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A Comparison Of The ICI Pillbox And The Random Tumble Methods Is Assessing Pilling And Appearance Change Of Worsted Spun Cashmere And Cashmere-Wool Blend Knitwear

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A Comparison Of The ICI Pillbox And The Random Tumble Methods In Assessing Pilling And Appearance Change Of Worsted Spun Cashmere And Cashmere-Wool Blend Knitwear*

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Abstract

This study evaluated the differences between two international test methods on the assessment of pilling and appearance change of worsted spun cashmere and superfine wool knitwear and their blends. Differences between the standard ICI Pill Box Method and the Random Tumble Method were found in both the significance and magnitude of resistance to pilling and appearance change and the amount of fabric mass loss of worsted spun cashmere and cashmere superfine wool blend knit fabrics. The ICI Pill Box Method differentiated to a greater extent the effects of wool type and blend ratio of cashmere and wool compared with the Random Tumble Method. Generally the addition of cashmere or low crimp superfine wool resulted in fabrics being more resistance to pilling and appearance change compared with fabrics made from high crimp superfine wool. This was associated with increased fabric mass loss when assessed by the ICI Pill Box Method but not with the Random Tumble Method. **KEYWORDS:** Cashmere, crimp, wool, pilling, appearance change, knitwear

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A Comparison Of The ICI Pillbox And The Random Tumble Methods In Assessing Pilling And Appearance Change Of Worsted Spun Cashmere And Superfine Wool Knitwear And Their Blends

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Introduction

Pilling is the progressive appearance, during wear, of small balls of fibre on the surface of garments. Pilling occurs most rapidly where friction is greatest. Bending, torsion and rubbing cause fibres to migrate to the surface of yarns and then to entangle, sometimes with contaminants, rolling into balls which are secured to the fabric surface by several anchoring fibres. Fibre migration is easier in knitted fabric, as a result of lower cohesive forces in lower twist yarn, compared with worsted woven fabric. The propensity to pill is a balance between pill formation and the removal of formed pills due to abrasion. Practically all the fibres in pills are broken fibres and the mean diameter of fibres in pills is finer than that of the fibres in the yarn (Anon 1965, Stryckman 1972).

There are many raw wool fibre properties that have been implicated in the cause of pilling but the presence of long strong fibres to act as anchors is important as is the structure of the yarn and fabric. Superfine and ultrafine wools pill more easily than coarser wools. By treating superfine and ultrafine wool with synthetic polymers or chlorine to reduce felting, propensity to pill is reduced but the handle of the wool is also reduced and the treated wool is perceived as being harsher than non-treated wool (Robinson 1998).

Cashmere is often blended with superfine wool for worsted woven fabrics but in knitwear, pure cashmere is frequently used in preference to blends. Cashmere knitwear is usually made from woollen spun yarns. Cashmere and wool have different fibre surface properties that may affect the propensity to pill when cashmere wool blends are worsted spun. There is no specific objective information available on the properties of cashmere and cashmere blends with wool on worsted spun knit fabric attributes.

The present work was part of a larger study undertaken to evaluate pilling and appearance change in cashmere and cashmere superfine wool blend worsted spun knit fabrics (McGregor 2001). The difference between test methods was evaluated in the absence of information on the performance of each test methods with worsted spun knit fabric made from cashmere, superfine wool and their blends.

Materials and Methods

The study was a replicated experiment with nine treatments each of three replicates. The design was: Blend / (Wool type x Blend ratio) x 3 replicates. **Blend** had two levels: **Control (CM)**, specified as 100% Australian cashmere; **Blends**, blends of cashmere with wool and the pure wool treatments. **Wool type (WT)**, wool type had two levels: **SW**, standard high crimp fine wool tops; **LCW**, soft

handling low crimp fine wool tops. **Blend ratio (BR)**, referred to blend ratio and had four levels specified as: 75, 50, 25 and 0 referring to the percentage of cashmere in the blend. In the graphical presentation of results, BR 100 refers to the control, CM. Each replicate had a different tightness factor applied to the plain knit fabric.

