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RESEARCH

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Effects of laughter on focus and stress in middle-aged adults: a single-blind, randomized controlled trial

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Abstract

Background Disorders associated with mental health significantly impact disability-adjusted life year values and represent an ongoing problem in stressed societies. Worsening mental health also affects cognitive function and quality of life. Increasing attention has thus been attracted to preventive measures for mental and brain health in daily life. This has created a growing interest in care using laughter. This study assessed the effects of a short-term, laughter-based intervention on the mental health and cognitive functions of middle-aged adults.

Methods The study applied a single-blind, crossover-controlled trial design. Cognitive tasks (e.g., digit vigilance) were performed after participants viewed a video clip of approximately four minutes (comedic or control video), and the resulting scores were treated as the primary endpoint. The secondary endpoints included cerebral blood flow in the dorsolateral prefrontal cortex (measured using NIRS), heart rate variability (calculated from ECG), subjective mood assessment, and salivary stress biomarkers (e.g., α-amylase activity).

Results The study was conducted on 25 healthy Japanese-speaking adults aged 40 to 65. Results revealed a significant increase in digit vigilance scores. Compared to viewing the control video, participants evinced a trend toward an increase in serial seven subtraction scores after viewing the comedic video. No significant differences were found for other cognitive tasks. The cerebral blood flow was also significantly higher in the dorsolateral prefrontal cortex during the cognitive tasks performed after the participants viewed the comedic video compared to the control video. The outcomes of heart rate variability, subjective mood state assessment, and salivary stress markers also suggested that the comedic video intervention could subsequently contribute to the activation of parasympathetic activity and reduce psychological stress levels.

Conclusions The outcomes indicated that interventions using short comedic videos can improve focus and may reduce psychological stress. These results support the clinical benefits of humor, which can be utilized as a simple, non-invasive approach to promoting the health of middle-aged adults.

Trial Registration The study was approved by the ethics committee of Kirin Holdings Company (No. 2020–014) and registered in the University Hospital Medical Information Network (UMIN) database (Registration No. UMIN000043332; http://www.umin.ac.jp/ctr/) on February 15, 2021.

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Keywords Laughter, Humor, Focused attention, Cerebral blood flow, Psychological stress, Parasympathetic activity, Mental health, Well-being

Background

Intense competition, along with high-pressure lifestyles and social conditions, adversely impact individuals in contemporary societies, causing stress and a poor quality of life, which have become urgent social problems [1, 2]. Mental health exerts a significant impact on the disability-adjusted life year values [3]. The deterioration of mental health is also associated with cognitive decline and significantly impacts productivity [4, 5]. Chronic mental health difficulties can trigger mood disorders like anxiety and depression; preventive care is therefore essential for addressing problems before they become severe. Given this context, recent years have seen a growing interest in care using laughter [6]. Laughter therapy is not costly, nor does it require specialized equipment, and has thus already been introduced in the medical domain in treatment programs without adverse side effects [7, 8]. An observational study of 14,233 individuals demonstrated an association between infrequent laughter and the heightened risk of developing a functional disability [9].

Laughter also contributes to psychosocial and physical health, and several studies [10–15] have shown that it can help alleviate anxiety and depression. Physiologically, laughter reduces stress hormones [6, 14] and increases T lymphocytes by activating natural killer cells, which causes an upsurge in white blood cells and immunoglobulin levels, thus increasing a body's immunity [15–17]. Laughter also lowers blood pressure: it reduces vasoconstriction through a decrease in the breakdown of nitric oxide—a vasorelaxant substance—and raises blood glucose levels by reducing cortisol [14, 18, 19]. Laughter therapy is non-invasive, non-pharmacological, and relatively easy to implement; it is thus considered an effective complementary treatment that can reduce the intensity of many diseases [20] and is expected to improve the health of middle-aged adults [21].

However, the extant research has not comprehensively tested how positive psychological states achieved from brief laughter influence cognitive functioning and stress responses. Previous studies [22] have shown that interventions using comedic videos improve short-term memory in healthy older people, suggesting that such means could improve cognitive functions. Nevertheless, the effects of these interventions on cognitive functions (such as focused attention and working memory) or the biological responses of middle-aged people remain unclear. The researchers therefore designed an intervention trial with middle-aged adults to assess the effects of a brief laughter-based intervention on their autonomic nervous systems and stress responses and determine the effects of autonomic improvement on cognitive functions, primarily attention. The hypothesis was that laughter-based interventions would be associated with improved cognitive functions and increased regional cerebral blood flow (rCBF) in the dorsolateral prefrontal cortex (DLPFC) while performing cognitive tasks. Near-infrared spectroscopy (NIRS) was used to measure rCBF during the intervention. The DLPFC region of the prefrontal cortex plays an essential role in the executive functions of working cognition flexibility [23], planning [24], memory, inhibition, and reasoning; it is also crucial for the executive functions of cognitive process management [25]. In addition, changes in salivary stress biomarkers [26–32] (cortisol, α-amylase, secretory immunoglobulin A [sIgA], and β-endorphin) were measured at every given event and autonomic nervous system activity was calculated using heart rate variability (HRV) [33] as biometric information associated with mood.

Methods

Ethics and registration

This study was conducted following the Declaration of Helsinki and Ethical Guidelines for Medical and Health Research Involving Human Subjects. It was approved by the Kirin Holdings Company ethics committee (No. 2020–014). Before enrolling participants, the study was registered in the University Hospital Medical Information Network (UMIN) database (Registration No. UMIN000043332, http://www.umin.ac.jp/ctr/; Registration title: Effects of watching videos on brain function: A single-blind, crossover comparative study) on February 15, 2021. All participants provided written informed consent.

