Sizing Of Trousers and Shirts for Indian Army Personnel : An Anthropometric Application.

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Abstract. The paper describes how anthropometric data obtained on 4400 Indian Army personnel was utilized in evolving size rolls for the trousers and shirts. A bivariate frequency distribution of abdominal circumference and abdominal height indicated that the data could be grouped into 14 sizes and such grouping could provide good fitting trousers to 92.52 percent of the troops. For shirts, the bivariate frequency distribution of chest circumference and arm length grouped army personnel again into 14 sizes. Such grouping encompassed 84.22 percent of the personnel studied. An extra large size has been provided for those not covered by these 14 size. In this study, 95 army officers' clothing measurements essential for their good fitting trousers and shirts were taken along with the relevant body measurements. A stepwise linear regression analysis was also carried out to predict clothing measurements from body measurements. These regression equations were used to work out the dimensions of the trousers and shirts for different sizes from the classified anthropometric data.

1. Introduction

The importance of body measurements as the basis for sizing clothing was appreciated during World War II. It resulted in publication of data on the body measurements of thousands of military personnel and the development of sizing of wearing apparel and personal equipment for the armed forces[1-3]. Two general approaches have been used in developing systems of sizing clothing. In the first, known as indirect approach,

two dimensions not directly involved in the fit of a garment, eg. height and weight are selected'. These are chosen because they are well correlated with most other body dimensions. Values for all body dimensions required in the fit of a garment are calculated from these controls using regression equations. In the second or direct approach, these dimensions are chosen as controls which are highly variable and at which a good fit of the garment is important. Tolerances that are appropriate to the requirements of the fit of the garments for which the system is intended are used to divide the population into size groups. Values for all the other dimensions that define the size and shape of the body may be calculated from regression equations or may be obtained by sorting punch cards on which the body measurements of the individuals in each size group have been recorded[1,5]. The latter procedure' is more accurate.

Whatever be the approach for dividing the population into different size groups, the clothing dimensions for each size group are generally determined by an experienced designer or a pattern grader. Usually considerable difficulty is experienced in translating anthropometric measurements into meaningful tailoring measurements. 'The reverse situation is equally true i. e. all tailoring measurements cannot be utilized in anthropometric surveys aiming to provide properly fitting ready made dresses to large populations. The present investigation was undertaken to provide meaningful communication between the anthropometritian and the dress maker. Such a necessity was expressed in the 12th Commonwealth Defence Conference on operational clothing and combat equipment held in Ghana in 1978, and the present investigation was undertaken at their recommendation.

The problem of constructing new size rolls of trousers and shirts for an army can be resolved in the following steps :

(i) An anthropometric survey of the army personnel should be carried out in order to ascertain the variability in body dimensions involved in the good fit of the clothing items. As racial, age and physical activity levels are basic factors that control variability in body dimensions, due attention must be paid to them while selecting samples from the army population. Using suitable sampling procedures a very small sample of army personnel was required that could represent the whole army from the point of view of its dimensional variability.

(ii) Prior to a large scale anthropometric survey of the personnel, scrutiny of published work is required for the selection of key measurements involved in the good fit of the concerned items. Fitting trials of existing clothing items on a small population of army personnel should be contemplated to ascertain the lacunae in the existing size rolls so that these could be eliminated in the new proposals.

(iii) Establishment of relationships between the good fitting clothing and anthropometric dimensions is required in order to convert proposed anthropometric size group means to the dimensions of clothing that would be made to fit the size groups.

(iv) Validation trials of prototype garments on a smaller sample of original population is necessary before these items could be introduced to the services.

The present paper illustrates the use of body measurement data in laying down size specifications of trousers and shirts of a given design for the Indian Army personnel, avoiding dependence on traditional pattern grading.

