MEASURING MOVEMENT EASE FOR CLOTHING PATTERN BY MEANS OF SPECIAL MADE SHIRT

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Abstract: *Direct approach, interaction with volunteers and a specially made shirt to study the influence of races, height, weight and age to the wearing ease of clothing pattern, were used in this work. Two groups of volunteers have participated in the process of the research: group 1) 43 Chinese volunteers from the Zhejiang Fashion Institute of Technology (ZFIT) and group 2) 25 Turkish volunteers from Istanbul Technical University (ITU). Both groups went through the same procedures which were: step 1) taking upper body measurements; step 2) choosing the majority group of volunteers by the mean value of the age, weight and height and step 3) trial wearing and questionnaire. Trial shirts in the research were made of 100% plain weave cotton of 139 g/m^2, thickness 0.43 mm, warp 26/cm, weft 24/cm. Results were compared and discussed.*

Keywords: *clothing pattern; woven shirt; body movement; wearing ease; allowance.*

1 INTRODUCTION

The clothing pattern is one of the important tools in the garment industry [1]. A good fit for clothing patterns not only can be graded into different sizes [2] and it will also give consumers wearing comfort and increases sales. Especially in online shopping businesses, the well-fitted garment will decrease returning purchases [3]. Well fitted clothing pattern allows the consumer to move freely without restriction [4] but yet not too loose or too bulky in style to satisfice consumer physical and psychological need. Hence, wearing ease or allowances are needed to build in the clothing [5]. It is essential because when there is no wearing ease, there is a very less air gap between skin and layers of clothing; then the movement will be restricted [6]. However, there is no standard or guideline to show that how much wearing ease should have for any kind of clothing pattern [7]. Expert pattern makers mostly use their experience to estimate wearing ease [8-9]. A lot of researchers have experimented in different methods to find out the perfect fitted pattern: Chan et al [10-11] compared four different clothing patterns from experienced pattern makers statistically and then predicted clothing sizes by linear regression. Fang, et al [12-13] and Sungmin [14] used mesh and geometric modeling to turn 3D patterns to 2D patterns. Wang, et al [15] created a pattern by analyzing between the static state and the dynamic postures. However no wearing trial or questionnaire concerning wearer's real comfort or sensual feeling in their research was done.

In this paper, the goal of the experiment is to find out the relationship between body movement and wearing comfort, then to estimate the suitable amount of wearing ease. The approach is direct interaction with volunteers in the wearing trial. The shirts' samples were pre-estimated with wearing ease and a few cording channels were installed with loose / tight knots on several major moving parts of the upper body. Using communication and adjusting the loose / tight knots on the shirt worn by the subject to find out the balance between movement ease and wearing ease. This work is part of a series of research works that focuses on how different parameters relate to men's shirt patterns; hence to understand more about the shapes of the pattern or even to develop a better and more efficient pattern shapes for men's shirt to improve wearing comfort. Parameters included were: thermal insulation, water vapor permeability, movement comfort and breathability of clothing. Results were collected from different parameters and followed by analysis. Finally, experimenting with pattern drafting should create the ideal clothing pattern for a particular size of a men's shirt in woven fabric.

