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Effects of dietary green tea polyphenol supplementation on the health of workers exposed to high-voltage power lines

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ABSTRACT

Although it has been several decades since the focus on the effect of extremely low frequency electromagnetic fields (ELF-EMF) of high-voltage power lines on human health, no consistent conclusion has been drawn. The present study aimed to investigate the change in oxidative stress after exposure to ELF-EMFs, and potential protective effects of green tea polyphenol supplementation (GTPS) on ELF-EMFs induced oxidative stress. A total of 867 subjects, including workers with or without exposure to ELF-EMFs of 110–420 kV power lines, participated and were randomized into GTPS and placebo treatment groups. Oxidative stress and oxidative damage to DNA were assessed by urinary tests of 8-isoprostane and 8-OHdG. Significant increased urinary 8-isoprostane and 8-OHdG were observed in workers with ELF-EMFs exposure, which were diminished after 12 months of GTPS. No protective effects of GTPS on oxidative stress and oxidative damage to DNA were observed after three months of GTPS withdraw. We found a negative impact of high-voltage power lines on the health of workers. Long-term GTPS could be an efficient protection against the health issues induced by high-voltage power lines.

1. Introduction

With the development of urbanization and increasing demands for energy, high-voltage power lines are being rapidly established in China, which is a known source of extremely low frequency (ELF) electromagnetic fields (EMFs). Epidemiological investigations have demonstrated ELF-EMFs as a physical risk factor of human health.

In 2005, a case-control study in a large population reported a significant effect of proximity of residence at birth to high-voltage power lines on the incidence of childhood leukemia (Draper et al., 2005). Since then, the association between high-voltage power line and childhood cancer, specifically acute leukemia, has been widely investigated (Sermage-Faure et al., 2013), but the conclusions were controversial due to limited knowledge of the etiology of childhood leukemia (Kheifets and Shimkhada, 2005). ELF-EMFs emitted from power lines have also been suggested as a potential carcinogenic factor which may result in brain/central nervous system cancers, leukemia malignant melanoma and female breast cancer (Kliukiene et al., 2004; Tynes et al., 1994; Tynes et al., 2003). In addition, several studies have argued the relation between ELF-EMFs and neurodegenerative disease such as Alzheimer's disease (Garcia et al., 2008). Specifically, occupational exposure to ELF-EMFs was considered to be an important risk factor for Alzheimer's disease (Garcia et al., 2008). The negative impact of ELF-EMFs on brain was also evidenced by a case study on students near high voltage power lines, suggesting that ELF-EMFs exposure may have an adverse effect on short-term memory (Ghadamgahi et al., 2016). These raised the concerns about the health status of workers in high voltage substations. Despite these specific diseases, there were also some non-specific complains such as headache, tiredness and neurological problems from residents living in close proximity to overhead power lines (Porsius et al., 2015).

Several mechanisms of how ELF-EMFs and MFs lead to cancer have been proposed. One possible mechanism is the impact of ELF-EMFs on free radical combination rates in certain enzymes, such as coenzyme B12-dependent ethanolamine ammonia lyase (Harkins and Grissom, 1994). It was evidenced that despite the small influence of ELF-EMFs on radical pair recombination, the enzyme reaction rate may be amplified by a factor of up to 100 (Eichwald and Walleczek, 1996). An alternative mechanism may be the interactions between electric field and airborne pollutant particles. The corona ions emitted from high voltage power lines are able to attach the pollutants and increase their electric charge

Abbreviations: ELF-EMF, extremely low frequency electromagnetic fields; GTPS, green tea polyphenol supplementation; ELF, extremely low frequency; EMFs, electromagnetic fields.

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Table 1
Inclusion and exclusion criteria.

Inclusion criteria
30–60 years old
Exposed to high-power lines
Background subjects were insignificantly exposed to electric field.
Subjects were living far from high-voltage substation.
Willing to give informed consent
Willing to have dietary supplementation intake and urine analysis
Exclusive criteria
People who are having regular green tea, vitamin C and vitamin E or in the past year
History of malignancy in the past 5 years
Endothelial dysfunction and other diseases such as inflammation
Inheritance disorders in family
BMI < 18.5 or > 30 kg/m^2
Previous long-term exposure to high voltage power lines
Smoker 1 year prior to entry into the study
Chronic diseases

states, which can be deposited on the skin or in the lung through inhalation (Fews et al., 1999; Swerdlow, 2004).

However, conclusions of the effects of ELF-EMFs on human health remain contradicted and inconsistent. A recent study demonstrated the health complaints after exposure to EMFs as a nocebo response. It is mainly due to the uncontrolled factors in epidemiological studies and difficulties in definition of the outcomes. Oxidative stress test has been proposed to be a possible tool for early detection of several diseases such as Alzheimer's disease, inflammation and endothelial dysfunction (Maschirow et al., 2015; Mota et al., 2015). Solid evidence of the adverse influence of ELF-EMFs on human health are urgently needed. In this study, we compared the oxidative stress by assessing 8-isoprostane and oxidative damage to DNA (Urinary 8-hydroxy-2-deoxy-guanosine, 8-OHdG) in subjects without ELF-EMFs exposure and workers who are exposed to electromagnetic radiation of 110-kV to 420-kV high-voltage lines. Daily intake of green tea polyphenol significantly reversed the negative impact of ELF-EMFs on oxidative stress.

