Green Tea Polyphenols Provide Photoprotection, Increase Microcirculation, and Modulate Skin Properties of Women¹,²

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Abstract

Dietary constituents including polyphenols and carotenoids contribute to endogenous photoprotection and modulate skin characteristics related to structure and function of the tissue. Animal and in-vitro studies indicate that green tea polyphenols affect skin properties. In a 12-wk, double-blind, placebo-controlled study, 60 female volunteers were randomized to an intervention or control group. Participants consumed either a beverage with green tea polyphenols providing 1402 mg total catechins/d or a control beverage. Skin photoprotection, structure, and function were measured at baseline (wk 0), wk 6, and wk 12. Following exposure of the skin areas to 1.25 minimal erythemal dose of radiation from a solar simulator, UV-induced erythema decreased significantly in the intervention group by 16 and 25% after 6 and 12 wk, respectively. Skin structural characteristics that were positively affected included elasticity, roughness, scaling, density, and water homeostasis. Intake of the green tea polyphenol beverage for 12 wk increased blood flow and oxygen delivery to the skin. Likewise, in a separate, randomized, double-blind, single-dose (0.5, 1.0, and 2.0 g) study of green tea polyphenols, blood flow was maximized at 30 min after ingestion. In summary, green tea polyphenols delivered in a beverage were shown to protect skin against harmful UV radiation and helped to improve overall skin quality of women. J. Nutr. doi: 10.3945/jn.110.136465.

Introduction

As the largest organ of the body, skin provides an indispensable barrier against light, heat, injury, and infection and plays a major role in the regulation of body temperature, water, and lipid stores. Nutrition influences skin condition and an optimal supply of macro- and micronutrients contribute to skin health and barrier function. Skin structure, texture, thickness, density, hydration, color, and shielding properties vary depending on endogenous and exogenous factors.

Numerous clinical, epidemiological, animal, and in vitro studies demonstrate a link between UV radiation and diseases of the skin, such as premature aging, melanomas, and nonmelanomas. Skin cancer remains the most common form of cancer in the US and >1 million new cases were estimated in 2010. Chronic excess solar UV radiation induces oxidative stress, DNA damage, and increased inflammation. Several antioxidants given systemically or topically as enriched foods and supplements provide photoprotection, including flavanols, carotenoids, tocopherols, and vitamin C. Lipids, proteins, and DNA are the cellular targets of photooxidation and damage to these molecules is involved in the pathobiochemistry of erythema formation, premature aging of the skin, development of photodermatosis, and skin cancer. However, disturbances of inter- and intracellular signaling also may mediate the dermatoxic properties of external factors.

Flavonoids comprise a group of secondary plant constituents widespread in nature that are available from dietary sources such as cocoa, green tea, soy, berries, or other fruits. Flavonoid-containing phytomedicinals are used as antiinflammatory and antiallergic remedies and a flavonoid-rich diet is suggested to play a role in the prevention of several kinds of cancer and cardiovascular disorders. Many of the alleged effects have been linked to the antioxidant properties of flavonoids; however, they also exhibit other biological activities.

In a study of high- and low-flavanol cocoa products, ingestion of cocoa dietary flavanols contributed to endogenous photoprotection and improved dermal blood circulation. In addition, cocoa flavanols affected cosmetically important characteristics of the skin surface and skin hydration. Currently, flavanoids are frequently used in cosmetics, primarily for antioxidant and soothing actions.

In vitro and animal studies provided evidence that tea flavanols, when applied orally or topically, ameliorated adverse skin reactions following UV exposure, including skin damage, erythema, and lipid peroxidation. Topical application of green tea polyphenols to human skin inhibited the UVB-induced erythema formation. Cocoa flavanols and green tea polyphenols inhibit UV-induced skin reactions, including skin damage, erythema, and lipid peroxidation.

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erythema response and decreased formation of cyclobutane pyrimidine dimers in skin, both in the epidermis and dermis (12). Pretreatment of skin with green tea extracts led to fewer sunburn cells after exposure to solar-simulated radiation with 2 minimal erythemal doses (MED) and protected epidermal Langerhans cells from UV damage.

Thus, when applied topically, green tea polyphenols protect DNA and prevent other damaging effects of UV light such as the sunburn response, immunosuppression, and photoaging of the skin (13,14). Few randomized controlled trials utilizing orally ingested green tea polyphenols have examined potential photoprotection and other skin health benefits. Given the results of previous studies, there is strong evidence to support the concept that the consumption of dietary flavonoids from tea may confer photoprotection, reduce the risk of skin cancer, and improve skin quality. The present study investigated the effects of repetitive intakes of a beverage enriched with green tea polyphenols on skin sensitivity toward UV exposure, skin structure, texture, and microcirculation.