2 EXPERIMENTAL PART

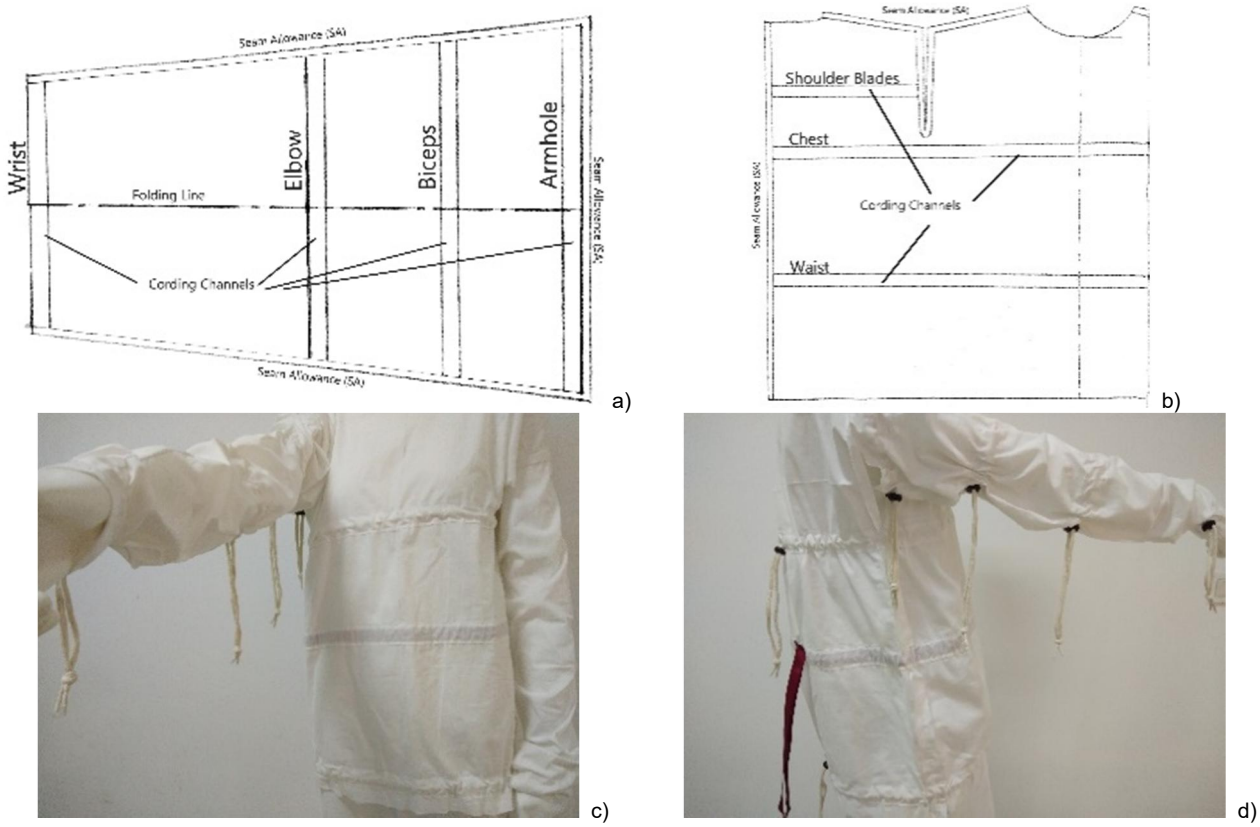
2.1 Materials

Four shirts were prepared by using the total mean values of measurements from 17 Chinese and 22 Turkish volunteers (Table 1). Two of these shirts were added in 3 cm estimated wearing ease and the other two were added in 7 cm. Shirts were made with 100% cotton of 140 g/m^2 in plain weave for each group. All materials were washed and

the fabric was flat-dried to eliminate shrinkage before samples were made. Samples included two long sleeves, left sleeve with cording channels (2 cm wide) on armhole, biceps, elbow and wrist area; the bodice had a round neckline and cording channels were on the back/shoulder blades, around the chest, around the waist and hips (Figures1a and 1b). Sleeve and bodice both have 1 cm seam allowance around. Nylon cording was inserted inside each channel and secured by a plastic loose/tight knot at the end for quick release or tighten wearing ease during the trial.

Table 1 The mean measurements of 17 Chinese and 22 Turkish volunteers and their combined means for pattern drafting

Body measurements [cm]	17 Chinese measurements		22 Turkish measurements		Total mean values of 17 Chinese and 22 Turkish
	Mean	SD	Mean	SD	
Neck	37.4	1.62	39.2	2.1	38.3
Shoulder	14.4	0.62	14.6	1.0	14.5
Shoulder to elbow	32.4	1.32	35.4	1.8	33.9
Shoulder to elbow to wrist	58.7	2.34	62.3	3.3	60.5
Wrist	16.3	0.92	16.7	0.8	16.5
Armhole	44.2	2.98	46.8	3.8	45.5
Biceps	27.5	2.15	29.1	2.3	28.3
Flexed biceps	30.2	2.58	32.0	2.6	31.1
Elbow	25.5	1.01	26.3	1.2	25.9
Front chest	37.0	1.56	40.0	2.0	38.5
Back chest	37.0	2.27	41.0	2.3	39.0
Full chest	86.0	3.61	98.1	5.7	92.05
Deep breath	89.0	3.55	101.0	5.7	94.8
Waist	73.8	4.63	78.9	9.6	76.35
Hips	93.3	3.95	102.4	6.3	97.85



a) b) c) d)