Participants

The researchers recruited 25 healthy middle-aged, Japanese-speaking adults aged between 40 and 65. In a previous study [22], the effect of humor on short-term memory was reported in 20 healthy older adults. Based on this report, an equivalent sample size was directly referenced for this study. The following exclusion criteria were established:

(i) Suffering from a hearing and/or visual impairment that interfered with daily life;
(ii) Wearing a device that interfered with heart rate measurements (e.g., pacemakers);

(iii) Developing symptoms of arrhythmia in the past 12 months.

Intervention

Experimental intervention

The experimental intervention required participants to view a sufficiently funny comic dialog video (comedic video) of approximately four minutes. The audiovisual clip was provided by Yoshimoto Kogyo Holdings Company, a famous entertainment company in Tokyo, Japan. The comedic video was among those offered by the company, and achieved the highest laughter score recorded in the preliminary trial conducted with a small number of participants. The comedian in the video has won the M-1 Grand Prix, a *manzai* (traditional Japanese double act comedy) competition, and has a widespread, positive reputation.

Control intervention

The control intervention made participants view a less funny, approximately four-minute-long comic dialog video clip (control video) provided by Yoshimoto Kogyo. The control video was chosen from among the less funny videos selected by Yoshimoto Kogyo and achieved the lowest laughter score in the preliminary trial. The comedian appearing in the video was not very famous.

After viewing both video clips, participants rated them on a questionnaire comprising seven items: funniness, frequency of laughter, understanding, sympathy, exciting language, enjoyable movement, and tempo. These items were defined by broadcasters from Yoshimoto Kogyo Holdings Company.

Procedure

A randomized, single-blind, crossover comparative design was applied for the experiment. The registered participants were alternately allocated to two sequences (1 and 2) by the order of their registration to exclude the order effect reflective of the experiment's experience. Participants assigned Sequence 1 viewed the comedic video as the experimental intervention in Phase 1 and the control video as the control intervention in Phase 2. The order was reversed for the participants assigned to Sequence 2. The interval between Phase 1 and Phase 2 was > 15 min. Figure 1 presents the examination flow on the day of the experiment.

The study sequence allocator and sequence allocation manager were not involved in assessing eligibility, data collection, or analysis. The manager stored the allocation information in a locked cabinet until the data analysis was complete. The research staff and outcome assessors left the room while participants watched the videos so that they would not know whether they had watched the comedic video or the control video. On the day of the experiment, the participants were instructed to avoid foods and beverages containing caffeine or alcohol, excessive exercise, and smoking. They were also instructed not to eat or drink anything except water during the two hours prior to the intervention. The data were collected in April, 2021, in Hamamatsu, Shizuoka Prefecture, Japan. This study was conducted by Kirin Holdings Company (Tokyo, Japan).

Primary outcomes

The primary outcome comprised the scores of the cognitive tasks performed by the participants. Participants took a five-minute rest after viewing the comedic or control video. They subsequently performed cognitive tasks

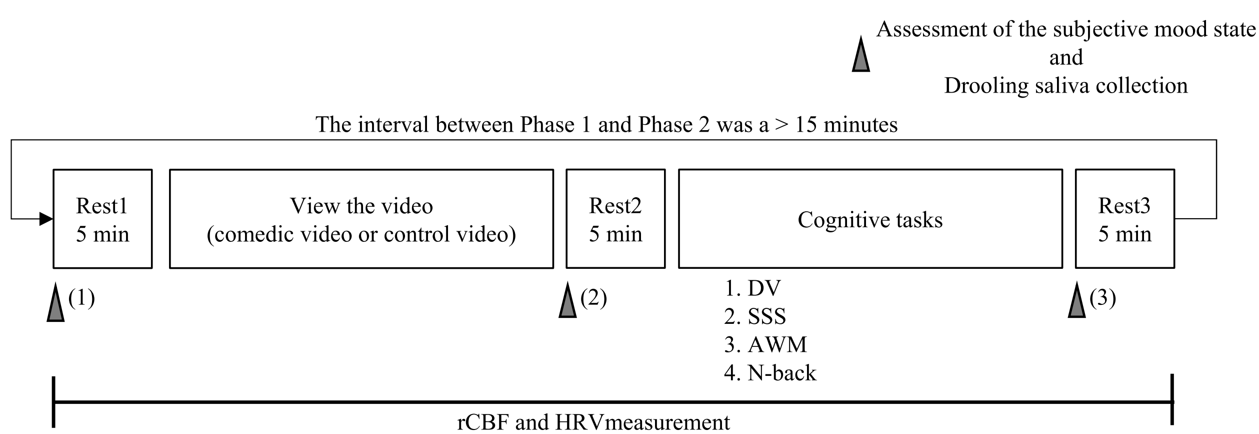

Fig. 1 Measurement Flow. Participants performed four cognitive tasks after viewing the video. Subjective mood assessment and saliva collection were performed in (1), (2), and (3). Levels of rCBF and HRV were measured throughout the study

comprising digit vigilance (DV), serial seven subtraction (SSS), alphabetic working memory (AWM), and n-back (Fig. 1). The participants were granted a 20-s rest period after each task. The DV, SSS, and AWM tasks were presented using the Computerized Mental Performance Assessment System (COMPASS, Northumbria University, Newcastle upon Tyne, UK), a purpose-designed software application for the flexible delivery of randomly-generated parallel versions of standard and novel cognitive assessment tasks. This assessment system has been previously utilized to measure the effectiveness of nutritional interventions [34, 35].