Materials and Methods

Materials. Catechin, epicatechin, epigallocatechingallate (EGCG), epicatechingallate (ECG), epigallocatechin (EGC), and glucuronidase/sulfatase (Helix pomatia) were obtained from Sigma-Aldrich. All other compounds were of per-analysis grade and from E. Merck. The green tea extract and a matching control beverage were provided by the Beverage Institute for Health and Wellness, The Coca-Cola Company. The compositions of the green tea beverage, control beverage, and the extract used as capsules were analyzed by HPLC (Table 1). Taiyo Kagaku provided the green tea extract (Sunphenol 90 decaffeinated; SP 90 DCF-T) used for preparation of the experimental beverage.

Study design. In a double-blinded, placebo-controlled trial, a total of 60 female volunteers aged 40–65 y with healthy, normal skin of type II according to Fitzpatrick (15) took part in a 12-wk study between May and September. Skin type II is characterized by light to normal UV sensitivity (Middle European skin type, blond or light brown hair). Skin type II was selected for comparable skin sensitivity conditions among the study volunteers and to former photoprotection studies from the Witten Institute (9,16). The BMI of the participants were between 18 and 25 kg/m². Exclusion criteria were pregnancy and breast-feeding, smoking, intake of medications that might influence the outcome of the study, sunbathing or the use of sun-beds, intake of vitamin supplements, or diets comprising a change of normal eating habits. The participants (n = 30/group) were randomly assigned to either the green tea beverage (GT) group or the beverage control (C) group. Participants were instructed to consume the beverages throughout the day and complete total consumption by the evening meal. In the GT, group volunteers consumed 1 L of the green tea beverage each day for 12 wk, providing 1402 mg total tea catechins (Table 1). The C group ingested 1 L/d of a constituent matched beverage.

An alternative sweetener system of sodium cyclamate, ascesulphame-K, and aspartame was utilized to mask the bitter taste of the green tea extract and ascorbic acid was added to stabilize polyphenols. The C group beverage contained the same non-nutritive sweetener system, ascorbic acid, and quinine hydrochloride to replicate the bitter taste of green tea extract.

At baseline (wk 0) and at the end of wk 6 and 12, blood samples were drawn for analysis of flavonoids and assessment of skin variables. Previous studies examining green tea polyphenol bioavailability suggested rapid absorption and achievement of peak plasma levels at ~2 h (7). Therefore, in the 12-wk study, blood samples (without anticoagulant) were collected 90 min after ingestion of one-third of the daily dose (i.e., ~333 mL). After 20 min of clotting, blood was centrifuged for 10 min and serum was taken and stored at ~80°C for further analysis by HPLC. Compliance was assessed by interview and counting of the remaining beverage bottles. Diet histories were not collected; however, participants were advised not to change their dietary habits and no supplements were allowed during the study.

The short-term effects of green tea extract on dermal blood flow were examined in a second, randomized, double-blinded study with 15 female volunteers who had not participated in the 12-wk study. The BMI of the participants in the short-term dosing study ranged from 18 to 25 kg/m². Women were randomized into 3 groups and each participant received a single dose of 0.5, 1.0, or 2.0 g green tea extract (SP 90 DCF-T; 500 mg capsule). Participants were provided the number of green tea extract capsules per assigned dosage level and the corresponding number of placebo capsules for a total intake of 4 capsules per test. The polyphenol composition of the capsules reflected the typical distribution of green tea polyphenols, with epigallocatechingallate (EGCG) representing the major catechin in both the experimental beverage and the capsules (Table 1). Ascorbic acid was not added to the capsules, because the green tea catechins were already protected against oxygen exposure due to the capsule format (Table 1). Delivery of high amounts of green tea extract by capsule maximized compliance and avoided the need for participants to ingest a large volume of test beverage over a short period of time. Exclusion criteria were identical for the single-dose study and the 12-wk study (see above). Capillary blood flow was measured between 0 and 240 min after intake by Laser-Doppler-flowmetry (O2C-System; Lea Instruments) at 1-mm skin depth. Blood samples were taken at 0, 30, 60, 120, and 240 min and serum was analyzed for total epicatechin.

