

Case study

Anthropometric data and Australian populations – do they fit?

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Background: Dimensions of stature, sitting height and buttock-knee length have been measured from tertiary design students in Sydney over the last four years as part of a learning exercise in anthropometry. Collected measurements from a total of 184 students now allow comparison with data from other surveys. **Aims:** The purpose of this study was to check the ‘fit’ of collected student measurements with comparable data from a range of countries. This was intended as a case study in extracting and comparing data from on-line anthropometric databases – in this case selecting data from samples with an age range similar to the undergraduate student group. **Method:** Students used tape measures against reference surfaces to collect the required dimensions from one another. Data from other studies for comparison were taken mainly from on-line civilian databases made available through the international WEAR Data Network. A search query was used in each case to select data only from surveys undertaken no earlier than 1997, with subjects 19-25 years old, and to extract measurements corresponding to those measured from the student group. **Results:** Data meeting the search requirements, for both males and females, were found in studies undertaken in the United States, Brazil and Netherlands. Data for stature only were found in studies undertaken in Korea, Japan (male only) and Australia (male only). An Australian study (females only) was found with data for stature and sitting height. Calculated 5th to 95th percentile ranges of included dimensions were compared. **Conclusions:** For the dimensions compared, the 5th to 95th percentile range of the student dimensions aligns reasonably closely, for practical purposes, with the combined 5th to 95th percentile ranges of two studies identified in the paper.

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Background

Students in an Ergonomics course in the undergraduate Industrial Design Program at the University of New South Wales (UNSW), have undertaken an exercise in anthropometry that involved each student recording measurements of their stature, sitting height, and buttock-knee length. They then established the percentile ranking of each of their own dimensions in relation to a larger population for which published anthropometric estimates were available. The purpose of this exercise was that students would gain some practical experience of anthropometry and using published data.

In the absence of comprehensive anthropometric data for the civilian Australian population, it has been common practice by designers in Australia to use data and design guidelines from other countries, such as Britain and the United States of America (USA). For example, a table of anthropometric estimates for British adults is included in an Ergonomics handbook published by Standards Australia [1], although it is noted in this publication that, “*direct dependence on overseas anthropometric data can be misleading to the designer because of Australia’s cosmopolitan population*”. The British adult dimensions in the Australian handbook appear to be the same as in a table provided by Pheasant [2] (p85) and identified as estimates for British adults aged 19-65 years. Accompanying notes state that values in the table other than

stature are estimates made with ratio-scaling methods. Stature measurements were taken from a nationwide British survey in 1981 and scaling ratios for the other dimensions were derived from several European and USA studies undertaken from 1965 to 1984. Also provided by Pheasant is a table of estimates for a subset of British adults aged 19-25 years that shows the mean stature to be 20mm taller for men and 10mm taller for women than the corresponding means for the whole adult population aged to 19 to 65 years. In the third edition of this book, by Pheasant and Haslegrave [3], it is recommended that the estimates for 19-25 year olds from the 1981 study should be taken as the best estimates for the overall adult British population in the early part of the 21st century – an indication of the effect of secular trend (an increase over time in the average size of individuals in a population).

A review undertaken for the Australian Safety and Compensation Council [4] found that Australian designers of workplaces and workplace equipment commonly rely upon anthropometric data from Britain and the USA. Summary statistics contained in reference publications such as *Bodyspace* [2, 3] and *Humanscale* [5] are widely used by designers despite concerns about the currency of the data and applicability to the Australian population and the workforce in particular. Measurements from other countries may also be the basis of standards, design guidelines, digital human models and other tools used by Australian designers.

The question of applicability had to be addressed when anthropometric information for a population were used for reference by design students in the process of learning to use available information and associated statistical tools. In the UNSW example described in this paper, it was recommended that most students use British adults 19-25 years old as the reference population in order to calculate percentile rankings of their individual measurements. However, some of the students of non-European birth or descent preferred to use anthropometric estimates for another population they more readily identified with. For example, estimates in *Bodyspace* for 'Hong Kong Chinese Industrial Workers' were used by some students.

The UNSW student measurements collected over the last four years, 2008 to 2011, have reached a total sample size of 184 students (102 male and 82 female) which is, arguably, enough to describe a "UNSW Design Students" population to be used as the reference population for this student exercise, and added to in the future. The collected data also allow comparison with surveys from other countries and making some useful, if tentative, observations about selecting anthropometric data from other countries for design purposes in Australia.

The aim of this study, in summary, was to find and compare relatively recent anthropometric data from studies in other countries with measurements collected so far from the UNSW student group. This should be seen as a case study in using recent data to perform a relatively simple 'reality check' since much of the published anthropometric information used by designers is based on surveys performed 30 or more years ago.

To this end, anthropometric databases that have recently been made available on-line by the international WEAR project group were investigated. Data for each individual in the measured population is preserved in these databases and a query can be run to extract information for a filtered selection of the surveyed population. Results of a query can be output as summary statistics and charts or, in some cases, the selected measurements and other details of every individual in the filtered population can be downloaded as a data file for further analysis. Access to these on-line databases provided the opportunity to collect better-matched data for comparison with the UNSW student population. Specifically, data could be selected from relatively recent studies and filtered for a sample of comparable age.

