standard deviation of 5.0°.

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