ORIGINAL ARTICLE

Effect of vestibular stimulation on auditory and visual reaction time in relation to stress

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ABSTRACT

The present study was undertaken to provide scientific evidence and for beneficial effects of vestibular stimulation for the management of stress-induced changes in auditory and visual reaction time (RT). A total of 240 healthy college students of the age group of 18–24 of either gender were a part of this research after obtaining written consent from them. RT for right and left response was measured for two auditory stimuli (low and high pitch) and visual stimuli (red and green) were recorded. A significant decrease in the visual RT for green light and red light was observed and stress-induced changes was effectively prevented followed by vestibular stimulation. Auditory RT for high pitch right and left response was significantly decreased and stress-induced changes was effectively prevented followed by vestibular stimulation. Vestibular stimulation is effective in boosting auditory and visual RT and preventing stress-induced changes in RT in males and females. We recommend incorporation of vestibular stimulation by swinging in our lifestyle for improving cognitive functions.

Key words: College students, response times, stress, swing, vestibular stimulation

INTRODUCTION

Reaction time (RT) is a simple and noninvasive test to assess central and peripheral neural structures.[1] RT is defined as the time interval between applications of a stimulus and elicitation of a response.[2,3] Earlier studies reported that excessive stress has a negative impact on cognitive functions and this negative impact was more profound in females than males.[4-6] Improvement in attention, motor speech parameters, RT was observed followed by vestibular stimulation in head injured patients.[7] Vestibular stimulation modulates the neuronal activity in the medullary cardiovascular areas through cerebellum, basal ganglia, and limbic system.[8] Interestingly, vestibular stimulation was found to boost the neurodegenerative brains.[8] Otolith and visual-vestibular stimulation was reported to interfere prominently on cognitive processing especially the spatial tasks.[9] Rotatory vestibular stimulation was reported to enhance the balance and eye-hand coordination.[10] The present study was undertaken to provide scientific evidence and for beneficial effects of vestibular stimulation for the management of stress-induced changes in auditory and visual RT.

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MATERIALS AND METHODS

Study design

This was a longitudinal follow-up study in which, participants were assessed 3 times. The first assessment was performed during regular classes (with no examination in preceding 2 weeks and coming 2 weeks), these are baseline values. The second assessment was performed after intervention and during regular classes, and third

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assessment was performed in stressed state (1 week before University theory examinations).

Setting

The present study was conducted at Little Flower Institute of Medical Sciences and Research, Angamaly, affiliated to Kerala University of Health Sciences, Kerala and Little Flower Medical Research Centre, Angamaly, approved by Mahatma Gandhi University, Kerala.

Study population

A total of 240 healthy college students of the age group of 18–24 of either gender were a part of this research after obtaining written consent from them. Participants involved in drug/alcohol abuse, and those taking any kind of medication or suffering from any somatic or mental disorders, participants with a history of use of corticosteroids in the past year, students with a history of antidepressant medication, and students on hormone supplements including oral contraceptives and ear infections or any vestibular disturbances, visual disorders, those with cardio-respiratory disorders were excluded from this study. Selected participants were randomly assigned to four groups by simple random sampling. This study was powered at 0.85% to identify 15%–20% of improvement followed by vestibular stimulation.

- Group MC ($n = 60$): Control male group (no vestibular stimulation was administered)
- Group FC ($n = 60$): Control female group (no vestibular stimulation was administered)
- Group MV ($n = 60$): Intervention male group (vestibular stimulation was administered for 268 ± 5 days)
- Group FV ($n = 60$): Intervention female group (vestibular stimulation was administered for 268 ± 6 days).

After recording baseline values, vestibular stimulation was administered to the intervention groups and post-intervention values were collected during regular classes (duration of intervention was 146 ± 5.6 days in males and 147 ± 6 days in females) and during preexamination period (duration of intervention was 268 ± 5 days in males and 268 ± 6 days in females) followed by vestibular stimulation. Vestibular stimulation was not administered to the control group. However, values were recorded at the corresponding points in time.

Vestibular stimulation

Vestibular stimulation was administered by making the participants swing on a swing, according to their comfort (back to front direction) once in a day, for 5 days in a week at their leisure time (8:30–9:30 am, 11:00–12:00 am, 1:00–2:00 pm, and 4:00–5:00 pm in four groups) as described earlier.[11]

