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Original Article

Effects of Vestibular Stimulation on Stress Induced Changes in Quality of Life

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Abstract

Background: Irrespective of source of stress, high levels of emotional stress promotes cardiovascular, neurological and behavioral changes and negative life style practices, which has negative impact on quality of life.

Objective: The present study was planned with the aim to provide scientific evidence for beneficial effects of vestibular stimulation in limiting stress induced changes in quality of life.

Materials and methods: 240 healthy college students were included in the study after obtaining written informed consent. Vestibular stimulation was administered by making the participants to swing on a swing in back to front direction, according to their comfort as per standard methods. This was a longitudinal follow-up study in which, participants were assessed three times. The first assessment was performed during regular classes (with no examination in preceding two weeks and forth coming two weeks), these are pre-intervention values. The second assessment was performed eight months after the intervention (during regular classes), and third assessment was performed sixteen months after the intervention in stressed state (A week before the University examinations). Quality of life was assessed by using WHOQOL-BREF.

Results: Significant increase in physical health, psychological, social relationships and environment scores was observed in both males and females followed by vestibular stimulation.

Conclusion: vestibular stimulation significantly improved overall quality of life. Hence, the study supports adoption of vestibular stimulation as an adjunctive therapy to achieve multiple life style benefits including better quality of life in general.

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Introduction

Quality of life is defined by the World Health Organization (WHO) as an individual's perceptions of her/his position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns (1, 2). Quality of life (QOL) is a well-accepted outcome variable in bio-behavioral research (3). As stress has a significant role in determining the quality of life, it was suggested to assess the stress levels as routine psychiatric practice (4, 5, 6). Irrespective of source of stress, high levels of emotional stress promotes cardiovascular, neurological and behavioral changes and negative life style practices, which has negative impact on quality of life (7, 8, 9, 10). Loss of vestibular functions was reported to cause behavioral changes in both animals and humans. These behavioral changes may occur spontaneously or as a response to stress (11, 12, 13). Higher co-existence of anxiety/depression was reported in patients with vestibular disorders (14). Under stimulation of vestibular system does not produce any effect and over stimulation produces nausea, vomiting and dizziness.. Hence, the stimulation should be desirable (optimal) to produce soothening effects without causing side effects. As the stress is subjective, the intervention to relieve stress also varies from individual to individual. Hence, in the present study, the subjects were requested to swing according to their comfort. Earlier studies recommended optimal vestibular stimulation to relieve stress and decrease cortisol, blood sugar and sympathetic activity within normal limits (15, 16, 17, 18, 19). Vestibular stimulation was reported to improve quality of life in healthy and disease conditions irrespective of age and gender (20, 21). Significant decrease in the quality of life was observed followed by vestibular lesions (22). The present study was planned with the aim to provide scientific evidence for beneficial effects of vestibular stimulation in limiting stress induced changes in quality of life.

Materials and Methods

Study design

This was a longitudinal follow-up study in which, participants were assessed three times. The first assessment was performed during regular classes (with no examination in preceding two weeks and forth coming two weeks), these are pre-intervention values. The second assessment was performed eight months after the intervention (during regular classes), and third assessment was performed sixteen months after the intervention in stressed state (A week before the University examinations). Filling up of the questionnaires and collection of salivary samples was done simultaneously.

Setting

The present study was conducted at Little Flower Institute of Medical Sciences and Research and Little Flower Medical Research Centre, Angamaly.

Study population

A total of 300 (130 males and 170 females) young adults were screened. 240 (120 males and 120 females) participants satisfying both inclusion and exclusion criteria were included in the study. A detailed medical history was obtained from all participants and standard physical examination was conducted. Written informed consent was obtained from all the participants included in the study. Selected participants were randomly assigned to four groups by simple random sampling.

Group Con-M (n = 60): Control male group (no vestibular stimulation was given)

Group Con-F (n = 60): Control female group (no vestibular stimulation was given)

Group Exp-M (n = 60): Experimental male group (vestibular stimulation was given)

Group Exp-F (n = 60): Experimental female group (vestibular stimulation was given).

Inclusion and exclusion criteria:

Healthy young adults in the age group of 18-24 years who were willing to participate in the study were included in the study. Individuals suffering from any

somatic or mental disorders, those with ear infections or any vestibular disturbances, visual disorders, cardio-respiratory disorders were excluded from this study (48).