Written informed consent was obtained from each participant. The Ethical Committee of the University Witten-Herdecke, Germany approved the study design, which was performed according to the Good Clinical Practice guidelines and the Declaration of Helsinki. All skin measurements were performed at the Witten University Institute for Experimental Dermatology under consistent room temperatures (21°C ± 1) and humidity (40%) that were closely maintained and monitored.

Analyses of serum samples. Serum (0.5 mL) was mixed with 1.0 mL buffer (100 mmol/L potassium phosphate, pH 5) and 20 μL glucuronidase/sulfatase (100 and 7.5 U/L, respectively) and incubated at 37°C for 30 min to hydrolyze glucuronate and sulfate conjugates. For extraction, 6 mL tert-butylmethyl ether was added and the mixture was vortexed for 30 s. After centrifugation (10 min, 5000 × g), 5 mL of the supernatant was transferred to a plastic tube. The residue was extracted again and the supernatants combined. The organic solvent was evaporated under a stream of nitrogen and the residue was dissolved in 200 μL solvent A for HPLC analyses.

The HPLC system consisted of a L-7100 pump equipped with a L-2200 autosampler, a 6535A column oven (Merck Hitachi). Detection was with an electrochemical detector (CLC100, Chromsystems) at +530 mV. Separation was performed on a reversed phase column (LChromsphere 100 RP-18e, 5 μm × 4 mm, E. Merck) operated at 35°C (flow rate, 1 mL/min).

### Table 1

<table>
<thead>
<tr>
<th>Constituents of the beverage enriched with green tea extract, the control drink and the green tea capsules</th>
<th>GT mg/L</th>
<th>C mg/L</th>
<th>Green tea capsules mg/100mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total catechins</td>
<td>1402</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Epicatechin</td>
<td>100</td>
<td>0</td>
<td>8.0</td>
</tr>
<tr>
<td>Catechin</td>
<td>23.2</td>
<td>0</td>
<td>1.2</td>
</tr>
<tr>
<td>Galloycatechin</td>
<td>2.4</td>
<td>0</td>
<td>2.3</td>
</tr>
<tr>
<td>EGCG</td>
<td>980</td>
<td>0</td>
<td>51.1</td>
</tr>
<tr>
<td>Epicatechin gallate</td>
<td>238</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Galloycatechin gallate</td>
<td>43.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Epicatechingallate</td>
<td>8.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>EGCC</td>
<td>6.0</td>
<td>0</td>
<td>3.9</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>119</td>
<td>119</td>
<td>0</td>
</tr>
</tbody>
</table>

¹ Neither beverage provided energy.

Abreviations used: C, beverage for control; ECG, epicatechingallate; EGC, epigallocatechin; EGCG, epigallocatechingallate; GT, beverage with green tea extract; MED, minimal erythemal dose; TEWL, transepidermal water loss.
Sensitivity toward UV irradiation. Prior to the start of the study, individual MED was determined for each participant (9). Irradiation was applied to dorsal skin (back, scapular region), with 1.25- MED using a blue-light solar simulator (Sol 3, Holled). At each time point (wk 0, 6, 12) skin color was measured before and 24 h after irradiation. Skin color was evaluated by chromametry (Minolta CR 300) using the 3-dimensional color system with L-, a-, and b-values (16). The a-value (red/green-axis) is a measure for reddening (erythema). The Δa-values (a-value 24 h after irradiation minus a-value before irradiation) were compared between wk 0, 6, and 12 of the study; decreasing Δa-values indicated a photoprotective effect.

Skin elasticity. Elasticity measurements based on the suction method were performed with the Cutometer SEM 474 (Courage and Khazaka Electronics). Resistance of the inner forearm skin to move toward an applied vacuum (viscoelasticity) and its ability to return to the original position (biological elasticity) were repeatedly displayed. Viscoelasticity and biological elasticity were calculated from these curves.

Skin structure and texture. High-frequency Ultrasound B-Scan (frequency, 20 MHz; DermScan C Vers.3) with 2-D-configuration (Cortex Technology) was used to analyze tissue structures and measure skin density and thickness (mm). Skin surface profiles of the inner forearm were determined with the surface evaluation of living skin method (Visioscan, Courage and Khazaka Electronics) in a 15 × 17-mm area. Four different variables were used to characterize skin surface: roughness, scaling, volume, and wrinkles.

