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Tanning as a Behavioral Addiction

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***Background*: Persistent tanning despite potentially fatal consequences suggests a compulsive behavior similar to other addictive disorders. *Objectives*: To review the literature supporting tanning addiction from an epidemiological, behavioral, and neurobiological perspective. *Methods*: A comprehensive review of the medical literature was conducted to assess the health consequences of tanning, behaviors and other psychiatric disorders associated with tanning, and central rewarding effects of ultraviolet light. *Results*: Many frequent tanners endorse signs and symptoms adapted from *Diagnostic and Statistical Manual-IV* (DSM IV) substance abuse or dependence criteria. Recent studies suggest biochemical mechanisms may reinforce ultraviolet light seeking behavior. *Conclusions and Scientific Significance*: Frequent and persistent tanning may reveal itself to be a dermatologic-psychiatric disorder with carcinogenic sequelae. Multidisciplinary studies are required to determine the validity of an addiction diagnosis and to explore pharmacologic and cognitive therapeutic options for affected persons.**

Keywords addictive, behavior, compulsive, light, ultraviolet radiation

INTRODUCTION

The cause of beauty and the fickle nature of fashion have claimed many sacrifices in health and well-being, and may have found their tour de force dragging multitudes back and forth in a love–hate relationship with the sun. For centuries, bleeding oneself into anemia and poisoning from lead-based cosmetics and arsenic ingestion were faithfully endured to obtain the palest skin possible. Presently, as the tan is redefined to represent a life of leisure rather than day labor outdoors, the same devotees endure blistering sunburns and die of cancer in their twenties.

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The advent of spray-on tanning options offered to reconcile the aesthetic aspect of sun worship with its dangerous sequelae. However, the percentage of converts to these methods has not slowed the ever thriving medium of ultraviolet (UV) radiation, revealing that for many it is not simply about looking baked; at least as important is the UV-mediated tanning process. As expressed by one tanner, “You might feel the same amount of self-image confidence with a spray-on tan, but it really won’t affect your mood like the UVB/UVA rays will” (1). Thus, despite growing awareness of the risk of cancer, and that the same mechanism of “bronzing” the skin accelerates its aging process, these threats have not deterred a legion of tanners. Like needing a drink or a cigarette, a sort of elation or relief offered by the tanning bed seems to eclipse thoughts of cancer patients, premature aging, and even physical disfigurement (2). It raises the question of whether the old fad of avoiding a tan felt as good as getting one. In the following review, the increasing phenomena of tanning will be explored, along with the consequences of this behavior, the biologic mechanisms driving it, and its relevance to addictive processes.

METHODS

Relevant literature was sought on Google Scholar and PubMed using the search terms “tanning,” “ultraviolet,” and “addiction.” In addition, the Center for Disease Control and World Health Organization Web sites were explored for official statements on UV radiation (UVR) related hazards. Relevant citations from the above searches were also included as appropriate. The review was also guided from the authors’ recent work in this area (3).

THE EPIDEMIC

The World Health Organization and the United Nations Environment Program (UNEP) report a global incidence of over

two million non-melanoma skin cancers, 200,000 malignant melanomas, and 60,000 melanoma-related deaths each year. The worldwide incidence of malignant melanoma continues to rise in strong correlation with the frequency of recreational sun exposure, history of sunburns (especially early in life), and intermittent exposure to UV radiation and sunlamps (4, 5), an association particularly evident in young people.

In the United States, where the lifetime risk of skin cancer is 1 in 5 and 1 in 63 for invasive melanomas, the enduring prevalence of sunbathing and indoor tanning reflects a similar trend. The Center for Disease Control and Prevention (CDC) reports yearly sunburns in 31.7% of subjects, with a higher incidence of 57.5% for young adults ages 18–29 years (6). Some study populations exhibit tanning parlor and/or sun lamp use by 45% of subjects, yearly sunburns in up to 83%, multiple sunburns in 30–36%, with highest burn rate among those who thought it was worth burning to be tanned (7–9). According to the American Academy of Dermatology (AAD), almost 30 million Americans visit indoor tanning salons each year, fueling a 5 billion dollar/year industry, and 20% of those ages 18–39 years have reported visiting a tanning bed (10, 11).