Power analysis or sample size estimation:

The sample size was estimated assuming the mean difference in the cortisol level to be 20% with 30% Standard deviation, for 3 groups (pre-test, 8 months and 16 months), 90% power and 0.05% significance. The estimated sample size was 58 and rounded off to 60 (control male-60; Experimental male-60; Control female-60; Experimental male-60). Sigma Plot 13.0 (Systat software USA) was used for calculating the sample size (49).

Vestibular stimulation

Vestibular stimulation was given by making the participants swing on a swing, according to their comfort (front and back direction) once a day, for 5 days in a week at their leisure timings (8:30-9:30 am, 11:00-12:00 am, 1:00-2:00 pm and 4:00-5:00 pm) in four groups (23). The total width of the seat was 16 inches, when divided into equal halves, each half is of eight inches. The exact distance covered by the swing in to and fro directions was marked and the calculations were done accordingly. For example, when the swing moves in the front direction, say about sixty inches, subtract eight inches from sixty inches to get the exact distance covered from swing movement from the point of fixation to the forward movement and vice versa. This was performed under the supervision of observers. The mean and SD values for the duration of vestibular stimulation were 4.86±0.99 minutes in males and 4.58±1.61 minutes in females. The mean and SD values of frequency in males is 20.60±2.45 cycles/min and in 21.0769±1.168 cycles/min in females. The mean and SD values obtained for the covered by the swing to and fro direction in males is 1.88±0.28 m and 1.73±0.27 m respectively and 2.05±0.28 m and 1.9±0.25 m in females respectively.

Assessment of quality of life

WHO-QOL BREF is a self-administered questionnaire which consists of 26 questions to assess four domains that is physical health, psychological status, social relationships and environment. Physical health domain is concerned with facets like daily life activities, fatigue, and energy. Psychological domain is concerned with the facets like cognitive functions, self esteem, positive and negative feelings. Social relationships domain is concerned with the facets like personal relationships, sexual activity and social support. Environmental domain is concerned with facets like home environment and freedom. Assessment of the four domains will enable us to understand individual's physical, mental and social status and effects of environmental factors. The participants were requested to assess their quality of life last two weeks on a five-point Likert scale. Raw scores of each domain were calculated by using the formulas provided along with the questionnaire. Raw scores were converted into transformed scores between 0-100 ranges by using the templates provided along with the questionnaire. Higher scores indicate higher quality of life (24, 25).

Ethics

The study was approved by Institutional Ethics Committee. 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 was analyzed by using Sigma Plot 13.0 (Systat software, USA). Median and percentile of all the observations were calculated. Friedman repeated measures analysis of variance on ranks was used to observe the significance of difference in the median values among the groups. Multiple comparisons were performed by using Student-Newmen-Keuls (SNK) method. Mann-Whitney rank sum test was used to observe the significance of difference between the two groups. $p<0.05$ was considered as significant.

Results

The effectiveness of vestibular stimulation in young adults on physical health (score) is presented in

Fig. 1: Flow diagram of study design.

Fig. 2. The median physical health score in the control male group was 63. After 8 months, there was no change in the physical health score whereas after 16 months, there was a slight decrease in the physical health score. The decrease in the physical health score was statistically significant ($p< 0.001$). The median physical health score in the experimental male group was 63. After 8 months there was a slight increase in the physical health score and after 16 months also there was an increase in the physical health score. The increase in the physical health score was statistically significant ($p< 0.001$). The median physical health score in the control female group was 63. After 8 months, there was no change in the physical health score whereas after 16 months, there was a slight decrease in the physical health score. The decrease in the physical health score was statistically significant ($p=0.007$). The median physical health score in the experimental female group was 69. After 8 months there was a slight increase in the physical health score which was statistically significant ($p=0.013$). After 16 months also there was no change in the physical health score. After 8 months, physical health score was significantly increased in the experimental male (T=2416; $p<0.001$) and female (T=2859; $p<0.001$) groups when compared to control male and female groups.