Skin hydration and transepidermal water loss. Skin hydration (arbitrary units) of the inner forearm was determined by corneometry (Corneometer CM 825, Courage and Khazaka Electronics); transepidermal water loss (TEWL; g m⁻² s⁻¹) was measured using a TEWA-Meter TM 300 (Courage and Khazaka Electronics).

Cutaneous blood flow and oxygen saturation of hemoglobin. The O2C-system (Lea Instruments) was used to measure peripheral blood flow and oxygen saturation of hemoglobin (17). The measurement of blood flow (arbitrary units) was determined by the frequency of light shifted by moving erythrocytes (the Doppler Effect) and was performed at the inner forearm of the volunteers. Hemoglobin amount and oxygen saturation were determined spectroscopically (17). All measurements were conducted at the same time of day (0900–1100 h).

Statistics. Results are expressed as means ± SD. Typically, dermatological studies assess skin changes over time compared with baseline. In the 12-wk study, descriptive statistics were calculated at each time point (wk 0, 6, and 12). For all variables, pre-post differences from baseline to wk 6 and 12, but not between wk 6 and 12, were calculated. Changes within each group were assessed using the Wilcoxon’s Signed Rank test. The pre-post differences between the 2 treatment groups were compared using the Wilcoxon’s rank-sum test. In the short-term study, Wilcoxon’s rank-sum test was used to compare the weighted AUC. All differences were considered significant at P < 0.05.

Results

In the 12-wk intervention study, a dose of ~1402 mg total catechins/L green tea beverage was consumed each day (Table 1). This volume corresponded to a daily intake of 100 mg epicatechin, 980 mg EGCG, and 238 mg ECG.

Flavanoids in serum. Flavanoids plus their glucuronide and sulfate metabolites were analyzed and expressed as total epicatechin, total catechin, total EGCG, total ECG, and total EGC (Table 2). EGCG was the dominating flavonoid in the beverage and serum levels of this compound were elevated in the experimental group. Serum concentrations of ECG and epicatechin, the 2 other major catechins in the GT, likewise increased at wk 6 and 12 (P < 0.05). Compared with the C group, concentrations of epicatechin, EGCG, and ECG at wk 6 and 12 were significantly higher in the GT group (P < 0.05).

Photoprotection. Reddening was measured by chromametry and expressed as Δa-values (Fig. 1; Table 3). In the GT group, the mean Δa-values decreased 16 and 25% from baseline by 6 and 12 wk, respectively, indicating increased photoprotection (P < 0.05). The Δa-values did not significantly change in the C group. There was improved photoprotection in the GT group compared with the C group (P < 0.05).

Skin function and structure. Several variables related to the function and structure of skin were modulated by green tea extract (Table 3). Viscoelasticity decreased by 21% and biological elasticity increased by 3.9% after 12 wk of intervention with GT (P < 0.05). Skin density significantly increased by 7.7% after 12 wk, but skin thickness was not affected. Among the surface variables evaluated by the surface evaluation of living skin system, roughness, volume, and scaling declined by wk 12 (P < 0.05), which was evident in skin photos (Fig. 2). Other changes in the GT group included reductions in skin roughness (~16%),

**TABLE 2** Serum flavanol concentrations in women who consumed GT or C beverages for 12 wk

<table>
<thead>
<tr>
<th>Flavanol</th>
<th>GT group</th>
<th>C group</th>
<th>GT group</th>
<th>C group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 wk</td>
<td>6 wk</td>
<td>12 wk</td>
<td>0 wk</td>
</tr>
<tr>
<td>Epicatechin</td>
<td>146 ± 90</td>
<td>442 ± 514*</td>
<td>355 ± 215**</td>
<td>75 ± 76</td>
</tr>
<tr>
<td>Catechin</td>
<td>128 ± 66</td>
<td>98 ± 47*</td>
<td>182 ± 181</td>
<td>94 ± 52</td>
</tr>
<tr>
<td>EGCG</td>
<td>116 ± 63</td>
<td>243 ± 189*</td>
<td>345 ± 191**</td>
<td>61 ± 53</td>
</tr>
<tr>
<td>ECG</td>
<td>124 ± 17</td>
<td>299 ± 197**</td>
<td>215 ± 198*</td>
<td>114 ± 20</td>
</tr>
<tr>
<td>EGC</td>
<td>2 ± 7</td>
<td>109 ± 257**</td>
<td>77 ± 169**</td>
<td>N.D.²</td>
</tr>
</tbody>
</table>

