Research Article Open Access

Effects of Ginger Extract Powder E on attention as a Cognitive Function: A randomized, double-blind, and placebo-controlled parallel study

Naoki Nakamura[1*], Yuichi Sano[1], Naoko Suzuki[2], Tsuyoshi Takara[3]

[1]Ikeda Food Research Co., Ltd., 95-7 Minooki, Fukuyama, Hiroshima 721-0956, Japan; [2]ORTHOMEDICO Inc., 1-4-1 Koishikawa, Bunkyo, Tokyo 112-0002, Japan; [3]Medical Corporation Seishinkai, Takara Clinic, 2-3-2 Higashigotanda, Shinagawa, Tokyo, 141-0022, Japan.

[*]**Corresponding Author:** Naoki Nakamura, Ikeda Food Research Co., Ltd., 95-7 Minooki, Fukuyama, Hiroshima 721-0956, Japan.

Submission Date: July 17th, 2025, **Acceptance Date:** September 10th, 2025, **Publication Date:** September 18th, 2025

Please cite this article as: Nakamura N., Sano Y., Suzuki N., Takara T. Effects of Ginger Extract Powder E on attention as a Cognitive Function: a randomized, double-blind, and placebo-controlled parallel study. *Functional Foods in Health and Disease* 2025; 15(9): 646 – 657. DOI: https://doi.org/10.31989/ffhd.v15i9.1714

ABSTRACT

Background/Objectives: Ginger Extract Powder E is a heat-processed ginger preparation enriched in 6-shogaol.. It has been reported to reduce fatigue caused by desk workload, as well as eye fatigue and shoulder stiffness. However, there is a lack of research investigating the effects of Ginger Extract Powder E on cognitive function. The purpose of this study was to evaluate the effects of Ginger Extract Powder E intake on cognitive function after Visual Display Terminal (VDT) work in healthy adults who experienced eye fatigue and reduced concentration during the task.

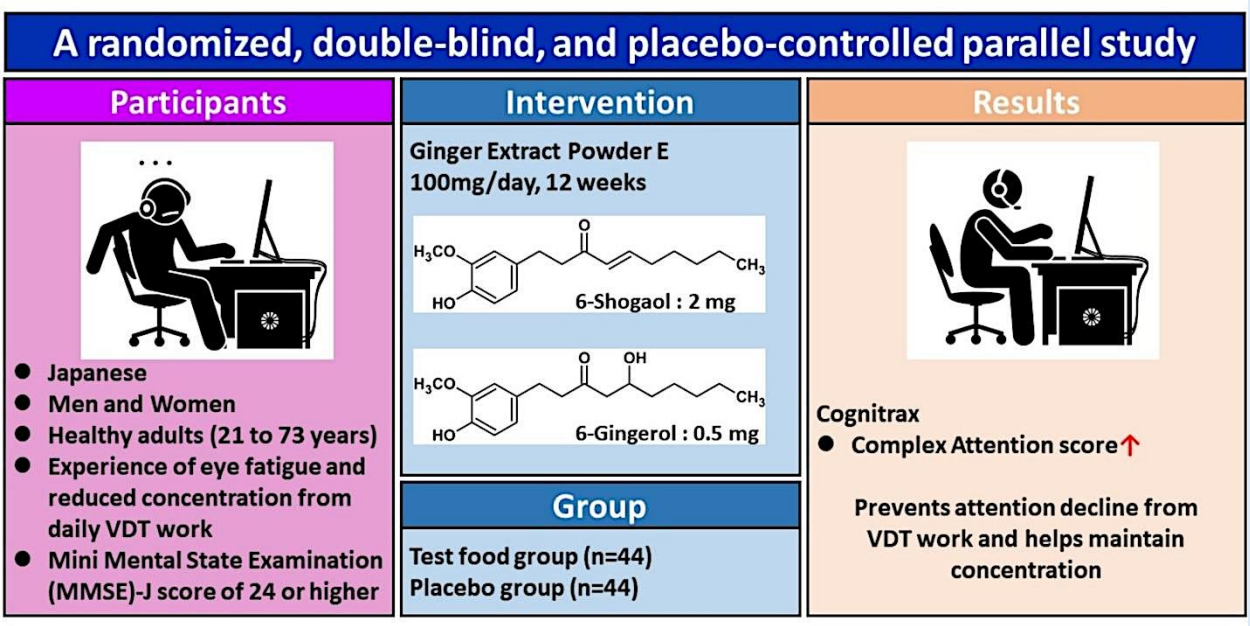
Methods: A randomized, double-blind, placebo-controlled, parallel-group study was conducted on 88 healthy adult male and female aged 21 to 73 years. Participants were randomly assigned to receive either a test food containing Ginger Extract Powder E (100 mg) or a placebo daily for 12 weeks. Participants were assessed at weeks 0 and 12 using Cognitrax and the critical flicker-fusion frequency after 60 minutes of VDT work.

Results: At 12 weeks of intervention, the primary outcome—Complex Attention score on the Cognitrax assessment—was significantly higher in the Ginger Extract Powder E group compared with the placebo group, with values exceeding the mean.

Conclusions: The results suggest that continuous intake of Ginger Extract Powder E prevents attention decline induced by VDT work and helps maintain concentration. Additionally, no adverse events were observed under the conditions of this study, and there were no safety issues.

Trial registration: jRCT 1030240208

Keywords: Ginger extract; VDT work; attention; concentration; cognitive function



INTRODUCTION

Ginger (*Zingiber officinale*) has long been used worldwide as both a spice and a herbal medicine. Its principal bioactive compounds are 6-shogaol and 6-gingerol [1], which exhibit antioxidant and anti-inflammatory properties, with 6-shogaol demonstrating greater physiological activity [2-5]. The antioxidant activity of 6-shogaol includes the inhibition of oxidative damage in skeletal muscle cells [6] and the protective effect against oxidative stress in melanocytes [7]. Regarding its anti-inflammatory activity, studies have reported the inhibition of neuroinflammation in *Proteus mirabilis*-induced Parkinson's disease animal model [8], and the mitigation of lung inflammation in a murine asthma model [9]. Additionally, 6-shogaol has been reported to increase optic nerve head blood flow in rats [10].