For the DV task, fixed numbers were displayed on the right side of the screen, and numbers that changed at the rate of 150 numbers per minute were presented one after another on the left side of the screen. Participants were required to respond when the number on the left matched the number on the right. The task lasted for 90 s and the participants were scored for accuracy (%), reaction times for correct responses (milliseconds), and false alarms (number).

A random number between 800 and 999 was presented on the screen for the SSS task, and participants were required to continually subtract seven from the presented number as quickly as possible. The starting number was cleared on the entry of the first answer, and asterisks indicated the next three digits. This task was scored for the number of responses (number), the number of correct responses (number), and the number of false alarms (number).

The AWM task displayed a series of five letters on the screen, one letter at a time, and the participants were asked to memorize them. Thirty new letters were then displayed on the screen one by one, and participants were required to press the computer keyboard keys corresponding to "yes" or "no" as quickly as possible to indicate whether these letters belonged to the original series. The task was scored for accuracy (%) and reaction times for correct responses (milliseconds).

The n-back task was presented on a touchpad using brain training apps (Kirin Holdings Company, Japan). This task required participants to memorize the colors and shapes of trains, which were displayed one after the other. Subsequently, the participants were asked to tap the train whose color and shape corresponded to the one displayed three trains ago. This task was scored for accuracy (%), the number of correct responses (number), and the number of false alarms (number).

Secondary outcomes

Cerebral blood flow

The rCBF was measured during the intervention using a 2CH NIRS system (HOT-2000, NeU Corporation, Tokyo, Japan) with a single wavelength of 810 nm, and the concentration change in total hemoglobin (Hb) was calculated as demonstrated in a previous report [36] (Fig. 1).

Two dual-source detectors were placed over the left and right DLPFC. This area corresponds to the Fp1-Fp2 region as defined by the 10–20 system used in electroencephalography [37, 38]. Total Hb was defined as the mean value of Hb in the left and right DLPFC. The pre-task baseline was defined as the mean value of total Hb in the 60 s before beginning the cognitive tasks. The mean values of the total Hb during the task period minus the baseline were then compared.

Heart rate variability

The electrocardiogram (ECG) was performed using a Silmee Bar type Lite (TDK, Tokyo, Japan) at a time resolution of 1000 Hertz (Hz) [39]. The participants were asked to apply the device to their anterior chest with a gel pad. ECG measurements were taken from before the start of the intervention until the end of the cognitive tasks (Fig. 1). The regular rhythm (RR) interval was calculated from the ECG data using the Silmee measurement and analysis system, and HRV analysis was then performed using Kubios HRV analysis software ver. 3.4.1 (Kubios Oy, Kuopio, Finland). A threshold-based artifact correction algorithm was employed to correct artifacts and ectopic beats in the RR interval data HRV parameters in the frequency domain, specifically low frequency (LF; 0.04–0.15 Hz), high frequency (HF; 0.15–0.4 Hz), the ratio between LF and HF band powers (LF/HF), and total power (TP; 0–0.4 Hz) were analyzed using fast Fourier transform. HF was used as the indicator of parasympathetic activity [40], LF/HF as the marker for sympathetic activity [41].

LF and HF were converted into normalized units [42] (i.e., [LF]nu and [HF]nu) and used to obtain the reactivity and recovery to video viewing and cognitive tasks through the calculation of delta values (Δ). Reactivity was calculated by comparing the difference between before and during video viewing, or the difference between after viewing the video and each cognitive task (i.e., while viewing—before viewing = reactivity1; DV—after viewing = reactivity2; SSS—after viewing = reactivity3; AWM—after viewing = reactivity4; n-back test—after viewing = reactivity4). Recovery was calculated by comparing the difference between during and after viewings (i.e., after viewing—during viewing = recovery1).

Subjective mood state

The visual analog scale (VAS) and Two-Dimensional Mood Scale (TDMS-ST) [43] were used to assess participants' moods. The VAS evaluated the fatigue, stress, motivation, depression, concentration, and drowsiness of the participants, who rated their current mood on the 100-mm (mm) VAS before and after the video intervention and again after performing the cognitive tasks (Fig. 1). The VAS scores were converted to z-scores for each participant to reduce the influence of subjective rating scales and ensure appropriate comparisons. The z-scores were calculated using the mean and standard deviation (SD) changes in the VAS scores of every participant. Consequently, the mean and SD were adjusted to a z-score of 0 and 1 for each participant.

The TDMS-ST comprises eight mood descriptors: energetic, lively, lethargic, relaxed, calm, irritable, and nervous. The participants reported their current mood by rating each item on a six-point Likert-like scale before and after the video intervention and after completing the cognitive tasks (Fig. 1). Vitality, stability, pleasure, and arousal scores were then calculated according to the established protocol.

Salivary biomarkers

Salivary cortisol, α-amylase, sIgA, and β-endorphin were measured as stress biomarkers, and salivary oxytocin was calculated as an indicator of psychological fulfillment. Participants were instructed to collect their saliva using a collection aid (SalivaBio, Carlsbad, CA, United States) before and after the video intervention and after accomplishing the cognitive tasks (Fig. 1). The collected samples were measured at the Yanaihara Institute (Shizuoka, Japan).

Statistical analysis

Data were expressed as mean ± standard error (SE). Comparisons between the experimental and control phases were accomplished using paired t-tests. The Sidak test was applied to compare temporal changes during the same phase. Statistical comparisons were performed using BellCurve for Excel (Social Survey Research Information, Tokyo, Japan) and Microsoft Excel 2016 (Microsoft, Redmond, WA, USA). Statistical significance was set at $p < 0.05$.

