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Changes in the Dimensional and other Properties of Knitted Cotton Vests due to Wear and Laundering

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CHANGES IN THE DIMENSIONAL AND OTHER PROPERTIES OF KNITTED COTTON VESTS DUE TO WEAR AND LAUNDERING*

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ABSTRACT

A range of men's sleeveless cotton vests has been subjected to wearer trials, involving 11 wearers, and to laboratory testing, particular attention being paid to dimensional changes and constants. The shrinkage results obtained in the wearer trials were generally lower and far more variable than those obtained in the laboratory wash test. According to fluidity and bursting strength results, most of the vests suffered some, but not excessive, damage during wear and home laundering.

INTRODUCTION

Changes in dimensions (i.e. dimensional instability) during wear, more particularly during the associated laundering processes have, for a long time, been a problem with knitted cotton garments[1-12] and considerable research and development have been directed towards finding a practical solution to this problem [1, 4, 8, 11–20, 20a]. An associated problem is that of predicting the in-use or wash-relaxed dimensions of knitted cotton fabrics and garments and the routine laboratory measurement of dimensional stability.

Studies in the field of knitted fabric geometry carried out by various workers have shown that, when a knitted fabric is washed and tumble-dried a suitable number of times [1,4,7,12,14,21 – 35] (usually five)[7, 23, 32, 35], it generally attains a fairly stable state (usually referred to as the "fully-relaxed", "minimum energy", "wash-relaxed", or "reference state") after which little further changes in dimensions occur upon washing and tumble drying. For shrinkproofed wool, the dimensions of the fabric in such a stable state are essentially dependent on fabric stitch length and structure and can be predicted fairly accurately using the appropriate dimensional constant (K-values or U-values)[21, 36–39]. From results obtained in a large number of studies [1,2,6,7,14,19,22–24,26–33,40-53] it appears reasonable to conclude, however, that cotton knitted fabrics do not have such a unique, well-defined and reproducible fully-relaxed state and corresponding dimensional constants. In addition to stitch length and structure, relaxed dimensions of cotton knitted fabrics appear to be significantly affected by factors such as yarn linear density and fabric finishing[7,14,23,24,26,27,32,40 – 43]. To

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further complicate matters, the fully-relaxed dimensions of a fabric or garment are probably rarely attained in practical use, considering the laundering and drying techniques commonly used by consumers. Various different test methods and washing machines are used in laboratories to assess the dimensional stability of knitted cotton fabrics [7,34,54–58] but these do not necessarily agree with each other or predict the behaviour of the fabric during service.

This article deals with the question of the changes in the dimensional and other properties of men's sleeveless vests (singlets) during wear (including home laundering) and laboratory washing, particular attention being paid to the correlation between laboratory and actual wear results.

EXPERIMENTAL

Wearer Trial

Three commercial brands of cotton vests (coded A, B and C) two of which (A and B) were interlock structure and one (C) was 1 x 1 rib structure, were included in this study.

For the wearer trial, 11 men of various occupations and sizes, were selected and each given two vests (one each from two of the three different brands). Each wearer was requested to treat (i.e. wear and launder) the vests according to his normal practice and to measure the dimensions of the vest prior to each wear cycle at the four positions (two length and two width) indicated in Fig 1. Eight of the wearers employed machine washing and line drying followed by ironing; one employed an automatic washing machine followed by either tumble-drying or line drying and then steam pressing and the other two employed hand washing and line drying followed by ironing. After 25 wear/laundering cycles the vests were returned to SAWTRI for final testing.

Laboratory Tests

All the vests, worn as well as unworn, were tested in the laboratory for the following properties:

Stitch length, yarn linear density and twist, mass per unit area, courses and wales per cm, bursting strength, cupramonium fluidity, bending length (i.e. stiffness) and air permeability.

The average yarn properties and stitch lengths (SCSL) are given in Table I. Table II gives the dimensional properties and constants and Table III the physical properties.