6-Shogaol is produced by heat treatment of 6-gingerol [1]. Ginger Extract Powder E, produced by powdering ginger extract with an increased concentration of 6-shogaol through heat treatment, has been reported to possess various health benefits. Continuous intake of Ginger Extract Powder E has been reported to reduce fatigue caused by desk workload [11]. Furthermore, it has been reported to reduce eye fatigue and improve shoulder stiffness in women [12]. These effects may be attributed to the antioxidant, anti-inflammatory, and blood flow-promoting properties of 6-shogaol.

In recent years, the rapid development of information technology has led to a significant increase in both the number of people using Visual Display Terminals (VDT), such as computers, tablets, and smartphones, and the amount of time spent on such devices [13]. Prolonged VDT use is known to cause symptoms of asthenopia, including eye strain, dry eye, and blurry vision, as well as musculoskeletal symptoms such as carpal tunnel syndrome, tension neck syndrome, and wrist tendonitis [14-17]. Additionally, VDT work has been suggested to induce psychological and brain fatigue, potentially leading to a decline in cognitive function [18-20]. Cognitive decline impairs concentration and affects sustained attention, potentially leading to a decrease in operational safety and an increase in operational errors [20]. Therefore, it is a matter of concern not only for individuals but also for society.

This study aimed to investigate the effects of continuous intake of Ginger Extract Powder E for 12 weeks on cognitive function after 60 minutes of VDT work. The participants were healthy adults who experienced eye fatigue and reduced concentration due to VDT work. In this study, the primary outcome was the Complex Attention score from Cognitrax assessed at 12 weeks of intervention, and the effects on cognitive function after VDT work were evaluated. Additionally, visual fatigue was evaluated before and after VDT work using the critical flicker-fusion frequency.

METHODS

Study design: This study used a randomized, double-blinded, placebo-controlled, parallel-group design with an intervention period of 12 weeks. Participants were randomly assigned to either the test food or placebo group in a 1:1 allocation ratio using a computer. Throughout the study, the principal investigator, participants, medical staff, and all other personnel involved in the study were blinded to the treatment provided. The primary outcome was the Complex Attention score from Cognitrax assessed at 12 weeks of intervention. The secondary outcomes included Cognitrax scores (excluding Complex Attention) at 12 weeks, along with their changes and percentage changes from baseline. Additionally, the critical flicker-fusion frequency scores (both eyes, dominant eye, and non-dominant eye) before and after VDT work at 12 weeks, along with their changes from baseline, were assessed. The VDT work consisted of participants operating a handheld gaming device for 60 minutes. This study was conducted at Medical Corporation Seishinkai, Takara Clinic (Tokyo, Japan) from July 2024 to February 2025 by a contract research organization ORTHOMEDICO Inc. (Tokyo, Japan).

Ethics Statement: The study complied with the Declaration of Helsinki (2013) and the Ethical Guidelines for Medical Research Involving Human Subjects. The study was approved by the Ethics Committee of Medical Corporation Seishinkai, Takara Clinic (Tokyo, Japan) under approval number 2406-04426-0061-10-TC and registered with the Japan Registry of Clinical Trials (jRCT 1030240208).

Participants: The participants were healthy Japanese adult men and women, who had received a prior explanation of the study, demonstrated comprehension of its contents, and provided written consent to participate. The participants experienced eye fatigue and reduced concentration due to their daily VDT work, causing the Complex Attention score in the pre-intervention Cognitrax assessment to significantly decrease after the VDT work. Additionally, participants had unaided or corrected binocular visual acuity of 1.0 or higher, did not wear contact lenses, and were able to switch to glasses during testing. Participants' eligibility for the study was determined by the principal investigator based on their Mini Mental State Examination (MMSE)-J score of 24 or higher, indicating no signs of dementia. The exclusion criteria were

recorded in the Japan Registry of Clinical Trials (jRCT1030240208).

Intervention: Participants consumed one capsule of either the test food or placebo daily in the morning for 12 weeks. The test food contained 100 mg of Ginger Extract Powder E (2 mg of 6-shogaol, 0.5 mg of 6-gingerol; Ikeda Tohka Industries Co., Ltd., Hiroshima, Japan) per capsule, while the placebo contained 100 mg of dextrin per capsule. The intervention was encapsulated in brown No. 2 capsules, rendering them indistinguishable in appearance, shape, color, odor, and taste. The capsules were provided by Ikeda Food Research Co., Ltd. (Hiroshima, Japan).

Cognitrax: Cognitrax (Health Solution, Inc., Tokyo, Japan) was used to assess cognitive function after 60 minutes of VDT work at pre-intervention (baseline) and at 12 weeks of intervention. Cognitrax consisted of 10 test items (Verbal Memory Test, Visual Memory Test, Finger Tapping Test, Symbol Digit Cording, Stroop Test, Shifting Attention Test, Continuous Performance Test, Perception of Emotions, Non-Verbal Reasoning Test, 4-Part Continuous Performance Test) which were administered in the order listed. The results were standardized to scores with a mean of 100 and a standard deviation of 15, which were then categorized into 16 cognitive domains (Neurocognitive Index、Composite Memory、Verbal Memory、Visual Memory、Psychomotor Speed、Reaction Time、Complex Attention, Cognitive Flexibility 、Processing Speed、Executive Function、Social Acuity 、Reasoning、Working Memory、Sustained Attention 、Simple Attention、Motor Speed). The mean score for each cognitive domain was 100, with higher scores indicating better cognitive function.