Figure 1 Trial shirt
a) Pattern of sleeve with 1 cm seam allowance and 2.5 cm wide cording channels on moving/expanding parts of the arm
b) Pattern of bodice with 1 cm seam allowance and 2.5 cm wide cording channels on moving/expanding parts of the torso
c) Front view of a sample shirt with cording channels for loose/tight knots on sleeve and bodice
d) Back and side view of a sample shirt with cording channels for loose/tight knots on sleeve and bodice

2.2 Procedures

Step 1 Volunteers were recruited to sign up for the research. Group 1) 43 Chinese volunteers from Zhejiang Fashion Institute and Technology (ZFIT) and group 2) 28 Turkish volunteers from Istanbul Technical University (ITU).

Step 2 Upper body measurements were taken from volunteers. Then according to their mean values of age, weight, and height to choose volunteer for wearing trial. Group 1) 17 volunteers were chosen, group 2) 22 volunteers were chosen (Figure 2).

Also, in Table 2 can be seen the comparison of the mean values of body measurements between group 1 and group 2. Body measurements were including: neck circumference, shoulder width - from neck to shoulder bone (acromion), shoulder to elbow - from the acromion to elbow, shoulder to elbow to wrist - whole arm, wrist circumference, armhole circumference, biceps circumference and after flexed circumference, elbow circumference, front chest - from the left under armpit across the chest to right under armpit, back chest - from the left under armpit across the shoulder blades to right under armpit, full chest - circumference around the fullest chest and the shoulder blades, deep breath - full chest and breath in, natural waist - the circumference around the waist where you bend, hips - circumference around the gluteus maximus to the pelvis to lower stomach, front length - from manubrium of sternum down to the level of hips, back length - from the C7 vertebra of the back neck down to the level of hips.

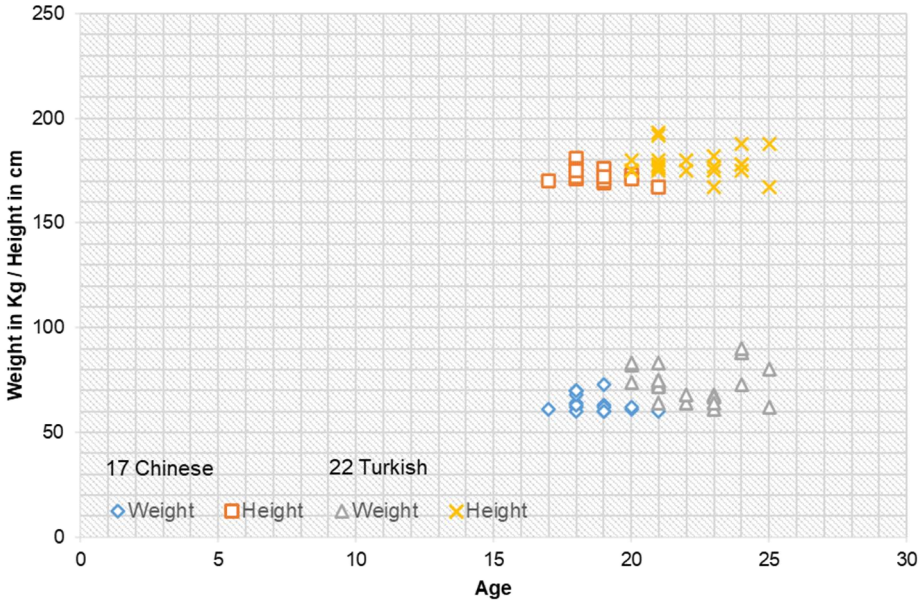


Figure 2 Comparison chart of 17 Chinese and 22 Turkish volunteers' age, height and weight distribution

