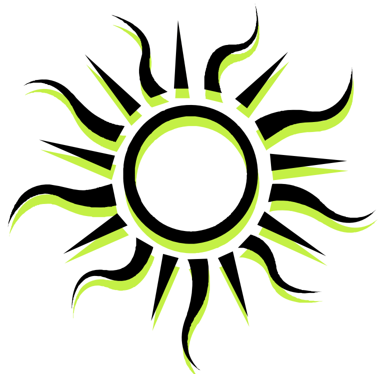

UV Rays Undercover
Which summer fabric will best block ultraviolet rays?

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Table of Contents

Abstract

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The purpose of this project was to discover which summer fabric would best block ultraviolet rays. The experiments involved mounting seven fabric swatches on plates covered with black construction paper and exposing the fabrics to direct sunlight at 12:00 P.M. on ten sunny days in August (controlled variables). A different type of fabric (manipulated variable) was used for each experiment, and an eighth plate covered with black construction paper without any fabric served as a control. Bracelets made of UV pony beads were placed under each fabric sample, and the beads changed color to reflect amounts of ultraviolet rays (responding variable) that penetrated each fabric. I developed Emily's UV Bead Scale to serve as an instrument to measure the amount of UV rays passing through the fabrics by analyzing the color changes in the UV pony beads.

The data supported my hypothesis that denim would best block UV rays. The amount of UV rays was .9 less on average with denim than terry cloth, the second best UV light blocking fabric. Denim was also the only fabric to score a rating of 1 (minimal UV rays) using Emily's UV Bead Scale on any of the experiment days.

I discovered that denim offers the most protection from ultraviolet rays of the fabrics that were tested. I also found that no fabric completely blocks ultraviolet rays.

Introduction

I spend a lot of time outdoors, especially in the summer when the sun is at its brightest. I use sunscreen on the skin that is showing outside of my clothes, but I wondered if the sun gets through any of my clothing.

Through reading about the sun, I learned more about its different rays. The sun emits different kinds of light: visible light, infrared light that is felt as heat, and invisible ultraviolet radiation. Ultraviolet, or UV, light has more energy than visible light and causes chemical reactions in objects and animals on Earth. UV rays cause skin to increase its production of a brown chemical called melanin. We see this as a tan. However, too much exposure to UV rays and high levels of melanin can cause skin cancer. Surprisingly, more than 80% of skin damage from the sun's rays occurs by the time a person is 18 years old. Other health concerns related to UV rays include cataracts, eye diseases, aging of the skin, and a suppression of the immune system. Therefore, it is important for people of all ages to protect their skin when they are in direct sunlight.

There are three types of UV rays. UVA radiation penetrates deep into skin and causes premature aging of the skin and skin cancer. UVB radiation causes sunburns, premature aging, and skin cancer. UVC radiation is the strongest and most dangerous UV light, but these rays are stopped by the earth's atmosphere and do not reach the earth's surface. The UV index is used to measure the intensity of the sun's UVA and UVB rays. Higher numbers represent stronger sun's rays and a greater risk of skin damage.

The amount of UV rays depend on the time of day (greatest at midday), the season (greatest in summer), the cloud cover (thick clouds block UV rays), the type of surface on which they strike (snow, sand, water, and concrete reflect UV rays back onto a person's skin), elevation (there are more UV rays on a mountain), where the rays strike on Earth (UV rays are stronger at the equator), the length of time spent in the sun, and what a person is wearing.

I wondered about which clothing would best block UV rays. Through reading, I learned that loose-fitting, closely-woven fabrics that cast a dense shadow when held to light are the best UV ray blockers. One of my sources reported that the density of the fabric, not the type of fiber or color, determines the effectiveness of the fabric as a sunscreen. Natural and synthetic fabrics were said to work about the same. Another report suggested that darker colors, tighter weaves, heavier weights, less stretch, and dryness of fabrics increase UV protection.

A fabric's ability to block ultraviolet rays is called its UPF (ultraviolet protection factor). The higher the UPF, the greater the protection from the sun's UV rays. A white t-shirt has a UPF rating of 5, but it is recommended that clothing have at least a UPF of 15 to be considered sun protective. As a result, some manufacturers are creating clothing made especially for sun protection.

I was curious about which fabrics typically worn in the summer would best block UV rays. I wanted to find out what I should wear on a very sunny day and during peak sun hours. I decided to test the following fabrics: denim, cotton knit, linen, muslin, terry cloth, cotton twill, and polyester knit.

As a result of my research, I formed the following hypothesis:

I believe that denim will block UV rays better than the other fabrics I am testing. My hypothesis is based on the following facts found through reading and my own experiences:

Denim is the most tightly woven of the fabrics, and light does not pass well through tightly woven fabrics.

Denim has less stretch than the other fabrics, and fabrics that do not stretch well will block more light.

Experiments and Summary of Results

Purpose: To determine which summer fabric best blocks ultraviolet rays.