Critical flicker-fusion frequency: Visual fatigue was evaluated using the critical flicker-fusion frequency test(Flicker Value Measuring Instrument II Automatic Type; Takei Scientific Instruments Co., Ltd. Niigata, Japan). Measurements were performed before and after 60 minutes of VDT work at baseline and after 12 weeks of intervention. The critical flicker-fusion frequency scores were measured for both eyes, dominant eye, and the non-dominant eye using both ascending and descending methods.

Safety Evaluation

At baseline and at 12 weeks, physical measurements, physical examinations, urine parameters, and blood parameters were measured. Physical measurements included height, weight, and BMI, and physical examinations included systolic and diastolic blood pressure. Urine parameters included protein, glucose, occult blood, and pH levels. Blood parameters included white blood cell count, red blood cell count, hemoglobin, hematocrit, platelet count, aspartate aminotransferase, alanine aminotransferase, γ-glutamyltransferase, total bilirubin, total protein, urea nitrogen, creatinine, uric acid, sodium, potassium, chlorine, serum amylase, total cholesterol, HDL-cholesterol, LDL-cholesterol, triglycerides, glucose, and hemoglobin A1c. Urine parameters and blood parameters were measured by the LSI Medience Corporation (Tokyo, Japan).

Statistical Analysis: All statistical analyses were performed using two-sided tests, and the significance level was set at 5%. IBM SPSS statistics software (version 23 and higher; IBM Japan, Ltd., Tokyo, Japan) was used. Outcomes were presented as mean and standard deviation (SD) for baseline data, and as estimated marginal means (EMM) and standard error (SE) for data at 12 weeks. Statistical analyses of outcomes were performed using Welch's t-test for comparisons between groups at baseline, and analysis of covariance (ANCOVA) with baseline as a covariate and for comparisons between groups at 12 weeks data. The incidence rates of adverse effects and adverse events were aggregated by group, and 95% confidence intervals were calculated both within each group and for the differences between

groups. The proportion of cases with deviations in urinary and blood parameters from reference values at 12 weeks was calculated, and statistical analysis was performed using the chi-square test.

RESULTS

Participants: The flow of participants is shown in Figure 1. Among the 162 individuals who consented to participate in the study, 88 participants who met the inclusion criteria and without any exclusion criteria were enrolled. Participants were randomly assigned to either the test food group or the placebo group, with 44 participants in each group. 5 participants who dropped out were excluded from the analysis. The efficacy assessment analysis dataset was defined as the Per Protocol Set (PPS), consisting of 80 participants (40 in the test food group and 40 in the placebo group). The safety assessment analysis dataset was defined as the Safety Analysis Population (SAF), consisting of 83 participants (41 in the test food group and 42 in the placebo group). The background characteristics of the participants are shown in Table 1. No significant differences were observed in the participants' background characteristics.

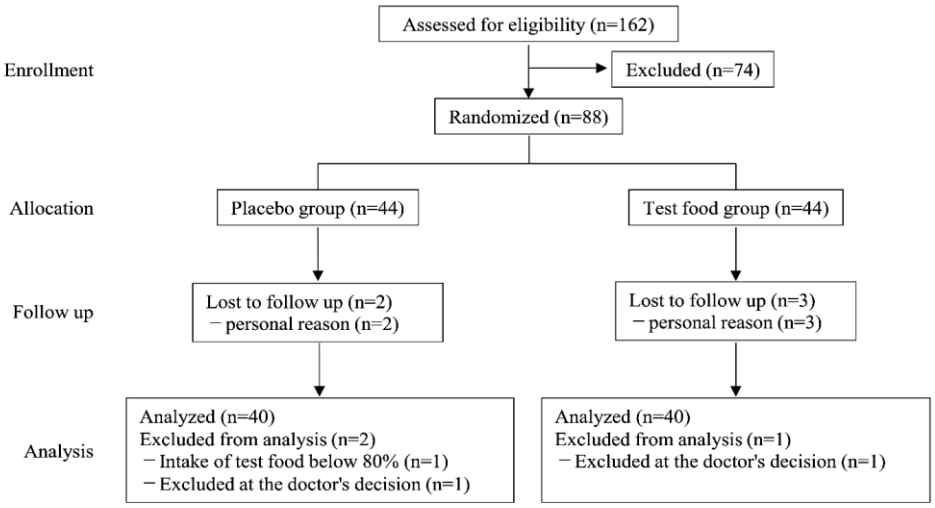


Figure 1. Flow of the participants.

Table 1. Background characteristics of the participants.

	Placebo Group (n=40)		Test food Group (n=40)	
	Mean	SD	Mean	SD
Sex (n, Male/Female)	18/22		17/23	
Age (years)	46.6	11.7	47.9	11.6
Height (cm)	164.3	8.8	165.2	8.5
Weight (kg)	62.5	13.1	61.5	13.4
BMI (kg/m^2)	23.0	4.0	22.4	3.5
SBP (mmHg)	123.1	14.5	125.0	16.8
DBP (mmHg)	78.1	11.5	78.6	12.5
MMSE	28.9	1.2	28.7	1.5
Complex Attention score (Cognitrax)				
– Before VDT work	105.0	11.1	103.6	12.0
– After VDT work	93.2	15.2	90.9	18.9

BMI: Body Mass Index, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, MMSE: Mini Mental State Examination, VDT: Visual Display Terminals.

Cognitrax: The results of Cognitrax are shown in Table 2. The primary outcome, the Complex Attention score after VDT work at 12 weeks of intervention, was significantly higher in the test food group compared to the placebo group (p = 0.037). The change in Complex Attention score after VDT work from baseline to 12 weeks was also significantly higher in the test food group compared to the placebo group (p = 0.037). At baseline, the Working Memory score after VDT work was significantly lower in the test food group compared to the placebo group (p = 0.045).

Critical flicker-fusion frequency: There was no significant difference observed in any of the measured critical flicker-fusion frequency scores.