All fibre was processed into separate tops and combed. The tops were allocated before blending at random into three replicates and treatments. Yarn (18 tex) was spun on a Zinser RM 421E1 spinning frame with a SKF drafting set and a 48 mm diameter ring using a twist factor of 3487 (822 tpm) to produce a strong yarn. Yarns were autoclaved after spinning and again after two folding the yarns using the following cycle: Vacuum at – 88 kPa; Steam 87.5°C; Hold 5 minute; Exhaust; Repeat cycle twice; Vacuum – 88 kPa; Exhaust; End of cycle; Cycle length 15 minutes. The autoclaved two folded yarns were waxed and wound. Knitting was conducted in standard conditions (20 ± 2 °C, RH $65 \pm 2\%$). Knitted plain jersey fabrics were constructed on a circular 23 gauge knitting machine to three different cover factors of 1.20, 1.32 and 1.45 by altering loop lengths. Fabrics were dried in an oven at 50°C for 8 hours and reconditioned for more than 4 weeks prior to sampling and testing.

The raw wool properties and those of the tops are provided in Table 1 and some have previously been provided (McGregor and Postle 2002).

Table 1. Attributes of greasy wool and processed tops for cashmere, low curvature (LCW) and standard high curvature (SW) superfine wool with the significance of difference between wool types (P)

Textile attribute	Fibre type			P
	Cashmere	LCW	SW	
Mean fibre diameter, μm	16.9	17.4	17.2	
Mean fibre diameter CV, %	20.5	19.9	18.3	
Staple crimp frequency/cm	3.2 ¹	3.8	7.2	< 0.001
Fibre curvature, °/mm	52	74	114	< 0.001
Resistance to compression, kPa	5.8	7.4	10.4	< 0.001
Total neps /100 g	9	138	246	< 0.001
Hauteur, mm	42.0	47.0	50.5	< 0.001

¹ Cashmere fibre crimp frequency

The following fabric tests were undertaken using standard conditions where appropriate;

1. Resistance to pilling and change in fabric appearance (ICI Pill Box Method, ISO 2000a). New cork liners were installed prior to the testing. Treatments were randomised within replicates prior to testing. The change in knitted fabric appearance was assessed after 14,400 revolutions.
2. Pilling resistance using the Random Tumble Method (ISO 2000b) was determined using a test period of 30 minutes.

An experienced independent observer was used to assess three fabric samples after each test using standard SM 54 Botany wool photographs for knitted fabrics in the absence of standard cashmere photographs. Mass loss was determined by drying and reconditioning samples before and after the test using standard procedures. For the ICI Pill Box Method mass loss was only determined in pure wool and pure cashmere samples following a separate test cycle.

Data were analysed using ANOVA analysis (Genstat Committee 2000). Results given in the text include the standard error of difference between means (sed). The subscript on the sed value indicates to which main effect comparison the value refers. Main effect comparisons include all blend ratios within a particular wool type. Most results have been graphed. Plotted with the control treatment (pure cashmere) are error bars indicating the effective standard error (ese) for the comparison of any two means using the sed for the Blend.WT.BR interaction (Genstat Committee 2000). The $ese = sed/\sqrt{2}$.

During analysis, the data were tested for linearity and curvature. Depending on the significance of these tests, the plotted graphs have been fitted with either:

1. two straight lines; indicating an effect of WT and an effect of BR. If these lines are parallel then the effect of BR was the same for each WT but if the lines have different slopes then there was an interaction of BR with WT;
2. separate curves; indicating a quadratic effect of BR and an effect of WT. If these lines are parallel then the effect of BR was the same for each WT but if the lines have different slopes then there was an interaction of BR with WT.

General linear regression analysis was used to determine the correlation between the two test methods and any additive significance of other parameters was tested (Genstat Committee 2000).