Missing values for each outcome were defined as meeting the following criteria:

(i) Score for cognitive tasks: Data from participants who self-reported that they gave up performing the task;
(ii) Measurements of rCBF: Data from subjects who self-reported that they gave up performing the task;
(iii) Measurement of HRV: Data evincing a data loss rate of more than 50% due to poor ground contact between the sensor and skin;
(iv) Assessment of participants' subjective mood states: Non-response data;
(v) Salivary biomarkers: Data below the detection limit.

Results

Baseline characteristics

Figure 2 presents the study flowchart. The researchers recruited 25 participants (male = 12; female = 13). The registered participants were alternately allocated as previously mentioned: Sequence 1 comprised 13 participants and Sequence 2 comprised 12 participants. Alternate assignments were made in each sequence for male and female participants to avoid gender bias. All participants completed the study; therefore, the total analyzed data included all 25 participants, whose characteristics are displayed in Table 1. There were no significant differences in the baseline characteristics between the sequences. No serious adverse effects were observed.

Evaluation of the video clips

Table 2 shows the participant ratings reported for each video after it was viewed. The comedic video was rated significantly higher than the control video on all assessment items (funniness, frequency of laughter, understanding, sympathy, exciting language, enjoyable movement, and tempo) ($p < 0.001$, all assessment items). This confirmed that the comedic video was appropriately funny in comparison to the control video.

Primary outcomes

Cognitive tasks scores

Table 3 records the scores for the cognitive tasks that were performed after viewing each video (comedic and control). Response speeds for the DV tasks were significantly faster for the comedic video than for the control video ($p = 0.039$). Similarly, the number of correct responses for the SSS tasks tended to be higher following the comedic video ($p = 0.079$). No significant differences were found in the other scores. However, participants frequently performed better after viewing the comedic video than after viewing the control video.

Secondary outcomes

Cerebral blood flow

The changes in total Hb concentration from the pre-task baseline to during the cognitive tasks were measured (Tables 4 and 5). There was no significant difference following the viewing. However, the total Hb concentration of participants increased significantly during the SSS, the AWM, and n-back tasks that were performed after viewing the comedic video ($p < 0.001$, $p = 0.0014$, $p < 0.001$, respectively). In contrast, no significant change was detected during the tasks performed after viewing the control video. Furthermore, the changes in total Hb concentration while undertaking