Table 2 The comparison table of the mean values of body measurements between 17 Chinese and 22 Turkish

Body measurements	17 Chinese	22 Turkish	Different
Age [year]	18.7	22.2	3.6
Weight [kg]	64.0	74.0	9.9
Height [cm]	173.2	178.7	5.5
Neck [cm]	37.4	39.2	1.8
Shoulder width [cm]	14.4	14.6	0.2
Shoulder to elbow [cm]	32.4	35.4	3.1
Shoulder to elbow to wrist [cm]	58.7	62.3	3.6
Wrist [cm]	16.3	16.7	0.4
Armhole [cm]	44.2	46.8	2.6
Biceps [cm]	27.5	29.0	1.7
Flexed biceps [cm]	30.2	32.0	1.8
Elbow [cm]	25.5	26.3	0.7
Front chest [cm]	36.9	40.0	3.0
Back chest [cm]	36.8	41.0	4.2
Full chest [cm]	86.2	98.1	11.9
Deep breath [cm]	88.9	100.5	11.7
Natural waist [cm]	73.8	78.9	5.1
Hips [cm]	93.3	102.4	9.1
Front length [cm]	62.7	59.9	2.9
Back length [cm]	66.0	65.5	0.5

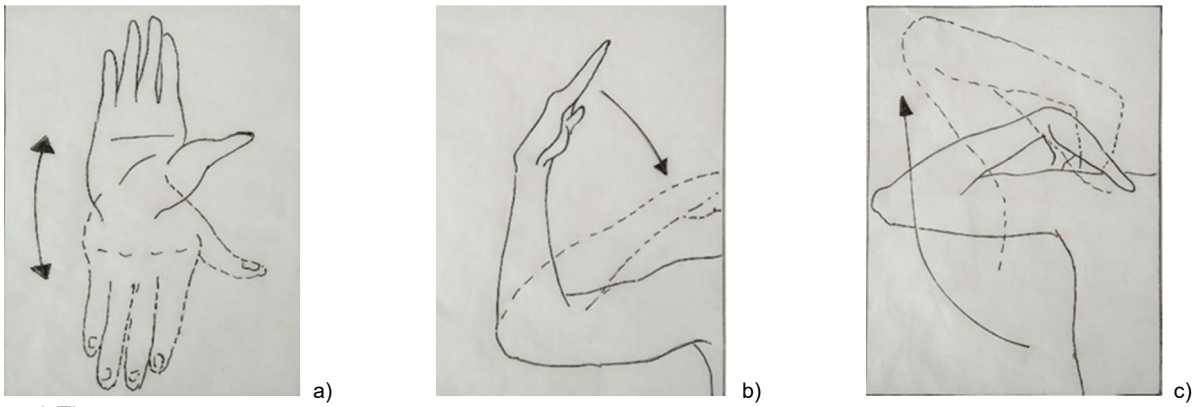


Figure 3 The arm movement
a) Wrist movement- up, down, left, right and rotate
b) Biceps and elbow movement- flexing biceps and bending an elbow
c) Shoulder joint/armhole movement- the whole arm is moving upward, downward, forward, backward and rotate

