Comparing the UV Protection of Cotton Fabrics with a Personal UV Exposure Monitor

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INTRODUCTION

Skin cancer is one of the most common skin cancers in the US. Ultraviolet (UV) radiation exposure is one of the main risk factors for the development of skin cancers (1). Sun protective behaviors such as wearing sunscreen, limiting sun exposure, and wearing protective clothing can play a role in reducing the risk for developing skin cancer (2). Clothing offers a simple and effective way to protect oneself from excess UV exposure. The purpose of this study is to assess natural UV exposure under black and white 100% cotton clothing, to compare sun protection factor (SPF) rated clothing, and to assess the difference in UV exposure of various fabric characteristics, such as color, weight, wetness and laundering treatment. We hypothesize that the use of black clothing will reduce UV exposure better than white clothing; heavier fabrics will reduce UV exposure better than lighter fabrics; laundered fabrics will protect better than non-laundered fabrics; and dry fabrics will protect better than wet fabrics.

METHODS

SunSense Coin(3): The SunSense Coin is a personal sun exposure monitor that measures UV radiation exposure that displays the radiation dose UV Index- Hours (1 hour of sun at UV index 1 = 1 UV Index-Hours).

100% Cotton Fabrics: Three weights of shirts of the same brand were assessed: Shirt A 4.5 oz., Shirt B 5.3 oz., Shirt C 6.1 oz. The shirts were cut into 10 cm by 10 cm swatches, avoiding all seams and hems. The cut swatches were tested under four conditions:1. Non-Laundered; 2. Water-only Laundered; 3. Wet treatment Non-Laundered; 4. Wet treatment Water-only Laundered.

Special UV rating: These fabrics were manufactured and produced for the purposes of protection from excess UV radiation. The special UV protection fabrics in colors: black, light grey and blue, composed of 66% bamboo rayon, 28% cotton and 6% spandex. Each UV protection fabric was assessed in two conditions: 1. Non-Laundered; 2. Wet treatment Non-Laundered

Fabric Treatments:

Laundered with water-only: The laundered protocol was adapted from the Wang et al study (3). Fabric swatches were washed in residential washing machine, Kenmore 80 Series and dried with a gas dryer, Kenmore Elite. The fabric was washed once without detergent and dried once with a queen-size bed sheet and a 100% cotton bath towel to simulate a laundry load in an average household.

Wet treatment: Fabric swatches were fully submerged and soaked in the same brand of purified bottled drinking water before data collection.

Data collection occurred during the months of June to August during the hours of 12:00PM to 2:00PM for 30 minutes. For control, one SunSense device was left uncovered by fabric. Data was collected four times for each treatment group. An ANOVA analysis was performed to compare Shirt A, Shirt B and Shirt C. A two-tailed t-test was performed between the black and white groups, the non-laundered and laundered groups, the dry non-laundered and wet non-laundered groups, and the dry laundered and wet laundered groups

RESULTS

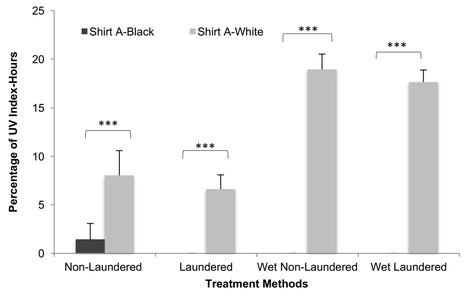

FIGURE 1: Percentage of UV Index-Hours of Shirt A in Black and White by Treatment Methods. All treatment groups, there was a statistically significant difference between the black and white groups for Shirt A at 4.5 oz. (*** = p<0.05).

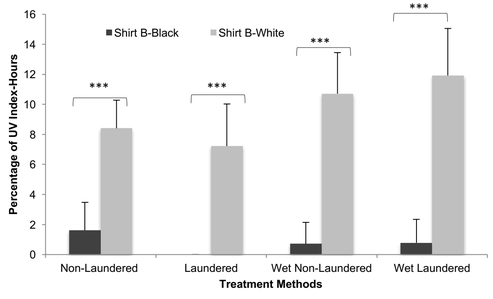

FIGURE 2: Percentage of UV Index-Hours of Shirt B in Black and White by Treatment Methods. All treatment groups, there was a statistically significant difference between the black and white groups for Shirt B at 5.3 oz. (*** = p<0.05).

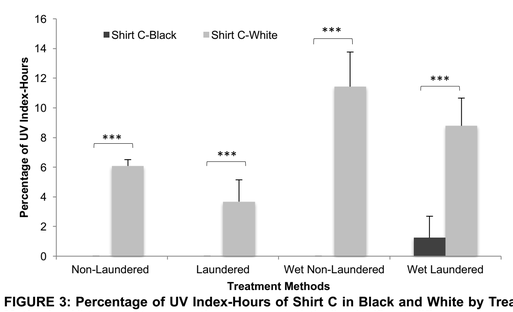

FIGURE 3: Percentage of UV Index-Hours of Shirt C in Black and White by Treatment Methods. All treatment groups, there was a statistically significant difference between the black and white groups for Shirt C at 6.1 oz. (*** = p<0.05).

