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Effect of whole body vibration on balance and attention in normal individuals

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Abstract
Background: There is growing evidence that physical exercise has positive effects on cognition. Especially executive functions benefit from physical exercise. Executive functions are associated with the prefrontal cortex. Whole body vibrations are known to stimulate the mechanoreceptors which have an effect on the prefrontal cortex, as it is known that the cognitive functions take place in the prefrontal cortex. Vibrations might have an effect on the cognitive functions because of the stimulation of the mechanoreceptors. Whole body vibrations are also known to increase strength in lower extremity and improve immediate mobility in normal individuals, it could have an impact on balance. In WBV physical fitness can be improved by using vibrating platform, which provides mechanical vibrations. Whole body vibration may be a suitable physical therapy for improving executive functions in persons who are not able to perform physical exercise.
Objective: To find out the effect of whole body vibration on balance and attention in normal individuals.
Methodology: Sixty normal individuals between the age of 18 to 30 years were selected. Participants had to take a pre-intervention test of one leg stance and colour word interface test. Intervention of whole body vibration was given at 30hz for 4mins and immediately post-intervention test was done and was repeated after 15mins & 30mins.
Result: Result of this showed that there is significant difference in pre and post values of one leg stance and colour word interface test. There is significant difference between the pre and the post test results.
Conclusion: Whole body vibration has a positive effect on balance and attention in normal individuals and the effect lasts till 30mins.

Key Words: whole body vibration, balance, attention, colour word interface test

Introduction

Balance is to maintain the line of gravity of a body within the base of support with minimal postural sway [1]. Sway is the horizontal movement of the centre of gravity even when a person is standing still. A certain amount of sway is essential and inevitable due to small perturbations within the body (e.g., breathing, shifting body weight from one foot to the other or from forefoot to rearfoot) or from external triggers (e.g., visual distortions, floor translations). An increase in sway is not necessarily an indicator of dysfunctional balance so much as it is an indicator of decreased sensorimotor control [2].

In case of a person standing quietly upright, the limit of stability is defined as the amount of postural sway at which balance is lost and corrective action is required [3]. Body sway can occur in all planes of motion, which make it an increasingly difficult ability to rehabilitate. There is strong evidence in research showing that deficits in postural balance is related to the control of stability and an increased risk of falling. To remain balanced, a person standing must be able to keep the vertical projection of their centre of mass within their base of support, resulting in little medial-lateral or anterior-posterior sway. Ankle sprains are one of the most common injuries among athletes and physically active people. The most common residual disability post ankle sprain is instability. Mechanical instability includes insufficient stabilizing structures and mobility that exceed physiological limits. Functional instability involves recurrent sprains or a feeling of giving way of the ankle [4]. nearly 40% of patients with ankle sprains suffer from instability and an increase in body sway [5]. Injury to the ankle causes a proprioceptive deficit and impaired postural control. Individuals with muscular weakness, occult instability, and decreased postural control are more susceptible to ankle injury than those with better postural control.

Balance can be negatively affected in a normal population through fatigue in the musculature surrounding the ankles, knees, and hips. Studies have found, however, that muscle fatigue around the hips (glutes and lumbar extensors) and knees have a greater effect on postural stability (sway) [6]. It is thought that muscle fatigue leads to a decreased ability to contract with the correct amount of force or accuracy. As a result, proprioception and kinaesthetic feedback from joints are altered so that conscious joint awareness may be negatively affected [7].

Balance can be severely affected in individuals with neurological conditions. People who suffer from a stroke or spinal cord injury for example, can struggle with this ability. Impaired balance is strongly associated with future function and recovery after a stroke, and is the strongest predictor of falls [8].

Focusing cognitive resources on important information and discarding unnecessary information can be described as attention. All other neurological or cognitive functions requires attention as a basic precursor. Clinical models of attention differ from investigation models. Model of Sohlberg and Mateer is one of the most used models for the evaluation of attention in patients with very different neurologic pathologies [9].