Safety: Under the conditions of this study, no adverse events were observed during the study period (Table 3). At 12 weeks of intervention, some urinary and blood parameters deviated from the reference range, and there was a significant difference in potassium concentration between the groups (Table 4). The principal investigator reviewed the deviations and confirmed that the intervention did not result in any medically concerning variations.

Table 2. Results of the Cognitrax.

Standard score		Placebo group (n=40)				Test food group (n=40)				*p* value
		Mean	SD	EMM	SE	Mean	SD	EMM	SE	
Neurocognitive Index	Pre	98.1	11.3	-	-	94.1	10.8	-	-	0.114
	Post	101.2	13.6	99.8	1.3	100.5	8.4	101.9	1.3	0.265
	Change	3.1	8.6	3.7	1.3	6.4	9.2	5.8	1.3	0.265
Composite Memory	Pre	94.7	20.2	-	-	87.2	20.4	-	-	0.103
	Post	99.4	19.9	97.6	2.6	95.6	18.1	97.3	2.6	0.938
	Change	4.7	17.9	6.7	2.6	8.4	21.3	6.4	2.6	0.938
Verbal Memory	Pre	95.7	20.0	-	-	90.7	22.9	-	-	0.301
	Post	101.9	18.5	101.0	2.7	96.7	18.8	97.6	2.7	0.384
	Change	6.2	19.6	7.8	2.7	6.0	23.6	4.4	2.7	0.384
Visual Memory	Pre	96.1	16.7	-	-	88.9	16.4	-	-	0.054
	Post	97.5	17.6	96.2	2.5	96.4	15.7	97.7	2.5	0.663
	Change	1.5	16.3	3.7	2.5	7.5	20.6	5.3	2.5	0.663
Psychomotor Speed	Pre	106.1	22.3	-	-	101.1	15.9	-	-	0.247
	Post	107.1	24.5	105.0	2.0	101.6	13.4	103.6	2.0	0.606
	Change	0.9	9.1	1.4	2.0	0.5	15.8	0.0	2.0	0.606
Reaction Time	Pre	99.1	13.8	-	-	96.5	12.4	-	-	0.369
	Post	100.5	12.0	99.6	1.2	99.7	10.1	100.5	1.2	0.598
	Change	1.4	7.1	1.8	1.2	3.2	10.4	2.7	1.2	0.598
Complex Attention	Pre	93.2	15.2	-	-	90.9	18.9	-	-	0.546
	Post	97.7	16.8	97.3	2.1	103.3	12.2	103.7	2.1	0.037
	Change	4.5	16.0	5.2	2.1	12.4	18.8	11.6	2.1	0.037
Cognitive Flexibility	Pre	97.2	12.6	-	-	95.4	12.8	-	-	0.511
	Post	101.1	15.2	100.5	1.9	102.6	12.0	103.1	1.9	0.354
	Change	3.8	13.7	4.3	1.9	7.2	12.9	6.8	1.9	0.354
Processing Speed	Pre	115.5	14.0	-	-	109.1	16.1	-	-	0.063
	Post	115.7	19.5	112.9	1.9	110.8	15.3	113.6	1.9	0.798
	Change	0.2	12.4	0.6	1.9	1.7	11.2	1.3	1.9	0.798

Executive Function	Pre	98.1	12.6	-	-	96.1	12.3	-	-	0.492
	Post	101.7	15.5	101.1	1.9	102.9	11.9	103.4	1.9	0.387
	Change	3.6	13.6	4.0	1.9	6.8	12.5	6.4	1.9	0.387
Social Acuity	Pre	90.1	18.0	-	-	89.5	22.7	-	-	0.888
	Post	90.6	21.8	90.5	3.8	82.1	29.8	82.2	3.8	0.131
	Change	0.5	18.2	0.7	3.8	−7.4	31.9	−7.5	3.8	0.131
Reasoning	Pre	102.1	14.5	-	-	100.2	15.7	-	-	0.576
	Post	105.1	12.1	104.9	1.9	102.5	12.1	102.7	1.9	0.412
	Change	3.1	16.9	3.8	1.9	2.4	16.4	1.6	1.9	0.412
Working Memory	Pre	106.9	11.0	-	-	100.9	15.1	-	-	0.045
	Post	107.4	11.2	105.9	1.7	102.6	13.8	104.1	1.7	0.479
	Change	0.5	10.3	2.0	1.7	1.8	14.4	0.3	1.7	0.479
Sustained Attention	Pre	106.3	9.5	-	-	104.0	10.8	-	-	0.316
	Post	106.6	12.0	106.0	2.3	102.8	18.3	103.5	2.4	0.446
	Change	0.4	8.7	0.9	2.3	−1.1	19.6	−1.6	2.4	0.446
Simple Attention	Pre	80.7	37.1	-	-	79.4	31.2	-	-	0.866
	Post	87.7	31.6	87.5	4.3	91.3	24.9	91.5	4.3	0.509
	Change	6.9	36.1	7.4	4.3	11.9	37.2	11.4	4.3	0.509
Motor Speed	Pre	97.9	27.9	-	-	95.6	16.0	-	-	0.656
	Post	99.0	28.2	98.1	2.4	94.8	16.8	95.7	2.4	0.478
	Change	1.2	9.2	1.4	2.4	−0.8	20.6	−1.0	2.4	0.478

Pre: Pre-intervention (baseline), Post: 8 Weeks of intervention, Change: change score from base-line to 8 weeks, EMM: Estimated Marginal Means, *p* value: inter-group comparison with Welch's t-test of baseline data (Pre), and analysis of covariance (ANCOVA) with baseline as a covariate and for comparisons between groups at 8 weeks data (Post, Change).

Table 3. Adverse events during the intervention.