Materials and Equipment

<u>Materials</u>

320 UV pony beads (40 of each color: purple, blue, pink, orange, yellow)
15 cm X 15 cm white linen fabric
15 cm X 15 cm white muslin fabric
15 cm X 15 cm white terry cloth fabric
15 cm X 15 cm white polyester knit fabric
15 cm X 15 cm white cotton knit fabric
15 cm X 15 cm white cotton twill fabric
15 cm X 15 cm white denim fabric
8 Styrofoam plates
8 pieces of black construction paper
straight pins
Scotch tape
white wool yarn

<u>Equipment</u>

scissors
clock
Emily's UV Bead Scale

Procedure

1. Trace eight circles on black construction paper using one of the Styrofoam plates. Cut out the seven circles and tape each circle to the bottom of a Styrofoam plate.

2. Cut a 15 centimeter X 15 centimeter square out of each of the following fabrics: linen, muslin, terry cloth, polyester knit, cotton knit, cotton twill, and denim. Center each square on the construction paper side of a Styrofoam plate and secure each of the four corners with a straight pin. Push the fabric up to the top of the pin so that there is some space (no more than 3 centimeters) between the fabric and the construction paper. There will be one construction-paper covered plate left over for the control. Label each plate with the type of fabric or "control".

3. Make eight bracelets using UV pony beads and white wool yarn. Cut eight pieces of yarn 25 centimeters in length. Make a large knot at the end of each piece of yarn. Thread pony beads on each piece of yarn in the following pattern: 5 yellow, 5 blue, 5 pink, 5 orange, 5 purple. Move the beads to the center of the yarn and make a knot with the two ends of yarn joining the beads at each end and forming a circle. Cut off excess yarn.

4. Place each of the bracelets under a piece of fabric mounted on one of the plates covered with black construction paper. Place the last bracelet on the plate without fabric to serve as the control.

5. Take each plate outside and place in direct sunlight at 12:00 P.M.

6. Record the reactions of the beads on each bracelet by carefully looking under each
piece of fabric without exposing the beads to any direct sunlight. Use Emily's UV Bead Scale to rate the amount of UV rays that are getting through the fabric.

7. Record the reaction of the control beads using Emily's UV Bead Scale.

8. Repeat steps 5 through 8 on ten different days in midsummer.

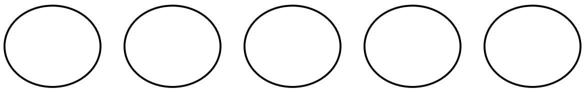
How I Developed Emily's UV Bead Scale

In order to measure the amount of UV rays passing through the fabrics, I created Emily's UV Bead Scale. I needed a way to use the UV beads to show different amounts of UV radiation. While using the beads for fun, I noticed that the colors of the beads changed gradually and that some colors turned faster than others. For instance, when there was just a little bit of light the purple and blue beads began to show hints of colors. When a little more light was added, the pink bead started to show color and the purple and blue beads started to get darker. It took even more light to see color in the orange and yellow beads. I decided to make a scale from zero to six with zero representing no color change (no UV rays) and six representing all of the colors at their brightest (extremely high UV rays). I observed and recorded the slight changes in the bead colors to make the rest of the scale from one through five. This scale helped me to measure the different amounts of UV radiation that passed through different fabrics.

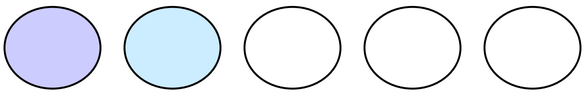
Emily's UV Bead Scale

Rating/Amount of UV Rays/Change in Beads:

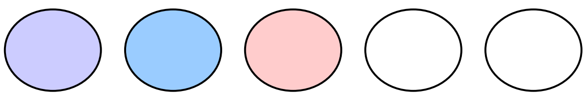
0 None
No color change.



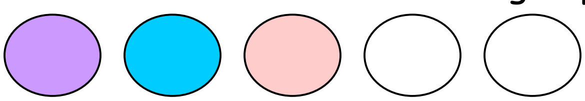
1 Minimal
Very pale purple and very pale blue.



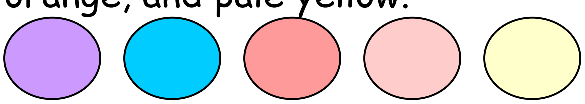
2 Low
Pale purple, pale blue, and very pale coral.



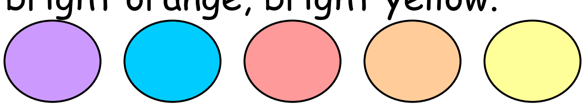
3 Moderate
Bright purple, bright blue, pale coral.



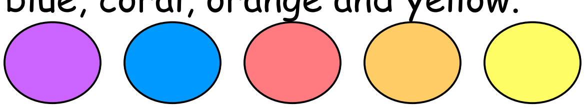
4 High
Bright purple, bright blue, bright coral, pale orange, and pale yellow.



