Appearance-based interventions to reduce UV exposure: A systematic review

Abstract

Purpose: As a majority of skin cancer cases are behaviourally preventable, it is crucial to develop effective strategies to reduce UV exposure. Health-focused interventions have not proved to be sufficiently effective, and it has been suggested that people might be more susceptible to information about the negative effects of the sun on their appearance.

Method: This systematic review of 30 separate papers, reporting 33 individual studies published between 2005 and 2017 assesses the overall effectiveness of appearance interventions on participants' UV exposure and sun protection behaviour.

Results: Appearance-based interventions have positive effects on sun exposure and sun protection, immediately after the intervention as well as up to 12 months afterwards. The meta-analysis found a medium effect size on sun protection intentions for interventions which combined UV photography and photoaging information: $r+ = .424$; $k = 3$, $N = 319$, CI = .279 - .568, $p = .023$.

Conclusions: We provide a review of current research on the effectiveness of appearance-based interventions to reduce UV exposure. As well as highlighting methodological issues we recommend that practitioners administer a UV photo intervention in combination with photo-aging information to reduce UV exposure. Furthermore, the review specifically recommends that future research focuses on the use of theoretical constructs to enhance photoaging information, and is conducted with older participants and in countries where people have less opportunity for sun exposure.

Keywords: Skin Cancer; UV Exposure; Appearance-based interventions; UV photography; Photoaging information

Appearance-based interventions to reduce UV exposure: A systematic review

Deaths from skin cancer are an increasing problem around the world; the World Health Organization (2015) reports that up to 2 million new cases occur globally each year. In the UK, non-melanoma skin cancers are by far the most common type of cancer with around 102, 000 new cases diagnosed annually (Cancer Research UK, 2016). There is an established link between ultraviolet (UV) radiation exposure and all types of skin cancer; this includes intentional (e.g. indoor and outdoor tanning) and incidental exposure (WHO, 2016). It is estimated that UV radiation causes 86% of malignant melanoma cases in the UK (Cancer Research UK, 2016). Thus, skin cancer is to a large degree behaviourally preventable, meaning that developing strategies to reduce UV exposure could be effective in limiting new incidences (Jackson & Aiken, 2006).

Although the health-related costs of UV exposure and the benefits of sun protection are relatively well known (Miles *et al*., 2005), interventions that highlight these consequences are not sufficiently effective (Mahler *et al.*, 2006). A possible reason for this is that tanning behaviour is primarily motivated by a desire to improve appearance, and, as such, it is perhaps less responsive to health warnings (McWhirter, 2015). Research on both men and women suggests that focusing on the appearance-related costs of UV exposure is effective in reducing UV exposure (Grogan *et al.*, 2015). A review by Dodd and Forshaw (2010) found that appearance-based interventions were generally successful in improving UV protective behaviours (e.g. sun protection use), but only moderately successful in altering behaviours relating to UV exposure. Another systematic review by McWhirter (2015) found that visual images, e.g. UV photography (i.e. showing participants current level of UV damage to their skin), were successful in promoting sun protection and reducing UV exposure.

The current study is modelled on the Williams *et al.* (2013) review and meta-analysis, which focused on the efficacy of appearance-based interventions to reduce UV exposure.

Williams *et al.* (2013) found an overall positive impact of appearance-based interventions on reducing UV exposure, and the meta-analysis indicated that UV photo (i.e. demonstrating actual UV damage to a participant's face) and/or photoaging information (i.e. providing participants with information about the ageing effect of the sun), had a significant effect on sun protection intentions and future indoor tanning behaviour. The authors identified a number of problems with the data set, including limited long-term follow-ups, homogeneity of settings, and limited priori power analysis. The current study aims to provide an updated review of the literature, which is considered relevant as the last data search was executed over five years ago. This is particularly important as research into appearance-focused interventions has developed significantly since this time, for instance by including novel techniques such as facial morphing (a type of intervention demonstrating potential future UV damage, by morphing a current image of the person using a specialised software). The current study also includes a larger meta-analysis.

1. Do appearance-based interventions reduce UV exposure immediately after the intervention and/or long-term?
2. What does new research (i.e. the studies not included in the Williams *et al.*, 2013 paper) add to current understanding of the efficacy of appearance-related interventions to reduce UV exposure, and has the quality of research improved?