	Placebo Group (n=42)		Test food Group (n=41)		*p* value
	Number	Rate (%)	Number	Rate (%)	
Adverse events	0	0.0	0	0.0	NA

Number: The number of adverse events, Rate: The rate of adverse events, NA: Not Available, p value: Asymptotic significance obtained using the chi-square test.

Table 4. Urine parameters and blood parameters after the intervention.

	Placebo Group (n=42)		Test food Group (n=41)		*p* value
	Number	Rate (%)	Number	Rate (%)	
Quantitative urinary protein	2	4.8	3	7.3	0.625
Quantitative urinary glucose	0	0.0	3	7.3	0.074
Urinary pH	1	2.4	0	0.0	0.320
Urinary occult blood	3	7.1	1	2.4	0.317
White blood cell count (WBC)	3	7.1	4	9.8	0.668
Red blood cell count (RBC)	3	7.1	3	7.3	0.976
Hemoglobin (Hb)	1	2.4	2	4.9	0.542
Hematocrit value (Ht)	2	4.8	2	4.9	0.980
Platelet count (PLT)	3	7.1	2	4.9	0.665
Aspartate aminotransferase (AST)	0	0.0	0	0.0	NA
Alanine aminotransferase (ALT)	0	0.0	1	2.4	0.309

	Placebo Group (n=42)		Test food Group (n=41)		*p* value
	Number	Rate (%)	Number	Rate (%)	
γ-Glutamyltransferase (γ-GT)	4	9.5	2	4.9	0.414
Total bilirubin (T-BIL)	1	2.4	1	2.4	0.986
Total protein (TP)	3	7.1	2	4.9	0.665
Urea nitrogen (UN)	4	9.5	1	2.4	0.175
Creatinine (CRE)	0	0.0	3	7.3	0.074
Uric acid (UA)	3	7.1	0	0.0	0.081
Sodium (Na)	0	0.0	0	0.0	NA
Potassium (K)	4	9.5	0	0.0	0.043
Chlorine (Cl)	0	0.0	1	2.4	0.309
Serum amylase (AMY/S)	2	4.8	1	2.4	0.571
Total cholesterol (T-Cho)	8	19.0	5	12.2	0.390
HDL- cholesterol (HDL-Cho)	6	14.3	1	2.4	0.052
LDL-cholesterol (LDL-Cho)	7	16.7	4	9.8	0.353
Triglycerides (TG)	3	7.1	3	7.3	0.976
Glucose (GLU)	1	2.4	2	4.9	0.542
Hemoglobin A1c (HbA1c: NGSP)	0	0.0	1	2.4	0.309

Number: The number of adverse events, Rate: The rate of adverse events, NA: Not Available, p value: Asymptotic significance obtained using the chi-square test.

DISCUSSION

In this study, we evaluated the effects of Ginger Extract Powder E on cognitive function in healthy adults who experienced eye fatigue and reduced concentration due to VDT work, using the Complex Attention score from Cognitrax as the primary outcome measure at 12 weeks of intervention. Cognitrax, used to evaluate cognitive function, consists of computerized neurocognitive tests that efficiently and objectively assess a broad-spectrum of brain function domains, providing millisecond precise measurements of important cognitive functions. It comprises ten test items that evaluate various aspects of cognitive function, including memory, attention, processing speed, and executive function [21]. The Complex Attention score, used as the primary outcome in this study, evaluates the ability to appropriately respond to various stimuli over an extended period and perform cognitive tasks quickly and accurately [21]. The participants in this study consisted of 88 individuals whose Complex Attention score at baseline showed a significant decline before and after 60 minutes of VDT work, suggesting that they were a population prone to reduced concentration due to VDT work. The Complex Attention score of the test food group at 12 weeks was above the mean value and significantly higher than that of the placebo group (P = 0.037; Table 2). Additionally, the 12 week change in the Complex Attention score was also significantly higher in the test food group compared to the placebo group (P = 0.037; Table 2). These results suggest that continuous intake of Ginger Extract Powder E may help suppress the decline in attention caused by VDT work and support the maintenance of concentration.

Prolonged VDT work is known to cause digital eye strain (DES), characterized by symptoms such as eye fatigue, headache, blurred vision, dry eye, and neck and shoulder pain [22]. It is estimated that 50% of computer users experience these symptoms [23]. It has been reported that subjective fatigue influences cognitive function [24], and that DES leads to reduced attention and concentration [25, 26]. Previous studies have reported that a four-week continuous intake of Ginger

Extract Powder E containing 6-shogaol and 6-gingerol reduces fatigue caused by desk workload [11]. It has also been reported that an eight-week continuous intake of Ginger Extract Powder E reduces eye fatigue and improves subjective symptoms of shoulder stiffness in women [12]. These results suggest that Ginger Extract Powder E, which contains 6-shogaol and 6-gingerol, improves feeling of fatigue and eye fatigue induced by VDT work, and may influence cognitive functions such as attention and concentration. The antioxidant [27], anti-inflammatory [28], and blood flow-enhancing effects [10, 29] of 6-shogaol and 6-gingerol may contribute to these functions.

In recent years, accumulating evidence suggests that ginger may have the potential to improve various cognitive impairments [30]. For example, it has been reported that ginger extract enhances working memory and improves cognitive function in healthy middle-aged women [31]. Additionally, it has been reported that ginger extracts containing the bioactive component 6-shogaol attenuate neuroinflammation and cognitive deficits in animal models of dementia [32]. The effects of 6-shogaol and 6-gingerol on cognitive function are suggested to be associated with neuroprotective effects mediated by their antioxidant and anti-inflammatory properties [8, 33, 34]. Although further studies are required to elucidate the underlying mechanisms, it has been suggested that Ginger Extract Powder E, which contains 6-shogaol and 6-gingerol, may help maintain neural function in the brain, thereby preventing attention decline induced by VDT work and contributing to sustained concentration.