It has been shown that WBV has positive acute effects on human physiology. For example, oxygen uptake, heart rate, diastolic blood pressure and muscle activity are increased during WBV compared to values during the performance of the same exercises without WBV [10-12]. Vibration sensitive mechanoreceptors are situated in the skin, such as the Meissner corpuscles which are sensitive to 10–80 Hz vibrations and specifically to 30–40 Hz vibrations, and these receptors can be stimulated by WBV [13-15]. Cutaneous mechanoreceptors transmit afferent signals to the primary somatic sensory cortex [16]. The sensory association areas have a direct and indirect connection to the prefrontal cortex [17], a region strongly involved in cognitive processing [18.19] .The indirect pathway involves the limbic system (e.g. ssthe amygdala and the hippocampus, regions important in learning and memory), which can mediate the influence of the sensory association areas on the prefrontal cortex [17]. Furthermore, the amygdala also has projections to non-thalamic nuclei (e.g. the cholinergic nuclei of the basal forebrain) that have diffuse connections to a number of regions in brain [17]. Hence, neurotransmission in sensory brain regions as well as the prefrontal cortex, hippocampus, amygdala and other brain regions can be influenced by sensory stimulation.

Whole body vibration (WBV) is a generic term used when vibrations (mechanical oscillations) of any frequency are transferred to the human body. Humans are exposed to vibration through a contact surface that is in a mechanical vibrating state. Human are generally exposed to many different forms of vibration in their daily lives. This could be a driver's seat, a moving train platform, through a power tool, a training platform, or one of countless other devices. [20] It is a potential form of occupational hazard, particularly after years of exposure.

Vibration training is the deliberate exposure to the body of varying frequencies/amplitudes/forces using certain joint angles for any limited time. It is also known as vibration therapy, biomechanical stimulation (BMS), mechanostimulation and biomechanical oscillation (BMO). It employs low amplitude, low frequency mechanical stimulation. It can be pivotal (vibrating from side to side) or lineal (vibrating up and down)

Vibration training has been advocated as a therapeutic method in the treatment of osteoporosis, sarcopenia, metabolic syndrome, COPD [21, 2] is used in the fitness industry, physical therapy, rehabilitation, professional sports, and beauty and wellness applications.

Materials and Methods

The research design used for the study was prospective analytical pre-post study. The source of data for this study was from Pravara institute of medical sciences, Loni (BK), Taluka- Rahata, Dist- Ahmednagar, and Maharashtra State, India. 60 normal individuals between the age of 18-30years were selected using simple random sampling(lottery method), the participants were included if they fulfilled the inclusion criteria, Males and Females participants of age group between 18 to 30 years [4], Normal individuals with no residue symptoms from any previous disorder, Participants who are willing to participate in the study. The participants were excluded if they had any foot deformity, any neurological residue symptoms like sensory or motor deficit, any higher mental disfunction and Pregnancy.

The materials used for the study were, Consent form, Colour sheet for stroop test.

Equipment used for the study: Whole body vibration machine was used for giving the intervention.

Outcome Measures

Colour word interference test

Colour-word interference test: In the CWIT a card with 20 colour names (blue, red, orange, green was presented to the participant. Each word was printed in one of five possible colours (blue, red, orange, green). However, the ink colour of each word was different from the colour name (e.g. the word blue was printed in red). Participants were asked to name the ink colour of the 20 words as fast as possible, thereby ignoring the written colour name. The time (in seconds) needed to accomplish the test was measured. Of the squares as fast as possible. Time (in seconds) needed to complete the test was measured. There are no estimations of reliability but test-retest reliability of the response time was quite high.

One leg stance

It is supposed to be performed with eyes open, and arms on the hips. The participant must stand unassisted on one leg and is timed in seconds, from the time one foot is flexed off the floor to the time it touches the ground or the standing leg, or an arm leaves the hip.

Reliability of one leg stance was ranged from 0.73-0.93.

Procedure

The study received ethical approval from the Institutional Ethical Committee (IEC), of PIMS, Loni (Ref. no. PIMS/CPT/IEC/2019/68). The participants were screened and after finding their suitability according to the inclusion and exclusion criteria, they were included in the study. The individuals who were willing to participate in the study were briefly explained about the nature of the study in the language best understood by them. They were encouraged to clarify queries regarding the study, if any. An informed written consent form, previously approved by the IEC was then obtained from the participants. The demographic data was obtained and demographic data was collected.

