Performance evaluation of the children's sleepwear against hot water splash

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Background and Problem. Tragically, 24% of all burn injuries in United States occur in children, and burn deaths were the 3rd and 5th among all injury deaths in children aged 5-9, and 1-4 years respectively during the period of 2011-2015 (Burn Association, 2018). Contact with hot liquid and hot surface are the most common cause of burn injury among children younger than 5 years of age (Stewart et al., 2016). Considering the distressful physical, psychological, and financial consequences faced by a child or the family for the burn injury, US consumer product safety commission has enforced children's sleepwear safety regulations in Flammable Fabrics Act (FFA, 16 CFR 1615 and 1616) requiring them to pass vertical flammability test. However, the protection performance against hot liquid exposure, a common cause of child burn injury, has never been studied or regulated. The objective of this research is to examine, for the first time, the hot splash protection provided by the commercially available children's sleepwear.

Experimental Design. Three types of commercially available children's sleepwear, knitted in different fabric structures (jersey, interlock, and fleece) with different fiber composition, were used in this study. *Physical properties* of the fabrics were determined with precision balance (MS104S, Mettler Toledo, Switzerland) for the fabric mass density, and compressometer (Frazier, USA) for the thickness of the fabrics. The flammability of the fabrics, as-purchased and after 50 washing and drying cycles, was tested by using *Vertical flammability* tester following the guidelines of ASTM D 6545-10. Protection performance against *hot splash* was tested following the guidelines of ASTM F2701-08 (Lu, Song, Ackerman, Paskaluk, & Li, 2012). Hot water at 85°C was sprayed on the fabrics for 10 seconds, and the heat energy transmitted through the fabrics was measured with three sensors positioned at different height. The 2nd degree burn (Burn involving epidermis and part of dermis layer of skin) time for 5 replications was measured by using Stoll burn injury curve (Stoll & Greene, 1959).

Results and Discussion. The physical properties of the children's sleepwear fabrics are presented in Table 1. The fabrics were made of polyester and a cotton rich blend of cotton/modacrylic fibers in three fabric structures including jersey, interlock and fleece in varied weight per square area. All the fabrics under study, as-purchased and after laundering, passed the vertical flammability test. The critical burning behavior exhibited by the fabrics are presented in Figure 1. Cotton/modacrylic fabrics were not much affected structurally by the flame, but both

polyester fabrics exhibited dangerous molten polymer hazard to the wearer in a short-term exposure of 3 seconds.

Table 1. Physical properties of the fabrics.

Fabric description	Thickness (mm)	Fabric mass (g/m^2)
Polyester Jersey (100 %)	0.47 ± 0.02	1.81 ± 0.06
Polyester Fleece (100 %)	0.79 ± 0.05	1.72 ± 0.03
Cotton / Modacrylic Interlock (55/45)	0.75 ± 0.01	2.70 ± 0.05

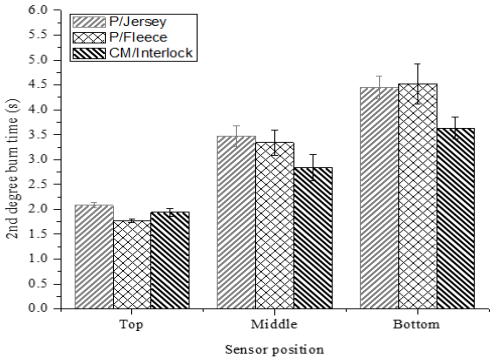

Figure 2: Time (s) for 2nd degree burn.

All the fabrics under study exhibited very poor resistance to hot splash, and there are not significant differences among them. Figure 2 provides the 2nd degree burn time (seconds) upon hot water exposure for 10 seconds at each of the three sensor positions. The general trend, as expected, was the increase of 2nd degree burn time with the progressive low measurement positions. A 2nd degree burn occurred in the place of exposure (position of top sensor) as soon as 2 seconds; at a lower position (middle or bottom sensor), it took a little longer (3-5 seconds). Cotton/modacrylic fabrics exhibited poorer protection than the polyesters due to the instantaneous hot water absorption of the cotton fibers.

Figure 1: Fabric response in vertical flammability tester. Fabrics from left to right are p/ jersey, p/fleece, and cotton/modacrylic (C/M) interlock.

Figure 3: Surface wetting of the fabrics after hot splash. Fabrics from left to right are p/ jersey, p/fleece, and C/M interlock

However, visual examination of the hot water spread behavior of the specimens (Figure 3) provided important insight into fabric performance. Polyester fabrics, due to better wicking property, spread hot water faster in both horizontal and vertical directions. As a result, a larger body surface area of the wearer would get burnt quickly. On the other hand, cotton/modacrylic interlock fabrics, due to cotton excellent absorption of water and high thickness of the interlock structure, less body surface area was affected, indicating superior splash protection provided. The performance could be further improved if the fabric were made modacrylic rich. This research would provide a critical insight into the selection of fiber and fabric structure in designing this sophisticated class of fabric for superior flame and splash protection to children.

References

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