

Umbrella with Ultraviolet Radiation Protection

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Abstract

Background: Ultraviolet radiation (UVR) causes harm to the eye and skin in human. There are many ways to protect one from UVR. Umbrella is widely used due to its convenience as well as its ability to protect one from rain. However, there are limited numbers of studies on UVR protection of different types of umbrellas. **Objective of study:** To determine UVR protection efficacy of different umbrella designs. **Methods:** The experimental study was performed on five sunny days. Six manikins were placed in an open area, five of which were equipped with five different types of black canopy umbrellas. One manikin was placed without an umbrella as a control sample. Polysulfone film badges were attached in six different areas in each manikin for measuring the UVR from 10 am - 3 pm **Results:** All types of umbrellas provides 64.5% - 92.3% UVR photo protection efficacy. An umbrella with UV-filter coating on the inner surface provides maximum UVR photo protection efficacy. However, UVR photo protection efficacies of an umbrella with UV-filter coating on the inner surface and one with UV-filter coating on the outer surface and one without UV-filter coating are not statistically significant (p -value = 0.37). Umbrellas with a diameter of 122 cm and 152 cm provide comparable UVR photo protection efficacy while an umbrella with a diameter of 112 cm provides the least UVR photo protection efficacy. However, UVR photo protection efficacies of umbrellas with different diameter are not statistically significant (p -value = 0.36). The area of the body that received the most UVR photo protection is the forehead which is statistically significant when compared with other areas of the body (p -value < 0.001). The areas of the body that received the least UVR photo protection are the left ear and the back of the neck, which are statistically significant when compared with other areas of the body (p -value < 0.001). **Conclusion:** All types of umbrellas provide UVR photo protection efficacy. The study shows that umbrellas with different canvas material including both the UV-filter coating and different diameter of umbrellas could effectively protect the user from UVR without significant group difference in this study.

Keywords

Umbrella, Ultraviolet, Protection, Filter Coating, Radius

1. Introduction

Ultraviolet radiation (UVR) is an electromagnetic wave [1] [2]. It is originated from the sun and travels to the surface of the Earth. While UVR is vital to human, it can also cause harm especially to the eye and skin such as burn, hyperpigmentation, photoaging skin, keratoconjunctivitis, stimulation of photodermatoses and cutaneous cancer [1]-[3]. For this reason, there are several ways to protect one from UVR [4] which can be categorized into two methods namely Chemical protection (Sunscreen) and Physical protection such as using hats [5], garments [6], sunglasses [7]. Umbrella is one of the ways to protect one from UVR [8] due to its convenience, availability as well as its ability to protect one from rain. Nevertheless, there are only few studies on UVR protection efficacy of different types of umbrellas [8]-[13] and no clear conclusions can be drawn.

2. Objective of Study

The objective of this study is to evaluate UVR photoprotection efficacies of umbrellas with different canvases (umbrellas with UVR-filter coating on the inner surface of the canvas, umbrellas with UVR-filter coating on the outer surface of the canvas and umbrellas with plain canvas) as well as umbrellas with different diameters (112 cm, 122 cm and 152 cm).

3. Methods

This study was an *in-vitro* experimental study. Five types of black umbrellas were selected—canopy umbrella with diameter of 122 cm and UV-filter coating on the inner surface of the canvas, canopy umbrella with diameter of 122 cm and UV-filter coating on the outer surface of the canvas, canopy umbrella with diameter of 122 cm without UV-filter coating on the canvas, canopy umbrella with diameter of 112 cm and UV-filter coating on the inner surface of the canvas, canopy umbrella with diameter of 152 cm and UV-filter coating on the inner surface of the canvas. Aluminium paste is used as UV-filter coating on the umbrella's canvas. All 5 umbrellas had exactly the same thickness and tightness of weave from the same company (Thai Ocean Industrial company limited). Each of the first five manikins was equipped with an umbrella and one manikin was placed without an umbrella. All six manikins were set facing north. The efficacy of UVR protection was measured by using Polysulfone film badges [14]. All Polysulfone film badges were standardized and UVR exposed film badges were sent to Manchester University, UK for readings of UVR exposure using CECIL CE292 Spectrophotometer and their readings were recorded in Standard Erythral Dose unit (SED; 1 SED = 100 Joules/m²). Six Polysulfone film badges were placed at various anatomical areas of each manikin; forehead, nose, left ear, right ear, occiput and the back of the neck (Figure 1). The experiment was performed in an open area of Srinakarinwirot University's arena (SWU), Bangkok, Thailand (Latitude 13.75, Longitude 100.57) during 10.00 am - 3.00 pm in five clear sky days in November, 2013.