Method

Protocol and registration

A review protocol was not used, however, the review has been reported in accordance with the PRISMA guidelines. See appendix for the PRISMA checklist.

Eligibility criteria

Eligibility criteria was identical to William's *et al.* (2013). Studies included an appearance-based intervention, either in isolation (i.e. assessing scores before and after the intervention) or in comparison with another intervention (or control condition); and were required to adopt a pre-test and post-test design, but not necessarily a randomised controlled design (RCTs). Correlational studies were not included. An appearance-based intervention was defined as an intervention that highlighted negative effects of UV exposure on appearance, such as UV photography or photoaging information. Furthermore, studies had to assess the effects of the intervention on sun seeking and/or sun protective behaviours or intentions. Sun seeking behaviours were defined as behaviour that increased UV exposure, and included spending time in the sun or using indoor tanning booths; sun protective behaviours were defined as behaviour intended to decrease UV exposure, such as sun lotion use or protective clothing. Finally, studies were required to administer a post-test measure to assess the effectiveness of the intervention.

Information sources

The primary source of articles was Web of Knowledge (Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Conference Proceedings Citation Index – Science and Social Science, Emerging Sources Citation Index); in addition to this seven other electronic databases (CINAHL, ZETOC, PsycARTICLES, PsycINFO, Medline, OVID, Proquest theses) were accessed to search for studies. To ensure the searched databases provided a relevant literature base, it was confirmed that the list of studies included in the William's *et al.* (2013) paper were found. An ancestry search, i.e. identifying references that cited the identified papers, was also carried out to identify any missing studies.

Search

The current study used the same search terms as Williams *et al's.* (2013), to ensure consistency: '(sun*OR UV) AND (appearance OR age spots OR photoaging OR damage OR wrinkles) AND (skin cancer OR melanoma OR health) AND intervention*AND (sunscreen

OR protect*OR tan* OR expos*OR prevent*OR behav*)', and included studies conducted Jan 1st 2005 – May 16th 2017. The search was conducted by the first author. 2005 was used as a starting point as research up until this point was sufficiently covered in previous reviews.

Study selection and data collection process

Eligibility assessment was performed by the first author (see PRISMA flow chart), but agreed upon by all authors. A total of 170 records were identified through database searches, and a total of 532 records were identified through the ancestry search, yielding a total of 702 screened records. Following this, 655 records were excluded based on irrelevancy and duplicity, leaving a total of 47 papers to be examined. In addition, six studies were excluded because the intervention focused on health consequences of UV exposure (Cheng *et al.*, 2011; Dykstra, 2007; Hernandez *et al.*, 2014; Lazovich *et al.*, 2013; Olson *et al.*, 2008 [included in the William's *et al. (2013)* review]; Thomas *et al.*, 2011), three due to not examining relevant research questions (Cox *et al.*, 2009; Hillhouse *et al.*, 2010; Walsh *et al.*, 2014), and seven for not containing an intervention (Cheetham & Ogden, 2016; Hillhouse *et al.*, 2016; Noar *et al.*, 2015; Pagoto *et al.*, 2009; Taylor *et al.*, 2016; Welch *et al.*, 2016; Williams *et al.*, 2013b). To identify potential prominent authors in this field were contacted (e.g. authors of the William's *et al.*, 2013 study) and asked whether they had any unpublished material. Additionally, ProQuest theses was searched for unpublished material. An extraction table was designed based on the main elements reported in the Williams *et al.* (2013) study. Data were extracted by the first author, with 10% checked blind (i.e. independently extracted by another member of the team and then compared to the data extraction conducted by the first author) by the sixth author during April – May 2017. Due to the high level of agreement (88%), the remainder of the data were checked non-blind by the same author, with agreement of 94.%. Any disagreements were resolved by discussion. All papers were further checked and agreed upon by the second author. The final review includes 30 separate articles (33 independent studies, as some articles reported more than one study); 18 of these papers (20 individual studies) were not included in the Williams *et al.* (2013) article. Information extracted from the studies included participant characteristics, study location and settings; intervention characteristics, outcome measures, and which, if any, theoretical constructs were utilised to inform the intervention, and methodological issues.

