Conventional sunscreen application does not lead to sufficient body coverage

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Abstract

OBJECTIVE: This study aimed to assess sunscreen application habits and relative body coverage after single whole body application.

METHODS: Fifty-two healthy volunteers were asked to use the test product once, following their usual sunscreen application routine. Standardized UV photographs, which were evaluated by Image Analysis, were conducted before and immediately after product application to evaluate relative body coverage. In addition to these procedures, the volunteers completed an online self-assessment questionnaire to assess sunscreen usage habits.

RESULTS: After product application, the front side showed significantly less non-covered skin (4.35%) than the backside (17.27%) (P = 0.0000). Females showed overall significantly less non-covered skin (8.98%) than males (13.16%) (P = 0.0381). On the backside, females showed significantly less non-covered skin (13.57%) (P = 0.0045) than males (21.94%), while on the front side, this difference between females (4.14%) and males (4.53%) was not significant.

CONCLUSION: In most cases, the usual sunscreen application routine does not provide complete body coverage even though an extra light sunscreen with good absorption properties was used. On average, 11% of the body surface was not covered by sunscreen at all. Therefore, appropriate consumer education is required to improve sunscreen application and to warrant effective sun protection.

Résumé

OBJECTIF: Le but de l’étude présente était d’évaluer les habitudes d’application de l’écran solaire et la couverture relative du corps après une seule application sur le corps entier.

MÉThODES: Cinquante-deux volontaires saints ont été invités à utiliser le produit d’essai une seule fois suivant leur routine d’application solaire habituelle. Pour évaluer la couverture relative du corps, des photographies UV normalisées évaluées par analyse d’image ont été menées avant et immédiatement après l’application du produit. En plus, les volontaires ont complété un questionnaire d’auto-évaluation électronique pour évaluer les habitudes d’utilisation d’écran solaire.

RÉSULTATS: Après l’application du produit, la face avant a montré significativement moins de peau non couverte (4.35%) que l’arrière (17.27%) (P = 0.0000). Globalement, les femmes ont laissé moins de peau découvert (8.98%) que les hommes (13.16%).

Conclusions: Dans la plupart des cas, la routine habituelle d’application d’écran solaire, ne résulte pas dans une couverture complète du corps, même si un produit ayant des bonnes propriétés cosmétiques est utilisé. En moyenne, 11% de la surface corporelle n’était pas couverte par le produit. Par conséquence, il est nécessaire de former le consommateur pour améliorer l’application d’écran solaire et pour garantir une protection solaire efficace.

Introduction

Intermittent UV radiation (UV) appears to be the key modifiable environmental risk factor for skin cancer and many other extrinsically determined skin conditions such as inflammation, premature skin ageing, etc. [1–4]. Reducing UV exposure can prevent many of these UV-induced pathologies [1], the incidence of which seems to have increased as a consequence of the lifestyle change from sun avoidance towards sun-seeking behaviour [3, 5, 6]. According to estimates for 2012, over 230 000 new cases of malignant melanoma occurred globally, of which 100 000 occurred in Europe [7]. Thus, to reduce the risk of skin cancer, health authorities recommend protecting the skin from excessive exposure to natural UV [8], for example by seeking shade, by wearing protective clothing and by appropriately applying sunscreen products if exposure to sunlight is inevitable [3].

Sunscreens have been developed to prevent sunburn [3], and in the recent years, they advanced in the perception of the general public to the most effective sun protection strategy [9]. It has also been shown, that if sunscreens are used properly, they can reduce the risk of developing actinic keratosis and non-melanoma skin cancer [10–12]. Proper application of sunscreens, under controlled conditions, reduced this risk [13, 14]. However, as shown recently, most people are not aware of the adequate amounts of sunscreen needed to achieve the sun protection factor (SPF) declared on the applied product [15]. It is clear that lying in the sun having the impression of a higher SPF than actually reached as a result of the wrong application routine is going to lead to sunburn, especially in case parts of the skin have not been covered at all. Therefore, the aim of this study was to assess the percentage of total body coverage achieved with the usual sunscreen application routine as well as the application habits of untrained healthy volunteers.
Materials and methods

Study design

This cosmetic, blind study was conducted at the Beiersdorf Test Center in Hamburg under dermatological supervision. Planning and execution were not subject to regulations set forth in paragraphs 40 & 41 of the German Drug Legislation (AMG). Nevertheless, the study was performed in accordance with the current version of the Declaration of Helsinki and the ICH GCP guideline. Before inclusion in the study, all subjects signed written informed consent.