¹ Values are means ± SD, n = 30. *Different from wk 0, P < 0.05; **different from wk 0, P < 0.001; ³Different from the pre-post difference of C, P < 0.05.
² N.D.: Not detectable (< 0.5 nmol/L).
³ NC: Not calculated.
volume (~20%), and scaling (~25%) (Table 3) (P < 0.05). Skin hydration increased 9 and 17% after wk 6 and 12 wk, respectively (P < 0.05). TEWL decreased by 12% compared with baseline (~3%) in the C group after 12 wk. In the C group, the only skin surface variables that decreased significantly were scaling (8.9%) and volume (~12.0%) after wk 12 (Table 3). Hydration increased 5.2% by wk 12 compared with wk 0 (P < 0.05), which pointed to an increased barrier function of the skin.

In the C group, the only skin surface variables that decreased significantly were scaling (~8.9%) and volume (~12.0%) after wk 12 (Table 3). Hydration increased 5.2% by wk 12 compared with wk 0 (P < 0.05), possibly reflecting an overall greater fluid intake than normal by women in the control group (Table 3). None of the other skin variables in the control group changed during the experiment.

Between-treatment group comparisons indicated over time a significant increase of hydration (17%) in the GT group compared with 5.2% in the C group by wk 12 (Table 3). TEWL was favorably reduced by ~12% in the GT group compared with negligible changes (~0.9%) in the C group after 12 wk. In contrast, surface variables did not differ between the GT and C groups.

### Cutaneous blood flow.

In the GT group, dermal blood flow increased 40 and 29% by wk 6 and 12, respectively, compared with baseline (P < 0.05) (Table 4). Concomitantly, oxygen saturation increased from ~30% (wk 0) to 38 and 40% at wk 6 and 12, respectively. Blood flow and oxygen saturation did not significantly change in the C group. Changes in blood flow at wk 12 differed between the GT (+29%) and C (+0.9%) groups, as did those in oxygen saturation (+34 vs. −3.6%, respectively) (P < 0.05).

In the short-term study, cutaneous blood flow was determined following a single dose of 0.5, 1.0, or 2.0 g green tea extract given by capsule. Blood flow responses were quick, with a maximum ~15–30 min post-dose for all 3 doses (Fig. 3B). The dose administered did not affect blood flow. Serum epicatechin concentrations increased over time and in the 2.0-g GT group, with the maximum concentration reached at ~2 h after ingestion (Fig. 3A). The AUC post-dose was greater for the 2.0-g (25.1 ± 7.5 nmol L−1 h) and 1.0-g (20.0 ± 6.0 nmol L−1 h) doses compared with the 0.5-g dose (6.6 ± 3.1 nmol L−1 h).

Serum epicatechin blood concentrations were ~3–30 times higher in the single-dose study than in the 12-wk study. This observation may be explained by differences in bioavailability and administration time. In the 12-wk intervention study, green tea catechins were consumed as a beverage over hours, whereas in the single-dose study, catechins were delivered by capsule.

### Discussion

Human intervention trials and animal and cell culture studies revealed that dietary constituents provide photoprotection and influence skin properties related to function and appearance of the tissue (18,19). Such beneficial effects have been attributed to carotenoids (20), PUFA (21), and selected polyphenols. Previously, using a cocoa beverage rich in flavanols, we demonstrated that dietary photoprotection was feasible with this class of compounds (9). Green tea polyphenols protect against many of the damaging effects of UV radiation such as UV-induced sunburn response, UV-induced immunosuppression, and photaging (4,13,14). Recently, oral consumption of EGCG, a major flavanol in green tea, was associated with a decreased MED in hairless rats (22).

We studied the cutaneous effects of tea catechins ingested for 12 wk as a beverage enriched with typical green tea catechins. The increased serum levels of the dominating green tea flavanoids EGCG, ECG, and EC demonstrated that the compounds were
absorbed and systemically available. Furthermore, the serum concentrations of the major tea catechins were comparable to levels reported in the literature (23,24). Previous human studies have shown that the green tea flavanols epicatechin and EGC are efficiently absorbed in the small intestine, with 20–50% of the dose being recovered in the urine. Thus, these flavan-3-ols have a higher bioavailability than most other dietary flavonoids (25).