The laboratory wash test, which was carried out on the unworn vests and also on the worn vests at the end of the 25 cycles, was according to AATCC, TM 135 - IIIB, the results being based upon 10 wash/tumble dry cycles. As in previous studies, it was found that there was little change in fabric dimensions

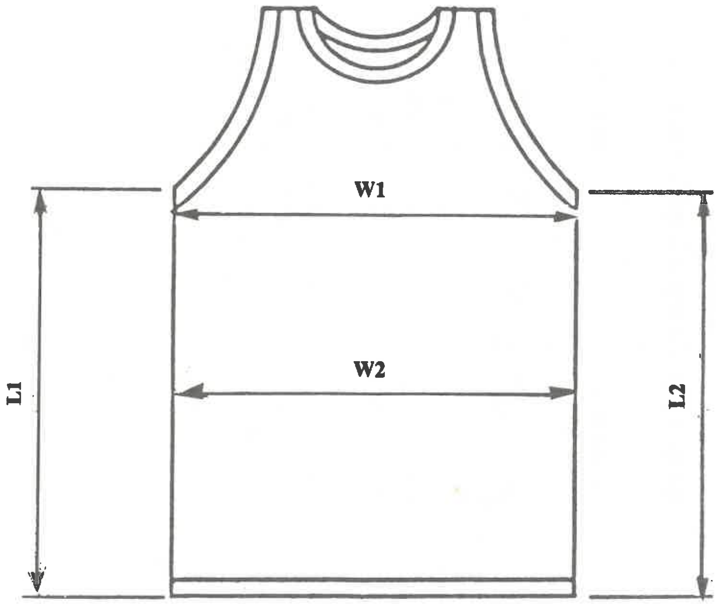

Fig. 1 – Measurement of Vest Dimensions

TABLE I
SOME YARN AND FABRIC DETAILS

	BRAND A				BRAND B			BRAND C		
Size	92	97	102	107	92	102	107	92/97	102	107
Yarn										
Lin. Density (tex)	17,5	17,5	16,5	16,5	15	15	15	17,5	17,5	17,5
Twist (turns/m)	820	820	850	850	850	850	850	900	900	900
Twist Factor*	34,3	34,3	34,5	34,5	32,9	32,9	32,9	37,6	37,6	37,6
Fabric										
SCSL (cm)	1,29	1,28	1,32	1,31	1,22	1,31	1,24	0,51	0,50	0,50
MTF**	13,0	13,1	12,3	12,4	12,7	11,8	12,5	16,4	16,7	16,7