Study population and test product

Adult, healthy, European volunteers, aged between 18 and 43 years, were eligible for this study. Participants had to refrain from using any body cream on the whole body for 3 days prior to study onset. In the evening prior to the scheduled assessment, subjects were required to remove make-up thoroughly, and on the day of assessment, they were not permitted to use any cream or make-up, but were allowed to clean the face and body with water only. Exclusion criteria were as follows: consumption of alcohol and/or drug addiction, pregnancy or breastfeeding, severe psychological illness or intellectual inability to understand the study, chronic or acute skin disease, severe diseases or chronic infections, proven allergies to cosmetic ingredients, wounds, sunburn, scars, tattoos or piercings, application of antibacterial products. Furthermore, participation in other studies within 4 weeks, anti-allergic or immunosuppressive topical drugs or physical and/or cosmetic treatments within two weeks prior and/or during the study, cancer in the last 10 years, illness with fever within the last 7 days, systemic application of anti-inflammatory or antibiotic agents within the last 2 weeks or antihistamines, immunosuppression treatments or retinoids within the 4 weeks prior to study initiation.

The test product was an ultra-light (viscosity of 4400 mPas at 25°C), easy to apply and fast absorbing lotion of SPF50 with following INCI composition: aqua, octocrylene, alcohol denat, homosalate, butyl methoxydibenzoylmethane, ethylhexyl salicylate, bis-ethylhexyloxyphenol methoxyphenyl triazine, phenylbenzimidazole sulfonic acid, tapioca starch, glyceryl stearate, hydrogenated coco-glycerides, synthetic beeswax, triacontanyl PVP, glycine, glycyrrhiza inflata root extract, tocopheryl acetate, xanthan gum, silica dimethyl silylate, sodium stearoyl glutamate, sodium acrylates/C10.30 alkyl acrylate crosspolymer, dimethicone, trisodium EDTA, sodium chloride, phenoxyethanol, perfume.

Subjects received the test product in the test centre, for a single document application status. The UVP set-up is only sensitive to sunscreens developed image analysis software. The percentage of non-covered skin area was calculated as the quotient of non-covered skin areas to total body area minus areas covered with clothes (shorts/bikini). Higher values indicated more non-covered skin areas.

After sunscreen application, the volunteers answered an online self-assessment questionnaire (SAS) to assess expectations from sunscreen products in general and to describe their usual application practices (outside of the study).

Statistical analysis

SAS was analysed descriptively via a tabular representation of frequencies. Descriptive statistics of IA was performed via tabular and graphic (box plots) representation of the location parameters (arithmetic mean, median, minimum and maximum), dispersion parameters (standard deviation, interquartile range (IQR) and coefficient of variation (CV)). Two-sided hypothesis testing and a significance level of 0.05 was applied for inductive statistics. Shapiro-Wilks test was used to test the normality of IA. In rejection of the normality hypothesis, analysis of the Blom-transformed ranks of the original IA data was applied. Analysis of variance was used to evaluate effects of the area or of gender or of both using them as the respective classification variable. If applicable, post-hoc pairwise comparisons were also performed. The software used was MICROSOFT EXCEL 2013 and SAS Software Package for Windows V9.4.

Results

Fifty-two subjects (29 female; 23 male) aged 32 ± 7.3 years were included and completed the study. After product application, the used sunscreen absorbs UVA radiation with chemical UVA filters; hence, they absorb the incoming UVA radiation. Therefore, body areas covered with these UVA filters appear dark in UVP images.

Whole body images were taken from the front and the backside of the subjects. Areas like armpits and soles, which are not visible in the images, could not be considered. In the images, it was clearly visible if a body area was covered with a sunscreen or not. Also differences in the amount of sunscreen application per body area were visible. Only areas with absolutely no sunscreen were considered as non-covered areas. Images were inspected, and non-covered skin areas were highlighted manually in red. Afterwards, the total body area, the area covered by clothing and the highlighted non-covered areas were automatically determined for each subject with a sponsor-developed image analysis software. The percentage of non-covered skin area was calculated as the quotient of non-covered skin areas to total body area minus areas covered with clothes (shorts/bikini). Higher values indicated more non-covered skin areas.

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Results

Fifty-two subjects (29 female; 23 male) aged 32 ± 7.3 years were included and completed the study. After product application, the
front side showed significantly less mean non-covered skin area 4.35 ± 4.56% (male 4.14 ± 4.53%; female 4.53 ± 4.65%) than the backside 17.27 ± 11.14% (male 21.94 ± 10.33%; female 13.57 ± 10.49%) (P = 0.0000) (Fig. 1) (Table I). As seen from the minimum non-covered skin values in Table I, there were female subjects, which achieved almost 100% body coverage (Fig 2). Male subjects left a larger mean body area non-covered (13.16 ± 6.44%) than female (8.98 ± 6.96%) (Fig.3) (Table I). These gender differences were significant for the whole body (P = 0.0381) and for the back area (P = 0.0045). On the front side, no significant difference in the percentages of non-covered skin could be detected between males and females.