The critical flicker-fusion frequency refers to the frequency at which a regularly recurring change of light stimuli is perceived as steady and can be used to evaluate visual fatigue and cognitive function [35]. In this study, continuous intake of Ginger Extract Powder E was found to prevent attention decline induced by VDT work, leading to expectations regarding its effect on the critical flicker-fusion frequency; however, no significant difference was observed. There are many factors that affect visual fatigue. For example, women and younger individuals are more susceptible to the adverse effects of VDT work [36]. Since random assignment was adopted in this study, participants were allocated to ensure no variation in sex and age between groups. However, when considering two or more factors simultaneously, there was variation between groups (the proportion of women below the average age at enrollment was 33% in the placebo group and 25% in the test food group). The variation introduced by two or more factors may have obscured the effect of the test food on the critical flicker-fusion frequency, and this possibility cannot be excluded. Additionally, visual fatigue becomes more severe as VDT work duration increases [37]. There have been reports suggesting that the critical flicker-fusion frequency may not be useful for assessing mild to moderate visual fatigue [38]. Therefore, the habitual VDT work duration of the participants and the duration of the VDT work (60 minutes) in this study may have influenced the results. By conducting further studies, including subgroup analyses that account for multiple factors and additional investigations into the impact of VDT work duration, a deeper understanding of the relationship between visual fatigue and cognitive function may be achieved.

A limitation of this study is that it did not consider factors contributing to reduce concentration other than eye fatigue caused by VDT work. For example, age and mental stress have been suggested as factors contributing to reduced concentration [39-42]. 6-Shogaol and 6-gingerol, which possess antioxidant, anti-inflammatory, and blood flow-promoting properties, have been reported to be beneficial for aging [27, 43], and mental stress [44, 45]. By suppressing aging and mental stress, these compounds may help maintain concentration or reduce its decline. Further studies on antioxidant effects and mental stress-reducing effects

are needed to elucidate the mechanisms underlying the findings confirmed in this study.

CONCLUSION

Continuous intake of Ginger Extract Powder E waseffective in preventing decline in attention performance following VDT work. These findings suggest that Ginger Extract Powder E supports cognitive function after VDT work, helping to prevent declines in attention and effectively maintain concentration. No adverse events were observed under the conditions of this study, and there were no safety issues.

List of Abbreviations: VDT, Visual Display Terminal; BMI, Body Mass Index; SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; MMSE, Mini Mental State Examination; SD, standard deviation; EMM, estimated marginal means; SE, standard error; ANCOVA, analysis of covariance; PPS, Per Protocol Set; SAF, Safety Analysis Population; DES, digital eye strain.

Authors' Contributions: Conceptualization, N.N. and Y.S.; methodology, N.N., Y.S. and N.S.; formal analysis, N.S.; data curation, N.S. and T.T.; writing, N.N.; visualization, Y.S. All authors have read and agreed to the published version of the manuscript.

Competing Interests: The author declares no conflict of interest. This study was funded by Ikeda Food Research Co., Ltd., commissioned to ORTHOMEDICO Inc., and conducted at Takara Clinic. N.N. and Y.S. are employees of Ikeda Food Research Co., Ltd.; N.S. is an employee of ORTHOMEDICO Inc.; and T.T. is the director of Takara Clinic.

Acknowledgments and Funding: We appreciate ORTHOMEDICO Inc. for supporting the work of this study as the contract research organization as well as all participants and staff who cooperated in this study. This study was supported by funding from Ikeda Food Research Co., Ltd.

REFERENCES

1. Mao QQ., Xu XY., Cao SY., Gan RY., Corke H., Beta T., Li HB. Bioactive compounds and bioactivities of ginger (*Zingiber officinale* Roscoe). *Foods*. 2019; 8(6): 185. DOI: https://doi.org/10.3390/foods8060185
2. Dugasani S., Pichika MR., Nadarajah VD., Balijepalli MK., Tandra S., Korlakunta JN. Comparative antioxidant and anti-inflammatory effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. *Journal of ethnopharmacology*. 2010; 127(2): 515-20. DOI: https://doi.org/10.1016/j.jep.2009.10.004
3. Bak MJ., Ok S., Jun M., Jeong WS. 6-Shogaol-rich extract from ginger up-regulates the antioxidant defense systems in cells and mice. *Molecules*. 2012; 17(7): 8037-55. DOI: https://doi.org/10.1016/j.jep.2009.10.004
4. Bischoff-Kont I., Fürst R. Benefits of ginger and its constituent 6-shogaol in inhibiting inflammatory processes. *Pharmaceuticals.* 2021; 14(6): 571. DOI: https://doi.org/10.3390/ph14060571
5. Adebodun GO., Kayode AAA., Adebodun SA. A review on alternative treatments of gestational diabetes mellitus: focus on phytotherapy. *Functional Food Science*. 2023; 3(9): 179-192. DOI: https://doi.org/10.31989/ffs.v3i9.1137
6. Hur J., Lee Y., Lee CJ., Park HY., Choi SY. 6-Shogaol suppresses oxidative damage in L6 muscle cells. *Applied Biological Chemistry*. 2020; 63: 57. DOI: https://doi.org/10.1186/s13765-020-00544-8
7. Yang L., Yang F., Teng L., Katayama I. 6-Shogaol protects human melanocytes against oxidative stress through activation of the nrf2-antioxidant response element signaling pathway. *International journal of molecular sciences*. 2020; 21(10): 3537. DOI: https://doi.org/10.3390/ijms21103537
8. Huh E., Choi JG., Choi Y., Ju IG., Noh D., Shin DY., Kim DH., et al. 6-Shogaol, an active ingredient of ginger, improves intestinal and brain abnormalities in *Proteus mirabilis*-induced Parkinson's disease mouse model. *Biomolecules and therapeutics*. 2023; 31(4): 417-424. DOI: https://doi.org/10.4062/biomolther.2023.098
9. Yocum GT., Hwang JJ., Mikami M., Danielsson J., Kuforiji AS., Emala CW. Ginger and its bioactive component 6-shogaol mitigate lung inflammation in a murine asthma model. *American journal of physiology. Lung cellular and molecular physiology*. 2020; 318(2): L296-L303. DOI: https://doi.org/10.1152/ajplung.00249.2019
10. Takahashi N., Sato K., Kiyota N., Tsuda S., Murayama N., Nakazawa T. A ginger extract improves ocular blood flow in rats with endothelin-induced retinal blood flow dysfunction. *Scientific reports*. 2023; 13(1): 22715. DOI: https://doi.org/10.1038/s41598-023-49598-w