Studies consistently show women are more likely to sunbathe, want to be tanned, use tanning beds, and endure sunburns to achieve their desired tan, with greatest tendency among Caucasian women ages 16–49 years (estimated by the AAD to represent 70% of the tanning population), and a peak in women in their teens and twenties. Over 25% of teen girls report having used tanning salons at least three times, with a prevalence of up to 40% among those ages 17–18 years (7, 11). This age group is particularly vulnerable to development of melanoma, and indoor tanning may impart an even greater risk than UV exposure from the sun (12).

Those who use tanning beds and endure burns to tan display a high level of knowledge about the risks of UV exposure, often knowing more than non-users. However, awareness of these adverse effects does not decrease desire to tan or alter tanning activity, especially for those in their teens and twenties (11, 13–15). Robinson et al. (16) observed that, whereas public knowledge regarding the hazards of sun exposure grew from 1986 to 1996, sun-burning and the regular use of tanning booths also increased. Ten annual tanning bed visits are reported to double the risk of melanoma for those over thirty and increase the risk almost eight-fold for those under thirty (17); yet even among young adults from melanoma-prone families, 35% have reported using tanning beds (18). Thus, even seeing family members face a deadly cancer and the immediate and literal consequence of getting burned by the analog of a hot stove do not sufficiently deter tanners from a habit they know to be self-destructive. In this glaring way (i.e., persistence in behavior despite a recognized physical harm), tanners resemble persons with substance dependence.

THE ADDICTION

Screening surveys suggest that approximately 70% of frequent indoor (3) outdoor (19) tanners meet a tanning-modified version of the CAGE criteria (Cut Down, Annoyed, Guilt, Eye-opener) for alcohol dependence (Table 1) or a modified *Diagnostic and Statistical Manual-IV* (DSM-IV) criteria for a substance abuse or dependence (Table 2) disorder. In these studies, subjects endorsed difficulty decreasing frequency of tanning, feeling annoyed when others comment on their habit, wanting to tan upon waking up in the morning, missing scheduled events to tan, having faced social or occupational consequences because of tanning, and continued tanning despite awareness of these consequences (see Tables 1 and 2) (20). Of particular interest was the finding that the three most common reasons endorsed by 100 frequent indoor tanners were to look good (90%), feel good (69%), and relaxation (56%) (3), the latter two items suggesting a subjective response possibly mediated by central, rewarding processes; see also (1). To our knowledge, there are no community-based surveys exploring the prevalence or incidence of problematic tanning behaviors. Frequent tanners also endorse symptoms of other addictive and substance-abuse related behaviors (21). Similar to smoking cessation, age of initiation and frequency of tanning in indoor salons are inversely correlated with success in quitting (22, 23).

TABLE 1.
Modified CAGE questions used to identify tanners with symptoms consistent with a tanning problem [from (3)].

Original CAGE Questions	Modified CAGE Questions
Have you ever felt that you needed to **C**ut down on your drinking?	Have you tried to stop tanning, but still continue?
Have people **A**nnoyed you by criticizing your drinking?	Do you ever get annoyed when people tell you not to tan?
Have you ever felt **G**uilty about drinking?	Do you ever feel guilty that you tan too much?
Have you ever had an Eye-opener—a drink first thing in the morning to steady your nerves or get rid of a hangover?	When you wake up in the morning, do you want to tan?

These behaviors could represent an expression or compulsion related to a form of body dysmorphic disorder (BDD) (1, 21), colloquially termed "tanorexia." BDD studies have found a subset of patients who meet criteria for a tanning-related type of BDD in which the skin is the body area of greatest concern (21) and subjects engage in ritual actions such as mirror checking, grooming, comparing/scrutinizing, and compulsively picking the skin (24). Tanning BDD subjects demonstrate functional impairment with social avoidance due to their BDD (some becoming housebound), some having attempted suicide, and most having received dermatologic treatment generally ineffective for BDD symptoms (21, 24). The disorder is much more prevalent

TABLE 2.
Modified DSM-IV criteria for substance dependence used to identify tanners with symptoms consistent with an addictive disorder [from (3)].