Assessment of Auditory and visual reaction time

RT apparatus for research, manufactured by Anand Agencies, Pune, was used to record auditory and visual RT. Anand Agencies (http://www.anandagenciespune.in). The apparatus has E side (examiner side), S side (subject side) and chronoscope. E side consists of switches for stimuli selection, selector switches to select desired response, fore period knob, start and reset switches and main switch. Four stimuli selection switches, which when pressed will latch and select the indicated stimulus, which will be automatically presented during the trial. Light emitting diode indicator was provided in front of each switch, which will glow and indicates the stimulus selected for the trial. Any and only one stimuli can be selected at a time. The apparatus provides two auditory (high and low pitch sounds) and two visual (red and green light). The arrangement was made to adjust the fore period at any desired value between 0.5 s and 5.5 s. The reset switch will reset the chronoscope and release the selected stimulus and makes the apparatus ready for the next trail. S side has red and green light mounted side by side which serve as stimuli. Speaker giving the auditory stimuli was mounted inside the apparatus. The chronoscope was built in to count the RT in milliseconds. S side was also equipped with two micro switches on either side which serves as subject's right and left response keys. The response was given by the subject by pressing a key with his index finger of corresponding hand. Time taken by the subject to give a response is displayed with an accuracy of 1 ms and is recorded as his auditory or visual RT.[12] Auditory and visual RT was recorded in a well-ventilated and noise free room in the Department of Physiology. The procedure was explained to all the participants, and they were made familiar with the apparatus. The location and direction of the RT apparatus and position of participant were maintained constant throughout the study period. The participant was allowed to relax before commencing with recording of RT. RT for right and left response was measured for two auditory stimuli (low and high pitch) and visual stimuli (red and green) and the sequence of application of stimuli was kept constant. The Procedure was explained to all the subjects individually. While recording the RT for each stimulus, after pressing the start switch, a "ready" or warning signal was given for a fixed period. The stimuli were then automatically presented after the preset fore period. The test subject was asked to press the button as soon as he received the stimulus. Emphasis was given on how quickly the response was obtained and the subject was instructed accordingly. Three readings of the RT were taken for each stimulus by randomly varying the fore period. The lowest value of three readings was considered as RT for that stimulus.

Ethics

The study was approved by Institutional Ethics Committee (January 10, 2014) of Little Flower Hospital and Research Center. A written, informed consent was obtained from all the participants. The study was performed in accordance with the "Ethical Guidelines for

Biomedical Research on Human Participants, 2006" by the Indian Council of Medical Research and the Declaration of Helsinki, 2008.

Data analysis

Data were analyzed by IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY. Mean and standard deviations of all the observations were calculated. Comparison between the groups was performed by two way ANOVA and post hoc by Bonferroni posttest. Statistical significance was accepted at $P < 0.05$.

RESULTS

Baseline values of both right and left responses of visual RT for green light were significantly higher in females than males. Stress-induced increase in visual and auditory RT (ART) (both right and left responses) was significantly higher in females [Figures 1 and 2]. Significant decrease in the visual RT for green light and red light was observed and stress-induced changes was effectively prevented followed by vestibular stimulation [Figure 1]. ART for high pitch right and left response was significantly decreased and stress-induced changes was effectively prevented followed by vestibular stimulation [Figure 2].

DISCUSSION

Stress affects cognitive function via epinephrine cortisol.[4] According to the distraction model, anxiety decreases accuracy of the movements execution so that the subject requires more attempts or more time to complete a task successfully.[13,14] Stress increases the load on the cognitive system and reduces a person's attention.[15] In contrast, according to the execution focus model, negative effects of anxiety on performance cannot be explained with limited attention resources.[16] Malathi and Parulkar reported that ART was decreased before examinations.[17] In the present study, we have observed a significant increase in the auditory and visual RTs in pre-examination period in both male and female control groups. However, this stress-induced change was effectively prevented in the intervention groups. This effect may be due to decrease in the cortisol and autonomic modulation by vestibular stimulation.[18-20] RT was related to cognitive function in healthy subjects and patients and serve as bedside measurements reflecting, cognitive function.[21] RT comprises of three parts that are perception time, decision time, and motor time.[22,23] Vestibular stimulation causes optimal arousal and decrease the RT.[10] Vestibular disorders causes a high level of alertness and vigilance, problems maintaining focus, problems paying selective attention, and alterations in precision and attention to stimuli.[24] Vestibular stimulation modulates somatosensory processing increases tactile sensitivity on the fingers of both hands.[25-29] Vestibular stimulation influences decision-making by modulating emotional circuits and pleasant and rewarding effect of acquisition.[30] Vestibulospinal reflexes maintain the coordination between anterior and posterior muscles and controls the timing and intensity of muscle contractions.[31] Vestibular stimulation modulates executive function through its connections with cortical and subcortical structures.[32] Vestibular exercises with head and body movements recommended for individuals