UVR exposure data in Standard Erythral Dose unit of Polysulfone film badges recorded in those five days were analyzed. Two analyses were performed.

3.1. Fundamental Analysis

Differences in UVR exposure were calculated against control sample data using the following formula:

$$\text{UVR different} = \text{UVR control} - \text{UVR umbrella} \quad (1)$$

UVR control = UVR exposure of control sample (manikin without an umbrella)

UVR umbrella = UVR exposure

UVR different = Amount of UVR protection (difference in UVR exposure)

UVR protection data were then calculated in percentage using the following formula:

$$\frac{\text{UVR different}}{\text{UVR control}} \times 100 \quad (2)$$

3.2. Statistical Analysis

Two groups of data were analyzed:

- 1) Compare UVR exposure of manikins under 122 cm diameter umbrellas with different types of canvas

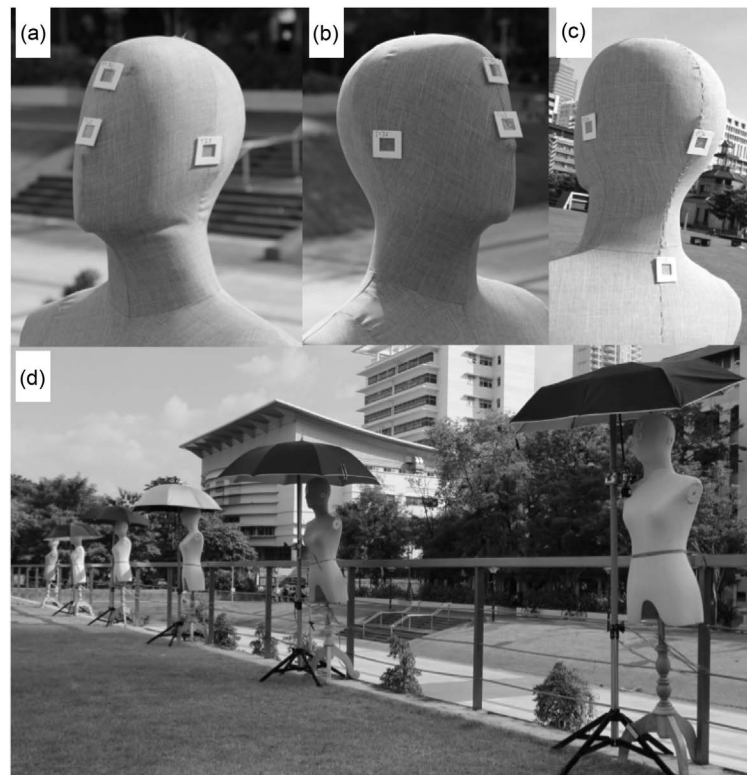


Figure 1. (a)-(c) showed the polysulfone film badges on the manikins; (d) showed all the manikins were set with umbrellas in the experiment.

materials (UV-filter coating on the inner surface of the canvas, UVR-filter coating on the outer surface of the canvas, and canvas with no UV-filter coating).

2) Compare UVR exposure of manikins under umbrellas with different radii (canopy umbrellas with UV-filter coating on the inner surface of the canvas with diameter of 112 cm, 122 cm and 152 cm)

With more than two groups of samples, ANOVA test and Bonferrini test were used.

4. Results

During the second day of the experiment, some of the manikins fell over. The amount of UVR exposure readings from these manikins significantly differed from other groups of samples. Therefore, results from the second day of the experiment were discarded and only data from four other days of experiments were used in the analysis.

Fundamental data analysis showed that average UVR exposure readings from four days of experiments were calculated (**Table 1**). Average UVR protection data (in percentage) from four days of experiments were also calculated (**Table 2**). The results showed that average UVR protection efficacies of all five umbrellas were in the range of 64.5% - 92.3%.