Results

ICI Pill Box Method

Compared with pure cashmere fabrics, fabrics made from Blends had significantly reduced resistance to pilling score ($P < 0.015$). Wool type affected resistance to pilling score with LCW having higher resistance to pilling scores than SW ($P < 0.05$). Increasing BR increased resistance to pilling score ($P < 0.001$, Figure 1). A BR x WT interaction showed that there were different responses to BR with each WT ($P < 0.005$). There were significant differences between wool types at BR0 and BR25 ($P < 0.05$). The main effects (all blend ratios combined) for wool type on the resistance to pilling and appearance change score were: CM 3.7, LCW 3.3, SW 3.0; sed_{CM-WT} 0.22; sed_{WT} 0.14.

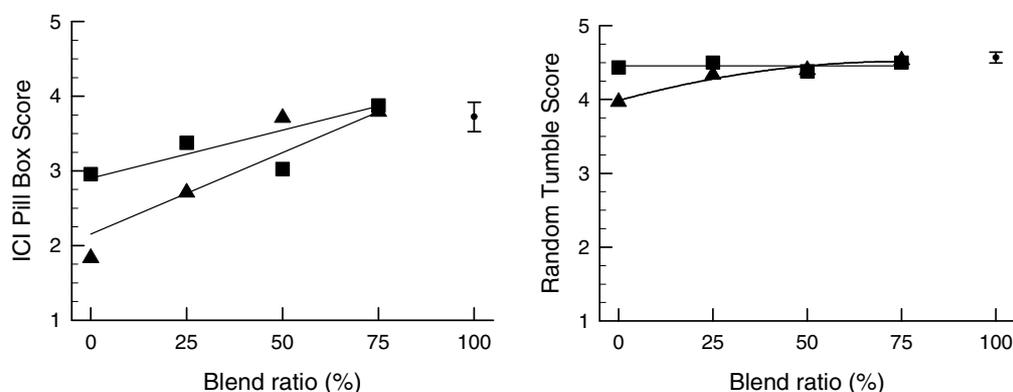


Figure 1. The resistance to pilling and appearance change scores following testing using the ICI Pill Box Method or the Random Tumble Method of fabrics made from R36 tex/2 yarns of different superfine wool types and blend ratios with cashmere knitted into plain jersey fabrics. The higher the score the greater the resistance to pilling and change in appearance. Blend ratio 100% refers to pure cashmere and shows the effective standard error for comparisons between treatments.

Symbols: ■ Low crimp wool; ▲ Standard wool; ● pure Cashmere

The high resistance to pilling scores, indicating low incidence of pills, were associated with higher fabric mass loss (Table 2).

Table 2. The mean loss of mass during ICI Pill Box Method testing and the treatment mean resistance to pilling and appearance change score for knitted fabrics (cover factor 1.32) made from worsted spun pure cashmere and pure wool

Fabric composition	Mean mass loss (%) \pm (SD)	Treatment Mean Score
100% cashmere	1.25 (0.28)	3.8
100% low crimp wool	0.86 (0.19)	2.6
100% standard wool	0.67 (0.23)	1.9
sed; Probability	0.13; P = 0.01	0.29; P<0.05

Random Tumble Method

Compared with pure cashmere fabrics, fabrics made from Blends had significantly reduced resistance to pilling and appearance change score ($P<0.05$). Wool type affected resistance to pilling and appearance change score with LCW having higher scores than SW ($P<0.015$). Increasing BR increased resistance to pilling and appearance change score ($P<0.005$, Figure 1) with significant differences between wool types. A BR x WT interaction showed that there was no effect of BR with LCW but increasing BR with SW improved resistance to pilling and appearance change score ($P<0.05$). At BR0, SW had a significantly lower resistance to pilling and appearance change score than LCW ($P<0.05$). The main effects (all blend ratios combined) for wool type on the resistance to pilling and appearance change score were: CM 4.6, LCW 4.5, SW 4.3; sed_{CM-WT} 0.08; sed_{WT} 0.05.