A formal tool was not utilised to assess methodological bias, but the first author assessed risk of bias in each study by examining the methodology (i.e. study design, proposed analyses, type of intervention, comparison groups etc.), randomization process, quality of the outcome measures (e.g. Cronbach's alpha), and research funding. No studies were deemed to be biased, aside from the Bae et al. (2017) paper, as it was neither controlled nor randomised, and did not compare the intervention with a control condition. However, this risk of bias did not adversely impact the meta-analysis, as it was excluded due to lack of sufficient details for effect-size calculation, and was therefore only commented on in the systematic review. In addition, small study bias and publication bias were assessed utilising Egger's regression (Stern & Egger, 2000) and trim and fill analyses (Duval & Tweedie, 2001). This was reviewed and agreed upon by the second and last authors. In sum, the main outcomes of interest included sun seeking behaviours and intentions (i.e. indoor and outdoor tanning), and sun protective behaviours and intentions (i.e. use of protective clothing or sun tan lotion).

Meta-analytical strategy

The meta-analysis employed a random effects model. All but one of the studies included in the review were also included in the meta-analysis. Bae *et al.* (2017) was not included as the main author declined a request for additional data to facilitate effect size calculations. Three studies (Mahler *et al.,* 2006; Mahler *et al.,* 2007; Mahler *et al.,* 2013) included separate UV photo and photoaging information components (with the same participants), hence were added as two separate studies under the two relevant interventions. Studies were categorised according to the type of appearance intervention, creating four separate data-sets: interventions with UV photo, photoaging information, UV photo in combination with photoaging information, and interventions that could not be classified as either, for instance facial morphing or group discussions. Due to the heterogeneous nature of the final category, it was not possible to further distinguish between these interventions. The process of categorisation into types of interventions enabled the inclusion of the same participants in separate analyses. In addition, studies described in Gibbons (2005) were originally analysed as one by that paper's authors, resulting in a total of 34 independent studies included in the meta-analysis. For each of these studies, correlation coefficient *r* was calculated to assess the relationship between the appearance-based intervention and the outcome variable, which was classified as sun protection or UV exposure. Following Cohen's (1992) recommendations, $r = .10$ was taken to represent a 'small' effect size, $r = .30$ a 'medium' effect size and $r = .50$ a 'large' effect size. Long-term (i.e. any follow-up longer than immediately following the intervention, ranging from one week to six months) effects of the interventions are commented on in the systematic paper review as there was not enough studies with similar levels of follow-ups to include this as a moderator analysis.

Where studies contained two (or more) conditions, the appearance-focused condition was defined as the one with the strongest focus on appearance, and the control condition contained, where possible, active element (e.g. another intervention, as compared to a passive control being waitlist only). Where studies contained more than one appearance-focused intervention, these were compared separately to a control condition, creating separate effect sizes. Where studies lacked relevant statistics, authors were contacted to provide additional information that could facilitate the effect size calculations. All authors except one (Bae *et al.*, 2017) responded with the requested information (Christensen *et al.*, 2014; Cornelis *et al.*, 2014; Gibbons *et al.*, 2005; Hevey *et al.*, 2010; Mahler *et al.*, 2010; Morris *et al.*, 2014;

Sontag & Noar, 2017; Stapleton *et al.*, 2010). These authors were also asked about any unpublished material they might have. As the majority of the studies included a follow-up immediately after the intervention, where possible, this point in time was used to calculate effect sizes to ensure homogeneity of the data. For studies that did not have an immediate follow-up ($N = 7$), or did not report sufficient data for this point, effect sizes were calculated for the nearest available time following the intervention.