2. Methods

2.1. Objectives

The substation workers were divided into placebo and green tea polyphenol supplementation groups. The characteristics and outcomes were compared in workers who are exposed to electromagnetic radiation of 110–420 kV and control subjects who work in administration with insignificant exposure to electric field. Recruitment for this study took place in the Jilin No. 1 People's Hospital from September 2010 to August 2011. The inclusion and exclusion criteria were based on scientific and ethical considerations, as shown in Table 1.

Potential participants and staff who were interested in this study received informed consents and subjects who agreed with the routines were scheduled to complete a personal questionnaire. At the end of the questionnaire session, participants signed the informed consents. As shown in Fig. 1, a total of 1842 people enrolled in this study. However, after selection by inclusion and exclusion criteria, 867 substation workers signed the informed consents and participated in further protocols. These participants were then randomized into two groups, background group and workers with exposure to ELF-EMFs of 110–420 kV. Each group were then sequentially divided into two subgroups, placebo or dietary green tea polyphenol supplementation groups. Green tea polyphenol (Purifa Biotechnology Co., Chengdu, China) and placebo were both administrated using gelatin capsules. One green tea polyphenol capsule contained 250 mg of standardized green tea extract without caffeine (99.25% pure, including 81.25% catechins and among them 56.8% epigallocatechin-3-galate) and additional substances (maltodextrin and magnesium stearate). The placebo capsule contained maltodextrin, magnesium stearate and 250 mg of pure microcrystalline cellulose instead of green tea polyphenols. The capsules were ingested with lunch and dinner and two capsules were given twice daily. In the end of this study, 321 participants completed the entire protocol and 546 participants dropped out.

2.1.1. Body mass index measurements

Weight and height were taken for all participants by trained clinic staff in the beginning of the study. Weight was measured to the nearest 0.1 kg using a digital scale at screening baseline. Standing height was determined to the nearest 0.1 cm at baseline. Both measurements were repeated twice and the average was recorded to the nearest 0.1 cm.

2.1.2. Health history questionnaire

Each participant completed an in-depth health survey including information about demographics, diabetes, hypertension, alcohol intake and medication use. History of vitamin supplementation was questioned and participants who were having regular dietary supplementations in the past year were excluded.

2.1.3. Measurement of oxidative stress

For sample collection, 24 h urine samples were collected by participants into a plastic container containing 3 g of ascorbic acid and kept at 4 °C until clinic visit the following day. Urine samples were purified by adding three volumes of ethanol to one volume of sample. After cooled to 4 °C, the mixtures were centrifuged for 20 min at 1500 × *g*. The supernatant was then decanted, and ethanol was evaporated off by using a speed vacuum.

Urinary 8-isoprostane was determined by a urinary isoprostane ELISA Kit (Northwest, USA) using a competitive ELISA strategy. In brief, the 8-isoprostane contained in urine samples and standards competed with 8-isoprostane-horseradish peroxidase conjugate for binding to pre-coated specific antibody on a microplate. After addition of the horseradish peroxidase substrate, blue color was developed and was inversely proportional to the amount of 8-isoprostane in the samples and standards. Stopping reagent was added in the end and the color was changed to yellow. Absorbance was measured at 450 nm.

Urinary 8-OHdG was determined by an 8-hydroxy-2-deoxy Guanosine EIA Kit (Cayman Chemical, USA), using a competitive assay. Anti-mouse IgG-coated plate and a tracer consisting of an 8-OHdG-acetylcholinesterase conjugate instead of an antigen-coated plate was employed to improve sensitivity and reduce variability. Briefly, 8-OHdG in the sample competes with the tracer for a constant amount of 8-OHdG monoclonal antibody. The tracer-antibody-complex binds to the pre-coated anti-mouse IgG. Acetylcholine and 5,5′-dithio-bis-2-nitrobenzoic aid (AChE)-substrate was then added and results in the enzymatic production of 5-thio-2-nitrobenzoic acid, which is yellow and can be measured spectrophotometrically at 412 nm. The reading numbers are inversely proportional to the amount of 8-OHdG in the original sample. Quantification of creatinine in the urine samples was determined by reaction with picrate as described previously (Slot, 1965).

2.1.4. Statistical analysis

Descriptive data is expressed as mean ± standard deviation (SD). Statistical analysis was performed with SPSS (Version 20, IBM Co). Student *t*-test or ANOVA analysis followed by a Tukey's post hoc test was employed to analysis the significance and p-value < 0.05 was considered as statistical significance.