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Original article

Acute black tea consumption improves cutaneous vascular function in healthy middle-aged humans

Kirsty A. Woodward [a], Nicola D. Hopkins [a], Richard Draijer [b], Young de Graaf [b], David A. Low [a], Dick H.J. Thijssen [a, c, *]

[a] Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK
[b] Unilever Research & Development, Olivier van Noortlaan 120, 3133 AT, Vlaardingen, The Netherlands
[c] Radboud Institute for Health Sciences, Department of Physiology, Radboud University Medical Center, Nijmegen, The Netherlands

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SUMMARY

Background & aims: Dietary flavonoids, such as those present in black tea, are associated with reduced risk of cardiovascular disease (CVD), possibly through improving nitric oxide (NO) mediated vascular function. The aim of this study was to examine the effect of acute black tea ingestion on cutaneous microvascular function.

Methods: Twenty healthy participants (58 ± 5 y, 9 men) attended two experimental trials (tea, placebo), 7-days apart in a randomised, controlled, double-blind, cross-over design. Participants ingested a single dose of 200 ml black tea or placebo, followed by assessment of forearm cutaneous perfusion using laser-Doppler flowmetry (LDF) using three distinct heating protocols, enabling us to distinguish between axon- and endothelium-dependent vasodilation: 1. *rapid 42°C*, 2. *rapid 39°C* and 3. *gradual 42°C*. On the contralateral arm, full-field laser perfusion imaging (FLPI) was used to assess forearm perfusion during *gradual 42°C*. Data were presented as cutaneous vascular conductance (CVC; flux/mean arterial pressure, MAP) and CVC expressed as a percentage of maximal CVC (%CVC_{max}).

Results: Rapid local heating to *39°C* or *42°C* demonstrated no effect of tea for flux, CVC or %CVC_{max} (all $P > 0.05$). Gradual local heating to 42 °C, however, produced a higher skin blood flow following black tea ingestion for absolute CVC ($P = 0.04$) when measured by LDF, and higher absolute flux ($P < 0.001$) and CVC ($P < 0.001$) measured with FLPI. No effect of tea was found for %CVC_{max} when assessed by either LDF or FLPI.

Conclusions: Acute tea ingestion enhanced cutaneous vascular responses to gradual local heating to 42 °C in healthy, middle-aged participants, possibly through a mechanism related to activation of endothelium-derived chemical mediators, such as NO. These improvements may contribute to the cardiovascular health benefits of regular tea ingestion.

1. Introduction

Cardiovascular disease (CVD) remains the leading cause of global mortality, representing ~30% of all deaths [1]. The role of dietary factors on CVD risk has been frequently explored in recent years, with a high dietary flavonoid intake being associated with a reduction in CVD risk [2]. Tea, produced from the plant *Camillia sinesis*, is the major dietary source of flavonoids in many countries globally [3] and can be found as catechins and flavonols in green tea and theaflavins, thearubigins and flavonols in black tea [4]. Accordingly, several studies have revealed a strong, inverse relation between regular intake of tea and cardiovascular risk [5,6].

A frequently cited explanation for the cardioprotective effects of black and green tea ingestion relates to the reduction in blood pressure following chronic consumption [5–7]. Further research found that acute and regular tea ingestion improves nitric oxide-mediated, endothelium-dependent dilation of conduit arteries [6,8–11]. Both conduit and resistance vessels have demonstrated improved endothelial function following tea ingestion in both healthy individuals [6,8] and in those with CVD [10]. Thus, the general consensus is that regular tea ingestion improves blood pressure by virtue of a generalised improvement of endothelial function and lowering of peripheral vascular resistance [6,8,10–12].

* Corresponding author. Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Byrom Street, L3 3AF, Liverpool, UK. Fax: +44 (0) 151 904 6284.
E-mail address: d.thijssen@ljmu.ac.uk (D.H.J. Thijssen).

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Despite encouraging data supporting a beneficial effect of tea ingestion in larger (conduit) vessels, no previous study has explored the effect of black tea on small vessels (skin microcirculation). Therefore, our aim was to examine cutaneous vascular responses to local skin heating. Given the complexity of the cutaneous vascular system and contribution of distinct mechanisms for skin dilation when gradually or rapidly heating the skin, we adopted a comprehensive approach of using rapid and gradual local skin heating protocols simultaneously. We hypothesised that black tea ingestion would be associated with increased cutaneous microcirculation responses for both rapid and gradual heating protocols.

2. Materials and methods

2.1. Participants

Twenty middle-aged male (n = 9) and post-menopausal female (n = 11) participants were recruited through local advertisement. All participants were healthy and non-smokers (58 ± 5 y, height 1.70 ± 0.1 m, weight 75.9 ± 16.1 kg, BMI 26 ± 4 kg/m^2, baseline mean arterial pressure 104±8 mmHg). Individuals with a medical history of hypercholesterolaemia (total cholesterol >6.5 mmol/l) [13], cardiovascular disease and hypertension (systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg) [14] were excluded. Participants were not taking any vasoactive medications or supplements. After being fully informed of the methods, written informed consent was obtained from all participants. The study conformed to the Declaration of Helsinki and was approved by the Research Ethics Committee of Liverpool John Moores University.