The meta-analysis assessed the effectiveness of the intervention on four specific outcome variables: sun protective intentions, sun protective behaviour, UV exposure intentions, and UV exposure. In addition, effectiveness was also assessed as a weighted-mean for multiple outcome variables, henceforth referred to as a combined outcome variable. If multiple outcomes were measured for one of the categories above, e.g., both sun exposure and sun lotion were measured to examine sun protective behaviour, an overall effect size was calculated as the weighted-mean of these measures. Random effect sizes were computed using SPSS version 22, and the macros developed by Wilson (2005). Effect sizes were weighted by sample, with a 95% confidence interval, and an estimate of heterogeneity. Publication bias and small study bias were also assessed (Duval & Tweedie, 2000; Stern & Egger, 2000)

Results

Descriptive features of the studies

Participants and settings

Across all samples, there were 7348 participants, with sample sizes ranging from 50 to 965 participants. Twelve studies specifically targeted females, whereas four studies targeted males. The remainder had a mixed-gender participant group. Twelve studies based their sample size on power calculations. The majority of the studies included participants aged between 16-35 years. Participants were predominately White. Seven studies targeted a risk group such as indoor tanners or highway workers A majority (75.8%) of the interventions were implemented in a research facility or University setting, with the remainder (24.2%) being administered online or in a community setting (e.g. a public beach).

Appearance-based interventions

The most common type of intervention (N=17) was UV photography, either in isolation or combined with information about photoaging. Three of the UV photo studies (Mahler *et al.*, 2006; Mahler *et al.*, 2007; Mahler *et al.*, 2013) administered two separate interventions on UV-photo and photoaging. The second most common type of intervention (N=7) was photoaging information. The remainder of the studies utilised alternative types of interventions, such as discussing and challenging the tanned ideal, manipulating media images or implementing facial morphing. Twenty-one of the studies based their interventions fully or in part on theory. See Table S1 for full details of the theoretical basis and critical points for each of the studies.

Measures employed

All studies administered post-intervention measures to assess the effect of an appearance-based intervention on UV exposure intentions and/or behaviours. All but one (Bae *et al.*, 2017) of the studies compared this to a control condition (passive control in six of the studies). All of the papers utilised some form of self-report measure to assess intervention efficacy. An alternative method to assess behavioural efficacy of the intervention examines skin colour. It involves the use of a skin reflectance spectrophotometer which, when based on hue lightness and saturation on various skin sites, can indicate level of UV exposure (Mahler *et al.*, 2006). This technique was utilised by four studies.

Descriptive results from systematic review

Table 1 provides a summary of the overall pattern of findings. Table S2 provides a detailed description of the individual studies, including intervention design and findings. Overall, a majority (N= 29) of the studies reported that an appearance-focused intervention had a positive effect on reducing UV exposure and/or increasing sun protection. Interestingly, four of the studies that reported positive findings only found this effect when examining a particular participant group or combination of conditions; Cornelis *et al.* (2014) found that an appearance intervention decreased intentions to tan when the argument against tanning was two-sided, but not when it was one-sided; Stapleton *et al.* (2010) found that their intervention decreased indoor tanning frequency among a sub-group of tanners with previously low knowledge of the health or appearance costs of tanning; and Walsh and Stock (2012) found than UV photo increased sun protection willingness among masculine men. Finally, Morris *et al.* (2014b) found that UV photo had a positive effect on sun protection intentions only when participants were primed with mortality.

For the studies including a longer (i.e. longer than immediately following the intervention) follow-up, the findings were generally positive. Up until a month after the intervention, participants reduced indoor and outdoor sunbathing frequency and increased use of sun protection (Chait, 2015; Gibbons, 2005a; 2005b). These effects were evident for up to six months, including reduced intentions to tan and increased intentions to use sun protection (Hillhouse *et al.*, 2008; Jackson & Aiken, 2006).

Three studies did not find an effect of the appearance based intervention on the main measured outcome; Christensen *et al.* (2014) found that participants in the UV photo condition did not progress in UV-protective stages of change long-term, and the health-oriented intervention was significantly more effective in increasing immediate sun-protective intentions; and Hevey *et al.* (2010) found no significant difference between a health and appearance-framed message on intentions to use sunscreen and sunbeds. Similarly, Sontag, and Noar (2017) reported no difference between a health and appearance-framed message on UV exposure intentions.

Pertaining to the second research question regarding the contribution of the 20 studies published since 2012 (i.e. those not included in William's *et al*., 2013), there was a similar selection of interventions, apart from the inclusion of two studies utilising facial morphing (Owen *et al.*, 2016; Williams *et al.*, 2013). This technique had positive results on participants' sun protection intentions and behaviour when compared to a health literature intervention. Moreover, three of the five studies specifically targeting a male population were found in this sample. Although most research is still conducted on a female sample, this suggests that research into UV exposure is increasingly considering men's motivation to tan and their barriers to sun protection. The majority of these studies reported modest results, or positive findings confined to a particular combination of conditions (e.g. mortality priming or two-sided arguments). This suggests that appearance-focused interventions to reduce UV exposure may need to consider drawing on other aspects of behaviour change or persuasion theory to enhance efficacy.