Typical body areas not covered at all by sunscreen were the same for men and women. Namely feet, upper back, area around shorts/bikini, backs of arms and hands (Fig. 5–7). These areas were in most cases different from the areas estimated by the subjects in the SAS questionnaire when answering the question about the body areas they experience most often sunburn despite using sunscreens (Fig. 4). Namely nose and bridge of the nose were the most often (21.2%) mentioned areas, followed by the face (19.2%), the shoulder/shoulder blades (17.3%), the back/upper back (17.3%) and the décolleté (15.4%) (Fig. 4). The awareness for sunburn risk of the upper back was high, and in this study, it was the area not sufficiently covered by sunscreen in the majority of the cases (Fig. 5–7). We also included a bald man into the study and noticed that his scalp was not covered by sunscreen at all (Fig. 7).

Based on the SAS, the majority of the subjects stated their skin being normal sensitive to the sun (57.7%) and not allergic to sun (86.5%). Protection against hyperpigmentation was the highest rated reason for applying sunscreen products (3.7 on a 4-step scale) followed by protection against premature skin ageing (2.7), against skin cancer (2.1) and against sun-burn (1.5). High sun protection was mentioned as the most important product property (86.5%) influencing choice, followed by quick absorption into the skin (82.7%).

No incompatibility reaction or discomfort from the test product was observed or reported by any of the subjects.

Discussion

Under controlled conditions, appropriate application of sunscreens has been shown to prevent skin cancer [13, 14]. However, in real life – despite the improved galenic properties of sunscreens – still lower (1.0–1.5 mg/cm²) than recommended (2.0 mg/cm²) [16] amounts of sunscreen are used, leading to reduced UV protection and to sunburn [17, 18]. In this study, not the amount used by
volunteers but the sunscreen application habits and the relative total body coverage after applying the cream according to their typical application routine were the main objectives of evaluation. The study showed that after single application by subjects of European origin, considerable surface of the body remained non-covered, especially on the backside of males. The front side showed less non-covered skin than the backside, and females covered their skin better than males (Fig. 5–7). Some women achieved even total body coverage (Fig. 2, Table I), indicating that the experimental conditions of the study allowed correct sunscreen application. Surprisingly, not only difficult to reach areas, as the back were left non-covered, but also the feet, hands and the area around the swimming suit, which are actually easy to be accessed. Usually, under controlled conditions, subjects are more cautious than in real life [19]. Thus, based on the results of this study, only less total body coverage can be expected in reality at least – based on the origin of the subjects – among Europeans, signifying the high educational need.

The absolute amount of sunscreen used by every subject was also tracked during the study (data not shown). High amount of sunscreen usage did not automatically result in perfect body coverage. Similarly, lower amount of sunscreen usage did not necessarily mean poor body coverage. Nevertheless, there was a weak correlation between the amount of sunscreen used and the total body coverage. Most of the subjects used between seven and 20 gr of the offered product. The subjects who reached a body coverage >90% used more than 10 gr of the product. That only means that they were able to cover more than 90% of their body with sunscreen, without meaning that it was the correct amount for sufficient protection of the covered body areas. Thus, another variable of

![Figure 4](image_url) Results of self-assessment of cream application habits regarding the areas, which get sunburned despite sunscreen application.

![Figure 5](image_url) Example of sunscreen coverage by a female.

![Figure 6](image_url) Example of sunscreen coverage by a male.
interest, not objective of this study, would be the usage of the correct quantity of the sunscreen per body area to obtain the protection declared on the product. Further to the results on body coverage, the study has shown that besides the worldwide ongoing campaigns for skin cancer prevention, which recommend direct sun avoidance, skin coverage and application of sunscreen [3, 20], the subjects mentioned as main reason for applying sunscreen, protection against hyperpigmentation and only as third and fourth reason protection against skin cancer and against sunburn, respectively. Still, the fact that high sun protection was the most mentioned product property when using sunscreen shows that alertness regarding effective protection exists. However, as revealed in this study, this does not lead to an adequate application of sunscreen.

This was the first quantitative study to show, using state-of-the-art methods of visualization and quantification, that average European application habits are not providing the coverage required to prevent photoaging, skin cancer and other UV-induced damages to the skin. A limitation of the study was that only one formulation has been tested. Sensorial characteristics might influence application habits, and a different product might have led to other results. In any case, the tested product was a light, easy to apply and fast absorbing lotion which is preferred for sun application as indicated also in the SAS results. It seems, that although high quality, well formulated, easy to be applied and fast absorbed sunscreen products are available, consumers are not applying them sufficiently leaving considerable areas of the body totally unprotected. This translates into high cumulative damage with potentially dramatic consequences for skin and overall health [1, 3].

In conclusion, the study results clearly demonstrate the need for further public education, not only considering the appropriate amount of sunscreen but also where to apply it to achieve complete body coverage. Professionals, such as dermatologists could play a key role in this. Therefore, the results of this quantitative study will hopefully increase the awareness of professionals as well as non-professionals towards improvement of sunscreen application behaviour.

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