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Development of a laboratory test for knicker tearing re-creation studies

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ABSTRACT

False sexual assault and rape claims result in wasted forensic and police resources and stigma for the alleged offender. In this work a laboratory method was developed to (i) recreate the ripping of knickers and (ii) measure the force required to rip the garments. The effect of laundering was considered as a means to mimic age of garment, and the effect of speed of ripping was used as a measure of forcible removal of garments. Whilst laundering resulted in visual damage to the thongs, it did not affect the mechanical properties. Faster test speeds resulted in higher measured forces and increased levels of damage. This may allow comment to be made regarding the level of force used during an attack.

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1. Introduction

Sexual assault is the most rapidly growing violent crime [1]. The legal definition of sexual assault in the UK is "A person (A) commits an offence if (a) he intentionally touches another person (B), (b) the touching is sexual, (c) B does not consent to the touching, and (d) A does not reasonably believe that B consents." [2]. Rape is defined as "A person (A) commits an offence if (a) he intentionally penetrates the vagina, anus or mouth of another person (B) with his penis, (b) B does not consent to the penetration, and (c) A does not reasonably believe that B consents." [2]. During an alleged sexual assault or rape of a female, knickers are often damaged. Knickers are "a woman's or girl's undergarments covering the body from the waist or hips to the top of the thighs and having leg-holes or separate legs" [3].

In 2013–2014 there were 67,805 sexual offences against children and adults in England and Wales, a reported 21% increase compared to 2012–2013 [4]. Current offences (as opposed to historic offences) accounted for 73% of these instances [4]. Instances of rape increased by 29% (n = 22,116) and other sexual offences by 18% compared to the previous year [4]. In the UK during 2008–2009 nearly 8,000 claims were made for compensation in relation to sexual offences, and involved a total of over £40 million [5]. Internationally, rape is reportedly one of the most under-reported crimes; it has been estimated that only approximately 15% of women who are raped report the attack to the police [4,6]. Reportedly, 44% of sexual assaults/rapes involve the use of significant force with general body trauma occurring in approximately 70% of cases [7–9]. Thus sexual assaults/rapes are generally associated with a high level of violence.

A false allegation of sexual assault or rape can be defined as "the intentional reporting of a forcible rape or assault by an alleged victim when none has occurred" [10]. It has been suggested that the frequency of false reports of sexual assault/rape is higher than for any other criminal act e.g. [6,11].

Females are more commonly subjected to sexual assaults/rape (86%–99% of all reported cases) although male rape is known to be severely under reported [4,5,8,9]. Highest rates occur in the 16 year–25 year age group [8,9]. The most likely piece of clothing to be presented to textile damage examiners during a sexual assault/rape investigation is the victim's underwear [12,13]. In the UK, the majority of underwear submitted to LGC's laboratories with respect to sexual assault/rape casework is from females and of the thong (g-string) style [13]. Information on victims' ages is important as it informs the likely size of knickers worn by victims; therefore national anthropometric data sets are useful. Anthropometric data for 16 year–25 year old women living in the UK are not easily accessible, but a 2009 study cited the mean circumference of a British woman's waist as approximately 870 mm, making the average dress size a UK 16 [14]. However, the same study also

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stated that the rate of obesity is lower in the 16 years–25 years age range. Therefore, it seems reasonable to assume that a UK female aged 16 years–25 years is likely to wear knickers that are smaller than UK 16.

Ripping of knicker fabrics with reference to alleged sexual assaults has been investigated [15]. Fibre content and age of fabric (described by the number of laundering cycles undergone) affected tearing behaviour. Torn fibre ends appeared similar to those previously observed when examining textile damage caused by sharp-weapon impacts, suggesting investigating fibre end morphology could lead to conflicting information. That fabric properties (including strength) and textile damage to fabrics are affected by laundering is well recognised e.g. [16–18]. Seam properties are also affected by laundering e.g. [19,20]. Thus understanding how laundering affects tearing of knickers is critical.

The aim of the work summarised in this paper was to develop a laboratory test to recreate the forcible ripping of knickers.

2. Materials and methods

2.1. Materials

White 100% cotton size 12–14 women's thongs[1] were used in this work (n = 5 per pack; n = 120 garments). A fibre content/care instruction label was sewn into the left side seam of each garment. The thongs typically measured waist = 650 mm, leg holes = 590 mm and length from the waist band to crotch-seam = 120 mm (Fig. 1). Garments were randomly assigned to one of three different batches for laundering (0, 6, 60 cycles).