11. Sano Y., Nakamura N., Suzuki N., Takara T. Effect of a supplement product containing Ginger Extract Powder E on reducing fatigue caused by workload. *Pharmacometrics*. 2024; 106(5/6): 127-134.
12. Higashikawa F., Nakaniida Y., Li H., Liang L., Kanno K., Ogawa-Ochiai K., Kiuchi Y. Beneficial effects of ginger extract on eye fatigue and shoulder stiffness: a randomized, double-blind, and placebo-controlled parallel study. *Nutrients*. 2024; 16(16): 2715. DOI: https://doi.org/10.3390/nu16162715
13. Wang G., Cui Y. Meta-analysis of visual fatigue based on visual display terminals. *BMC ophthalmology*. 2024; 24(1): 489. DOI: https://doi.org/10.1186/s12886-024-03721-1
14. Parihar JK., Jain VK., Chaturvedi P., Kaushik J., Jain G., Parihar AK. Computer and visual display terminals (VDT) vision syndrome (CVDTS). *Medical journal, Armed Forces India*. 2016; 72(3): 270-276. DOI: https://doi.org/10.1016/j.mjafi.2016.03.016
15. Fjaervoll K., Fjaervoll H., Magno M., Nøland ST., Dartt DA., Vehof J., Utheim TP. Review on the possible pathophysiological mechanisms underlying visual display terminal-associated dry eye disease. *Acta ophthalmologica*. 2022; 100(8): 861-877. DOI: https://doi.org/10.1111/aos.15150
16. Fjaervoll H., Fjaervoll K., Magno M., Moschowits E., Vehof J., Dartt DA., Utheim TP. The association between visual display terminal use and dry eye: a review. *Acta ophthalmologica*. 2022; 100(4): 357-375. DOI: https://doi.org/10.1111/aos.15049
17. Ellahia A., Shahid Khali M., Akram F. Computer users at risk: health disorders associated with prolonged computer use. *E3 Journal of Business Management and Economics*. 2011; 2(4): 171-182.
18. Watanabe E., Kuchta K., Kamei T., Mazda O. The effects of performing tasks on visual display terminals for 90 minutes on salivary cortisol, moods and work efficiency in healthy men. *Japan Society of Physiological Anthropology*. 2018; 18(3): 105-113. DOI: https://doi.org/10.20718/jjpa.18.3-105
19. Khin YP., Matsuyama Y., Tabuchi T., Fujiwara T. Association of visual display terminal usage with self-rated health and psychological distress among japanese office workers during the COVID-19 pandemic. *International journal of environmental research and public health*. 2021; 18(17): 9406. DOI: https://doi.org/10.3390/ijerph18179406
20. Sun L., Guo Z., Yuan X., Wang X., Su C., Jiang J., Li X. An investigation of the effects of brain fatigue on the sustained attention of intelligent coal mine VDT operators. *International journal of environmental research and public health*. 2022; 19(17): 11034. DOI: https://doi.org/10.3390/ijerph191711034
21. CNS Vital Signs Interpretation Guide: [https://www.cnsvs.com/WhitePapers/CNSVS-BriefInterpretationGuide.pdf] Retrieved May 27, 2025.
22. Pucker AD., Kerr AM., Sanderson J., Lievens C. Digital eye strain: updated perspectives. *Clinical optometry*. 2024; 16: 233-246. DOI: https://doi.org/10.2147/OPTO.S412382
23. Sheppard AL., Wolffsohn JS. Digital eye strain: prevalence, measurement and amelioration. *BMJ open ophthalmology*. 2018; 3(1): e000146. DOI: https://doi.org/10.1136/bmjophth-2018-000146
24. Lin F., Chen DG., Vance DE., Ball KK., Mapstone M. Longitudinal relationships between subjective fatigue, cognitive function, and everyday functioning in old age. *International psychogeriatrics*. 2013; 25(2): 275-85. DOI: https://doi.org/10.1017/S1041610212001718
25. Kaur K., Gurnani B., Nayak S., Deori N., Kaur S., Jethani J., Singh D., et al. Digital eye strain- a comprehensive review. *Ophthalmology and therapy*. 2022; 11(5): 1655-1680. DOI: https://doi.org/10.1007/s40123-022-00540-9
26. Bin Maneea MW., Alamawi HO., Almuqbil A., Abukhlaled JK., Alsuwailem G., Alabdulminaim J Jr., Aladawi AMM., et al. Digital eye straining: exploring its prevalence, associated factors, and effects on the quality of life. *Cureus*. 2024; 16(5): e59442. DOI: https://doi.org/10.7759/cureus.59442
27. Mohd Sahardi NFN., Jaafar F., Mad Nordin MF., Makpol S. *Zingiber officinale* Roscoe prevents cellular senescence of myoblasts in culture and promotes muscle regeneration. *Evidence-based complementary and alternative medicine: eCAM*. 2020; 2020: 1787342. DOI: https://doi.org/10.1155/2020/1787342
28. Bischoff-Kont I., Primke T., Niebergall LS., Zech T., Fürst R. Ginger constituent 6-shogaol inhibits inflammation- and angiogenesis-related cell functions in primary human endothelial cells. *Frontiers in pharmacology*. 2022; 13: 844767. DOI: https://doi.org/10.3389/fphar.2022.844767
29. Murata P., Kase Y., Ishige A., Sasaki H., Kurosawa S., Nakamura T. The herbal medicine Dai-kenchu-to and one of its active components [6]-shogaol increase intestinal blood flow in rats. *Life sciences*. 2002; 70(17): 2061-2070. DOI: https://doi.org/10.1016/S0024-3205(01)01552-1
30. Talebi M., İlgün S., Ebrahimi V., Talebi M., Farkhondeh T., Ebrahimi H., Samarghandian S. *Zingiber officinale* ameliorates Alzheimer's disease and cognitive impairments: lessons from preclinical studies. *Biomedicine and pharmacotherapy = Biomédecine and pharmacothérapie*. 2021; 133: 111088. DOI: https://doi.org/10.1016/j.biopha.2020.111088