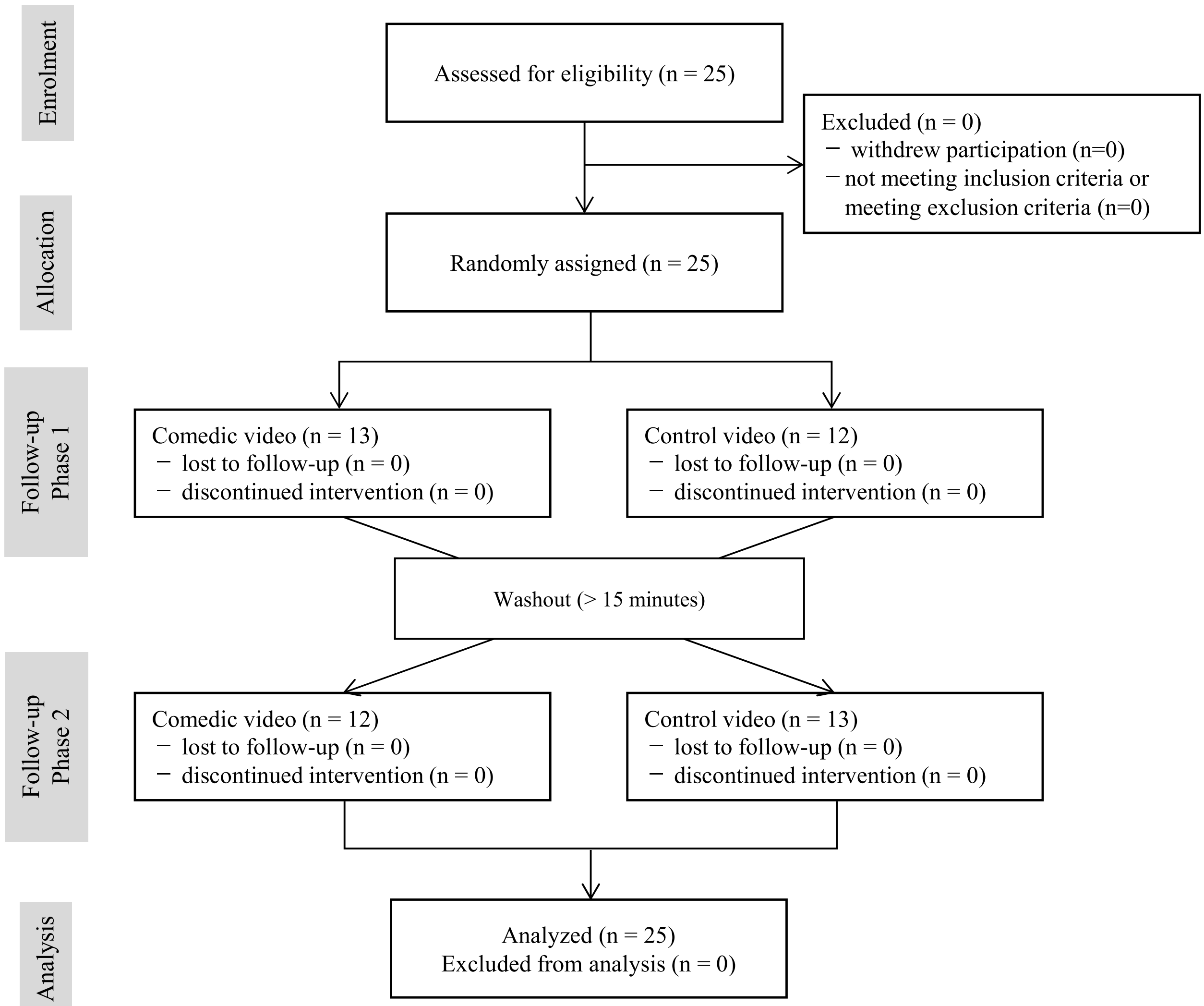

Fig. 2 CONSORT diagram. All 25 recruited participants met the entry requirements. Participants were assigned alternately to Sequence 1 ($n=13$) and Sequence 2 ($n=12$). All participants were included in the analysis

Table 1 Participant characteristics at baseline

Characteristics	Sequence 1 ($n=13$)	Sequence 2 ($n=12$)	*p*-value
Age	49.5 ± 6.7	52.8 ± 6.9	0.25
Male/Female	6/7	6/6	0.74

Data are presented as the mean standard deviations (SD). The *p*-value of age was calculated using unpaired t-tests. The sex ratio was analyzed using the χ2 tests

the cognitive tasks were significantly greater than the pre-task baselines after the participants viewed the comedic video compared to after viewing the control video ($p=0.022$; Fig. 3; Table 5).

HRV

Supplementary Table 1 and Fig. 4 show the time series changes in HRV values, and Supplementary Table 2 shows a comparison of the ΔHRV between the phase of the comedic video and the phase of the control video. ΔLH/HF was significantly higher when viewing the comedic video than when viewing the control video (reactivity1) ($p=0.0025$), and there was also a significant change in the recovery value (recovery1) afterward ($p=0.0026$). On the other hand, there was no significant difference in ΔLF/HF due to cognitive function tasks (reactivity2-5). The change in HF exhibited an inverse trend to the changes noted in LF/HF (Supplementary Tables 1 and 2).

Table 2 Participants' video evaluations

Evaluation item	Comedic video	Control video	*n*	*p*-value	Cohen's D
Funniness	5.9 ± 0.3	2.2 ± 0.2	25	**$p < 0.001$**	2.9
Frequency of laughter	4.0 ± 0.2	1.6 ± 0.1	25	**$p < 0.001$**	2.9
Understanding	6.5 ± 0.2	3.4 ± 0.4	25	**$p < 0.001$**	2.06
Sympathy	5.8 ± 0.3	2.6 ± 0.3	25	**$p < 0.001$**	2.09
Exciting language	6.2 ± 0.2	2.7 ± 0.4	25	**$p < 0.001$**	2.4
Enjoyable movement	5.3 ± 0.3	2.4 ± 0.2	25	**$p < 0.001$**	2.3
Tempo	6.5 ± 0.1	3.6 ± 0.4	25	**$p < 0.001$**	2.2

Data are presented as the mean standard error (SE). The *p*-value was calculated using paired t-tests

Table 3 Cognitive task scores

Cognitive task	Item	Comedic video	Control video	*n*	*p*-value	Cohen's D
DV	Accuracy (%)	97.39 ± 0.69	97.54 ± 0.67	23	0.87	0.045
	Reaction times for correct responses (ms)	462.78 ± 6.81	473.00 ± 6.64	23	**0.039**	0.32
	False alarms (number)	0.74 ± 0.20	0.83 ± 0.21	23	0.70	0.091
SSS	The number of responses (number)	21.24 ± 1.63	20.33 ± 1.42	21	0.26	0.13
	The number of correct responses (number)	19.10 ± 1.51	17.57 ± 1.42	21	0.079	0.23
	False alarms (number)	2.14 ± 0.42	2.76 ± 0.44	21	0.30	0.32
AWM	Accuracy (%)	94.49 ± 1.25	94.30 ± 1.25	23	0.88	0.033
	Reaction times for correct responses (ms)	984.96 ± 30.88	983.18 ± 32.40	23	0.94	0.012
N-back	Accuracy (%)	87.87 ± 2.6	87.19 ± 2.48	21	0.79	0.06
	The number of correct responses (number)	12.30 ± 0.36	12.21 ± 0.35	21	0.79	0.06
	False alarms (number)	1.70 ± 0.36	1.79 ± 0.35	21	0.79	0.06

Data are presented as the mean standard error (SE). The *p*-value of the participants' ages was calculated using paired t-tests

Table 4 Changes from the pre-task baseline in total Hb concentration

Step	Cognitive task	Hb concentration	*n*	*p*-value
After viewing comedic video	DV	0.08 ± 0.04	23	0.73
	SSS	0.28 ± 0.06	23	**$p < 0.001$**
	AWM	0.18 ± 0.05	23	**0.0014**
	N-back	0.23 ± 0.07	23	**$p < 0.001$**
	All tasks	0.18 ± 0.05	23	**$p < 0.001$**
After viewing control video	DV	0.03 ± 0.06	23	1.00
	SSS	0.11 ± 0.06	23	0.064
	AWM	0.06 ± 0.05	23	0.87
	N-back	0.08 ± 0.05	23	0.39
	All tasks	0.07 ± 0.05	23	0.74

Data are presented as the mean standard error (SE). The *p*-value was calculated using a Sidak test