2. Materials and Methods

There are 29 population groups from which the soldiers for Indian Army are drawn. For recruitment purposes, the physical standards vary from one group to another. Since Indian Army is very large, only a small fraction of it could be measured for this survey. These were pooled into 11 selection groups on the basis of apparent physical similarity of the troops. While making these selection groups, it was ensured that the ethnic groups catering significant proportion of the troops were adequately represented in the sample. The selection groups are listed in Table 1. While drawing samples,

Table 1. List of population/ethnic groups surveyd

Selection Group	Population/ethnic groups included
1.	Gorkha (Indian & Nepali) and Bhutanis
2.	Sikh and Punjabi
3.	Jat, Ahir and Gujjar
4.	Rajput and Gujarati
5.	South Indians. These include people from Andhra, Tamil Nadu, Kamataka and Kerala
6.	Naga and Ladakhi
7.	Dogra and Kashmiri
8.	Assamese and Bengalis
9.	Maratha and Mahar
10.	Santhal, Oriya and Bihari
11.	Garhwalis and Kumaonis
12.	Miscellaneous : This includes Christian, Muslim, Saurastrian, Bhil, Gond and other classes.

due weightage has been given to non-infantry formations like Army Supply Corps (A.S.C.), Electrical and Mechanical Engineers (E.M.E.), Artillery etc. In these formations the levels of physical activity of the soldiers may be somewhat different from those of the Infantry soldiers. Since the physical variability of the troops is not

merely due to racial origins only, but is also governed by age and the level of physical activity, it was decided to draw 100 men in the age categories 18-23; 23– 28, 23 – 33 and 33 & above.

Thus, a random sample of 400 men was drawn for each population group. The Army Headquarters were then requested to suggest units where the scientific team could go and select the required sample for the study. In each army unit detailed by the Head quarters for such work, a team of statisticians made a complete nominal roll of the soldiers including the Junior Commissioned Officers who were available for the study at the unit. The required number of troops in each age category was then selected using the procedure of random sampling.

3. Body and Clothing Measurements

Twelve body measurements were taken on 4,400 soldiers and 95 officers for the preparation of the size rolls of trousers and shirts. Martin's anthropometer and a flexible steel tape were used for taking the linear and circumference measurements respectively. The techniques of taking these measurements are described below :

Circumference of abdomen-I : The circumference of the abdomen was taken in a horizontal plane at the minimum waist line.

Circumference of abdomen-II : Horizontal girth of the abdomen at the umbilicus was taken.

Abdomen height : Vertical distance from the standing surface to the centre of the umbilicus was measured.

Crotch height : Vertical distance from the standing surface to the junction of the scrotum with the right leg was measured.

Thigh circumference : Horizontal circumference of the right thigh was measured at the level of the gluteal fold.

Buttocks circumference : Circumference around the hip region at the maximal protrusion of the buttocks and over the public region was measured.

Crotch length : While the subject placed his feet slightly apart, the surface distance from the centre of the umbilicus to a corresponding point at the back was measured.

Chest circumference : Horizontal circumference of the chest at the level of the nipples and at mid tidal volume was measured.

Arm length : The distance from the edge of the acromion process to the most distal point on the styloid process of the ulna was taken.

Shoulder width : The horizontal distance across the maximum lateral protrusions of the right and left deltoid muscles was measured.

Neck circumference : Maximum circumference of the neck including the hyoid bone was measured.

Sleeve length : The distance from mid-back to the tip of the styloid process of right ulna was measured. The tape passed over the elbow, while the arms were held horizontally and the forearms were flexed.

All the measurements were taken while the subject stood erect and looked forward. Measurements were also taken on best fitting trousers and shirts of 95 officers. The details of the clothing measurements are given below :

3.1 Trousers

Waist girth : Length of the waist band from the centre of the button hole to the centre of the button, round the waist.

Side seam length : Length of the trousers from the top of the waist band along the side seam to the bottom.

Back and front rise : It is the length measured from the'top of the waist band at the back along the back rise and from the bottom of the fly to the top of the waist band in the front.

Seat girth : The girth of one of the legs is measured at the junction of the legs and the fly. This is doubled to equate it with buttocks circumference.

Inside leg length : The length of the inseam from the junction of the legs to the bottom of the trousers.

Knee girth : The girth of one of the legs of the trousers at the level of the knee.

Bottom girth : It is the girth of one of the legs of the trousers at the bottom.