Results of meta-analysis

Table 2 presents the summary of the meta-analyses results (with combined effect sizes), and figure 1 plots effect sizes and Standard Errors. The meta-analysis was carried out on four sub-sets categorised according to the type of intervention utilised; this because some participants took part in more than one intervention, thus is was not possible to analyse the sample as one.

Ten studies (Christensen & Cooper, 2014; Dwyer, 2014; Heckman *et al.*, 2013; Mahler *et al.*, 2013a, Mahler *et al.*, 2006; Mahler *et al.*, 2007a; Morris et al., 2014a, 2014b; Pagoto *et al.*, 2010; Walsh & Stock, 2012) examined the effectiveness of UV photo on the combined outcome variable, and on sun protective intentions specifically. For the overall effect of this intervention on all outcomes, the combined effect size was small: $r^+ = .19$; $k = 10$, $N = 1{,}564$, 95% *CI*: .084 to .296, $p < .001$. The effect size on sun protective intentions only was also small $r^+ = .165$; $k = 8$, $N = 1{,}251$, 95% *CI*: .036 to .295, $p = .012$. Effect sizes were heterogeneous, Q(9) = 35.38 , $p < .001$.

Four studies (Mahler *et al.*, 2006b; Mahler *et al.*, 2007b, Mahler *et al.*, 2013b, Tuong & Armstrong, 2014) examined the effectiveness of photoaging information on sun protective behaviour and intentions combined, and sun protective intentions separately. For the overall effects of photoaging on all of the above outcome variables, the combined effect size was medium $r^+ = .327$; $k = 4$, $N = 836$, 95% *CI*: .206 to .447, $p < .001$. On sun protection intentions only the effect size was small $r^+ = .272$; $k = 3$, $N = 813$, *CI* = .203 to .341, $p = .039$. Effect sizes were heterogeneous, Q(9) = 7.65 , $p = .054$, using Higgins *et al*'s (2003) proposed significance level of .10.

Six studies (Gibbons *et al.*, 2005; Mahler *et al.*, 2008; Mahler *et al.*, 2010c; Mahler et al., 2005; Sontag & Noar, 2017; Stock *et al.*, 2009) examined the effectiveness of UV photography combined with photoaging information on a combination of three outcome variables: sun protective behaviour and intentions, and UV exposure, and sun protective intentions separately. For the effectiveness of this intervention on the above outcome variables, the combined effect size was small, $r^+ = 0.261$; $k = 6$, $N = 918$, *CI* = .047 to .475, $p = .017$. The combined effect size on sun protection intentions only was medium, $r^+ = .424$; $k = 3$, $N = 319$, *CI* = .279 - .568, $p = .023$. Effect sizes were heterogeneous, Q(13) = 54.89 , $p < .001$.

Fourteen studies (Chait *et al.*, 2015; Cooper *et al.*, 2014; Cornelis *et al.*, 2014; Hevey *et al.*, 2010; Hillhouse *et al.*, 2008; Hillhouse *et al.*, 2017; Heckman *et al.*, 2017; Jackson & Aiken, 2006; Mahler *et al.*, 2010a, 2010b; Stapleton *et al.*, 2010; Stapleton *et al.*, 2015; Williams *et al.*, 2013; Owen *et al.*, 2016) examined the effectiveness of interventions not classed as either of the above on a combination of all of the outcome variables, as well as sun protection intentions, UV exposure and UV exposure intentions separately. For the effects of these interventions on the above outcome variables, the combined effect size was small, r^+ = .191; k = 14, N = 3895, CI = .117 to .265, p < .001. On UV exposure intentions only, the combined effect size was small, r^+ =.235; k = 7, N = 1798, CI = .133 to .371, p < .001. On actual UV exposure, the effect size was small, r^+ = .1542, k = 6, N = 1878, CI = .007 to .302, p = .040. Finally, the effect on sun protection intentions was small but non-significant, r^+ = .223; k=5, N=773, CI = -.015 to .461, p = .067. Effect sizes were heterogeneous, Q(6) = 26.67 , p <.001.