Statistical analysis showed that canopy umbrellas with UV-filter coating on the inner surface provided the most UVR photo protection efficacies (81.6%) but is statistically insignificant (p -value = 0.37) when compared with that of canopy umbrellas with UVR-filter coating on the outer surface (UVR photo protection efficacies of 77%) and that of canopy umbrellas without UV-filter coating (UVR photo protection efficacies of 76.5%) as shown in **Table 3**. In addition, canopy umbrellas with diameter of 122 and 152 cm provided UVR photo protection efficacies of 81.6% and 81.4% respectively while canopy umbrellas with radii of 22 inches provided the least UVR photo protection efficacies (77.2%). However, UVR photo protection efficacies of canopy umbrellas with diameter of 112, 122 and 152 cm were statistically insignificant (p -value = 0.36) as shown in **Table 4**.

While umbrellas with different canvas types and their radii showed insignificant differences in UVR photo protection efficacies, data from **Table 2** were analyzed further to see how well different parts of the body are

Table 1. The fundamental data of the mean UVR values^a of different areas and different types of umbrella.

	Control	122 cm, UV-filter inner	122 cm, No UV-filter	122 cm, UV-filter outer	112 cm, UV-filter inner	152 cm, UV-filter inner
Forehead	5.9 (0.3)	0.5 (0.1)	0.8 (0.8)	0.6 (0.8)	0.5 (0.1)	0.5 (0.1)
Nose	5.9 (0.6)	0.5 (0.1)	1.5 (1.1)	0.8 (0.8)	0.9 (0.4)	0.7 (0.3)
Left ear	2.7 (0.4)	0.8 (0.1)	0.9 (0.4)	1.0 (0.5)	1.0 (0.5)	0.7 (0.1)
Right ear	5.9 (0.5)	0.8 (0.4)	1.1 (0.4)	1.1 (0.8)	0.9 (0.4)	1.0 (0.4)
Occiput	6.0 (1.8)	1.3 (0.5)	1.4 (0.6)	1.9 (1.4)	1.7 (1.1)	1.4 (0.6)
Upper back	10.1 (0.8)	2.9 (1.0)	2.7 (1.4)	3.0 (2.2)	3.6 (1.7)	2.6 (0.9)

^aUnit in Standard Erythema Dose (SED; 1 SED = 100 Joules/metre²).

Table 2. The UVR values and photoprotection efficacy of various types of umbrella on different anatomical sites type styles.

	Control	122 cm, UV-filter inner	122 cm, No UV-filter	122 cm, UV-filter outer	112 cm, UV-filter inner	152 cm, UV-filter inner	
Forehead	Percent		91.1 (1.0)	86.5 (11.8)	89.9 (11.7)	91.0 (2.2)	92.3 (1.9)
	Different	5.9	0.5	0.8	0.6	0.5	0.5
Nose	Percent		91.7 (1.7)	75.1 (18.0)	87.3 (11.9)	85.6 (6.3)	88.6 (4.1)
	Different	5.9	0.5	1.5	0.8	0.9	0.7
Left ear	Percent		69.6 (3.7)	66.6 (11.7)	64.5 (12.8)	65.8 (15.4)	72.7 (2.5)
	Different	2.7	0.8	0.9	1	1	0.7
Right ear	Percent		86.9 (6.2)	81.3 (7.1)	80.9 (12.9)	84.1 (15.9)	83.8 (6.5)
	Different	5.9	0.8	1.1	1.1	0.9	1
Occiput	Percent		78.0 (9.0)	76.1 (10.2)	70.1 (18.5)	72.3 (15.4)	76.9 (8.9)
	Different	6	1.3	1.4	1.9	1.7	1.4
Upper back	Percent		71.9 (8.4)	73.2 (13.5)	69.6 (23.1)	64.2 (17.8)	73.8 (10.1)
	Different	10.1	2.9	2.7	3	3.6	2.6

Table 3. It showed mean percentage of UVR protection in various canopy types.

Canopy type (122 cm)	Mean (SD)	p-Value
Inner UV-filter	81.6 (10.5)	0.37
No UV-filter	76.5 (12.8)	
Outer UV-filter	77.0 (17.0)	

Table 4. It showed mean percentage of UVR protection in various diameters.