Sixty healthy individuals were selected for sampling was simple random sampling method. Pre-intervention test of stroop colour interface test was done, colour word interface test was done using colour sheet. Participants were asked to name the actual colour of the word rather than the name of the colour written. Balance was assessed using one leg stance the participant was supposed to perform with eyes open, and arms on the hips. The participant must stand unassisted on one leg and is timed in seconds, from the time one foot is flexed off the floor to the time it touches the ground or the standing leg, or an arm leaves the hip. The participants were then given the intervention of whole body vibration on the Galileo type of machine with a linear vibrating plate, given for 4 minutes. It was done in standing upright position hands rested on the handle of the machine, knees in a locked position and feet should be bare or with sports shoes placed completely on the surface of the plate of the vibratory machine and immediately post intervention test of cwit, one leg stance, blood pressure and pulse rate was done. Participants were made to rest for 15mins and then the tests were performed again, and the procedure was repeated after 30mins to check for the sustainability of the intervention.

The pre and post intervention results were compared and analysed statistically.

Results

A total of 62 participants were screened from August 2018 to December 2018 of which 60 participants were selected according to selection criteria. Healthy young individuals under the age group of 18-30 years of age were selected [4]. Effect of whole body vibration was seen on balance and improvement of attention using an electronic device for blood pressure & pulse rate, stroop test was used to analyse attention. The outcomes were checked before the intervention, after and post 15 & 30 mins of intervention. Comparison of pre, post, post 15&30 min intervention on balance

Table 1

	Pre intervention	Post intervention	Post 15min	Post 30mins
Mean	50.52	69.81	63.75	56.98
Sd	8.95	9.87	8.96	9.09

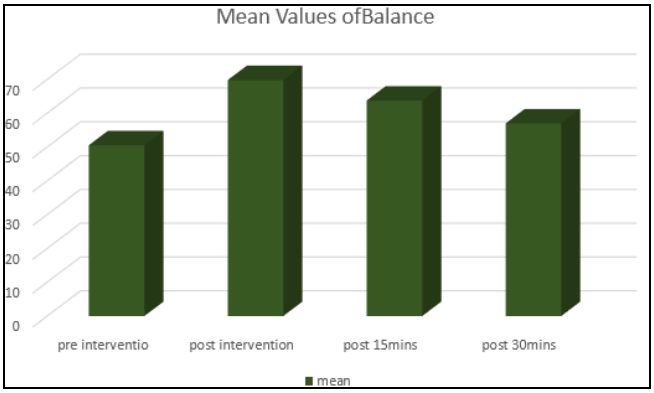

Fig 1

Mean values of balance of balance were compared pre interventionally (50.52), post interventionally (69.81), post 15mins (63.75) and post 30 mins (56.98) and analysed statistically using ANOVA test which showed that the values were extremely significant at the p value was <0.0001 at a 95% confidence interval. when pre and test values were compared to the post test values the p value was <0.001 and the q value of 16.19.when the groups were compared internally using paired t-test there was significant difference between pre and post intervention as the p value was <0.0001 with correlation coefficient of 0.864, t value of 29.96 and at a confidence interval of 95% when immediate post intervention was compared to post 15mins the p value was <0.0001 with correlation coefficient of 0.978, t value of 21.85 and at a confidence interval of 95%.comparing post 15&30 min of intervention the p value was <0.0001 with correlation coefficient of 0.962,t value of 21.22 and at a confidence interval of 95%.

Table 2: Comparison of colour word interface test values (attention)

CWIT	Pre-intervention	Post-intervention	Post 15mins	Post 30mins
Mean	64.08	47.47	50.49	53.01
s.d	10.51	6.66	6.87	7.59