DSM-IV Criteria	Modified Question
Tolerance	
Need for markedly increased of amounts of substance to achieve intoxication or desired effect	Do you feel that you need to spend more and more time in the sun or tanning bed in order to maintain your tan?
Withdrawal	
Withdrawal symptoms if use of substance is decreased or stopped	Do you feel unattractive or anxious to tan if you do not maintain your tan?
Loss of control	
Substance often taken in larger amounts or over a longer period than intended	Do you think that you should stop tanning or decrease the time you spend tanning?
Persistent desire or unsuccessful efforts to cut down or control substance use	Have you tried to stop tanning, but still continue?
Compulsive use	
Important social, occupational, or recreational activities are given up or reduced because of substance use	Have you ever missed a social engagement, work, school, or other recreational activities because you went to the beach or tanning salon instead?
Continued use despite adverse consequences	
Substance use is continued despite having persistent or recurrent physical or psychological problems that are likely to have been caused or exacerbated by the substance	Have you ever gotten into trouble at work, with family, or with friends due to tanning?
	Do you continue to tan despite knowing that it is bad for your skin (can cause wrinkles, premature aging, sun spots, etc.)?
	Have you ever had a skin cancer? Do you have a family history of skin cancer?

in women, and for most patients, onset occurred during adolescence, consistent with the gender and age patterns of tanners (25).

While BDD and compulsivity may contribute to some degree of disordered tanning behavior, these models do not explain reports of the effect of tanning on mood and the suggestion of physical dependence—that is, observations of tolerance and, possibly, withdrawal. Recent studies suggest that ultraviolet radiation has reinforcing properties that are physiologic and distinct from any known psychosocial benefits of having a tan (26). When queried regarding their reasons for tanning, we found that for patrons of indoor tanning salons two of the top three reasons were physiologic in nature: to feel good and to relax. A study of female undergraduate students reported an 80% correlation of frequent tanners (defined as tanning $\geq$ 40 per year) with seasonal affective disorder (SAD) or sub-syndromal seasonal affective disorder (s-SAD) (25). The investigators suggested that tanners use tanning beds for their mood-enhancing effects as "bright light therapy," the most common treatment for SAD. Recent controlled studies by our group and others (26) using UV-emitting tanning beds versus an identically appearing sham tanning bed suggest physiologic preference for UV light by frequent tanners. Subjects chose the UV-emitting tanning bed, when given the choice, over an identical tanning bed from which the UV light was filtered. After UV exposure, tanners reported a more relaxed mood and subsequent decreased craving to tan, as compared with sessions without UV exposure (26).

The high frequency of sunburns among intentional tanners and the persistence in tanning to the point of scorching the skin, resulting in over 700 emergency room visits per 10,000 tanning facilities annually (27), suggest that many subject themselves to UV exposure beyond the threshold necessary to obtain a tan. This could imply a form of tolerance to UV light that is beyond the level the skin can withstand, analogous to patients who consume dangerous amounts of alcohol or opioids in order to experience the effects of reward that others experience at much lower doses.

There is preliminary evidence for the existence of UV withdrawal. In a double-blind, randomized study using UV-emitting versus sham tanning beds, the opioid antagonist naltrexone was randomly administered prior to UV exposure to both frequent tanners (defined as those tanning 8–15 times per month, i.e., more than necessary to maintain a tan) and infrequent tanners (those who have never tanned $>$ 12 times per year) (28). When given naltrexone before UV exposure, 50% of frequent tanners reported nausea, a symptom consistent with opiate withdrawal, while infrequent tanners experienced no adverse symptoms. In the absence of naltrexone, the frequent tanners showed marked

preference for the UV-emitting tanning bed over its identically appearing non-UV counterpart, while after naltrexone they showed much less preference for the UV tanning bed (28, 29).

THE MECHANISM

When examining a pathologic entity, one may consider a physiologic counterpart of that trait responsible for its evolutionary survival. In the case of sun-seeking behavior, the frontrunner among teleological arguments involves the UV-mediated synthesis of vitamin D in the skin. For its multiple health benefits (e.g., bone integrity, calcium homeostasis, anti-colon cancer properties), mechanisms may have evolved to reward behaviors that augment vitamin D acquisition (30).

One possible mechanism involves proopiomelanocortin (POMC), a polypeptide precursor present throughout the central nervous system and skin. POMC is cleaved in a tissue-specific manner to yield multiple biologically active downstream products, including melanocyte-stimulating hormone (MSH), adrenocorticotrophic hormone (ACTH), and β-endorphin (31, 32). Through its multiple downstream effectors, POMC affects the regulation of stress, sleep, energy homeostasis, and skin pigmentation. Under the stimulus of UV-induced DNA damage and repair, the protector of genome integrity, p53, up-regulates the transcription of POMC in keratinocytes. This triggers the secretion of α-melanocyte stimulating hormone (α-MSH) to induce melanogenesis, increasing the free-radical absorbing molecule melanin and thus the photoprotective mechanism represented by a suntan (33–36).