Method

Data collection from UNSW students

UNSW student data presented in this paper were collected each year from 2008 to 2011 during a tutorial exercise in an ergonomics course. Measurements were taken by students in small groups measuring one another with tape measures, set squares and straight edges against reference surfaces. This was done with supervision from tutors and following instructions about the methods for taking measurements of:

- **Stature;** measured standing erect against a wall without shoes. A set square was placed on top of the head by another student to place a mark on the wall. Height from the floor was measured with a tape measure.

- **Sitting height;** measured sitting upright on a horizontal surface with buttocks and in contact with the wall behind. A set square and tape measure were used by another student to measure height from the sitting surface to a point level with the top of the head.
- **Buttock-knee length;** measured while sitting on a horizontal surface with buttocks in contact with the wall behind. A straight edge was held across the front of the knees by another student and distance between the straight-edge to the wall measured on both sides. If each side was different, an average was recorded.

Other than removing shoes for measuring stature, the measurements were taken with students wearing their normal clothes. The definitions of measurements used were as described by Pheasant [2] (pp72-75) and each involved measuring to a flat reference surface. Skill in locating bony landmarks was not required for the selected measurements. However, the potential for inaccuracy when using basic measuring devices and inexperienced students is acknowledged.

Selecting comparable population data

Collections of on-line anthropometric databases were accessed via the WEAR Data Network (WDN) home page [6]. For each database within the collections there is information about the year of the study, the population surveyed and the size of the sample. The surveys selected for this study from WDN were all relatively recent (1997 to 2002) civilian surveys. Data from these surveys were filtered to include only subjects 19-25 years old. Information from another study, by Long [7], of male Australian students, aged 20-32, was also found and included in the comparison.

Table 1 below shows the sources of data used for comparison, the year(s) in which the measurements were taken and numbers of females and males in the sample. Included in the table are Pheasant's estimates for British adults 19-25 years-old although the estimates are based on surveys undertaken earlier than the others.

Table 1. Details of data used for comparison.

Nationality	Survey/Source of data	Year	Age	n female	n male
Australia	UNSW student (by author)	2008-2011	Note 1	82	102
USA	CAESAR (accessed via WDN)	2002	19-25	139	110
Korea	Chonnam National University (CNU) (accessed via WDN)	2001	19-25	204	3803
Brazil	Istituto Nacional de Tecnologia (INT) (accessed via WDN)	2001	19-25	55	94
Netherlands	TNO (accessed via WDN)	1999-2000	19-25	121	107
Australia	Sharp Dummies Pty Ltd (SD) (accessed via WDN)	2002	19-25	68	0
Japan	Digital Human Research Center (DHRC) (accessed via WDN)	1997	19-25	0	107
Australia	Sydney Students (Long)	1997-2001	20-32	0	141
Britain	Pheasant	1981	19-25	unknown	unknown

Note 1. Ages of the students in this study were not recorded. As undergraduate students in a second-year University course, the most common ages would be 19-22.

From each of the surveys the mean and standard deviation for each dimension was obtained, if available, or calculated in a spreadsheet if the all the individual measurements for the sample were available. The 5th and 95th percentile values for each included dimension were also taken from the source publication, if available, or estimated from the mean and standard deviation assuming a normal (Gaussian) distribution. The assumption of a normal distribution was not tested.

Results

Results from all the sources referred to in Table 1 are shown separately for females in Table 2 and males in Table 3. Not all dimensions were available from all studies.

Discussion

In making some observations about the comparison of anthropometric information from different sources in the tables above we might ask what difference would it make, pragmatically, if designers were to substitute information from one source for another. A rough guide, commonly adopted by designers, is to design for the 5th to 95th percentiles (or another suitable range) of dimensions determined to be important for accommodation of intended users. For a mixed male and female population, a designer may choose to accommodate, say, the 5th percentile female size to the 95th percentile male size. Although other percentiles for a

given dimension can be estimated, the adoption of 5th and 95th percentiles as convenient limits seems to be encouraged by the common inclusion of these values in published anthropometric tables. The limitations of using linear dimensions with percentile information as an indication of human variability are, hopefully, understood by the designer.

Tables 2 and 3 reveal some expected differences in the means of a particular dimension between countries and regions. For example, the Asian populations surveyed in Korea and Japan had, on average, shorter stature than populations sampled from 'western' countries. However, the differences in standard deviations, and consequent differences in estimated 5th and 95th percentile values, are of interest as well as the means. We can make the following observations:

From Table 2 – female dimensions:

- Although the mean Korean female stature is less than other means in the table, the 5th to 95th percentile Korean female stature of stature (1544mm to 1668mm) would still be accommodated within the 5th to 95th percentile range of all other populations in the table with the exception of the Netherlands, which has an estimated 5th percentile stature 1580mm, 36mm more than the Korean 5th percentile, despite the mean for female stature being 97mm more.
- The 5th percentile UNSW student stature (1534mm) is only 6mm less than the corresponding USA female dimension but 14mm more than the British and 8mm more than in the other Australian female study. The 95th

Table 2. Female dimensions from surveys listed in Table 1.