Summary of risk of bias scores

As only two unpublished studies were included in the analysis, it was not possible to assess publication bias by directly comparing effect sizes of published and unpublished studies. Thus, a trim and fill analysis was performed (Duval & Tweedie, 2000) using STATA version 11 (STATA Corp, 2009). Results revealed that there was no bias in interventions utilising UV photo, photoaging information or interventions classed as neither. It did, however, reveal a publication bias in interventions utilising UV photo in combination with photoaging information, filling three studies, rendering the results non-significant, p = .410. To ensure the meta-analytical effect sizes were not adversely impacted by underpowered studies from relatively small samples, an Egger's regression was also performed (Stern & Egger, 2001) using STATA version 11 (STATA Corp, 2009). Results revealed no small-study bias in any of intervention types.

Discussion

Summary of evidence

The current study provides a valuable contribution to the existing literature, as it includes 20 individual articles (consisting of 22 independent studies) published between 2012 and 2017 that were not included in Williams *et al.*, (2013), providing an updated examination and analysis of current directions within research on appearance-based interventions. Furthermore, as the meta-analysis contains more individual studies, it represents a more reliable reflection of the effectiveness of these interventions. Additionally, the current review includes two unpublished papers, a factor that goes some way towards counteracting publication bias.

Appearance-based interventions were generally successful in reducing UV exposure, supporting the findings reported by Williams *et al.* (2013). The inclusion in the current review of research utilising facial-morphing indicates that this could be an effective intervention for behaviour change. However, three studies did not find an effect of appearance-based intervention when compared to a health-based intervention, which was not identified by William's *et al.* (2013). One observation made in the current review is that two of these studies used active rather than passive control. This therefore calls for further investigation.

The results of the meta-analyses indicate that appearance based interventions were associated with a small positive effect on intentions and behaviours. The largest effect sizes were associated with UV photography combined with photoaging information. These results may indicate that providing individuals with two sources of information - visual and descriptive - with subjective and objective focus, could be an effective way to influence UV-related behaviours. The component of photoaging information can also be manipulated according to theory, which may be beneficial, as it could enhance health interventions with theoretical constructs. For instance, Mahler *et al*. (2005) utilised Theory of Alternative Behaviours (Jacard, 1980) by aiming to alter participants' perceptions of UV exposure and providing an alternative to tanning (sun-less tanning products). Other effective theoretical constructs in this sample included Social Comparison Theory (Festinger, 1994) and Theory of Planned Behaviour (Cialdini *et al*., 1991). As these interventions appeared to be effective in reducing UV exposure and increasing sun protection among students as well as the general public, it is likely they could be widely implemented. However, due to the issue of publication bias in this sample, it is difficult to draw definitive conclusions. Future research could benefit from investigating this issue further, to determine whether two sources of information could increase the effectiveness of appearance-focused interventions in reducing UV exposure.

There are a number of things to consider when interpreting the results of the meta-analysis. The most common outcome variable was sun protective intentions, which limits the conclusions that can be drawn on other variables. Given the relatively small number of studies, it was not possible to include follow-up length as a mediator in the analysis, it is therefore difficult to determine whether the techniques used would have long term effect on behaviour, as well as immediate effect on intentions. Considerable variability of research methodologies (e.g. control group conditions and inclusion/exclusion of darker skin tones) and reporting style (e.g. inclusion of baseline comparisons and non-significant variables) between the studies makes it difficult to directly compare results between the studies. Furthermore, there was a wide span of effect sizes in the sub-set of the meta-analysis which included any intervention that did not utilise UV photo or photoaging information. This suggests that some of these interventions are more effective than others, and should be further investigated in future research. Lastly, the meta analysis identified a publication bias among studies utilising UV photo in combination with photoaging information. We would therefore encourage researchers and journals alike to consider null results for publication.

