AN ESTIMATION OF LUMBAR HEIGHT AND DEPTH FOR THE DESIGN OF SEATING

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The horizontal and vertical position of the apex of the lumbar curve of 773 seated persons were measured. The position of the lumbar landmark is given. Three common seated anthropometric measurements were also taken: popliteal height, buttock-popliteal length, and elbow rest height. The three common measurements are compared with data from an existing anthropometric data base.

INTRODUCTION

The location of the apex of the lumbar curve in the seated posture is regarded as an important piece of information for the design of the back shape of the chair. Anthropometric surveys do not include data for lumbar landmarks. Branton (1984) reports locations of spinal landmarks for 114 British Railways employees. Without recent information for the U.S. population, chair designers resort to using recommendations from the standards literature or replicating past designs. For this study specimen values were taken of a large sample using an efficient measuring device to help understand the lumbar shape.

METHOD

This study included 773 subjects from seven sites throughout the United States. Five measurements were taken:

1) The depth of the lumbar region of the back at its maximum curvature
2) The height at the deepest part of the lumbar curve
3) The popliteal height including heels
4) The buttock-popliteal length
5) The elbow rest height

The sample was taken from attendees at six furniture exhibitions and ergonomic conferences during 1993-1994, and from one U.S. corporation.

The five dimensions were measured using an apparatus that can quickly and unobtrusively estimate each dimension. The device uses a series of sliding shelves that act as probes to relate a landmark to a datum plane that the subject is sitting upon or leaning against (Figure 1). The distance from the datum plane is listed on the shelf. The device is referred to as the Anthropometric Percentile Estimator, or APE. All dimensions except lumbar depth were made to the nearest inch (2.54 cm), hence the term estimator. Lumbar depth was measured to the nearest half inch (1.27 cm).

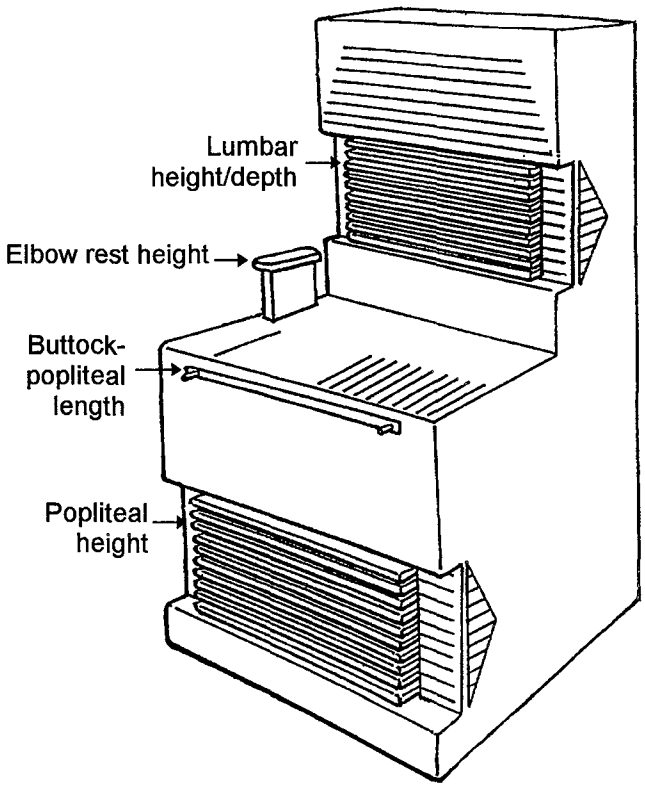

Figure 1. The Anthropometric Percentile Estimator

To measure the subjects, they sat upon the device in the 90 degree upright posture. The thoracic region of their backs and their buttocks touched the vertical plane. They sat upon the horizontal plane.

- Popliteal height is measured as the researcher selects the particular shelf that satisfies the following three criteria: 1) the subject's feet are flat on the shelf, 2) the subject's femur is approximately parallel with the floor, and 3) there is little pressure under the thigh.

- Buttock-popliteal length is measured by extending the shelf directly under the seating plane out to the popliteal crease.
- Elbow rest height is measured on the right side by extending a small flat adjustable arm support up to the elbow which is bent at 90 degrees. The researcher took special notice that the subjects shoulders were parallel with the floor, and that their upper arms were not abducting.