* Twist Factor = turns/cm x $\sqrt{\text{tex}}$

$$**MTF = \frac{n_t \times \sqrt{\text{tex}}}{SCSL}$$

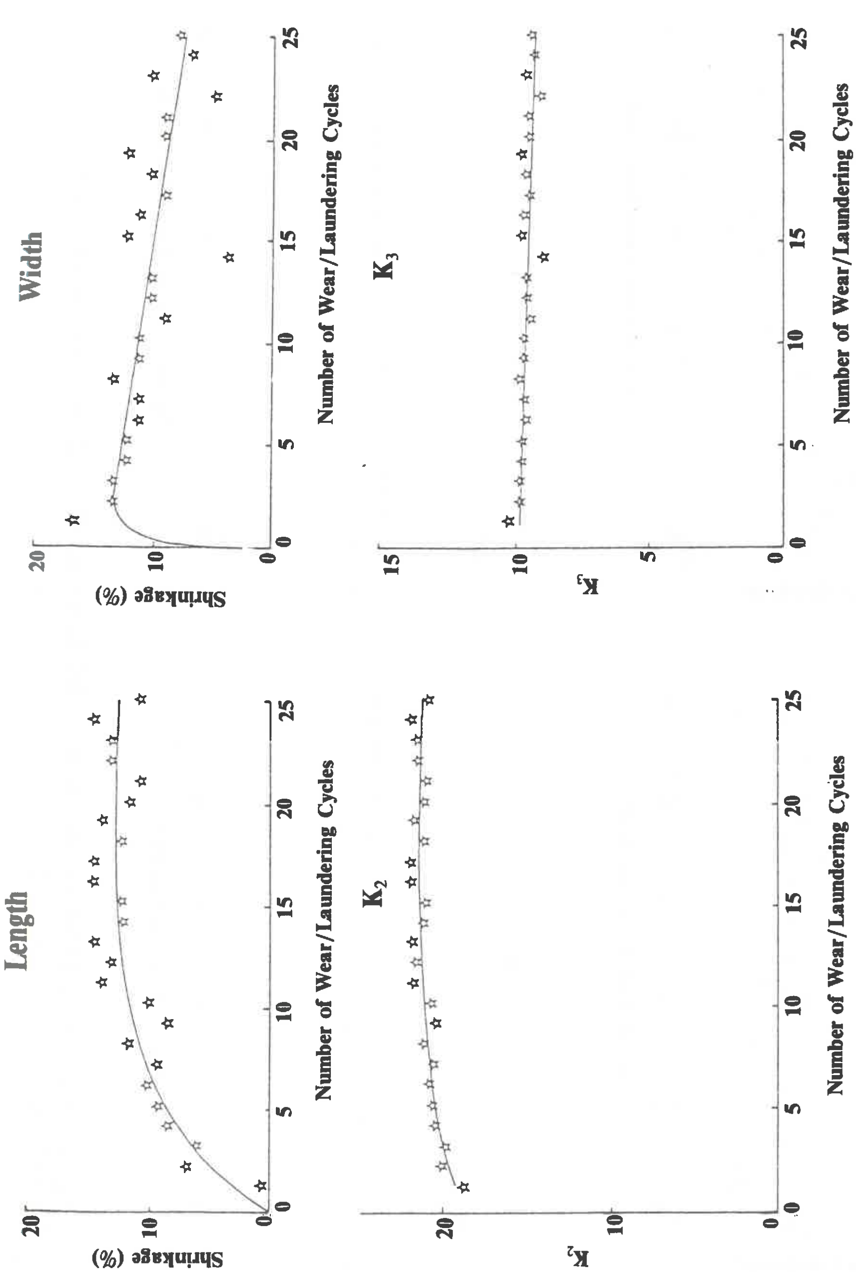

Fig. 2 – An Example of Dimensional Changes with Repeated Wearing and Laundering (Interlock vest).