There was no significant differences between Blends and wool types in fabric mass loss, CM 1.20, LCW 1.40, SW 1.36; sed_{CM-WT} 0.10; sed_{WT} 0.07; $P<0.1$. While BR significantly affected fabric mass loss, this occurred because BR75 fabrics lost more mass (1.63%) than both pure cashmere (1.20%) and other blends (1.30%) (sed_{CM-WT} 0.11; sed_{WT} 0.09; $P<0.005$).

Correlation between the test methods

A simple linear regression between the scores from two test methods accounted for 42% of the variation between the methods (Table 3), however this was not the most significant relationship. A multiple quadratic relationship existed between the scores from each test method accounting for 60% of the variation. The following factors and attributes were not significant in improving this relationship: blend, wool type, blend ratio, cover factor, mean fibre diameter, fibre diameter coefficient of variation, fibre curvature, total neps, the interaction of (ICI Score x Hauteur) and (Hauteur)². The final regression indicated that increasing hauteur marginally reduced Random Tumble Score.

Table 3. Regression constants, correlation coefficients and probability (*P*) for relationships between the ICI Pill Box Method Score and the Random Tumble Method Score for resistance to pilling and appearance change in cashmere, superfine wool and blends of the two fibres.

(Pooled data, n = 27)

Dependant variate	Fitted parameters	Estimate	se	RSD	R	<i>P</i>
Random Tumble Score	Constant	3.851	0.126	0.152	0.65	<0.001
	ICI Score	0.171	0.0381			<0.001
Random Tumble Score	Constant	4.508	0.706	0.127	0.77	<0.001
	ICI Score	0.678	0.0224			
	(ICI Score) ²	-0.0956	0.0368			0.016
	Hauteur	-0.0271	0.0117			0.029

Discussion

Under the test conditions applied, the ICI Pill Box and the Random Tumble methods differed in both the significance and magnitude of responses to appearance change and pilling and in the loss of fabric mass. While the Scores from these test methods were correlated, under the test conditions applied, the ICI Pill Box Method differentiated to a greater extent the effects of wool type and blend ratio of cashmere and wool compared with the Random Tumble Method.

In the present work, pure cashmere and low crimp wool were associated with a significant improvement in resistance to pilling and appearance score when determined with the ICI Pill Box method. Increasing the content of cashmere improved resistance to pilling score. Using low crimp wool instead of standard high crimp wool also improved resistance to pilling and appearance change score.

Fibre type was associated with differential fibre loss in the ICI Pill Box Method indicating that the increasing resistance to pilling score as fibre type changed and/or blend ratio was increased was associated with loss of either the pills or fibre. These data therefore do not indicate the lack of pill formation *per se*.

Under the test conditions it would appear that the ICI Pill Box Method may be the preferable standard for the assessment of pilling and appearance change in cashmere and cashmere-wool blend knitwear compared with the standard Random Tumble method. Further work is required to optimise the time to

detect pill formation. In the present work, when fabric mass loss was used in combination with the ICI Pill Box Score a more complete assessment of fabric changes was obtained. These conclusions compare favourably with those of Li and Zhou (2004) who evaluated pilling of woollen spun pure Chinese cashmere knitwear with a mean fibre diameter of 15.4 μm , mean fibre length 32 to 37 mm and yarn count of 31 x2 to 56 x 2 tex. However Li and Zhou (2004) reported that the ICI Pill Box Method was preferred over the Random Tumble and Martindale abrasion tests which were regarded as being too severe, the opposite of the findings in this study.

Conclusion

There were differences between the methods used for the assessment of resistance to pilling and appearance change in worsted spun cashmere and cashmere wool blend knit fabrics. Generally the addition of cashmere or of low crimp superfine wool resulted in fabrics being more resistant to pilling and appearance change compared with high crimp superfine wool and this was associated with increased fabric mass loss when assessed by the ICI Pill Box Method.

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