Diameter (inner UV-filter)	Mean (SD)	p-Value
112 cm	77.2 (14.9)	0.36
122 cm	81.6 (10.5)	
152 cm	81.4 (9.5)	

protected from UVR as shown in **Table 5**. It was found that differences in UVR photo protection for six different parts of the body are statistically significant. The results showed that the area of the body that received the most UVR photo protection is the forehead which is statistically significant when compared with other areas of the body (UVR photo protection efficacy of 90.2% with p-value <0.001). The areas of the body that received the least UVR photo protection are the left ear and the back of the neck, which are statistically significant when compared with other areas of the body (UVR photo protection efficacy of 67.8% with p-value <0.001 and UVR photo protection efficacy of 70.6% with p-value <0.001 respectively).

5. Discussion

Based on the results of this research, differences in UVR photo protection efficacies of umbrellas with different

Table 5. Showed mean percentage of UVR protection in various anatomical sites.

Anatomical site	Mean (SD)	p-Value
Forehead	90.2 (7.0)	
Nose	80.7 (10.8)	
Left ear	67.8 (9.8)	<0.001
Right ear	83.4 (7.6)	
Occiput	74.6 (11.9)	
Upper back	70.6 (14.2)	
Compare forehead with other sites		
Forehead	90.2 (7.0)	<0.001
Other sites	76.4 (12.9)	
Compare left ear with other sites		
Left ear	67.8 (9.8)	<0.001
Other sites	80.9 (12.7)	
Compare occiput with other sites		
Occiput	74.6 (11.9)	<0.001
Other sites	80.3 (12.4)	

canvas types were statistically insignificant. It might be possible that black nylon canvas could effectively absorb UVR. Thus, additional UVR photo protection of umbrella canvas with UVR-filter coating was only marginal. That differences in UVR photo protection efficacies of umbrellas with diameter between 112 - 152 cm were statistically insignificant may be explained by the fact that Polysulfone film badges were placed at manikins near the center of the umbrella. More Polysulfone film badges placed further away from the center of the umbrella may give significantly different results. Umbrellas with wider range of diameter may also give significantly different results.

With regards to different areas where Polysulfone film badges were placed, the reason why the forehead received the most UVR photo protection might be for the fact that it is the closest to the center of the umbrella and to the umbrella canopy. However, the fact that the left ear received the least UVR photo protection might be for the fact that the manikins were facing slightly North-east, the left ears of all manikins were facing North-west and the experiments were conducted in November from 10 am - 3 pm when the sun was slightly towards the South, making the North-west less exposed to the sun light and all the center of the umbrellas were on the right side of manikin, making unequal angles on the umbrella and both ears. Therefore, the UVR exposure readings on the left ear were much lower than those in other areas of the manikins and resulted in low UVR protection efficacies. The fact that the back of the neck received significantly low UVR protection might be explained by additional UVR reflected from white canvases that were placed behind each manikin compared with UVR reflected from the yard at the front.

There are other factors that the researcher did not study due to some limitations such as Solar Zenith Angle which might affect UVR photo protection. This is because the fact that the duration of the experiments expanded over five hours resulted in different Solar Zenith Angle. Additional comparison on the ground, reflected UVR, colour of umbrella canvas, canvas materials and other different areas of the body, especially both cheeks, chin, shoulders and arms of the manikins might be helpful.

6. Conclusion

All types of umbrellas in this study provided UVR photo protection efficacy in the range of 64.5% - 92.3%. Canopy umbrellas with UVR-filter coating on the inner surface provided the most UVR photo protection efficacies. Canopy umbrellas with diameter of 122 and 152 cm provided the most UVR photo protection efficacies. However, differences in UVR photo protection efficacies of umbrellas with different canvas types and diameters are statistically insignificant. The area of the body that received the most UVR photo protection is the forehead which is statistically significant while the areas of the body that received the least UVR photo protection are the left ear and the back of the neck, which are statistically significant. Therefore, it can be included that the type of umbrella canvas and the radius of the umbrella are not significant factor in UVR photo protection efficacy and

that the forehead receives the most protection from UVR. Additional means of UVR protection for the back of the neck should also be considered.

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