The effectiveness of vestibular stimulation in young adults on psychological (score) is presented in

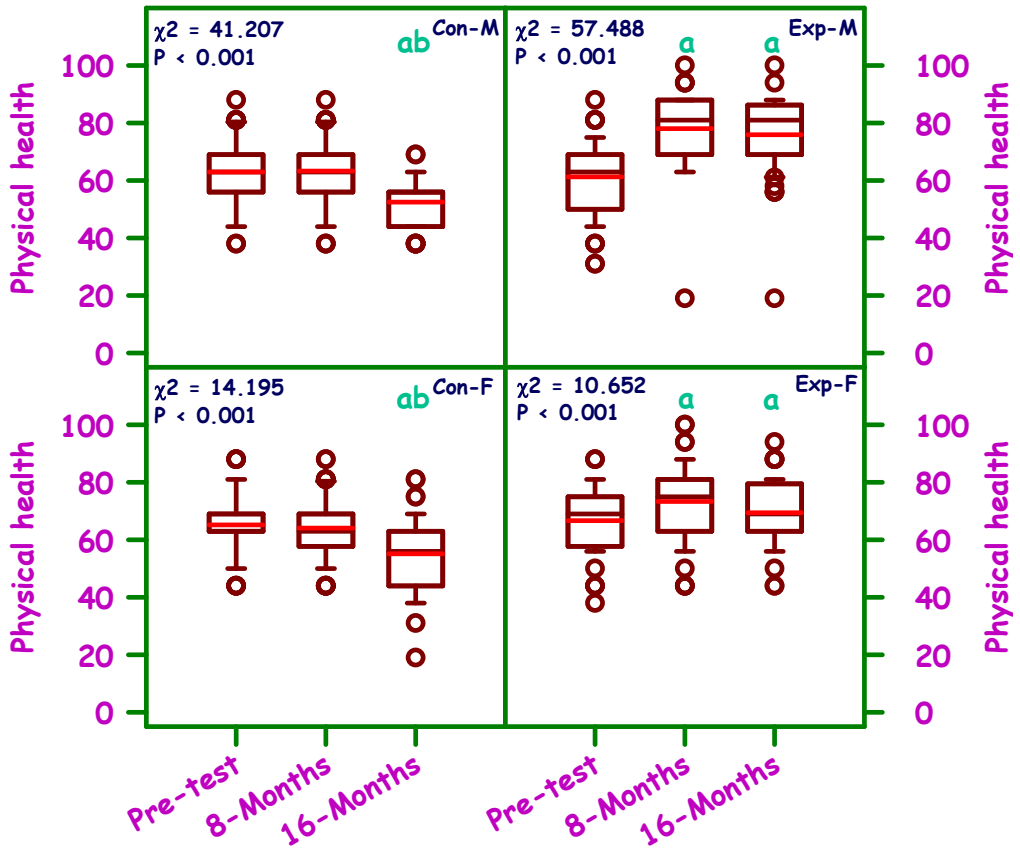

Fig. 2 : Effectiveness of vestibular stimulation in young adults on physical health (score).
Con = Control; Exp = Experimental; M = Male; F = Female
The middle brown line is the median and the red line is the mean.
n – Control = 60 each; Experimental = 60 each.
The 'χ^2' and 'P' values are by Friedman RM ANOVA on ranks with SNK multiple comparison test.
[a]Significantly different from the pre-test group.
[b]Significantly different from the 8 months group.

Fig. 3. The median psychological score in the control male group was 63. After 8 months, there was no change in the physical health score whereas after 16 months, there was a slight decrease in the psychological score. The decrease in the psychological score was statistically significant (p<0.001). The median psychological score in the experimental male group was 56. After 8 months, there was an increase in the psychological score whereas after 16 months, there was a slight increase in the psychological score. The increase in the psychological score was statistically significant (p<0.001). The median psychological score in the control female group was 59.5. After 8 months, there was a slight decrease in the psychological score whereas after 16 months also there was a slight decrease in the psychological score. The decrease in the psychological was statistically significant (p=0.519 and p=0.029). The median psychological score in experimental female group was 63. After 8 months, there was a slight increase in the psychological score whereas after 16 months also there was a slight increase in the psychological score. The increase in the psychological score was not statistically significant. After 8 months, psychological score was significantly increased in the experimental male (T=2537; p<0.001) and female (T=3106; p=0.005) groups when compared to control male and female groups.