3.2 Shirt

Collar : Length of collar from the front of button hole to the centre of the button, round the neck.

'Yoke length : Length of the yoke from one shoulder edge to other shoulder edge.

Sleeve length : Length from shoulder edge of the yoke to the bottom of the cuff.

Chest girth : Girth under the arms when the shirt is buttoned.

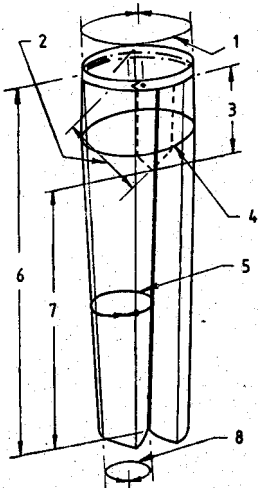
Waist girth : Girth around waist when buttoned,

Front length : Length from the side of the collar to bottom at front.

Back length : Length from the bottom edge of collar to bottom at the back.

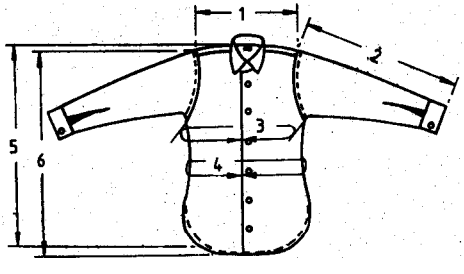
Mid Yoke to cuff: Length from the middle of the yoke (bottom edge) to the bottom of the cuff.

The trouser and shirt dimensions described above have been illustrated in the Fig. 1 & 2.



1 WAIST GIRTH
2 BACK RISE
3 FRONT RISE
4 SEAT GIRTH
5 KNEE GIRTH
6 SIDE SEAM LENGTH
7 INSIDE LEG LENGTH
8 BOTTOM GIRTH

Figure 1. Dimensions of men's trouser.



1 YOKE LENGTH
2 SLEEVE LENGTH
3 CHEST GIRTH
4 WAIST GIRTH
5 BACK LENGTH
6 FRONT LENGTH

Figure 2. Dimensions of men's shirt.

These dimensions have been considered by the Indian Standards Institution[6,7] to be critical for the good fit of the clothing. Multiple linear regression equations between clothing and anthropometric measurements were established to predict critical clothing dimensions from the relevant anthropometric measurements. These regression equations have been shown in Table 2 and 3 and have been utilized to derive critical clothing dimensions for different size groups observed in the survey of the army personnel.

Table 2. Derivation of clothing size specifications (trousers)

Size group IA N-139	cms	Trousers measurements	cms.
Abdomen II cir. (range)	70-75	1. Waist girth = 21.03560 + 0.74300 (Abdomen-11 cir) (R = 0.89, SEE = 3.16) Range = 69.00-95.50	= 76.8
Abdomen height (range)	83-92	2. Side seam length = 2.81583 + 0.63206 (Abdomen height) -0.24165 (Abdomen II cir)	
Crotch length (mean ± SD)	57.4±2.5	+ 0.31586 (Crotch height) + 0.33344 (Buttocks cir.) (R=0.87, SEE=2.50)	= 93.7
Crotch height (mean±SD)	72.0±5.6	Range = 91.60-117.00	
Thigh circumference (mean±SD)	48.1±3.3	3. Back and front rise=21.32057+0.44919 (Thigh cir,)+0.14785 (Abdomen II height)	
Buttocks circumference (mean±SD)	84.4±2.8	- 0.22170 (Abdomen II cir) + 0.31285 (Buttocks cir) (R=0.61, SEE=3.32) Range-58.00-79.00	= 66.3
		4. Seat girth= 51.52734 +0.70181 (Abdomen II cir.) +0.41432 (Crotch length) (R=0.64, SEE=8.86) Range=96.80—164.00	=127.9
		5. Inside leg length = 1.69575 +0.43128 (Abdomen height)+0.37364 (Crotch height)- 0.16381 (Abdomen II cir.) +0.24646 (Thigh cir.) (R=0.87, SEE-2.11) Range=67.50-85.00	= Tailor's assessment
		6. Knee girth -26.42871 +0.11771 (Buttocks cir.) +0.10531 (Abdomen II height) (R=0.29, SEE=2.95) Range=40.00-55.60	= 46.1
		7. Bottom girth= 18.99240+0.27896 (Abdomen II height)-0.25158 (Abdomen II cir.) t 0.36334 (Thigh cir.) (R=0.44, SEE-4.04) Range= 38.80-59.00)	= 43.2