Subjective mood

The VAS z-scores for fatigue, stress, motivation, depression, and concentration were significantly higher ($p = 0.0012$, $p < 0.001$, $p < 0.001$, $p = 0.0031$, $p = 0.0032$, respectively; Table 6) after viewing the comedic video compared to the control video. Furthermore, the scores allotted by participants for stress, motivation, and depression after completing the cognitive tasks were significantly higher after viewing the comedic video compared to the control video ($p = 0.0027$, $p = 0.0021$, $p = 0.0083$ respectively; Table 6). However, no significant differences were observed in drowsiness scores. The actual scores of vitality, stability, and pleasure were significantly higher in the TDMS-ST after the participants had viewed the comedic video compared to the control video ($p = 0.0017$, $p = 0.013$; Supplementary

Table 5 Comparison of changes from the pre-task baseline in total Hb concentration

Cognitive task	After viewing comedic video	After viewing control video	*n*	*p*-value	Cohen's D
DV	0.08 ± 0.04	0.03 ± 0.06	23	0.25	0.18
SSS	0.28 ± 0.06	0.11 ± 0.06	23	**0.014**	0.6
AWM	0.18 ± 0.05	0.06 ± 0.05	23	**0.031**	0.56
N-back	0.23 ± 0.07	0.08 ± 0.05	23	**0.023**	0.53
All tasks	0.23 ± 0.07	0.07 ± 0.05	23	**0.022**	0.55

Data are presented as the mean standard error (SE). The *p*-value was calculated using paired t-tests

Table 3). No significant differences were observed in arousal scores.

Salivary biomarkers

Supplementary Table 4 displays the salivary cortisol, α-amylase, sIgA, β-endorphin, and oxytocin measurements before and after the participants had viewed each video and after performing the cognitive tasks, respectively. No significant differences were observed between the experimental and control interventions. The changes in α-Amylase between before viewings to after performing cognitive tasks tended to be higher after viewing the control video compared to after viewing the comedic video ($p = 0.060$). No differences were noted in the levels of cortisol, sIgA, β-endorphin, and oxytocin.

Discussion

This single-blind, crossover, and comparative study recruited 25 healthy adults aged between 40 and 65 to investigate how a short comedic video affected their cognitive functions and mood states. The study utilized the DV task to assess focused attention [44, 45] and employed the SSS, AWM, and n-back tasks to assess working memory [46–48]. The results revealed that DV scores improved significantly and that SSS scores also tended to increase after viewing the comedic video. Therefore, it is possible that viewing short comedic videos could enhance attention focus. A previous study [22] found that viewing comedic videos improved short-term memory in healthy older people, but the current study is the first to examine focused attention. In addition, the present study demonstrated the effects of video-based interventions on middle-aged adults (40–65 years), whereas previous investigations [22] have targeted people over 65. Notably, while previous studies [22, 49] have used 20-min comedic videos, the current study confirmed the constructive effects of viewing even short clips of only four minutes.

The experiment also measured the real-time biometric impact of the intervention using a NIRS [39, 50]. The rCBF in the DLPFC region was significantly higher during the cognitive tasks performed after viewing the comedic video compared to the control video. The DLPFC region of the prefrontal cortex plays an essential role in the executive functions of cognitive process management [25]. Extant research has shown that damage to the DLPFC impairs focused attention [51]. DLPFC dysfunction has also been associated with increased mental

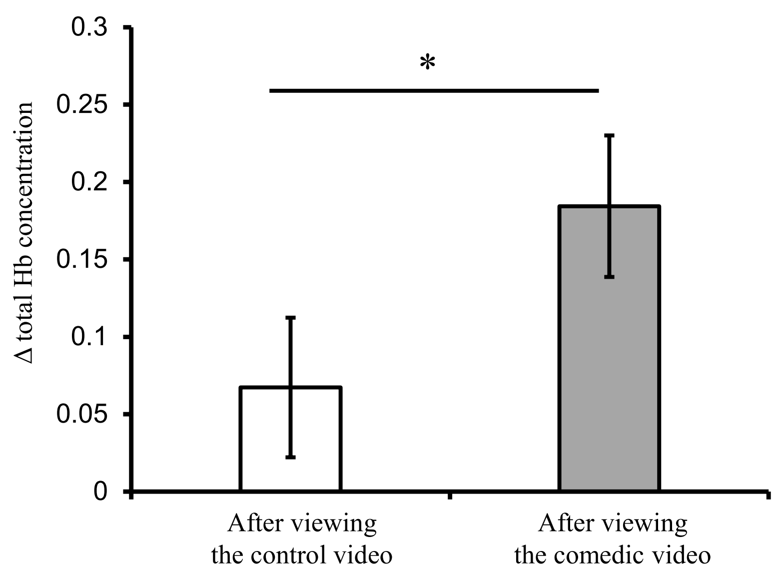

Fig. 3 Measurement of rCBF. The total Hb concentration was measured using 2CH NIRS. The mean values of the total Hb concentration during all task periods minus the baseline are shown. Data are represented as the mean ± standard error (SE) for after viewing each video. Group differences were identified by paired t-tests; *$p < 0.05$