The effectiveness of vestibular stimulation in young adults on social relationship (score) is presented in Fig. 4. The median social relationship score in the control male group was 69. After 8 months, there

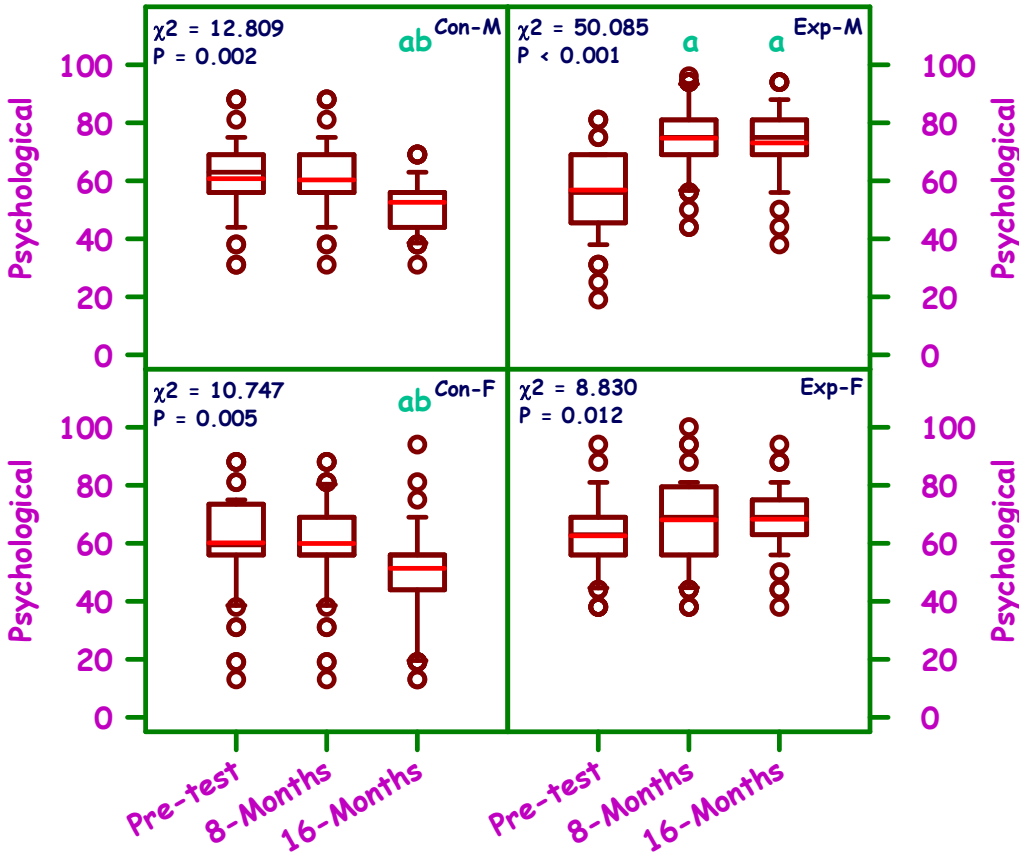

Fig. 3 : Effectiveness of vestibular stimulation in young adults on psychological (score).
Con = Control; Exp = Experimental; M = Male; F = Female
The middle brown line is the median and the red line is the mean.
n – Control = 60 each; Experimental = 60 each.
The 'χ^2' and 'P' values are by Friedman RM ANOVA on ranks with SNK multiple comparison test.
[a]Significantly different from the pre-test group.
[b]Significantly different from the 8 months group.

was no change in the social relationship score whereas after 16 months, there was a decrease in the social relationship score. The decrease in the social relationship score was statistically significant (p<0.001). The median social relationship score in the experimental male group was 69. After 8 months, there was a slight increase in the social relationship score whereas after 16 months also there was a slight increase in the social relationship score. The increase in the social relationship score was statistically significant (p<0.001). The median social relationship score in the control female group was 69.000. After 8 months, there was no change in the social relationship score whereas after 16 months, there was a decrease in the social relationship score. The decrease in the social relationship score was statistically significant (p=0.005). The median social relationship score in the experimental female group was 69. After 8 months, there was an increase in the social relationship score whereas after 16 months also there was a slight increase in the social relationship score. The increase in the social relationship score was statistically significant (p<0.001). After 8 months, social relationship score was significantly increased in the experimental male (T=2526; p<0.001) and female (T=2485; p=0.005) groups when compared to control male and female groups.