Table 3. Derivation of clothing size specifications (Shirt)

Size group 1A N=170	cms.	Shirt measurements	cms.
Chest circumference (range)	80-85	1. Collar=24.46756+0.10064 (Abdomen I cir.)+0.18511 (Neck cir.) (R=0.45, SEE=2.05) Range= 34.00-45.00	= 38.0
Arm length (range)	51.0-53.5		
Shoulder width (mean± SD)	41.7± 1.5	2. Yoke length=17.15302+0.28434 (Shoulder width)+0.09773 (Chest cir.) +0.08321 (Sleeve length) (R=0.61, SEE=1.69) Range=40.00–50.00	= 42.4
Neck circumference (mean±SD)	33.8± 1.1		
Abdomen I circumference (mean±SD)	72.5± 2.9	3. Chest girth=33.48297+0.59747 (Abdomen I cir.)+0.45524 (Arm length) (R=0.65, SEE=5.72) Range=92.00– 121.00	=101.1
Sleeve length (mean-t SD)	75.6± 2.3		
		4. Waist girth=35.54613+0.83371 (Abdomen I cir.)+ 0.46040 (Arm length) -0.68090 (shoulder width) (R=0.74, SEE=5.29) Range=78.39– 123.00	= 92.2
		5. Sleeve length= 13.10662+0.30835 (Anthr. sleeve length)+0.33931 (Neck cir.)+0.18497 (Arm length) (R=0.60, SEE=2.58) Range = 54.00—68,00	= 57.7
		6. Front length=35.78845+0.02781 (Chest cir.)+0.39576 (Arm length) + 0.15907 (Abdomen I cir.) (R=0.46, SEE=3.73) Range=64.50–86.00	= 70.9
		7. Back length=27.07983+0.10941 (Chest cir.)+0.42585 (Arm length) + 0.42878 (Neck cir.) (R=0.45, SEE=3.94) Range=68.80—90.00	= 73.6
		8. Mid Yoke to cuff=29.05318+0.36643 (Sleeve length)+0.09518 (Abdomen.1 cir.)+0.24835 (Arm length) (R= 0.62, SEE= 2.96) Range=73.00–86.60)	= 76.9

3.3 Sizing System Adopted

Body weight and stature were selected as key measurements for the preparation of the size rolls in the earlier study[4] because these were most closely related to other body measurements. This approach is, however, unsuitable for the Indian Army which is racially heterogeneous. In the present study, it was preferred to use key measurements having direct involvement in the fitting of the clothing.

Many tailors were consulted regarding the choices of the measurements that would guide sizing of trousers and shirts, and the length of the interval of two measurements that would be appropriate to define a group of individuals which would be fitted well by a specified trousers or a specified shirt. In the case of the trousers the consensus was in favour of the abdomen circumference and abdomen height. Both these measurements can be easily taken at the unit level by technically less qualified personnel with some training in anthropometry. Interval of 5 cms for abdomen circumference was chosen because this magnitude of variation in the waist girth of the trousers could be easily adjusted by means of buckles and would not impair the overall good fit of the trousers. Intervals of greater length would pose fitting problems and of smaller magnitude would unnecessarily increase the number of sizes, For the abdomen height, increments to the tune of 2.5 cms were initially considered but these were extended to 9 cms because such an increment did not significantly influence the means of other girth measurements in common waist girth ranges. As the length of the trousers could be easily adjusted as per requirement of the user at the bottom fold, such a procedure led to a fall in the proposed number of trousers sizes in comparison to the existing sizes.