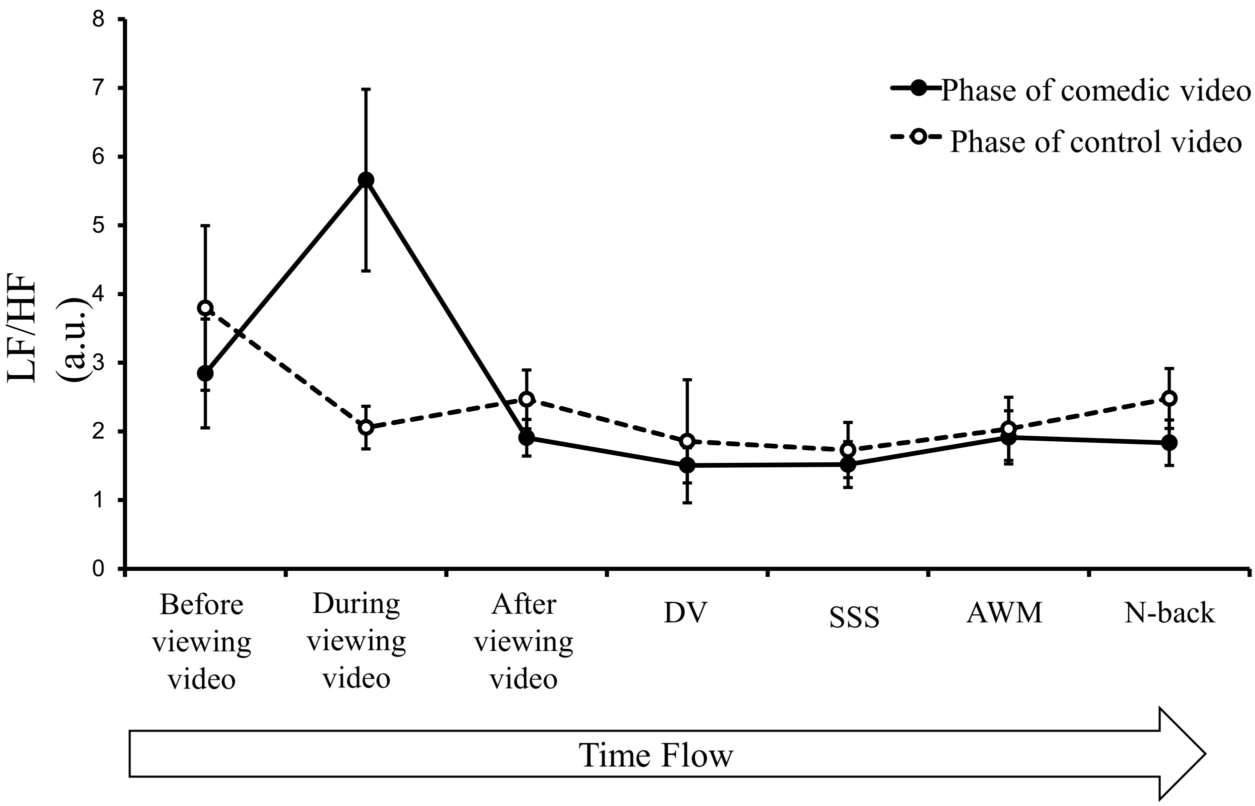

Fig. 4 Measurements of LF/HF. LF/HF was calculated by ECG using Silmee Bar type Lite. The time flow of LF/HF in the phases of the comedic video and control video is shown through a solid line and dashed line, respectively. Data are represented as the mean ± standard error (SE)

Table 6 VAS scores

Mood states	Step	Comedic video	Control video	*n*	*p*-value	Cohen's D
Fatigue	Before video intervention	−0.04 ± 0.17	−0.02 ± 0.10	24	0.78	0.1
	After video intervention	0.79 ± 0.12	−0.05 ± 0.17	24	**0.0012**	1.2
	After performing cognitive tasks	−0.49 ± 0.19	−0.87 ± 0.16	24	0.15	0.46
Stress	Before video intervention	−0.03 ± 0.15	−0.08 ± 0.12	24	0.093	0.032
	After video intervention	0.86 ± 0.11	0.03 ± 0.15	24	***p* < 0.001**	1.3
	After performing cognitive tasks	−0.42 ± 0.15	−1.13 ± 0.14	24	**0.0027**	1.02
Motivation	Before video intervention	0.02 ± 0.16	−0.15 ± 0.17	24	0.75	0.11
	After video intervention	0.64 ± 0.12	−0.25 ± 0.16	24	***p* < 0.001**	1.3
	After performing cognitive tasks	0.12 ± 0.17	−0.95 ± 0.16	24	**0.0021**	0.96
Depression	Before video intervention	0.04 ± 0.16	0.03 ± 0.17	24	0.093	0.03
	After video intervention	0.65 ± 0.14	−0.01 ± 0.15	24	**0.0031**	0.97
	After performing cognitive tasks	−0.32 ± 0.13	−0.95 ± 0.16	24	**0.0083**	0.82
Concentration	Before video intervention	0.26 ± 0.13	−0.13 ± 0.19	24	0.18	0.48
	After video intervention	0.38 ± 0.15	−0.38 ± 0.16	24	**0.0032**	1.01
	After performing cognitive tasks	0.13 ± 0.17	−0.43 ± 0.25	24	0.058	0.6
Drowsiness	Before video intervention	0.12 ± 0.15	0.00 ± 0.22	24	0.75	0.1
	After video intervention	0.17 ± 0.17	−0.20 ± 0.14	24	0.14	0.45
	After performing cognitive tasks	0.06 ± 0.19	−0.42 ± 0.20	24	0.069	0.57

Data were presented as means standard error (SE); *p*-value of the age was calculated using paired t-tests health problems [52], and reduced rCBF in the region. The outcomes suggested that the viewing of short comedic videos promotes DLPFC activity during cognitive tasks, is associated with improvements to DLPFC-related cognitive functions, and may even exert constructive effects for mental health problems.