The effectiveness of vestibular stimulation in young adults on environmental (score) is presented in Figure 5. The median environmental score in the control male group was 69. After 8 months, there was no change in the environmental score. After 16 months,

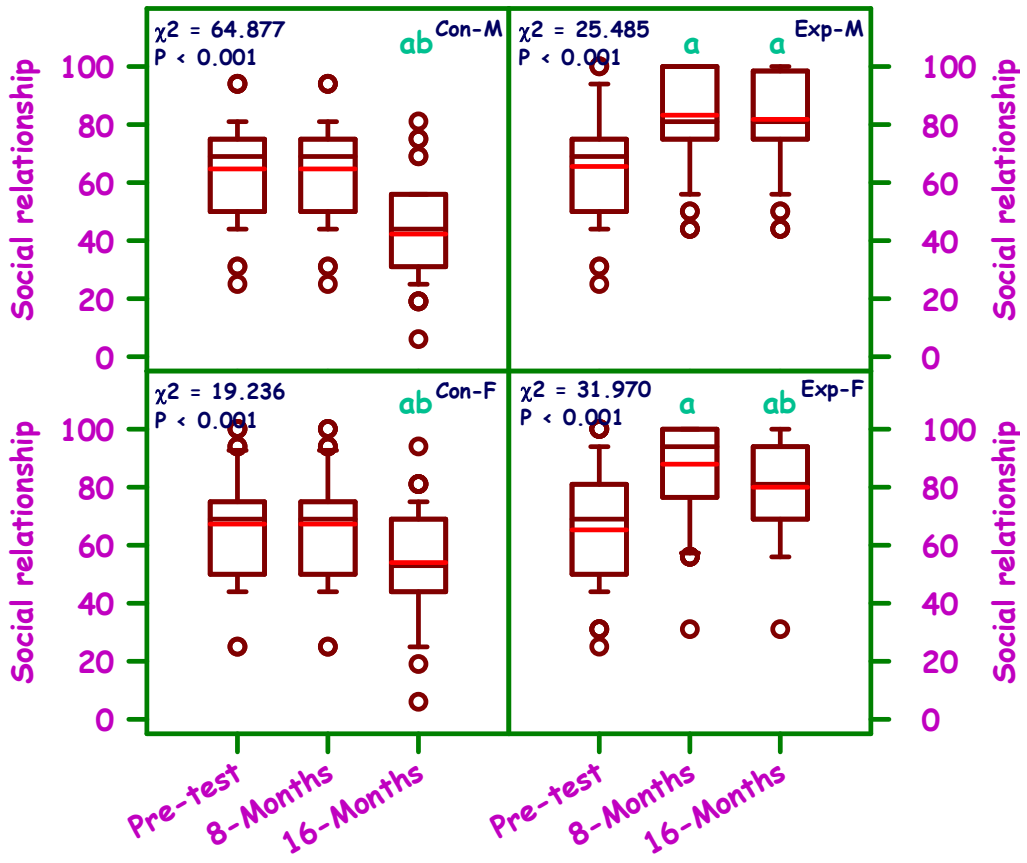

Fig. 4 : Effectiveness of vestibular stimulation in young adults on social relationship (score).
Con = Control; Exp = Experimental; M = Male; F = Female
The middle brown line is the median and the red line is the mean.
n – Control = 60 each; Experimental = 60 each.
The 'χ^2' and 'P' values are by Friedman RM ANOVA on ranks with SNK multiple comparison test.
[a]Significantly different from the pre-test group.
[b]Significantly different from the 8 months group.

there was a decrease in the environmental score. The decrease in the environmental score was statistically significant (p<0.001). The median environmental score in the experimental male group was 63. After 8 months, there was an increase in the environmental score whereas after 16 months also there was increase in the environmental score. The increase in the environmental score was statistically significant (p<0.001). The median environmental score in the control female group was 63. After 8 months, there was no change in the environmental score. After 16 months, there was a decrease in the environmental score. The decrease in the environmental score was statistically significant (p<0.001). The median environmental score in the experimental female group was 63. After 8 months, there was an increase in the environmental score whereas after 16 months, there was a slight increase in the environmental score. The increase in the environmental score was statistically significant (p< 0.001). After 8 months, environmental score was significantly increased in the experimental male (T=2464; p<0.001) and female (T=2858; p=0.005) groups when compared to control male and female groups.