We demonstrated that dietary intervention with a beverage rich in green tea catechins modulated sensitivity of the human skin toward UV light, determined as a degree of erythema intensity following irradiation with a solar light simulator. Compared with baseline, skin response decreased by 16% after 6 wk of GT intervention and by 25% after 12 wk. No change, however, in UV sensitivity occurred in the C group. Similarly, a longer term oral supplementation with 500 mg green tea polyphenols/d for 24 mo significantly reduced of overall solar damage at 6 mo and erythema and telangiectasias at 12 mo (26). At the end of 24 mo, however, the changes were not sustained. Lack of compliance in the study and a 40% attrition rate in the GT group after 24 mo of supplementation could be the explanation for the unsustained benefits. Furthermore, photodamaging and histological changes were assessed by a dermatologist, who was less likely to discern minor skin changes over 24 mo. In contrast, our study utilized several quantitative techniques (hydration by corneometry, TEWL by TEWA-meter, and skin surface changes by ultrasound) to assess even minor skin changes over 12 wk.

Our green tea catechin beverage data are in accordance with the literature reporting protective effects of various polyphenols against UV-induced photo oxidation, induction of inflammation, oxidative stress, and DNA damage from different stress sources in cell cultures and animals (11–14). Compared with an earlier study on cocoa polyphenols, the extent of UV protection with green tea catechins was in the same range (9). The mechanisms underlying photoprotective effects of flavonoids in humans have not been elucidated; however, they are efficient antioxidants (27) contributing to photoprotection in plants. Due to their structure, flavonoids absorb UV light, which represents a mechanism of protection in the first line of defense.

Maintaining skin integrity is vital to skin function and appearance and requires an optimal supply of nutrients. We demonstrated that ingestion of green tea catechins improved skin hydration, TEWL, density, and elasticity. These observed skin changes were probably an outcome associated with long-term consumption of green tea polyphenols and not likely a transitory response over a 2- to 4-h period. Likewise, Chiu et al. (28) found that a combination of topical and oral green tea extract supplementation significantly increased skin elastin content of women after 8 wk (28). Nevertheless, by using a combination of topical and oral supplementation of green tea polyphenols, the specific contribution of topical compared with oral ingestion of green tea extract on elastin content could not be elucidated.

Improvements of skin structure may be related to flavanol-mediated increases in cutaneous blood flow. Microcirculation is important for nutrient and oxygen supply of the skin and an improved delivery likely affects skin condition and appearance. In the present study, cutaneous blood flow increased 29% in volunteers supplemented for 12 wk with a beverage enriched with green tea flavanols. In the short-term study, we also provided evidence that this was a transient effect that occurred almost immediately but was not dose dependent when GT extract (0.5–2.0 g) was administrated over a short period of time. In contrast, a

### TABLE 4 Capillary blood flow and oxygen saturation of hemoglobin in skin of women at 1-mm depth that consumed GT and C beverages for 12 wk

<table>
<thead>
<tr>
<th></th>
<th>GT group</th>
<th>C group</th>
<th></th>
<th>GT group</th>
<th>C group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 wk 6 wk 12 wk</td>
<td>0 wk 6 wk 12 wk</td>
<td>0–6 wk 0–12 wk</td>
<td>0–6 wk 0–12 wk</td>
<td></td>
</tr>
<tr>
<td>Relative blood flow, <strong>AU</strong></td>
<td>13.3 ± 6.0** 12.3 ± 5.2* 11.4 ± 4.6 10.6 ± 4.5 11.5 ± 4.3</td>
<td>+40† +29#</td>
<td>−7.0  +0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen saturation, %</td>
<td>38.2 ± 21.1** 39.7 ± 20.2** 25.2 ± 20.0 23.2 ± 16.7 24.3 ± 17.8</td>
<td>+29† +34#</td>
<td>−7.9  −3.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Values are means ± SD, n = 30. **Different from wk 0, P < 0.001; *different from the pre-post difference of C, P < 0.05.
2 **AU,** Arbitrary units.
single 0.33-g dose of cocoa-flavanols produced an acute increase in dermal blood flow that paralleled changes in plasma epicatechin (10). Mechanistically, the cocoa polyphenol benefits were likely linked to effects of epicatechin on NO signaling, which was also observed in other tissues (29). Future studies should explore the relationship between the other major green tea extract catechins such as EGCg and ECG with alterations of skin microcirculation and determine the timing of the first appearance of photoprotection and other skin changes.

In summary, the present study demonstrated that dietary constituents protected skin and improved overall skin quality. Regular consumption of a beverage rich in tea flavanols contributed photoprotection against harmful UV radiation and helped maintain skin structure and function.

Acknowledgments

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Literature Cited