It is interesting to note that Indian tailors preferred abdomen height to inside leg length (crotch height) for sizing purposes. In the west, inside leg length is generally preferred.[1,2,5]. The key measurements for sizing the shirt are chest circumference and the arm length. An interval of 5 cms has been assigned to chest circumference and of 2.5 cms to the arm length.

It was recognised that for men's shirts a sizing system based upon height and weight is not satisfactory, because neck girth and arm length which are critical measurements for a good fit are not well controlled by height and weight. Our study on officers however did not qualify neck girth as one of the key measurements. The Indian tailors also preferred chest girth to neck circumference for sizing shirts.

4. Results

A bivariate frequency distribution of abdomen circumference and abdomen height in the Indian Army personnel is shown in Table 4. 14 size groups (1 B to 4E) included 92.52% of the sample studied. Even four sizes 2B, 2C, 3B & 3C include

Table 4 Trousers : Bivariate frequency distribution of army personnel with respect to abodomen circumference and abdomen height.

Abdomen II Height cm.	Abdomen II Circumference (cms)										
	60-65	65-70	70-75	75-80	SO-85	85-90	90-95	95-100	100-105	105-I 10	110-115
83-92	(1)	(57)	(139) 1B	(49)	(20)	(9)	(6)	(0)	(0)	(0)	(0)
92-101	(12)	(241) 2 A	(940) 2 B	(663) 2C	(233) 2D	(115) 2 E	(44)	(14)	(2)	(2)	(0)
101-I 10	(2)	(103) 3A	(609) 3 B	(597) 3 c	(254) 3 D	(1 1 2) 3 E	(51)	(13)	(5)	(0)	(1)
110-119	(0)	(7)	(24)	(45) 4 c	(15) 4 D	(5) 4 E	(6)	(2)	(0)	(0)	(0)

Selected 14 sizes include 92.52% of the population. N = 4400

The frequencies are given in brackets for all 44 sizes

64% of the sample studied. Table 5 gives the bivariate distribution of arm length and chest girth in 4400 men. This table reveals that 14 sizes (1 A to 6D) include 84.22 per cent of the population.

Table 5. Shirt : Bivariate frequency distribution of army personnel with respect to chest circumference and arm length.

	Chest circumference (cms)							
	75-80	80-85	85-90	90-95	95-100	100-105	105-110	110-115
	(6)	(24)	(9)	(0)	(0)	(0)	(0)	(0)
48.5-51 .0								
	(48)	(170)	(96)	(0)	(7)	(1)	(0)	(0)
51.0-53.5								
	(70)	(412)	(293)	(63)	(4)	(0)	(0)	(0)
53.5-56.0								
	(80)	(598)	(646)	(138)	(41)	(0)	(1)	(0)
56.0-58.5								
	(27)	(362)	(501)	(196)	(37)	(7)	(0)	(0)
58.5-61 .O								
	(4)	(109)	(210)	(92)	(36)	(5)	(0)	(0)
61.0-63.5								
	(1)	(18)	(45)	(17)	(9)	(0)	(0)	(0)
63.5-66.0								
	(0)	(0)	(9)	(6)	(0)	(0)	(1)	(0)
66.0-68.5								
68.5-71.0	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)

14 sizes (1A to 6D) include 84.22% of the population. N = 4400

The frequencies are given in brackets for all size considered in the table.

These bivariate frequency distributions only show the extent of the anthropometric variability of the army personnel as far as trousers and shirts are concerned. Table 6 gives mean of stitched trousers measurements and the means of corresponding anthropometric measurements. It also shows mean difference between the two measurements and the standard deviations of each measurement. While waist girth and abdomen girth are nearly equal, the seat girth and buttocks circumference differ by 44.37 cms.

Table 6. Comparison of tailoring and anthropometric measurements : Trousers.