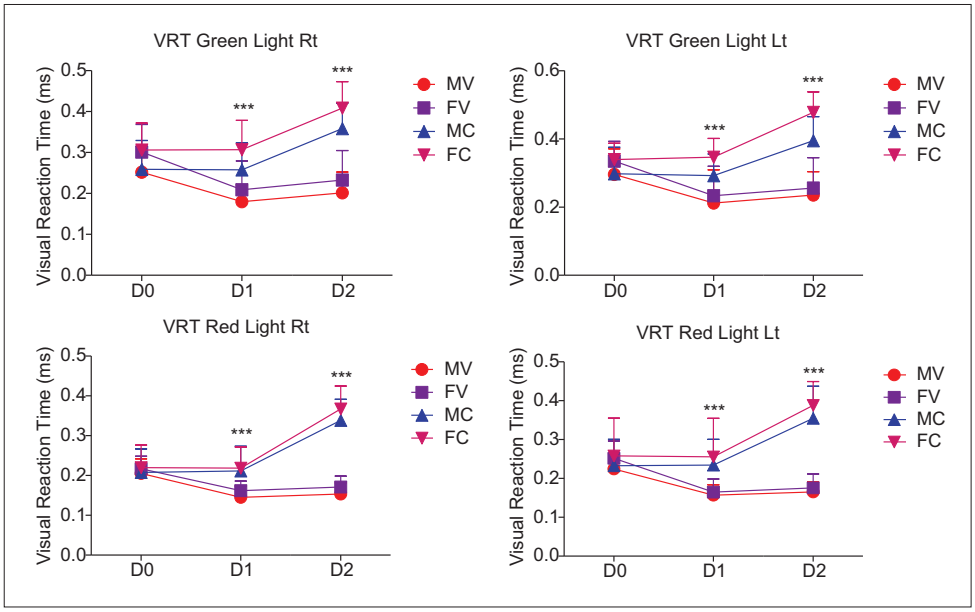

Figure 1: Visual reaction time (VRT) (ms) of the participants before and after vestibular stimulation. (Data expressed are mean ± standard deviation) (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$), MV: Vestibular males, FV: Vestibular females, MC: Control males, FC: Control females. D0: Preintervention score (during regular classes), D1: Postintervention score (during regular classes), D2: Postintervention scores (during preexamination period). Rt: Right response, Lt: Left response

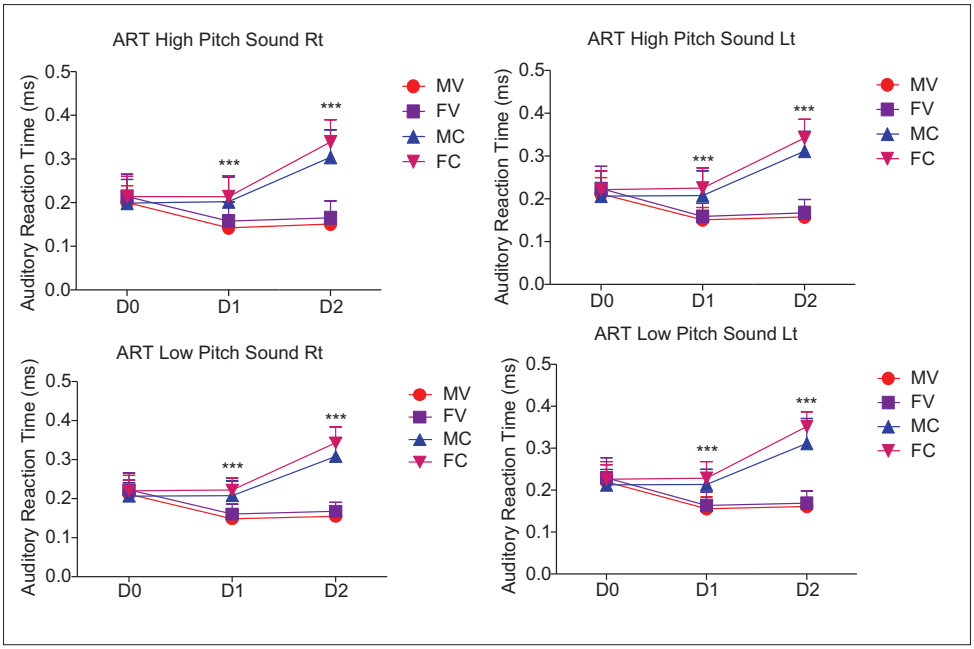

Figure 2: Auditory reaction time (ms) of the participants before and after vestibular stimulation. (Data expressed are mean ± standard deviation) (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$), MV: Vestibular males, FV: Vestibular females, MC: Control males, FC: Control females. D0: Preintervention score (during regular classes), D1: Postintervention score (during regular classes), D2: Postintervention scores (during preexamination period). Rt: Right response, Lt: Left response

with visual impairments for better balance retention.[33-36] Vestibular stimulation was reported to activate intraparietal sulcus, the parietal–temporal junction and central sulcus, the superior temporal gyrus and insula, ventral premotor areas, cingulate gyrus, and hippocampus.[37] Our results are in accordance with earlier research reports as we have observed significant decrease in the visual RT for red and green light (both right and left responses) and ART for high pitch and low pitch sound (both right and left responses) followed by vestibular stimulation in males and females. Vestibular stimulation effectively prevented stress-induced changes in visual and ART in males and females.

Limitations

We could not exclude the effect of movement activity and norepinephrine release on the evaluated indices, as we have no suitable control group for this purpose. Hence, the findings from this study should be interpreted considering these limitations.

CONCLUSION

Vestibular stimulation is effective in boosting auditory and visual RT and preventing stress-induced changes in RT in males and females. We recommend incorporation of vestibular stimulation by swinging in our lifestyle for improving cognitive functions.

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Conflicts of interest

There are no conflicts of interest.

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