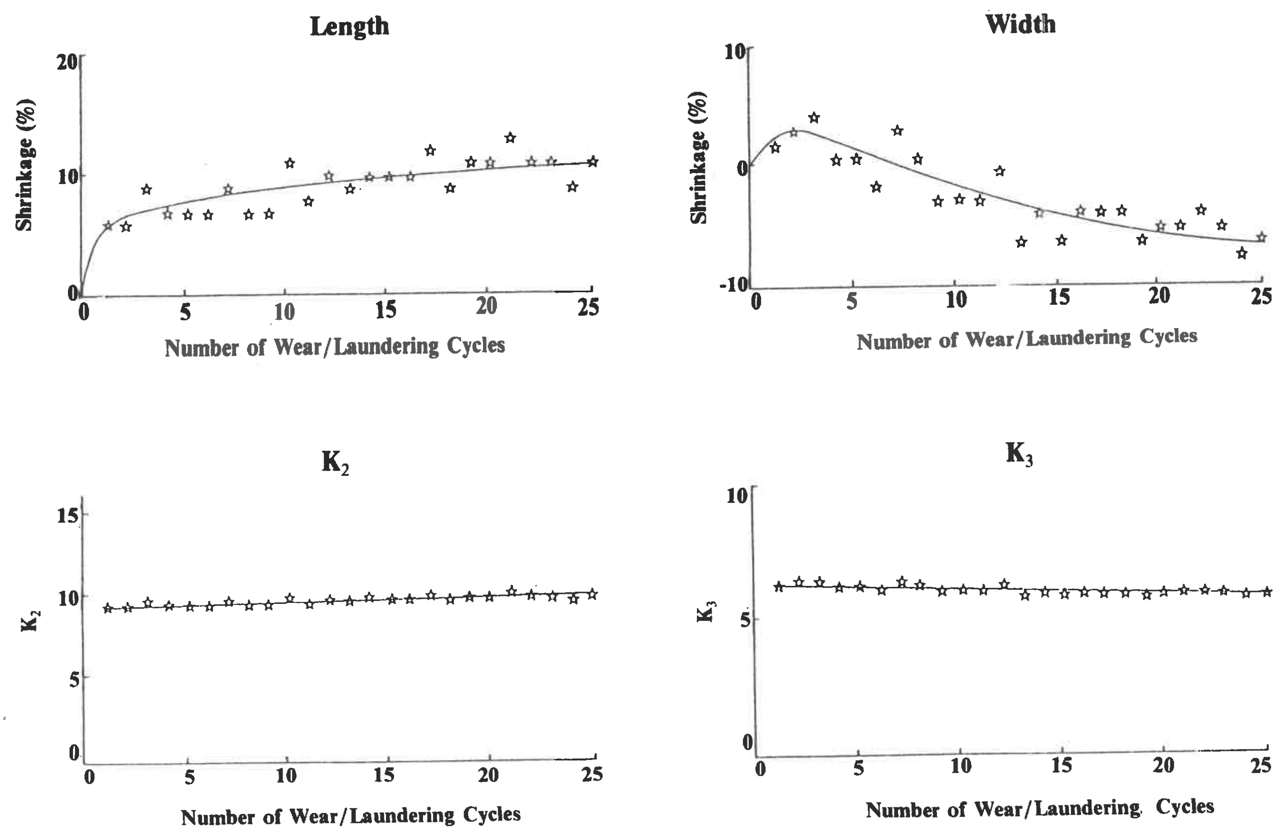

Fig. 3 – Example of Dimensional Changes with Repeated Wearing and Laundering (1 x 1 rib vest).

TABLE IV
AVERAGE SHRINKAGES AND K-VALUES*

		Length (%)	Width (%)	K_1	K_2	K_3
INTERLOCK	Dry-relaxed	—	—	158 (5)	18,2 (2)	8,7 (4)
	Worn**	10,5 (35)	3,2 (217)	183 (11)	20,3 (4)	9,0 (9)
	Laboratory Washed	15,4 (10)	8,1 (69)	204 (6)	21,5 (3)	9,5 (7)
	Worn** + Lab. Washed	18,8 (17)	5,5 (107)	206 (9)	22,4 (4)	9,2 (6)
RIB	Dry-relaxed	—	—	52 (1)	7,8 (2)	6,7 (2)
	Worn**	11,3 (20)	-5,6 (97)	55 (5)	8,8 (3)	6,3 (6)
	Laboratory Washed	15,4 (4)	3,5 (84)	64 (5)	9,2 (2)	6,9 (4)
	Worn** + Lab. Washed	18,5 (13)	-0,9 (653)	63 (5)	9,5 (3)	6,6 (7)

* CV values given in parenthesis

** 25 wear/laundering cycles

for length. The wear results were correlated (r = 0,78) with the laboratory results although the correlation was too low to enable the one set of results to be predicted from the other with the required degree of accuracy.

Dimensional Constants

K_2

According to Table II, the dry-relaxed K_2-values of the various interlock vests were similar and agreed fairly well with values published previously[60]. The values after 25 wear/laundering cycles were, as expected from the shrinkage values, much higher and more variable than the dry-relaxed values (Table IV).

The results in Table IV illustrate the generally greater variability of the wear results compared to the laboratory results and illustrate that the laboratory wash-relaxed dimensions are generally not attained in a wear situation. The K_2-values obtained on the interlock vests after laboratory washing show fairly good agreement with typical wash-relaxed values published previously[60].

K_3

According to Tables II and IV, the average dry-relaxed K_3-value for the interlock structure was slightly lower than that of the worn vests, which in turn was lower than that of the worn and unworn vests washed in the laboratory. The values obtained after laboratory washing show fairly good agreement with the typical wash-relaxed value published previously[60].