Sample limitations and recommendations for future research

While skin cancer incident rates do not differ significantly between genders (Skin Cancer Foundation, 2016), there was an overwhelming majority of female participants. Given that the current review identified only four studies of male participants, future research would benefit from including men in the study population, particularly as men also value a tanned appearance (Cancer Research UK, 2016; Day et al., 2016). As men may perceive tanning and appearance norms in different terms than women, such as reluctance to engage in practices regarded as feminine (Grogan, 2016), future appearance interventions with men may need to consider the role of masculinity. Moreover, study samples were overwhelmingly young (16-35 years); as age increases, the risks of skin damage build-up, so it therefore seems relevant to include an older population in future studies (Cancer Research UK, 2016). Most participants were white; as populations with darker skin are by no means immune to skin cancer, future research would benefit from more ethnically diverse samples (Skin Cancer Foundation, 2016). Finally, some studies included a sample where a large number of participants had experienced skin cancer themselves, or known a family member to do so (Mahler *et al.*, 2013), whereas others did not include this as a variable in the analyses; this is a factor that could skew results, and should be considered in future studies.

The majority of the studies were conducted in the USA, raising concerns about generalisability of findings to other areas; they were also conducted in locations with high level of sun exposure (such as Florida), and it might therefore be difficult to predict whether interventions are effective in countries with fewer days of sun. Qualitative research has indicated that people living in locations with fewer hours of sun (such as the UK) associate UV exposure with leisure time and holidays; this may affect the effectiveness of an intervention to impact motivations to reduce UV exposure among these participants (Persson *et al.*, 2017).

Twelve studies based their sample size on a priori power calculations, with the remaining studies stating a lack of power, or not specifying power calculations. This is problematic, as a potential lack of power in a majority of the examined studies may limit the conclusions that can be drawn from their results, as it can over or under-estimate the effect of the intervention, particularly in combination with publication bias (Charles *et al.*, 2009; Minarik *et al*., 2016). It is therefore recommended that future research consistently include a priori power calculations, as well as comparing any intervention with an active, rather than a passive, control condition.

Conclusions

This review and meta-analysis provides a valuable perspective on current research on appearance-based interventions to reduce UV exposure. The findings suggest that appearance-based interventions are associated with small positive effects on reducing sun-seeking behaviours and/or increasing sun protective behaviours. These results were generally supported by a meta-analysis. With the previously discussed high levels of skin cancer rates across Western Europe and the US, this would suggest that implementation of these interventions could have scope to prevent skin cancer in a large number of people.

We recommend that practitioners who are looking to increase sun protection intentions administer UV photo in combination with photo-aging information, as this was associated with the largest effect size. These interventions could be administered to men and women alike, over a wide age-span, and they appear to be effective when implemented in a clinical and/or research setting.

A number of methodological issues may limit the conclusions that can be drawn from the results. However, within the current context, this review contributes significantly to the existing body of research into appearance-based interventions to reduce UV exposure, and recommends that future research consistently employ a rigorous methodology (e.g. inclusion of power calculations) and focus on more varied outcomes and a diverse sample population from a wider array of cultures. As motivations for UV exposure might differ in populations living in locations with less opportunities for sun exposure, this review specifically recommends that additional future research on the effectiveness of appearance-focused interventions is conducted in places such as the UK and Northern Europe.

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Table 1. General summary of results

Sample	**Settings**	**Interventions**	**Outcomes measured**	**Follow-up**	**Findings**	**Theoretical basis**
N = 7348 (M = 222.67, Median = 148, SD = 189.96)	75.8% Research facility or University	17 = UV photo (with or without photoaging information)	12 = Sun protective intentions and behaviours	12 = Immediately only	Positive findings = 29 studies	27 = theoretical basis
72.9% women	15.2% Online	7 = photoaging information	10 = UV exposure and intentions	21 = between 1 week and 12 months	Positive findings confined to specific participant group/condition = 4	6 = no theoretical basis
12 – 75 years age range	9% Other	9 = neither UV photo or photoaging info	11 = combination of both		No difference = 4	
12 = utilised power calculations						

Table 2. Meta-analyses results

Relationship between UV photo interventions and outcome variables

Outcome variable	r^+	*p*	95% confidence interval	*k* (studies)	*N* (participants)
Combined outcome variable	.19	<.001	084 - .296	10	1564
SPI[1]	.165	.012	.036 - .295	8	1251

