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Sports Surface Research

Evaluation of the Efficacy of Ultraviolet-C Light to Eliminate *Staphylococcus aureus* from Infilled Synthetic Turf Surfaces

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INTRODUCTION

Staphylococcus aureus is a common bacterium found on human skin and is the causal agent of a number of relatively minor skin infections including boils, pimples, and impetigo (Marples et al, 1990). Isolates of *S. aureus* that are resistant to commonly used antibiotics began to appear in the 1960s, primarily in health care settings (Panlilio et al, 1992). Recently these methicillin resistant *S. aureus* (MRSA) isolates have been responsible for infections in otherwise healthy individuals, including athletes at all levels (Seppa, 2005).

Ultraviolet light has been shown to be effective in the elimination of *S. aureus* from a variety of surfaces (Silva et al, 2003) and has been shown to reduce the population of MRSA bacteria in patients with infected wounds (Thai et al, 2002).

More recently a device (GreenZapr, GreensGroomer Worldwide, Indianapolis, IN) has been developed that can be used as a maintenance tool for synthetic turf surfaces utilizing UV light as a disinfectant. The efficacy of this device in killing *S. aureus* along with the light intensity and required duration of exposure to this light intensity has not been previously reported in the scientific literature.

The objective of this study is to evaluate the efficacy of a UV-C generating device with similar light intensity and light exposure duration to the GreenZapr in eliminating *S. aureus* from synthetic turf surfaces.

PROCEDURES

Synthetic turf surfaces were established by adding 100% cryogenic crumb rubber infill to a monofilament fiber fabric to a depth of 3.9 cm. The backing and fiber system was Revolution from FieldTurf, Inc. (Dalton, GA).

A *S. aureus* isolate obtained from American Type Culture Collection (ATCC) (Manassas, VA) that was originally obtained from a human lesion was maintained on R2A agar plates (Eaton, et al, 1995) in order to gain sufficient bacterial cells for use. The cells were dislodged from the plates by washing the plates with sterile 0.1% peptone broth. The concentration of bacteria was determined using a hemacytometer, adjusted to 4×10^5 colony forming units (CFU)/ml using sterile 0.1% peptone broth and applied to the synthetic turf systems using a sterile needleless syringe (McNitt and Petrunak, 2008). The concentration of bacteria on the surface was approximately 6000 CFU/cm^2.

Treatments consisted of a negative control with no bacteria applied, a positive control with no UV-C light applied, and a treatment with bacteria applied and UV-C light treatment. The UV-C light was applied at 15 minute intervals with a total of four applications of light at a rate equivalent to the output of the commercially available light unit (6.558 mJ/cm^2).

The UV box (Fig. 1), which consisted of 4 UV-C generating tubes mounted inside a 17.8 x 47 x 19.1 cm stainless steel box with a handle was passed over the infilled turf surface in three directions: parallel to the stitching of the fibers, perpendicular to the stitching of the fibers, and at a 45^o angle to the stitching of the fibers. After each light cycle exposure, samples were taken from all treatments.

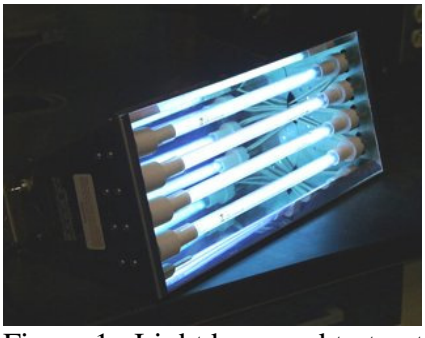

Figure 1. Light box used to treat test plots with UV-C light.

Sampling occurred by pressing Baird-Parker (BP) agar plates directly onto the infilled surfaces. BP agar is a medium that is selective for *S. aureus* (Bennet & Lancette, 1998). This media was used to eliminate the culture of other organisms present on the synthetic turf which may interfere with the detection of *S. aureus*. Additionally, samples of crumb rubber were taken from all treatments. The crumb rubber samples were collected using a sterile plastic test tube inserted directly into the crumb rubber infill. The collected granules were mixed with 10 ml of a sterile 0.1% peptone broth. A 0.1 ml aliquot of this solution was plated onto BP agar.

The plates were incubated at 36°C for 48 hours and evaluated for the presence of *S. aureus*. After a 48 hour incubation period at 36°C, *S. aureus* colonies appear as dark black, circular colonies on the media.

RESULTS

The results of this study are listed in Table 1. After the first application of light, bacteria were eliminated from both the fibers and the crumb rubber of the UV-C treated plots. No *S. aureus* was detected on the fiber surface of the synthetic turf and the data indicates that *S. aureus* populations on the fibers were reduced to zero in this experiment after the first application of UV-C light.

The results from the crumb rubber sampling were similar to the results from the fiber testing, with no *S. aureus* being detected on the UV-C treated surfaces. While the overall number of bacteria detected from the crumb rubber of the positive control was less than that detected on the fibers of the positive control, it appears that UV-C light was effective in eliminating *S. aureus* from the crumb rubber portion of the infill system.

Table 1. Number of bacterial colonies detected after treatment with UV-C light.

	Fibers[1]			
Treatment	Cycle 1[3]	Cycle 2	Cycle 3	Cycle 4
Control	0	0	0	0
S. aureus only	38.8	23.3	16.3	14.0
S. aureus + UV-C	0	0	0	0
LSD (0.05)	17.7	18.8	21.3	11.2

	Crumb rubber infill[2]			
Treatment	Cycle 1[3]	Cycle 2	Cycle 3	Cycle 4
Control	0	0	0	0
S. aureus only	0	0.3	1.3	3.3
S. aureus + UV-C	0	0	0	0
LSD (0.05)	NA	0.8	0.8	3.0

[1]Fibers were sampled by pressing a petri dish containing BP agar directly onto the fibers.
[2]Crumb rubber was sampled by extracting a sample of crumb rubber from the infill system, mixing the sample with sterile 0.1% peptone broth and plated an aliquot of the liquid onto BP agar.
[3]One light cycle is equivalent to two passes with the UV-C light box (parallel and perpendicular to the stitching to the fibers to the backing.) and brushing of the fibers and crumb rubber with a coarse comb between the two passes with the UV-C light box.

In conclusion, the application of UV-C using light energy equivalent to two passes with the GreenZapr appears to be effective in eliminating *S. aureus* from the fibers and crumb rubber of an infilled synthetic turf system.

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