The Brand B interlock vests had significantly higher K_3-values than the Brand A vests excepting for the dry-relaxed values. This difference in K_3-values could be due to the differences in yarn linear density and MTF (Table I) or to differences in finishing routines or to a combination of these factors.

With respect to the rib vests (Table IV), the average K_3-value for the worn vests was slightly lower than those for the dry-relaxed and laboratory washed vests. These values are all higher than the typical value reported previously[60].

The CV-values in Table IV again illustrate the higher variability present in the wear test results than in the laboratory test results.

PHYSICAL PROPERTIES

Mass per Unit Area

Consolidation (shrinkage) of the vests during wearing and washing caused a corresponding increase in the fabric mass per unit area, the increase being greater for the laboratory washed samples than for the worn and home laundered samples. The total mass of the vests hardly changed with laboratory washing.

Bursting Strength

When comparing the bursting strength results of the dry-relaxed samples with those of the worn or laboratory washed samples, the consolidation of the vests should be kept in mind since this could affect the results. Here the fabric mass provides a measure of fabric consolidation.

It can be seen from Table III that, in all cases, bursting strength decreased after wear and home laundering in spite of the increased consolidation (mass) of the fabrics. This suggests that some fibre damage occurred during wear and home laundering, this generally being supported by the fluidity results.

The bursting strengths of the vests which had been washed in the laboratory were, with one exception, higher than those of the vests which had been worn and laundered and in some cases they were even higher than the unworn and unwashed vests. The latter was probably due to the washing having consolidated the vests and possibly also having increased the inter-fibre friction.

Air Permeability

Air permeability generally decreased after wearing and home laundering and also after laboratory washing, mainly because the fabrics became more consolidated and increased in mass per unit area. The laboratory washed samples generally had lower air permeabilities than the worn and home laundered samples, this being due to the greater consolidation and mass of the former.

Stiffness

In virtually all cases, the bending length (i.e. stiffness) of the fabrics was increased by wearing and home laundering and also by laboratory washing, the latter generally producing the stiffest fabrics. The increase in stiffness can be ascribed to the increased fabric consolidation and mass and possibly also to increased yarn-to-yarn friction.

Fluidity

The fluidity values of the unworn and unwashed (i.e. dry-relaxed) Brand A interlock vests were very similar, being approximately 8, while those of Brand B were also very similar at around 5. In the case of Brand C, however, the fluidities of the unworn and unwashed vests varied widely, ranging from about 9 to about 39. Wear, together with home laundering, in most cases increased the fluidity values, indicating that some chemical damage had taken place during wear and home laundering. In most cases the fluidities of the worn and home laundered samples were higher than those of the laboratory washed samples.

SUMMARY AND CONCLUSIONS

Wearer trials, involving different brands of men's cotton vests and 11 wearers, have shown that, the length shrinkages recorded after 25 wear/laundering cycles were generally lower than those recorded on the unworn vests after the laboratory wash test. The difference was up to 10% (absolute) and averaged about 5% absolute. The results obtained after wear and home laundering were more variable than those obtained after laboratory washing and the two sets of results were not correlated. This illustrates the difficulty of attempting to develop a laboratory test which will correlate with wear. One solution appears to be to use a laboratory test which measures the maximum dimensional changes involved in achieving a stable (or equilibrium) state and then to apply a correction factor so as to approximate the dimensional changes under "average" wear/home laundering conditions. Such a laboratory test could involve five or more wash (or rinse) and tumble dry cycles and the correction factor with which the laboratory length shrinkage values must be multiplied could then be something like 0,65.

The width shrinkage values were found to be far more variable than those for length shrinkage, the values depending greatly upon the brand of vest.

The bursting strength of all the vests decreased after wear and home laundering in spite of the fact that the fabrics had become more consolidated (i.e. had increased in mass per unit area because of shrinkage in area). This, together with the fluidity results, indicate that the fibres had suffered some chemical damage. All the vests increased in stiffness and decreased in air permeability after wear and home laundering and also after laboratory washing, mainly due to the fabrics having consolidated and increased in mass.

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