Among the cleavage products of POMC are the glucocorticoid precursor ACTH and β-endorphin, an endogenous ligand of the μ-opioid receptor. β-Endorphin exerts analgesic effects and promotes feelings of relaxation and well-being, much like its exogenous counterparts in the morphine family of drugs (36, 37). The respective anti-inflammatory and analgesic properties of these endogenous steroid and opioid byproducts of POMC are thought to translate into the relief from pain and irritation in the skin associated with ultraviolet light. They offer one possible explanation for how UV radiation alleviates inflammatory skin conditions such as eczema and psoriasis. Human epidermal keratinocytes express a μ-opiate receptor on both the mRNA and protein level, and down-regulate it when incubated with naloxone or β-endorphin (38). In this way, UV radiation on a local level may actually cause the skin to "feel better," and via increased plasma levels of β-endorphin, may act centrally to serve as positive reinforcement for sun-seeking behavior (37, 39). One small study found increased plasma levels of β-endorphin following UV exposure in frequent tanners (40). If this finding can be reproduced on a large scale, it could be a link in an opioid-mediated model for tanning behavior. [It should be noted that whereas salon tanning beds provide both UVB and the more penetrating UVA radiation, phototherapy for dermatologic conditions, such as psoriasis, is limited to less penetrating (UVB) and narrow band (311–313 nm) wavelength. In addition, treatment is limited in individual session duration (2–3 minutes) and total treatment time (6 weeks, with subsequent taper). Similar to the prescribing of opioids to patients for short-term therapy, this approach most likely limits future abuse potential.]

A common and highly geographically biased p53 gene polymorphism, encoding proline at amino acid position 72 (72Pro isoform), is much more prevalent in regions closer to the equator (41), and is speculated to be a more competent inducer of POMC and therefore also of more robust melanogenesis and sun-seeking behavior (42). In its genome protective function of absorbing UV radiation, melanin simultaneously minimizes UV-mediated synthesis of vitamin D, rendering more darkly complexioned individuals less prone to skin cancer and more prone to vitamin D deficiency. This (72Pro) p53 polymorphism might underlie a mechanism encouraging these individuals to seek out sunshine more actively than those of fairer skin.

UV light can also alter serotonin levels, a neurotransmitter strongly implicated anxiety disorders and depressive disorders such as SAD. Serotonin (5-hydroxytryptamine) is converted to melatonin (5-methoxy-N-acetyltryptamine) in the pineal gland via an N-acetyltransferase enzyme (called the "melatonin rhythm enzyme"), which displays diurnal variation with 15–30 fold greater activity at nighttime (43). Some biochemical theories of SAD attribute it to a relative lack of serotonin and/or polymorphisms involving its conversion to melatonin, supported by the success of SSRI's in the treatment of SAD (44). Melatonin is central to regulation of sleep and circadian rhythms and suggested to affect mood by reducing anxiety level, while possibly worsening severe depression and increasing fatigue (45, 46). Patients with SAD may exhibit a longer nocturnal period of active melatonin secretion during winter than in summer, compared with healthy volunteers, who display no seasonal change (47)

Ambient lighting can impact N-acetyltransferase activity and levels of serotonin and melatonin (48, 49). SAD has been associated with certain gene variants in a class of retinal ganglion cells (containing a photopigment called melanopsin) that sense light and affect the "circadian clock" (50). These cells are most specific for short-wave visible light (near the range of UV) (51) and project to the suprachiasmatic nucleus (SCN) of the hypothalamus, which controls the pineal gland's conversion of serotonin to melatonin (52). Norepinephrine release onto pinealocytes by the SCN/pineal circuit inhibits the N-acetyltransferase enzyme, as does light exposure, thereby decreasing melatonin and increasing serotonin levels (53). This may explain the efficacy of modafinil, a narcolepsy medication which increases norepineprine levels, in some SAD patients (54). The light/norepinephrine effect may help offset the vegetative symptoms of SAD and somewhat account for the existence of Reverse SAD, seen in spring and summer months with symptoms of insomnia, anxiety, irritability, decreased appetite, and weight loss (55). Some individuals may be genetically prone to irregularities in the appropriate response to external light signals and/or downstream regulation of serotonin and

melatonin. They may attempt to relieve the resulting disruption of their circadian rhythms and mood via exposure to short wavelength light emitted by tanning beds (56).