Discussion

Stress in daily life increases negative feelings and decreases the quality of life. Hence, approaches to effectively manage stress are essential to improve quality of life. Excessive stress can impair physiology of vestibular system (26) and conversely stimulation

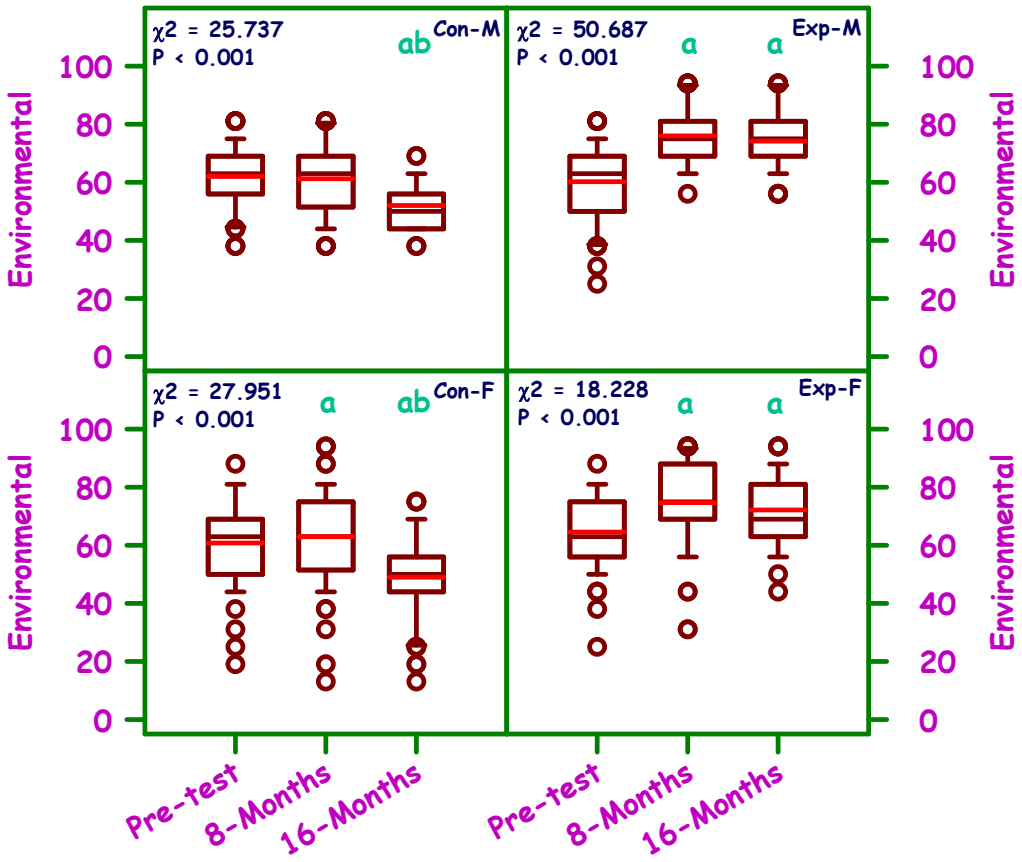

Fig. 5 : Effectiveness of vestibular stimulation in young adults on environmental (score).
Con = Control; Exp = Experimental; M = Male; F = Female
The middle brown line is the median and the red line is the mean.
n – Control = 60 each; Experimental = 60 each.
The 'χ^2' and 'P' values are by Friedman RM ANOVA on ranks with SNK multiple comparison test.
[a]Significantly different from the pre-test group.
[b]Significantly different from the 8 months group.

of vestibular system is likely to relive stress (16). Hence the present study tested the hypothesis that longitudinal vestibular stimulation may help in improving quality of life among female and male student cohort. Previous studies have reported varying potential of vestibular stimulation in inhibiting stress axis based on the intensity, frequency and duration of stimulation (27). However, the optimal intensity, duration and frequency are yet to be standardized. Hence, in the current study, participants were given opportunity to decide their own intensity, frequency and duration in an adjustable and comfortable mode accordingly. As vestibular stimulation by swinging on a swing is a simple intervention to reduce stress, compliance of participants was high, which is the likely reason for zero attrition rates in this study.