The apex of the lumbar curve is determined by visual inspection of the profile of the lumbar region.

- Lumbar height is measured as the researcher selects the particular shelf at the height of the apex of the lumbar curve.
- Lumbar depth is measured by extending that shelf out to the apex of the lumbar curve.

RESULTS

One method of evaluating the accuracy of the measuring device (APE), is to compare the mean measures for popliteal height, buttock-popliteal length, and elbow rest height with the same dimensions obtained by traditional measuring instruments. These dimensions were measured for the Anthropometric Survey of U.S. Army Personnel: Summary Statistics, Gordon, et al (1988), Natick, Massachusetts, also known as ANSUR.

Visual inspection indicates a tight consistency with the existing data for these dimensions. For popliteal height in males, the two samples are not statistically different at the 0.05 level. For the five other comparisons, the two samples are statistically different.

Table 1. Summary statistics for *female* subjects. The value for ANSUR popliteal height includes a 1.0 inch (2.54 cm) heel. Dimensional values are in inches and (centimeters).

	N	Mean	SD
APE- popliteal height	354	16.47 (41.83)	1.28 (3.25)
ANSUR- popliteal height	2208	16.33 (41.48)	0.93 (2.37)
APE- buttock-popliteal length	354	18.41 (46.76)	0.93 (2.36)
ANSUR- buttock-popliteal length	2208	18.96 (48.17)	1.05 (2.66)
APE- elbow rest height	354	9.54 (24.2)	0.89 (2.26)
ANSUR- elbow rest height	2208	8.68 (22.1)	1.05 (2.68)

Table 2. Summary statistics for *male* subjects. The value for ANSUR popliteal height includes a 1.0 inch (2.54 cm) heel. Dimensional values are in inches and (centimeters).

	N	Mean	SD
APE- popliteal height	419	18.19 (46.20)	1.25 (3.18)
ANSUR- popliteal height	1774	18.09 (45.95)	0.98 (2.49)
APE- buttock-popliteal length	419	19.59 (49.76)	1.06 (2.69)
ANSUR- buttock-popliteal length	1774	19.70 (50.04)	1.05 (2.66)
APE- elbow rest height	419	9.92 (25.2)	1.00 (2.54)
ANSUR- elbow rest height	1774	9.08 (23.1)	1.07 (2.72)

Table 3. Summary statistics for the height and maximum depth of the lumbar curve. Dimensional values are in inches and (centimeters).

	N	Mean	SD	Max.	Min.
Female lumbar height	353	9.75 (24.77)	1.09 (2.77)	14.0 (35.56)	7.0 (17.78)
Female lumbar depth	352	0.98 (2.49)	0.43 (1.09)	2.5 (5.72)	0.0 (0.0)
Male lumbar height	415	9.95 (25.27)	1.12 (2.84)	14.0 (35.56)	6.0 (15.24)
Male lumbar depth	415	0.87 (2.21)	0.43 (1.09)	2.5 (5.72)	0.0 (0.0)

DISCUSSION

This study reports seated lumbar dimensions for a large U.S. sample. When compared with the dimensions reported by Branton (1984), these results seem reasonable. The accepted opinion that women are more lordotic than men is reinforced by the data reported here.

The comparison between the U.S. Army data and those same dimensions measured using the APE device is interesting. Because both samples were large, significant statistical differences are easily detected. It should also be noted that ANSUR does not claim to represent the U.S. civilian population. There are anthropometric restriction criteria for entry and retention in the military, and the military sample is younger than the civilian population. None the less, the narrow dimensional differences between the two data bases for the same measurements seem to validate the ability of the APE device to accurately locate anthropometric landmarks.

Finally, compared with more traditional anthropometric surveys, it could be said that a limitation of this study is that all of the subjects were fully clothed when they were measured. This may be an acceptable limitation when considering the approximate nature of seating back shape design. This limit can also be considered a strength as it is typical in the operation of most seating that the users remain clothed.

ACKNOWLEDGMENTS

I would like to thank Bruce Bradtmiller and the Anthropology Research Project, Inc., for the statistical comparison of the APE sample with the ANSUR data base.

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