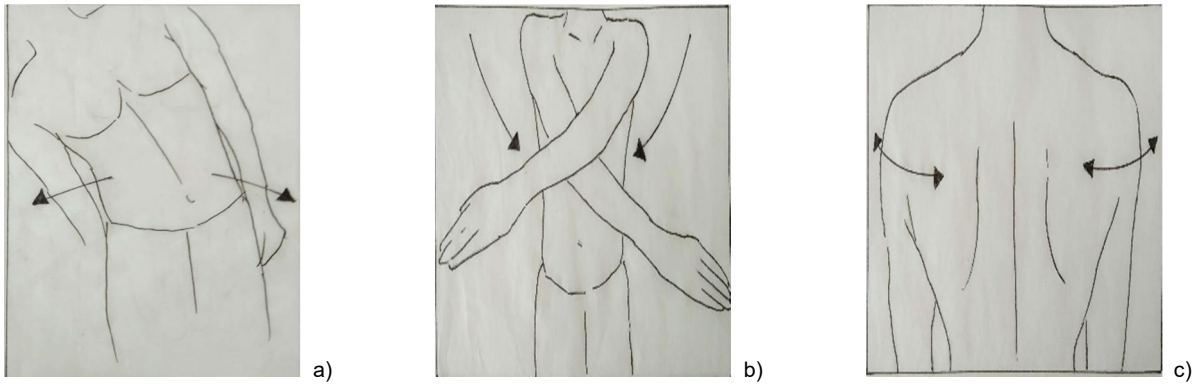


Figure 4 The upper body movement
a) Waist movement- moving waist sideways left and right, bending forward and backward
b) Chest movement- stretching both arms inward, outward and deep breath
c) Back/shoulder blades movement- shrugging shoulders upward, downward, forward and backward

Step 3 Wearing Trial. Each volunteer only wore a light undershirt or bared before he put on the sample shirt. Then he would follow the protocol of movement as the following steps:

The arm movement

(1) Volunteers would be told the goal of the trial was to find out how much of wearing ease would give him comfortable movement for a fitted shirt. This helped volunteer to understand the purpose of the test.
(2) All loose/tight knots were tightened on the arm then the cording would be marked with a water-soluble pen.
(3) Volunteers would follow instructions to move his wrist, elbow, biceps and the whole arm accordingly (Figures 3a-3c).
(4) For each movement, the loose/tight knot would be loosened a bit until the volunteer feels satisfied and comfortable. Then the second mark was drawn on the cording.
(5) The distance between the first and second mark would be the wearing ease of movement which is satisfying the comfort as well as the mobility of the shirt for the wearer.

The upper body movement

The same procedures were applied on the back/shoulder blades, chest and waist (Figures 4a-4c). The loose/tight knot on the hips was only to secure the shirt when the waist movement perform.

3 RESULTS AND DISCUSSION

3.1 Measurements comparison

Group 1) 43 Chinese volunteers were recruited. The mean value of their: age was 18.56 years old, weight was 59.77 kg and height was 170 cm. According to this result, 17 volunteers were chosen for the wearing trial and their mean values increased a bit: ag0e is 18.65 years old, weight is 64.06 kg and height is 173.18 cm. Results from the wearing trial show that the mean value of movement ease needed for the wrist, elbow, biceps and armhole is under 5 cm, chest and waist each needs over 5 cm and back/shoulder blades need the most movement ease which is over 10 cm (Table 3).

Table 3 The mean values and standard deviation of 17 Chinese and 22 Turkish movement ease

Body measurements [cm]	17 Chinese measurements		22 Turkish measurements		Difference
	Mean	SD	Mean	SD	
Wrist	2.2	1.0	1.6	1.2	0.6
Elbow	4.1	1.2	2.8	1.5	1.3
Biceps	3.6	1.2	3.0	1.9	0.6
Armhole	2.6	2.7	1.5	1.9	1.1
Chest	6.3	2.1	5.0	2.5	1.3
Waist	5.6	1.8	4.5	3.0	1.1
Shoulder blades	10.4	3.4	9.0	3.0	1.4

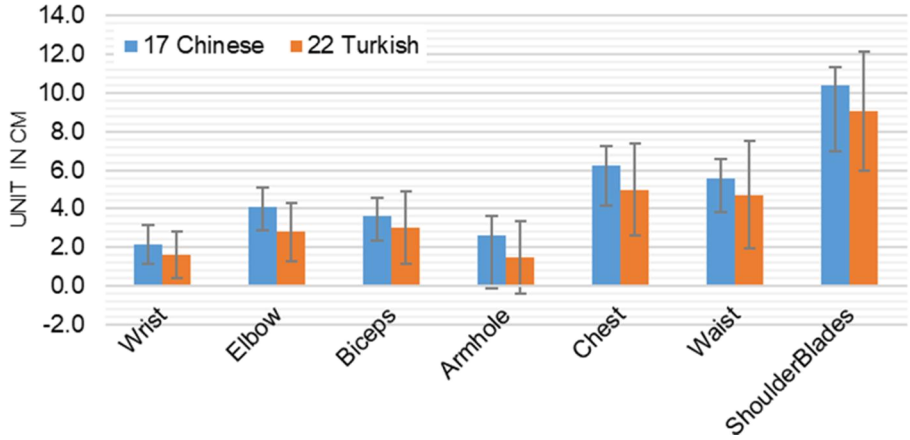


Figure 5 The mean values of difference of movement ease between 17 Chinese and 22 Turkish