2.2. Methods

2.2.1. Laundering

Garments were laundered using a domestic washing machine[2] with a 40 minute cycle at 50 °C; detergent was not used. The laundering regime was informed by the care label sewn into the garments. Three laundering regimes were considered to represent different levels of garment age (i) 0 cycles (as-new), (ii) 6 cycles (dimensionally stable) and (iii) 60 cycles (over one year of use, assuming laundered once a week). On removal of the garments laundered for 6 cycles from the washing machine, 500 g of 100% cotton single jersey fabric ballast[3] (160 g/m^2) was added to ensure the same total mass in the washing machine for the following 54 laundering cycles for the 60 cycle garments.

2.2.2. Physical properties

The effect of laundering on garment mass and fabric thickness was determined. Garments were conditioned according to ISO 139:2005 [21] and mass of garment and thickness of fabric (50 mm from the waistband front centre of garment) were recorded using a Sartorius balance and a Mitutoyo thickness gauge respectively.

2.2.3. Tensile properties

Tensile testing was performed using an Instron 5567 fitted with a 1 kN load cell. Four test speeds were used (i) 50 mm/min, (ii) 100 mm/min, (iii) 200 mm/min and (iv) 400 mm/min in an attempt to mimic different levels of applied force. Prior to testing, specimens were conditioned according to ISO 139:2005 [21]. Garments were tested using a custom designed and manufactured fixture for the Instron. The fixture was in two parts (i) a stylised pelvis (representing the body segment between the waist and crotch) on which whole garments could be placed and that was bolted to the base of the Instron and (ii) a stylised hand that was fitted to the crosshead of the Instron and hooked under the centre front waistband of the thong (Fig. 2). By moving the crosshead vertically, thongs were ripped off the pelvis allowing the force and extension involved during ripping of the garments to be measured. A randomised block experimental design was used to investigate the effects of laundering (n = 3 levels) and test speed (n = 4 levels) on whole garment tensile properties (n = 10 replicates for each level of laundering and test speed; n = 120 tests in total). Reference data was collected to assess variability among blocks (thongs; as received; 50 mm/min). During testing, a graph of force vs. extension was generated using Bluehill 2 software. The force (N) required and work done (J) to initiate tearing, and the maximum force (N) were obtained using custom written macros (Visual Basic v 6.5) (Fig. 3).

Fig. 1. Thong.

2.3. Analysis

Specimens were photographed after tensile testing using a Nikon D90 camera (Nikon DX AF-S NIKKOR 18-105 mm lens). Selected specimens of fabric and seams removed from new and laundered thongs were mounted on 20 mm aluminium stub using carbon tape, sputter coated with gold palladium using an Emitech K575X Peltier-cooled high resolution sputter coater, and examined using a JEOL field emission scanning electron microscope (FE-SEM) (1.5 kV; 8 μA; 15 mm working distance).

Descriptive statistics (mean, standard deviation (s.d.), coefficient of variation (CV)) were calculated for the physical and mechanical properties. Analysis of variance (ANOVA) and Tukey's HSD test were used to determine significant differences due to laundering and test speed (when appropriate) on the physical and mechanical properties of specimens (IBM SPSS Statistics 21). All data was checked for normality and equality of variance, and these were considered satisfactory.

3. Results

3.1. Physical properties

The effect of laundering on the physical properties of the thongs is summarised in Table 1. Garment mass was not affected by laundering ($F_{2,\ 117}$ = 2.23, p = NS). Mean garment mass was 12.52 g (s.d. = 0.51 g). Fabric thickness was affected by laundering ($F_{2,\ 117}$ = 136.56, $p \leq 0.001$). Mean fabric thickness for as-new garments was thinner (0.41 mm, s.d. = 0.02 mm) compared to garments that had been laundered (6 cycles = 0.49 mm, s.d. = 0.03 mm; 60 cycles = 0.49 mm, s.d. = 0.02 mm). This change

[1] Primark, Swindon, Wiltshire, SN1 1JQ, UK
[2] Hotpoint WF540 washing machine, Aquarius 6 kg with 1400 spin
[3] Fabric Magic, 14 Silver St, Trowbridge, Wiltshire, BA14 8AE, UK

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