Protection from Sunburn with β-Carotene—A Meta-analysis[†]

Wolfgang Köpcke[1] and Jean Krutmann*[2]

[1]Department of Medical Informatics and Biomathematics, Münster University Hospital,
Münster, Germany
[2]Institut für Umweltmedizinische Forschung (IUF) at the Heinrich-Heine-University
Düsseldorf gGmbH, Germany

ABSTRACT

Nutritional protection against skin damage from sunlight is increasingly advocated to the general public, but its effectiveness is controversial. In this meta-analysis, we have systematically reviewed the existing literature on human supplementation studies on dietary protection against sunburn by beta-carotene. A review of literature until June 2007 was performed in PubMed, ISI Web of Science and EBM Cochrane library and identified a total of seven studies which evaluated the effectiveness of β-carotene in protection against sunburn. Data were abstracted from these studies by means of a standardized data collection protocol. The subsequent meta-analysis showed that (1) β-carotene supplementation protects against sunburn and (2) the study duration had a significant influence on the effected size. Regression plot analysis revealed that protection required a minimum of 10 weeks of supplementation with a mean increase of the protective effect of 0.5 standard deviations with every additional month of supplementation. Thus, dietary supplementation of humans with β-carotene provides protection against sunburn in a time-dependent manner.

INTRODUCTION

Ultraviolet (UV) radiation exerts a number of detrimental effects on human skin (1,2). The most familiar one, which is virtually known to every human being, is a sunburn reaction, which develops within hours after exposure to shorter wavelengths UVB (290–315 nm) radiation. Avoidance of sun exposure and topical application of sunscreens prior to exposure represent the established strategies for protection against sunburn (3). In recent years, however, nutritional protection against sunburn formation has been discussed as well (4–6). Among the substances that are being suggested for such a nutritional approach β-carotene seems to be an interesting candidate. β-Carotene is a potent biological antioxidant. It is a strong singlet oxygen quencher *in vitro* and experiments in animal models indicate that β-carotene may provide skin photoprotection *in vivo* (7,8).

Systemic photoprotection by *β*-carotene supplementation could contribute significantly to skin health and add to photoprotection by sunscreens, because it could provide a lifelong, overall, basic protection against the development of sunburn reactions (6). In this study, we have therefore conducted a meta-analysis of the existing literature about the effectiveness of *β*-carotene for sunburn prevention. We have focused on this substance and this biological end point because—to the best of our knowledge—only for *β*-carotene and only for prevention of sunburn the number of studies that exist is sufficient to allow a meta-analysis.

METHODS

The literature until June 2007 was searched using the following databases: PubMed, ISI Web of Science (Science Citation Index Expanded) and EBM Cochrane library using the keywords "betacarotene" or "carotenoids" and "sunburn." In addition to the mentioned databases, manual search was done of references cited in the selected articles as well as in selected books on nutrition and skin. No language restriction was applied.

Primary inclusion criteria for the selection of relevant articles were original publications about clinical trials. Case reports, reviews and editorials were not considered eligible.

The selected articles were reviewed and data were abstracted by means of a standardized data-collection protocol using the following criteria: Only placebo-controlled clinical studies on the supplementation with *β*-carotene on protection against sunburn were used.

We identified seven studies, the characteristics of which are listed in Tables 1 and 2, and their full references are cited in the reference list at the end of this report (9–15).

A classical meta-analysis for studies with continuous outcome was performed according to published work (16,17). In studies of the effects of a treatment that measure the outcome on a continuous scale, a natural effect size is the standardized mean difference (SMD). The SMD is the difference between the mean outcome in the treatment group and the mean outcome in the control group divided by the within group standard deviation. Once an effect size is estimated for each study, the next step is to summarize these results in an overall effect. To test whether the sample effect sizes are themselves homogeneous (from a single population), one uses the so-called Q statistics, a form of weighted sums-of-squares, which can be tested against a χ^2 distribution with $n-1$ degrees of freedom. A significant result indicates that the variance is greater than expected due to sampling error. In this case, the assumption of a fixed-effects model that there is a single true effect in all studies (or for each group of studies) and that any observed variation is due to sampling error is not true and an alternate model, the random-effects model, which assumes that there is an average effect with a certain degree of variation around this mean, is used.