Group 2) 25 Turkish volunteers were recruited. The mean value of their: age was 23.76 years old, weight was 75.12 kg and height was 178.24 cm. According to this result, 22 volunteers were chosen for the wearing trial and their mean value of age was 22.23 years old, weight was 74 kg and height was 178.68 cm. Overall the decrease is insignificant. Results from the wearing trial show that the mean value of movement ease needed for the wrist, elbow, biceps and armhole is under 3 cm, chest and waist each needs about 5 cm and back/shoulder blades need the most movement ease which is 9 cm (Table 3). In Figure 5 is shown the comparison of the mean values of movement ease between 17 Chinese and 22 Turkish.

3.2 T-test

To find out the significant difference of movement ease between the Chinese and the Turkish group, 17 out of 22 Turkish volunteers were randomly chosen to match up with 17 Chinese volunteers for the T-test; and the test was done three times. The T-test formula is shown below:

$$t = \bar{x}_1 - \bar{x}_i / \sqrt{S_1^2/n_1 + S_i^2/n_i} \quad (1)$$

where: $\bar{x}_1$ is the mean value of movement ease of each body part from the Chinese group and $\bar{x}_i$ is the mean value of movement ease of body part from one out of three Turkish groups; S_1^2 is the variance of each body part from the Chinese group and S_i^2 is the variance of each body part from one out of three Turkish groups; n_1 and n_i both have 17 volunteers for the T-tests.

The results are in Table 4. The critical *t* value at 0.05 is 1.75, only the elbow movement ease shows the significant difference through all three T-tests (grey areas).

Table 4 The results of T-test

Body measurements [cm]	t 0.05	Test 1	Test 2	Test 3
Wrist	1.75	1.24	2.13	1.64
Elbow	1.75	2.08	2.54	2.29
Biceps	1.75	0.19	0.39	0.95
Armhole	1.75	1.12	1.21	2
Chest	1.75	1.4	1.73	2.76
Waist	1.75	1.27	1.55	1.73
Shoulder blades	1.75	0.29	0.8	1.23

4 CONCLUSIONS

The specially made shirt services two purposes: 1) knowing the actual comfortable point of the wearer, 2) knowing the movement ease that the wearer needs. Cut and sew process is simple but it may take some time to finish. However; the finished shirt can be reuse for a long time and can be transferred to another institute for research purposes. Besides, when comparing the results from group 1 (17 Chinese) and group 2 (22 Turkish), group 2 is 3.67 years older, 9.94 kg heavier and 5.5 cm taller than group 1. However, group 1 has a bigger movement range than group 2 (Table 3) so that a bigger ease allowance is needed for each body part for group 1.

Also, the biggest difference between group 1 and group 2 is around 1.35 cm on the shoulder blades and the smallest differences are on the wrist and the biceps which are 0.58 cm and 0.6 cm respectively. Other body movements' differences are under 1.35 cm. With this result, it shows that race, age, weight and height do not influence the movement ease proportionally. Taller and heavier race does not automatically need a bigger movement range (Figure 5). Overall, from the biggest difference 1.35 cm to the smallest difference 0.58/0.6 cm is not a big amount of differences in clothing pattern drafting. Also, from the T-test; only the elbow movement ease shows the significant difference among three testes. Furthermore, the height and weight of the younger generation of different races are increasing [16] and the differences between the individual races are getting less and less [17]. This is due to different factors as food, work type and climate as well as other factors as income, education and health [18]. This phenomenon is especially clear in modern big cities because of a similar lifestyle. If this trend will continue, it will be possible to develop a new set of men's shirt pattern that can fit a large population of men globally and may even set the new pattern standard for the future generations to come. Fitting a large amount of the population globally is still a major issue to be solved [19]. More works needed to be done.

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