Female - dimensions in millimetres												
Survey/source	Stature				Sitting Height				Buttock-knee Length			
	Mean	Std Dev.	5th %ile	95th %ile	Mean	Std Dev.	5th %ile	95th %ile	Mean	Std Dev.	5th %ile	95th %ile
UNSW student	1632	60	1534	1730	865	33	811	919	569	37	508	630
USA-CAESAR	1648	66	1540	1756	872	35	815	929	583	32	531	635
Korea-CNU	1606	38	1544	1668	-	-	-	-	-	-	-	-
Brazil-INT	1619	53	1532	1706	852	27	808	896	569	24	530	608
Netherlands-TNO	1703	75	1580	1826	898	33	844	952	608	33	554	662
Australia-SD p/l	1644	72	1526	1762	872	35	815	929	-	-	-	-
British (Pheasant)	1620	61	1520	1720	855	35	800	915	565	29	517	613

Table 3. Male dimensions from surveys listed in Table 1.

Male – dimensions in millimetres												
Survey/source	Stature				Sitting Height				Buttock-knee Length			
	Mean	Std Dev.	5th %ile	95th %ile	Mean	Std Dev.	5th %ile	95th %ile	Mean	Std Dev.	5th %ile	95th %ile
UNSW student	1757	72	1639	1875	925	49	845	1005	603	34	547	659
USA-CAESAR	1770	72	1652	1888	920	37	859	981	613	30	564	662
Korea -CNU	1720	62	1618	1822	-	-	-	-	-	-	-	-
Brazil-INT	1734	63	1631	1837	896	34	840	952	602	31	551	653
Netherlands-TNO	1833	74	1712	1954	950	38	888	1012	639	33	585	693
Japan-DHRC	1706	54	1617	1795	-	-	-	-	-	-	-	-
Australia (Long)	1765	68	1653	1877	-	-	-	-	-	-	-	-
British (Pheasant)	1760	73	1640	1880	915	37	855	980	595	32	545	650

percentile female UNSW student stature (1730mm) was between the 95th percentile statures for British females (1720mm) and USA females (1756mm).

- The 5th percentile female sitting heights of all sampled populations in the table, with the exception of the Netherlands, vary only from 800mm to 815mm. There is more variation in the 95th percentile end, but the UNSW student 95th percentile (919mm) is within the USA female 95th percentile value (929mm) and close to the British 95th percentile (915mm).
- The UNSW female students had the smallest 5th percentile buttock-knee length (508mm) This was 9mm less than the corresponding value for British females (517mm). The UNSW student 95th percentile dimension for buttock-knee length (630mm) was between the corresponding dimensions for British females (613mm) and USA females (635mm).

From Table 3 – male dimensions:

- The 5th percentile values for stature of Korean and Japanese males (1618mm and 1617mm respectively) are less than 5th percentile values of all other populations in the table. The next lowest 5th percentile value is the Brazilian male 1631mm
- The UNSW male student 5th percentile dimension for stature (1639mm) is only 1mm less than the corresponding British dimension, 13mm less than the USA dimension (1652mm) and 14mm less than for Australian male students surveyed by Long. The 95th percentile UNSW male student stature (1875mm) is 2 to 13mm less than the corresponding dimension for the USA, British and the other Australian male student surveys (1888mm, 1880mm and 1877mm, respectively).
- The UNSW male sitting height has a mean value of 5 to 10mm more than corresponding USA and British means but the unusually large standard deviation (47, compared with 37 for USA and Britain) has resulted in a substantially higher 95th percentile dimension for UNSW male students (1005mm, compared with 981mm for USA males and 980mm for British males). Only the Netherlands 95th percentile male dimension (1012mm) is larger.
- In buttock-knee length, the 5th percentile dimension for UNSW male students (547mm) is 2mm more than the British male 5th percentile (545mm) while the 95th percentile UNSW student dimension (659mm) is only 3mm less than the USA 95th percentile dimension (662mm)

From these observations it would appear that, for the dimensions reviewed, use of combined 5th to 95th percentile ranges of both British and USA dimensions would accommodate the UNSW student 5th to 95th percentile

dimensions in most cases. The sitting height for male UNSW students stands out as an exception to this statement due to the relatively large standard deviation for this dimension. The USA dimensions compared are generally larger than the British and this could be partly accounted for by secular trend as the British measurements were based on a survey about 20 years earlier.

Conclusion

The comparisons in this study have been limited to only a few dimensions and with subjects within or close to the age range of 19-25 years. The dimensions reviewed are mainly applicable to design problems of headroom and knee clearance and do not tell us about width or problems of reach and movement. Nevertheless, the study has served its purpose as quick check and shows that the means and standard deviations of student measurements collected give a 5th to 95th percentile range that aligns reasonably well, for practical purposes in design, with the combined British and USA-CAESAR dimensions included in the comparison. It is tentatively suggested that using at least these two data sources may be better, if designing for Australia, than the British data alone. Designers should be aware that relatively recent data for a number of countries are available and should be considered in relation to the needs of each design problem. A wider survey of the Australian population is still needed.

References

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