Trousers dimensions and relevant body measurements (cms)	Mean	±	S.D.
Waist girth	80.88		1.41
Abdomen II cir.	80.71		8.63
Difference	0.17		
Seat girth	135.65		11.49
Buttocks cir.	91.28		5.93
Difference	44.31		—
Front & back rise	70.09		8.12
Crotch Length	63.91		4.10
Difference	6.18		—
Side seam length	104.48		4.95
Abdomen II height	103.35		4.73
Difference	1.13		—
Inside leg length	76.35		4.20
Crotch height	80.57		4.13
Difference	—4.22		—
Knee girth	48.29		2.98
Bottom girth	46.91		4.67

Cir. = Circumference

Trousers' front and back rise together are 6.2 cms longer than the crotch length. The side seam length and the abdominal height differ by 1 .1 cms. The inside leg length is 4.22 cms shorter than the crotch height.

Table 7 shows the mean difference and standard deviations of shirt measurements and corresponding anthropometric measurements. The collar is 3.0 cms greater than the neck circumference, yoke length is 1.1 cms greater than shoulder width, sleeve length is 3.2 cms bigger than arm length, shirt chest girth is 18.5 cms greater than anthropometric chest girth and shirt waist girth is 19.5 cms greater than the anthropometric waist girth (Abdomen-I circumference). Anthropometric sleeve length, however, is 1 cm longer than mid yoke to cuff. Table 2 illustrates the use of multiple linear regression equations obtained from the officers, anthropometric and clothing data. In the size group designated as 1 B the soldiers have abdominal girths ranging between 70 to 75 cms, and abdominal heights between 83-92 cms. While calculating different

Table 7. A comparison of tailoring and anthropometric measurements: shirt

Shirt dimensions and relevant body measurements (cms.)	Mean	± S.D.
Collar	38.95	2.32
Neck cir.	36.01	2.05
Difference	2.94	—
Yoke length	45.59	2.29
Shoulder width	44.69	2.29
Difference	1.10	—
Sleeve length	61.97	3.12
Arm length	58.69*	2.80
Difference	3.28	
Chest girth	108.43	7.77
Chest cir. (anthropometric)	89.85	6.13
Difference	18.58	—
Waist girth	98.95	7.60
Abdomen I cir.	19.38	7.88
Difference	19.57	
Mid Yoke to cuff	81.91	3.67
Sleeve length (anthropometric)	82.92	3.97
Difference	-1.01	—

Cir. = Circumference

trousers dimensions, maximal value of abdominal II circumference and abdominal height are fed into the equation. Mean values for other dimensions are entered.

Inside leg length values have not been calculated because side seam length, 'back and front rise and seat girth have been specified. It has been left for the tailor to work out this dimension himself. The bottom girth equation has also not been utilized for reasons discussed later.

Table 3 shows the derivation of the dimensions of shirt for size group IA from anthropometric measurements. Maximal values of chest circumference and arm length have been entered in the regression equations while means of other measurements have been entered for this size group. Based on these regressions Table 8 gives trousers specifications for different size groups. Likewise, Table 9 gives shirts specifications. These specifications have been recommended for use by the army after consultations with Defence Materials Stores Research and Development Establishment, Kanpur.

Table 8. Trousers polyester/cotton/khaki

Measurement of man (cm)			Measurement of garment (cm)						
Size No.	Abdomen height	Abdomen circumference	Front rise	Back rise	Crotch girth × 2	Waist girth	Knee girth	Bottom girth	Side seam length including turning
1	2	3	4	5	6	7	8	9	10
1B	83--92	70-75	32	35	128	77	49	46	97
2A	92-101	65-70	31	37	125	73	50	47	106
2B	92—101	70-75	31	37	129	77	50	47	106
2c	92-101	75-80	31	38	133	81	50	47	106
2D	92-101	SO-85	31	38	137	85	51	48	106
2E	92-101	85-90	32	38	141	90	51	48	106
3A	101-110	65-70	32	38	125	73	52	49	115
3B	101-110	70-75	3 2	38	129	77	52	49	115
3c	101-110	75—80	33	38	133	81	52	49	115
3D	101-110	80—85	33	38	137	85	53	50	115
3E	101-110	85-90	32	39	141	90	53	50	115
4c	110 119	75-80	31	40	133	81	53	50	124
4D	110— 119	80-85	32	40	137	85	53	50	124
4E	110 119	85-90	33	41	141	90	53	50	124
E.L.	119-128	SO-105	35	43	146	105	56	53	133
Tolerance ±			0.5	0.5	1.5	1.0	0.5	0.5	1.5

Note : All dimensions are in cm.