2.2. Experimental design

All participants performed two experimental trials (tea and control), 7-days apart in a randomised, controlled, double-blind, cross-over design (Fig. 1). The cross-over design was chosen to eliminate between-participant variability, taking into account a 6-day washout period between the two interventions to avoid any carry-over effects, which is in accordance with previous similar designed cross-over tea vascular function studies [6,7]. Computer-generated randomisation was used to reduce potential selection bias. Upon arrival to the laboratory, and 2 h prior to microvascular assessment, participants ingested a tea drink (containing 300 mg flavonoids, 75 mg caffeine and 2.8 g sucrose) or a taste and appearance matched placebo drink (0 mg flavonoids, 75 mg caffeine, 2.7 g sucrose, tea flavour and caramel colour), prepared by dissolving two sachets in 200 ml hot water. Participants subsequently rested for 2 h prior to commencement of testing to match peak plasma concentrations of flavonoids and other metabolites such as phenolic acids, with testing of skin microcirculation. During each testing day, baseline and thermally stimulated forearm cutaneous blood flow was examined simultaneously using rapid (to 39 and 42 °C) and gradual (to 42 °C) local heating protocols. Since these protocols reflect different dilator mechanisms and a distinct role of the NO-pathway, they provide complementary insight into the impact of black tea on cutaneous microvasculature. Rapid local heating was performed at two different sites (i.e. two different local heating protocols) on the dominant forearm and examined using laser Doppler flowmetry (LDF). Gradual local heating to 42 °C was performed on the dominant forearm using LDF and on the contralateral (non-dominant) arm using laser speckle imaging to provide whole forearm cutaneous microcirculation function (Fig. 2).

2.3. Experimental measures

All participants fasted for at least six hours and refrained from alcohol, food products high in polyphenols (dark chocolate, red wine), caffeine and exercise for 24 h prior to testing [15].

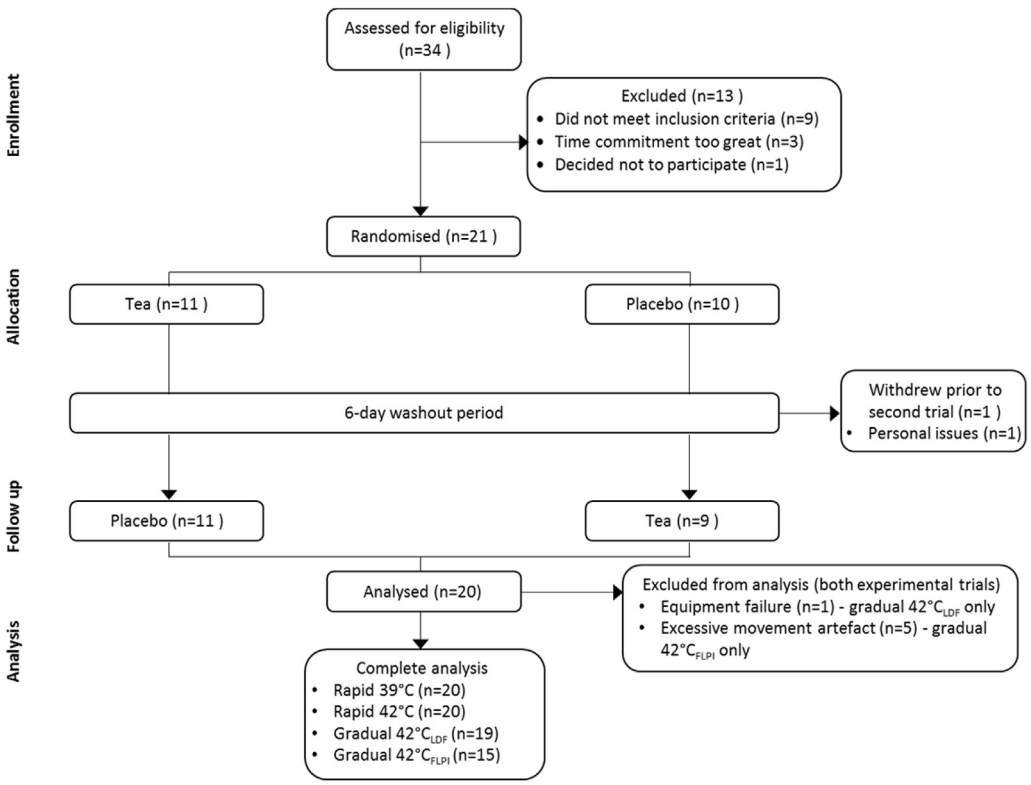

Fig. 1. CONSORT diagram showing the flow of participants through each stage of the randomised trial.

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