The VAS and TDMS-ST scores were used to assess subjective mood states and were significantly higher for all categories (except sleepiness and arousal) after the participants had viewed the comedic video compared to the control video. As previous studies have described [12, 13], laughter has been found to create temporary improvements to mood. LF/HF is an indicator of sympathetic activity, and HF is an indicator of parasympathetic activity [34, 42, 53]. LF/HF rose transiently while watching the comedic video, then quickly declined (Reactivity1 and Recovery1). HF showed a significant increase after watching the comedic video (Recovery1). Laughter may have stimulated the transient activation of sympathetic activity, which may in turn have increased subsequent parasympathetic activity under the influence of homeostasis. Parasympathetic activity has been reported to be associated with reduced stress [53], suggesting that psychological stress can be reduced immediately by viewing a comedic video. At the same time, the changes registered after the cognitive tasks in the VAS scores for stress, depressed mood, and motivation were significantly higher after the participants had viewed the comedic video compared to after they had viewed the control video. These results suggest that the comedic video intervention could have subsequently contributed to the activation of the parasympathetic nerve and reduced the stress levels induced by the cognitive task.

Furthermore, changes in α-amylase activity between pre-viewing to following the cognitive tasks tended to be higher after the participants viewed the control video compared to the comedic video. The α-amylase activity is a known indicator of physical and mental stress [54] and is known to respond relatively quickly. The results suggest that the comedic video may have prevented an increase in stress levels during the tests. Unlike previous studies [6, 14, 18], the current investigation observed no changes to cortisol concentrations. This could be attributed to the relative brevity of the comedic video, which was only around four minutes and may not have allowed enough time for these indicators to change. These results support the hypothesis that the viewing of short comedic videos by middle-aged adults could promote their DLPFC activity and thus enhance their cognitive functions while also reducing their stress levels.

The study included several limitations. First, the sample size was small. The sample had adequate power as confirmed by the results of previous studies. However, a larger sample size would have allowed for the wider assessment of the middle-aged population. It should also be noted that the study only included Japanese participants. More detailed and diverse verification is needed to generalize the results. Second, the study did not determine whether the observed reactions are specific to comedic videos. To prove this, it is necessary to conduct experiments using videos that involve different emotions (e.g., fear). Finally, the effects of repeated interventions using comedic videos were not measured, nor were the long-term post-intervention effects of the comedic video, meaning that it is unknown how long the effects of such videos last. Future initiatives should explore the effectiveness of repeated interventions and the persistence of the effects. This would strengthen the case for laughter to be routinely and continuously utilized as a tool for improving cognitive functions and alleviating stress levels in daily adult life.

Conclusions

This study analyzed the immediate impact of a short comedic video intervention on the cognitive functions, mood states, and associated biometric information of middle-aged adults. The outcomes indicated that, for healthy middle-aged Japanese people, the short comedic video clip increased their rCBF during the subsequent cognitive tasks and may thus have improved their focused attention. The results also suggested that interventions involving short comedic videos could be associated with a reduction in stress, especially when carrying out cognitive tasks. This demonstrates that enjoyable interventions can serve as a practical approach to resolving stress-induced inattentiveness in everyday life and contribute to improving the cognitive functions and mental health of middle-aged adults.

Abbreviations

AWM	Alphabetic working memory
COMPASS	Computerized Mental Performance Assessment System
DV	Digit vigilance
DLPFC	Dorsolateral prefrontal cortex
ECG	Electrocardiogram
Hb	Hemoglobin
HF	High frequency
HRV	Heart rate variability
LF	Low frequency
rCBF	Regional cerebral blood flow
NIRS	Near-infrared spectroscopy
RR	Regular rhythm
SD	Standard deviation
SE	Standard error
sIgA	Secretory immunoglobulin A
SSS	Serial seven subtraction
TDMS-ST	Two-Dimensional Mood Scale
UMIN	University Hospital Medical Information Network
VAS	Visual Analogue Scale
Δ	Delta values

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12906-025-04863-5.

Supplementary Material 1. Table 1. (a) Time-series changes in HRV (b) Multiple comparison test for HRV in each interval (a) Data are presented as the mean standard error (SE). (b) Data are presented *p*-value, using a Sidak test.

Supplementary Material 2. Table 2. Comparisons of delta (Δ) HRV values between the phase of comedic video and control video. Data are presented as the mean standard error (SE). The *p*-value was calculated using paired t-tests.

Supplementary Material 3. Table 3. TDMS-ST scores. Data are presented as the mean standard error (SE). The *p*-value was calculated using paired t-tests.

Supplementary Material 4. Table 4. (a) Comparison of the salivary biomarkers (b) Comparison of the changes of salivary biomarkers from before the video intervention to after performing the cognitive tasks (a) Data are presented as the mean standard error (SE). The p-value was calculated using paired t-tests. (b) Data are presented as the mean standard error (SE). The *p*-value was calculated using paired t-tests.

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Authors' contributions
TY, YA, and AyK designed the study, posited the conceptual ideas, and wrote the draft outline. TY, YA, and TF collected the data. AtK and RS contributed to the interpretation of the results. YT wrote the manuscript with support from YA. All authors have read and approved the final manuscript.

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Data availability
The datasets used in this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
This study was conducted following the Declaration of Helsinki and Ethical Guidelines for Medical and Health Research Involving Human Subjects and was approved by the ethics committee of Kirin Holdings Company (No. 2020–014). The study was registered in the UMIN database before subject enrollment (Registration No. UMIN000043332; http://www.umin.ac.jp/ctr/; Registration title: Effects of viewing videos on brain function: A single-blind, crossover comparative study) on February 15, 2021. All participants provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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