Quality of life is an important health indicator to measure the major health outcome and is a reliable tool to evaluate the effectiveness of an intervention (28). Hence this study evaluated the WHO-QOL parameters as a tool to test the impact of vestibular stimulation on improving general wellbeing in female and male young adults. Quality of life was reported to be lowered by several factors, such as depression, lack of social support, poor sleep quality, poor eating behavior and disempowerment (29). Young adults experience mild to severe stress in their day-to-day activities and few individuals will eventually burnout, which may have negative impact on academic performance, emotional and/or on physical and mental health (30). Academics, personal situations, environment, time and economic circumstances are reported as sources of stress in young adults (31).

Stress levels are indirectly proportional to the quality of life (32). In the present study, vestibular stimulation significantly improved physical health, psychological, social relationships and environment scores in both male and female intervention groups. These observations are consistent with established literature on this topic reporting the quality of life being significantly impaired in patients with bilateral loss of vestibular function, which can be effectively restored by stimulation of vestibular system using vestibular implants, spinning, swinging, rocking and other forms (33).

The facets of physical health include daily life activities, including dependence on medications, energy, fatigue and mobility, pain, sleep and work capacity. Spinning, sliding, bouncing up and down induced vestibular stimulation and improved balance in spastic diplegic cerebral palsy children was better when compared to conventional physiotherapy alone (34). Vestibular stimulation increases the efficiency of physical activity by increasing the muscle strength of upper and lower extremities (35). Increased physical activity was reported to increase the physical health by increasing the fitness (50). This observation is consistent with the results of current study, wherein significant improvement in physical health was observed in both female and male cohorts following vestibular stimulation. Similar to this study other forms of vestibular stimulation such as galvanic and rotatory chair vestibular stimulation is reported to cause metabolic shift towards fat burning and improvement in physical health (36). In comparison caloric vestibular stimulation is reported to reduce pain in chronic central post stroke patient as assessed by functional magnetic resonance imaging (37). It was reported that, vestibular stimulation facilitates the transmission from wakefulness to sleep through relaxation (38). Hence the present study results are in line with earlier studies as it showed a significant improvement in physical health domain scores following vestibular stimulation.

The facets of Psychological domain include bodily image and appearance, positive and negative feelings, self-esteem, spirituality, thinking, learning, memory and concentration. Consistent with this study, vestibular stimulation is reported to improve psychological wellbeing by influencing beta waves of the frontal cortex (39), increase release of acetylcholine (40) increase in cerebral blood flow (41) and altering brain metabolism (42). In contrast, vestibular diseases are associated with depersonalization/derealization symptoms, which can be modulated by vestibular stimulation (43). As it is very effective in diseased conditions, it may help to prevent those disease conditions if the healthy individual practice vestibular stimulation on regular basis. Earlier studies have reported that, vestibular stimulation improved postural control, movement, emotional well-being and social participation of a child with hypotonic cerebral palsy (44). Further, vestibular stimulation balances emotions through its projections to cerebral cortex, limbic system, autonomic nervous system, insula, parabrachial nucleus, dorsal raphe nucleus (45). Hence, vestibular stimulation improves self-esteem through improving the complete physiological balance. Such balance as observed in this study allows the individual to participate in everyday activities and improves the competence behavior. Vestibular stimulation improves learning and memory by decreasing acetylcholine esterase levels and increasing arborization of dendrites (40). The present study results were in concurrence with the earlier studies as significant improvement in psychological domain scores were observed following vestibular stimulation.

Social relationships domain includes personal relationships, social support and sexual activity, which are vital to quality of life. Vestibular stimulation modulates behavior, mood attention, social relationships, memory through its interactions with cortical and subcortical areas (46, 16). Vestibular influences on social relationships may be due to its projections to multi-sensory regions (47). Earlier studies reported that vestibular stimulation through the use of the swings improved social participation in children with hypotonic cerebral palsy (44). These observations are in accordance with this study, as significant improvement in the scores of social relationships domain were observed following vestibular stimulation among both female and male participants. Environment domain include financial resources, physical safety, security, freedom, health and social care, transport, physical and home

environment, leisure activities and opportunities for acquiring new information and skills. Vestibular stimulation may improve environment domain through improving the physical health, psychological and social relationships domains of quality of life, as supported by the observation in this study.

Conclusion

Vestibular stimulation significantly improved overall quality of life. Hence, the study supports adoption of vestibular stimulation as an adjunctive therapy to achieve multiple life style benefits including better quality of life in general

Limitations

We could not exclude the effect of confounders like lack of social support, as we have no suitable control group for this purpose. Hence the findings from this study should be interpreted considering these limitations.

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