31. Saenghong N., Wattanathorn J., Muchimapura S., Tongun T., Piyavhatkul N., Banchonglikitkul C., Kajsongkram T. *Zingiber officinale* improves cognitive function of the middle-aged healthy women. *Evidence-based complementary and alternative medicine : eCAM*. 2012; 2012: 383062. DOI: https://doi.org/10.1155/2012/383062
32. Moon M., Kim HG., Choi JG., Oh H., Lee PK., Ha SK., Kim SY., et al. 6-Shogaol, an active constituent of ginger, attenuates neuroinflammation and cognitive deficits in animal models of dementia. *Biochemical and biophysical research communications*. 2014; 449(1): 8-13. DOI: https://doi.org/10.1016/j.bbrc.2014.04.121
33. Shim S., Kwon J. Effects of [6]-shogaol on cholinergic signaling in HT22 cells following neuronal damage induced by hydrogen peroxide. *Food and chemical toxicology: an international journal published for the British*. 2012; 50(5): 1454-9. DOI: https://doi.org/10.1016/j.fct.2012.02.014
34. Park G., Kim HG., Ju MS., Ha SK., Park Y., Kim SY., Oh MS. 6-Shogaol, an active compound of ginger, protects dopaminergic neurons in Parkinson's disease models via anti-neuroinflammation. *Acta pharmacologica Sinica*. 2013; 34(9): 1131-1139. DOI: https://doi.org/10.1038/aps.2013.57
35. Muth T., Schipke JD., Brebeck AK., Dreyer S. Assessing critical flicker fusion frequency: which confounders? A narrative review. *Medicina*. 2023; 59(4): 800. DOI: https://doi.org/10.3390/medicina59040800
36. Parihar JK., Jain VK., Chaturvedi P., Kaushik J., Jain G., Parihar AK. Computer and visual display terminals (VDT) vision syndrome (CVDTS). *Medical journal, Armed Forces India*. 2016; 72(3): 270-276. DOI: https://doi.org/10.1016/j.mjafi.2016.03.016
37. Wang Y., Zhong X., ZhangY., Tu Y., Wang L., Chen Y., Zhang C., et al. Visual fatigue following long-term visual display terminal work under different light sources. *Lighting Research and Technology*. 2017; 49(8): 1034-1051. DOI: https://doi.org/10.1177/1477153516677559
38. Singh S., Downie LE., Anderson AJ. Is critical flicker-fusion frequency a valid measure of visual fatigue? a post-hoc analysis of a double-masked randomised controlled trial. *Ophthalmic and physiological optics: the journal of the British College of Ophthalmic Opticians (Optometrists)*. 2023; 43(2): 176-182. DOI: https://doi.org/10.1111/opo.13073
39. Lin F., Chen DG., Vance DE., Ball KK., Mapstone M. Longitudinal relationships between subjective fatigue, cognitive function, and everyday functioning in old age. *International psychogeriatrics*. 2013; 25(2): 275-285. DOI: https://doi.org/10.1017/S1041610212001718
40. Veríssimo J., Verhaeghen P., Goldman N., Weinstein M., Ullman MT. Evidence that ageing yields improvements as well as declines across attention and executive functions. *Nature human behaviour*. 2022: 6(1): 97-110. DOI: https://doi.org/10.1038/s41562-021-01169-7
41. Vallesi A., Tronelli V., Lomi F., Pezzetta R. Age differences in sustained attention tasks: a meta-analysis. *Psychonomic bulletin and review*. 2021; 28(6): 1755-1775. DOI: https://doi.org/10.3758/s13423-021-01908-x
42. Saffari F., Norouzi K., Bruni LE., Zarei S., Ramsøy TZ. Impact of varying levels of mental stress on phase information of EEG signals: a study on the frontal, central, and parietal regions. *Biomedical Signal Processing and Control*. 2023; 86: 105236. DOI: https://doi.org/10.1016/j.bspc.2023.105236
43. Ballester P., Cerdá B., Arcusa R., García-Muñoz AM., Marhuenda J., Zafrilla P. Antioxidant activity in extracts from *Zingiberaceae* family: cardamom, turmeric, and ginger. *Molecules*. 2023; 28(10): 4024. DOI: https://doi.org/10.3390/molecules28104024
44. Afzal M., Kazmi I., Quazi AM., Khan SA., Zafar A., Al-Abbasi FA., Imam F., et al. 6-Shogaol attenuates traumatic brain injury-induced anxiety/depression-like behavior via inhibition of oxidative stress-influenced expressions of inflammatory mediators TNF-α, IL-1β, and BDNF: insight into the mechanism. *ACS Omega*. 2021; 7(1): 140-148. DOI: https://doi.org/10.1021/acsomega.1c04155
45. Simon A., Darcsi A., Kéry Á., Riethmüller E. Blood-brain barrier permeability study of ginger constituents. *Journal of pharmaceutical and biomedical analysis*. 2020; 177: 112820. DOI: https://doi.org/10.1016/j.jpba.2019.112820