Relationship between photoaging interventions and outcome variables

Outcome variable	r^+	*p*	95% confidence interval	*k* (studies)	*N* (participants)
Combined outcome variable	.327	<.001	.206 - .447	4	863
SPI[1]	.272	.039	.203 - .341	3	840

Relationship between UV photo combined with photoaging information and outcome variables

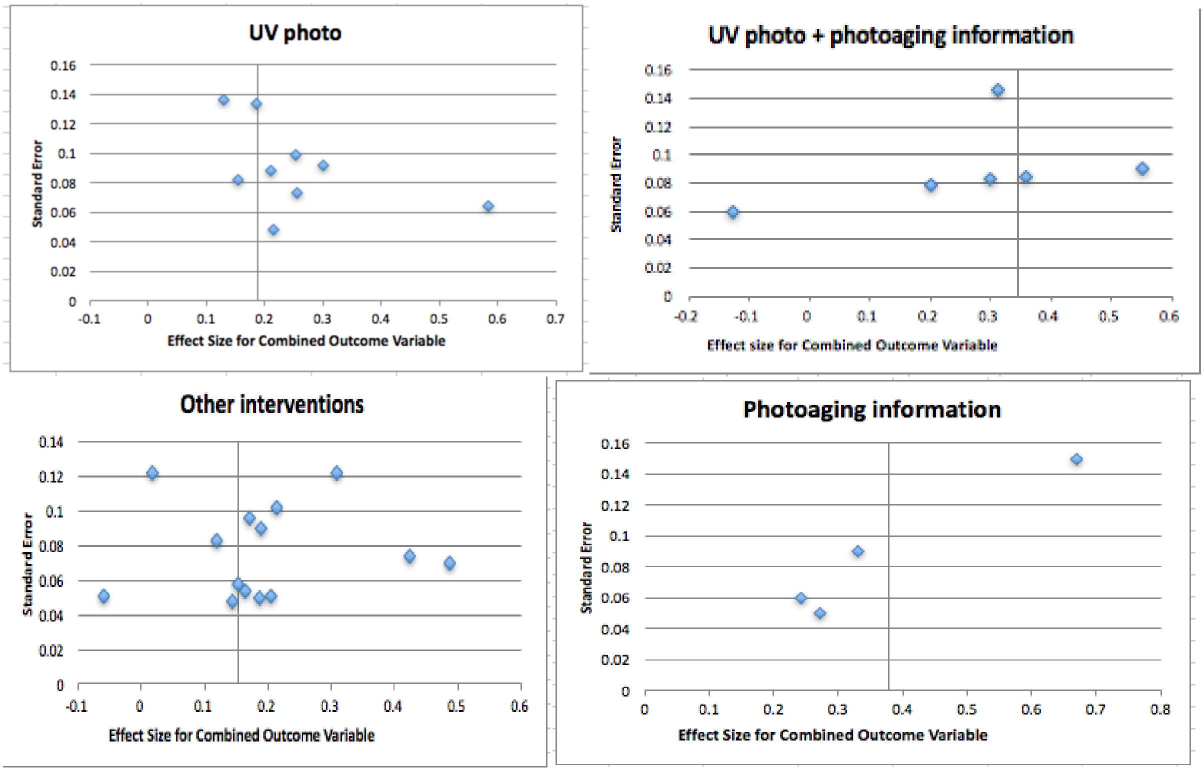
Outcome variable	r^+	*p*	95% confidence interval	*k* (studies)	*N* (participants)
Combined outcome variable	.261	<.017	.047- .475	6	918
SPI	.424	.023	.279 - .568	3	319

Relationship between other interventions and outcome variables

Outcome variable	r^+	*p*	95% confidence interval	*k* (studies)	*N* (participants)
Combined outcome variable	.191	<.001	.117 - .265	14	3895
SPI	.223	.067	-.015 - .461	5	836
UV exposure	.154	.040	.007 - .302	6	1878
UVEI[2]	.235	<.001	.133 - .371	7	1798

[1] Sun protection intentions
[2] UV exposure intentions

Figure 1. Figures demonstrating of effect sizes and SE
Vertical line demonstrating the combined effect size (r^+)



Appendix: PRISMA (2009) flow diagram