Table 9. Shirts **polyester/cotton/OG/khaki**

Sl. No.	Measurement of man		Measurement of Garment										Remarks
			Size Round						Sleeve			Collar	
	Arm length	Chest circumference	Under arm when buttoned	Waist when buttoned	Seat when buttoned (at curvature point)	length From side of collar to bottom at front.	length From bottom edge of collar to bottom at back	Width Across shoulder	Length from top to bottom of cuff	Length from cuff button hole to centre of button	Length of opening from bottom of cuff	Length of collar from front of button-hole to centre of button	
1	2	3	4	4A	5	6	7	8	9	10	11	12	13
1A	51-53.5	SO-85	101	92	101	71	74	43	55	21	22	38	(A)
2 A	53.5-56	SO-85	102	93	102	72	75	43	59	21	22	38	Width of
2B	53.5-56	85-90	105	9s	105	73	76	44	59	21	22	39	cuff is 7 cm
3A	56-58.5	SO-85	103	94	103	73	76	43	60	21	22	38	(B)
3B	56-58.5	85-90	106	96	106	74	77	44	61	21	22	39	Total
3c	56-58.5	90-95	109	100	109	75	78	45	61	21	22	40	length of
4A	58.5-61	SO-85	104	9s	104	74	77	44	63	21	22	38	cuff is
4B	58.5-61	85-90	107	97	107	7s	78	44	63	21	22	39	23 cm
4c	58.5-61	90-95	110	101	110	76	79	45	63	21	22	40	(C)
5A	61-63.5	SO-85	105	95	105	75	78	44	64	21	22	38	Pocket
SB	61-63.5	85-90	108	98	108	76	79	44	64	2	1 22	39	size is
6B	63.5-66	85-90	108	98	108	76	80	46	66	21	22	39	15X 13 cm
6C	63.5-66	90-95	111	101	111	77	81	47	66	21	22	40	
6D	63.5-66	95-100	113	102	113	78	82	48	66	21	22	40	
E.L.	66-69	100-	122	113	122	81	85	SO	68	21	22	42	
Tolerance±			2.0	2.0	2.0	1.0	1.0	0.5	1.0	0.5	0.5	0.5	

Note : All dimensions are in cms.

An extra large size (EL) has been provided for both trousers and the shirt to cater for the needs of those not covered by the 14 sizes. This size may require refitting for individual users.

5. Discussion

Bivariate frequency distribution of abdominal girth and abdominal height in 4400 army personnel indicated that 14 suitable sizes of trousers could fit 92.52 per cent of the army population. A similar frequency distribution with respect to chest girth and arm length indicated that shirts in 14 suitable sizes could meet the requirements of 84.22 per cent of the army population. With slight lowering of the fitness quality, a still larger percentage of the army population could be accommodated with the new proposed size rolls.

The trousers length would normally be a little longer than the exact requirement of the users. The user can adjust the length of the specified trousers at the bottom fold. Increments in the length of the clothing have been associated with numeral increase in the size number 1,2,3 etc. Thus size 2A is 9 cms longer than size 1B. Likewise trousers 3A is 9 cms longer than 2A. The alphabets (A,B,C etc) are associated with the variations in the girth within the same size group. Thus, waist girth of trousers size 2B is 4 cms larger than the waist girth of the trousers 2A. For the shirt, size number increments indicate increase in length, and chest girth changes are labelled by alphabets. The multivariate regression analysis carried out on 95 officers relating body measurements to clothing measurements has upheld the choice of the key measurements for both the trousers and the shirt, as the key measurements predominate over other measurements in the prediction equations. The multivariate regression equations based on significant multiple correlation coefficients, predicting clothing measurements from body measurements, have been utilized in specifying clothing dimensions of each size group. A cursory glance at these equations indicates that multiple correlation coefficients are generally stronger in equations predicting trousers dimensions than those predicting dimensions of the shirt. This could be due to the fact that a greater harmony between body measurements and trousers dimensions is required for a good fit. On the other hand, a much greater variability in the dimensions of the shirt is tolerated.