	Number of Treatments	Mean	Standard Deviation	Standard Error	Minimum	Maximum
Shirt A	8	6.5713	7.8535	2.7766	0	18.9
Shirt B	8	5.1675	4.9162	1.7381	0	11.9
Shirt C	8	3.5725	3.8605	1.3649	0	8.79
Total	24	5.1037	5.6770	1.1588	0	18.9

TABLE 1: Cumulative Data collected from Shirts A-C. This table shows the aggregate data of UV Index-Hours collected from the SunSense Coins from Shirts A-C, displaying the number of treatments, mean, standard deviation, standard error, minimum value and maximum value.

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	36.0188	2	18.0094	**0.5363**	**0.5927**
Within Groups	705.2402	21	33.5829		
Total	741.2590	23			

TABLE 2: One Way ANOVA Comparison of Shirt A-C. When comparing the shirt weights, the difference between the shirts yielded a significance value of 0.5927, which is greater than 0.05. The F-statistic of the one-way ANOVA is also higher than 0.05 (F=0.5363). This suggests that the amount of penetrance between the difference shirt weights is not significant.

	Q Statistic	P-value	Significance
Shirt A **Shirt B**	0.6851	0.87553	Not Significant (NS)
Shirt A **Shirt C**	1.4636	0.56192	NS
Shirt B **Shirt A**	0.6851	0.87553	NS
Shirt B **Shirt C**	0.7785	0.83793	NS
Shirt C **Shirt A**	1.4636	0.56192	NS
Shirt C **Shirt B**	0.7785	0.83793	NS

TABLE 3: Multiple Comparison – Tukey HSD of Shirt A-C. The results from a multiple comparisons test show: Shirt A and Shirt B have no significant differences (p=0.87553, p>0.05). Shirt A and Shirt C have no significant differences (p=0.56192, p>0.05). Shirt B and Shirt C have no significant differences (p=0.83793, p>0.05). The Tukey HSD analysis is consistent with results from the the one-way ANOVA analysis.

	Shirt A	Shirt B	Shirt C
Non-Laundered (Black) (% of UV Index Hours)	1.43	1.61	0
Laundered (Black) (% of UV Index Hours)	0	0	0
p-value	0.13	0.13	No change
Non-Laundered (White) (% of UV Index Hours)	8.03	8.41	6.08
Laundered (White) (% of UV Index Hours)	6.62	7.23	3.68
p-value	0.38	0.51	**0.02**

TABLE 4: Comparison of the Percentage of UV Index-Hours between the Non-Laundered and Laundered groups in Black and White for Shirt A-C. There was no significant differences noted between non-laundered and laundered black shirts (A-C). The only group that had a significant difference in laundering is Shirt C in white (p=0.02, p<0.05). The white fabric for Shirt A and B did not show a statistically significant difference in laundering (p>0.05).

	Shirt A	Shirt B	Shirt C	Special SPF Fabric
Non-Laundered (Black) (% of UV Index Hours)	1.43	1.61	0	0
Wet Non-Laundered (Black) (% of UV Index Hours)	0	0.71	0	0
p-value	0.13	0.47	No change	No change
Non-Laundered (White) (% of UV Index Hours)	8.03	8.41	6.08	0
Wet Non-Laundered (White) (% of UV Index Hours)	18.9	10.71	11.42	0
p-value	**0.0003**	0.21	**0.004**	No change

TABLE 5: Comparison of the Percentage of UV Index-Hours between the Non-Laundered and Wet Non-Laundered groups in Black and White for Shirt A-C and Special SPF Fabric. There was no significant differences noted between the dry and wet non-laundered black shirts (A-Special SPF fabric). For the white shirts, there are two groups with noted differences in wetness: Shirt A (p=0.0003, p<0.05) and Shirt C (p=0.004, p<0.05). The white fabric for Shirt B did not show a difference in wetness for the non-laundered shirts. There was no change noted between the wet and dry non-laundered special SPF fabric, as there were 0% UV dosage accumulated for both groups.

	Shirt A	Shirt B	Shirt C
Laundered (Black) (% of UV Index Hours)	0	0	0
Wet Laundered (Black) (% of UV Index Hours)	0	0.78	1.25
p-value	No change	0.355	0.133
Laundered (White) (% of UV Index Hours)	6.62	7.22	3.68
Wet Laundered (White) (% of UV Index Hours)	17.6	11.9	8.78
p-value	**0.000**	0.06	**0.005**

TABLE 6: Comparison of the Percentage of UV Index-Hours between the Laundered and Wet-Laundered groups in Black and White for Shirt A-C. There was no significant differences noted between the dry and wet laundered black shirts (A-C). Shirt A exhibited no change between the dry and wet state, as there were 0% UV dosage accumulated for both groups. There are two groups that did show a difference in wetness: Shirt A (p=0.000, p<0.05) and Shirt C (p=0.005, p<0.05). The white fabric for Shirt B did not show a difference in wetness for the laundered shirt.

SUMMARY AND CONCLUSIONS

1. Darker hues protect better as there is increased absorption of the UV rays. The greater the color intensity of the fabric, the greater UV protection offered by the fabric (4).
2. Heavier fabrics are more protective than lighter fabrics as there is less space between fabric yarns, resulting in an increased area of coverage (5,6).
3. Laundered fabrics provides better protection than non-laundered fabrics because laundering causes shrinkage of the pores to increase the area of coverage (3).
4. Dry fabrics are more protective than wet fabrics. Wet fabrics reduce the amount of scattering of UV radiation causing increased UV penetration through the fabric (7).
5. Special SPF rated clothing are the most efficacious in protecting from excess UV exposure.

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