5 Very High
Bright purple, bright blue, bright coral, bright orange, bright yellow.



6 Extremely High
Intensely bright purple, blue, coral, orange and yellow.



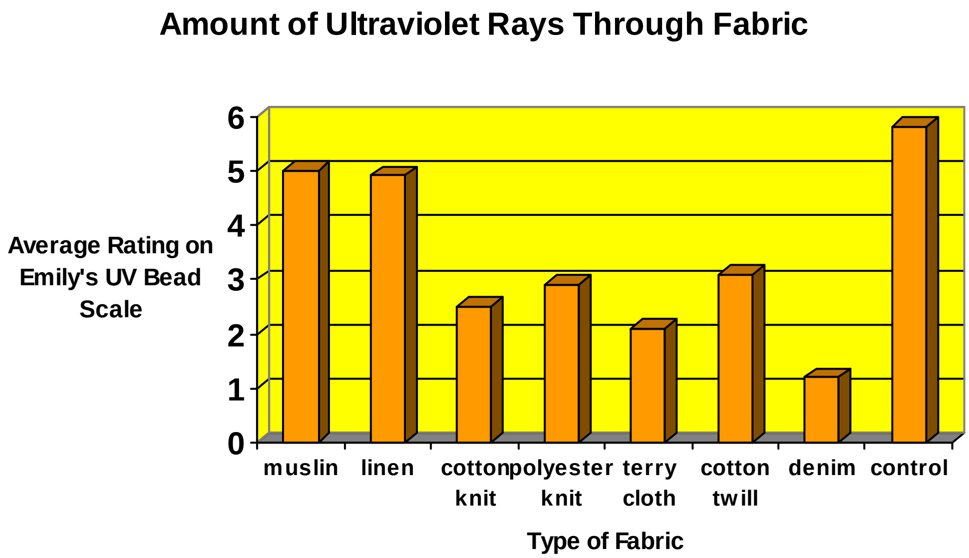
Summary of Results

I performed the experiments at 12:00 P.M. on ten different sunny days during the month of August 2005 in my backyard. I took out a tray that held all of the test fabrics mounted on paper plates covered with black construction paper. Using Emily's UV Bead Scale, I was able to give each fabric a score based on the color changes of the beads on the bracelet that was located under each fabric swatch. The control bracelet was exposed to direct sunlight. Table A shows the data that I collected from the experiments.

Table A

Fabric	Aug. 8	Aug. 11	Aug. 15	Aug. 17	Aug. 18	Aug. 19	Aug. 21	Aug. 24	Aug. 25	Aug. 28	Average
muslin	5	4	5	5	6	5	5	5	5	5	5
linen	5	4	4	5	5	6	5	5	5	5	4.9
cotton knit	2	2	2	5	2	4	2	2	2	2	2.5
polyester knit	3	2	3	3	3	3	3	3	3	3	2.9
terry cloth	2	2	3	2	2	2	2	2	2	2	2.1
cotton twill	3	3	3	3	3	3	3	3	3	4	3.1
denim	1	1	1	1	2	2	1	1	1	1	1.2
control	6	5	5	6	6	6	6	6	6	6	5.8

The fabric that best prevented UV rays from penetrating it was denim. The denim scored an average of 1.2, or minimal UV rays, on Emily's UV Bead Scale. The second best fabric was terry cloth with an average of 2.1, or low UV rays. The cotton knit fabric was third and had an average score of 2.5, or low rays. Fourth was the polyester knit with an average score of 2.9, or low rays. The cotton twill was fifth with an average score of 3.1 on the scale, or moderate UV ray penetration. Sixth was the linen fabric with an average score of 4.9, or high UV rays. The seventh best UV ray blocking fabric was the muslin with an average score of 5, or very high UV rays. The beads of the control had an average score of 5.8, or very high UV rays on Emily's UV Bead Scale.



Conclusions

I accept my hypothesis that denim best blocks ultraviolet light better than other summer fabrics. The experimental data supported my hypothesis. Denim best blocks UV light because the amount of UV light was .9 less on average according to Emily's UV Bead Scale than terry cloth, which was the second best UV light blocking fabric. Denim was the only fabric to score a rating of 1 (minimal UV rays) during any of the experiment days. The reason that denim stopped more UV light from going through it was because denim is tightly woven and has less stretch than the other fabrics tested.

None of the fabrics tested blocked ultraviolet rays completely. This discovery is important, because it made me realize that some ultraviolet rays are reaching people's skin at all times when they are in the sun. A person cannot be fully protected from UV rays.

My findings are important to all people who are in bright sunlight for long periods of time, especially those who are prone to sun damage of the skin and those who live in areas of the world where more UV rays reach the earth's surface. Clothing manufacturers would find my results useful in making clothes for the people I mentioned above.

An error that might have occurred in my experiment was with the daily weather conditions. It was impossible to control every aspect of the weather including temperature and humidity. These factors may have affected the outcome of my experiment.

Some future experiments that involve ultraviolet ray protection might include testing which sunscreen best blocks UV rays, whether wet or dry fabrics block UV rays the best, whether darker or lighter fabrics will best block UV rays.

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