Although most of the body measurements were well correlated with the relevant clothing measurements, unexpected deviations have also been observed. In the case of the shirt, the correlation between neck circumference and the collar length was much lower than expected and this measurement does not qualify to serve as a key measurement for sizing the shirt. The crotch length was expected to be closely related with front and back rise of the trousers but this was not observed. For predicting front and back rise other measurements were chosen. These multiple linear regression equations for the trousers and the shirt are valid within the range of dependent variables indicated in the Tables 2 & 3. Beyond these ranges there may be a considerable error in prediction.

The multiple linear regression equation predicting bottom girth needs some explanation. In this equation the abdominal-II circumference is associated with a negative regression coefficient. The equation predicts smaller bottom girth of trousers for people having larger waist girths. It would be worth while to investigate the basis of such computational observations. Larger waist girths are associated with older people. The younger officers with smaller waist girth were more fashion conscious and preferred slightly wider bottoms of their trousers. The Army dress regulations, however, prevented them from wearing bell bottoms which were in vogue at the time of the survey. The older officers on the other hand clung more rigidly to the dress regulations. While laying down size specifications, one cannot differentiate between young and old as only one specification is desired. Therefore, the results of this equation have been set aside. The bottom girth specifications have been considered by taking into account user's comfort and operational requirements. A few words may be said about loose allowance incorporated in the size rolls. In the old size rolle, constant loose allowance for each size of the garment was provided. In the new size rolls, the loose allowance increases with increasing size of the garment. This has been inferred from the officers' trousers and shirt wearing patterns.

The regression equation for shirt chest girths has given some weightage to arm length as well. Greater loose allowance is suggested for people having longer arms. This is a reasonable choice. With similar arm lengths but with increasing obesity, people perhaps prefer to look slim by wearing a close fitting garment. The magnitude of variation in loose allowance with increasing arm length and chest girths is not alarming. Trousers loose allowance at the seat tends to increase with increasing waist girths and crotch lengths.

It is interesting to note that waist girths of trousers do not increase as much as the increase in the abdomen II circumference in different sub-sizes (A to E) of the same size group and strangely enough, the predicted side seam lengths are slightly shortened from A to E in the same size group. Since no fitting problems were encountered, we were eager to know the basis of such computer choice. The fitting trials solved the puzzle. We observed that with increasing obesity soldiers tend to wear the trousers a little below the navel the point where maximum value of abdomen girth is observed. In the size rolls finally accepted for introduction, these apparent anomalies have disappeared due to rationalisation of trousers side seam lengths and waist girths. The proposed new size rolls of trousers and shirts compare well with those proposed by Australia or Malaysia recently. King[9] pointed out that the Australian Army had 38 sizes of shirts which fit only 54 per cent army population. By increasing the size numbers to 51, he claimed that those would fit 90 per cent of the total army population. Collar and sleeve lengths were the principal sizing criteria. He has also proposed 42 new sizes of trousers which fit only 86 per cent of the population. Tn the new specifications for men's trousers he provided two seat sizes for each waist size as he found that there was a scatter of more than 6 cms in men's seat dimensions.

The Malaysian army has 24 sizes of trousers which provide coverage to less than 50 per cent of the army population. Based on an anthropometric survey data, Mi[10] has reduced them to 23. Stature and waist circumference serve as key measurements in the proposed size rolls. Size interval of 6 cm was selected for body height and 5 cm for waist circumference. The new size roll for the trousers is expected to provide coverage to 95.36 per cent of the population. As regards the shirt, the Malayasian army has 9 sizes covering only 62 per cent of the population. In the new proposal, neck and chest circumference have been selected as key measurements. With the size intervals of 1.5 and 7.5 cm respectively, the 10 new sizes are expected to provide coverage to 89.8 per cent of the population. However, these are yet to be confirmed by actual fitting trials.

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