The neural response mechanisms underlying compulsive tanning remain largely unexplored. In a preliminary pseudo-randomized, single-blind study, we employed a methodology developed by Feldman et al. (26) to assess the neural response to ultraviolet (UV) versus sham (UV filtered) light in subjects who met criteria consistent with an addictive tanning disorder. Regional cerebral blood flow, assessed by single photon emission tomography (SPECT), was increased in the striatum following UV relative to sham light. Subjects exposed to the UV-radiation also reported a decreased craving to tan relative to the filtered light and were more likely to prefer the UV bed versus the sham bed. These findings suggest that UV radiation exhibits centrally rewarding properties in frequent tanners, and highlight the utility of imaging studies to further explore the neural response to UV.

DIAGNOSTIC CONSIDERATIONS

Further studies may add "tanning" to the rapidly expanding list of process addictions. While several studies have documented in frequent tanners signs and symptoms that are consistent with the criteria used for substance abuse and dependence disorders (17–19), the construct and predictive validity, as well as the reliability, of these criteria have yet to be demonstrated. Sensitivity and specificity of these diagnostic criteria must be further evaluated, coupled with the more general question of the validity and meaning of "addiction" for behaviors outside those involving substances of abuse.

Evidence demonstrating neural changes in response to UV light in infrequent versus compulsive tanners is the key for assessing its addictive potential. Experimental models employing functional imaging modalities, in conjunction with UV filters for sham controls as described earlier, will be of value, as well as the development of animal models. If the central rewarding properties of UV light can be confirmed, this model will also provide a unique methodology to assess mesostriatal activation in the absence of drug administration or the gustatory, visual, auditory, olfactory, or overt tactile evidence of the rewarding stimulus. Other considerations include vulnerability to UV reward as a function of skin type, if neural responses persist after non-use in the frequent tanner, and if there is a threshold of UV exposure beyond which compulsive tanning becomes more likely. The rewarding and potentially addictive qualities of UV light, such as serotonin/melatonin interactions, POMC cleavage products, and p53 transcription, may also offer insights into more general biologic underpinnings of reward and addiction.

TREATMENT CONSIDERATIONS

To our knowledge, there have yet to be studies of pharmacological or psychosocial treatments for tanning addiction. While education regarding related risks may be helpful for occasional tanners, there is evidence suggesting little benefit of this approach in the frequent tanner (9, 11–16). Future pharmacologic interventions may offer options to compulsive tanners. Given the correlation between tanning and SAD, medications that increase levels of serotonin and norepinephrine, which are effective for SAD patients, may help frequent tanners.

For the broader population of tanners, mapping of the p53-POMC pathway may yield options for aesthetic and mood enhancing effects via mechanisms other than UV light. For example, current efforts to develop small molecules that stimulate p53 function in cancers could also give rise to topical agents that induce melanogenesis via activation of p53 or downstream targets. This approach could induce a tan and its "sun-seeking" byproduct keratinocyte-derived β-endorphin without the exposure and cell damage of UV (58). However, even without UV, these new approaches may still illustrate the old maxim of Paracelsus that "poison is in the dose," in that overactivation of p53 by small molecules could cause keratinocyte senescence or cell death, much like a sunburn, and could also mimic the "high" and perpetuate sun-seeking behavior of tanners.

Treatment considerations for frequent tanners must consider possible underlying diagnoses. As discussed above, frequent tanning may be "self-medication" of SAD, or a behavior symptomatic of a BDD. Both SAD and BDD can best be approached through an appropriate diagnosis and directly treating the identified disorder.

CONCLUSION

Whatever the original driving forces for sun-seeking may have been, the medical community must evaluate whether condoning recreational UV exposure is valid in our current society, where skin cancer is rampant and oral vitamin D supplements offer a more direct and quantifiable source of repletion than tanning beds or the sun (59). For those who feel the need or craving to tan, identification of process disorders such as tanning could be a critical step for intervention. Increased scientific attention to UV-related behaviors will hopefully further understanding of a possible psychiatric disorder with carcinogenic consequences and give rise to greater therapeutic options for these patients.

Declaration of Interest

The authors report no conflict of interest. The authors alone are responsible for the content and writing of this paper.

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