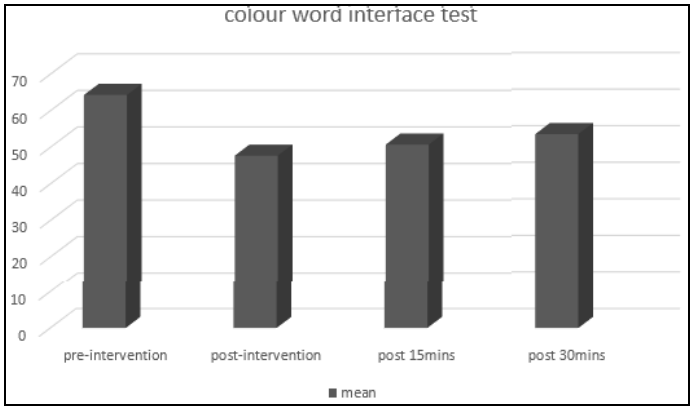

Fig 2

Comparison of mean cwit from pre-intervention, post intervention, post 15&30 mins of intervention with values 64.08, 47.47, 50.49, 53.01 respectively. There was significant difference when analyzed statistically using ANOVA test the p value was <0.001 and q value was 34.90 for pre-intervention v/s post intervention, 28.55 for pre intervention v/s post 15mins of intervention, 23.26 for pre intervention v/s post 30mins of intervention with a confidence interval of 95%. When pre intervention and post intervention values were compared using paired t-test the p value was <0.0001 with correlation coefficient of 0.782, t value of 19.11 at a confidence interval of 95%. Immediate post intervention values when compared to post 15mins of intervention had a p value of <0.0001 with coefficient correlation of 0.855, t value of 6.41 at a confidence interval of 95% comparison of post 15mins&30mins had a p value of <0.0001 with coefficient correlation of 0.911, t value of 6.47 at a confidence interval of 95%.

Discussion

The general aim of this study was to investigate the acute effects of passive WBV on balance & attention in healthy young adults. The secondary objective was to know how long would the effect of vibration last. Tests were done before the intervention, immediately after the intervention, post 15&30 mins after the intervention.

The result of the study showed significant difference in balance & attention when compared statistically using ANOVA test and the groups were internally compared using paired t-test which showed that whole body vibration has a positive effect on attention and balance and the effect sustained till 30 mins. Attention was assessed using stroop test in which colour word interface test was used and for balance, one leg stance was used and calculated in seconds.

There was positive effect of vibration on balance as shown in the results, the mean values of balance were pre-interventionally 50.52(SD-8.95) post-interventionally 69.81(SD-9.87) post 15mins 63.75(SD-8.96) post 30mins 56.98(SD-9.09). The mean values were compared statistically and it has significant difference as the p value was <0.0001 which shows that vibration had positive effects on balance. Values of pre, post, post 15&30 mins were compared internally using paired t-test and there was significant difference amongst pre, post, post 15&30 mins.

Major effect is seen immediately after the intervention and it reduces overtime, but still the effect lasts till 30mins. Mechanical vibration exert a tonic excitatory influence on the muscles exposed to it. Vibration applied to whole body (1±30 Hz) has been shown to elicit a response named `tonic vibration reflex' (TVR) (Hagbarth & Eklund, 1985, Seidel, 1988). The vibration induced TVR involves activation of muscle spindles, mediation of the neural signal by 1a afferents (Hagbarth, 1973), and activation of the muscle fibres via large a-motor neurones. The TVR induced by the vibration is also capable of causing an increasing recruitment of motor units via activation of muscle spindles and polysynaptic pathways (De Gail et al., 1966), which is seen as a temporary increase in the muscle activity. The improved strength and power of the lower extremities and the improved body balance after the vibration intervention suggests that neurogenic adaptation may have occurred in the muscles of the lower extremities in response to vibration.

There was positive effect of vibration seen on attention as well, as seen in the results the mean values for attention pre interventionally was 64.08(SD-10.51) post interventionally 47.47(SD-6.66) post 15 mins 50.49(SD-6.87) post 30 mins 53.01(SD-7.59). The values were compared statistically and it showed significant difference as the p value was <0.0001. The values were compared internally using paired t-test and the values showed significant difference. Immediate post intervention showed the maximum effect and the effect sustained till 30mins as there was significant difference seen between the pre-intervention and post 30 mins of intervention.

It was hypothesized that passive WBV would improve executive functions in young adults, possibly as a result of increased neurotransmission in the prefrontal cortex by sensory stimulation. Hypothesis was based on the neuroanatomical connections between mechanoreceptors and cognition-related brain regions [23, 24], and the positive effects of WBV on cognition. Indeed, the results of the study showed that four minutes passive WBV with 30 Hz frequency and approximately 0.5 mm amplitude improves CWIT performance in young adults, notwithstanding the already high level of cognitive functioning of the subjects.

The improvement in CWIT performance by WBV may be explained by improved functioning of the prefrontal cortex and regions around the inferior frontal sulcus, because these brain regions are associated with CWIT performance[25]. Since afferent signals of cutaneous mechanoreceptors are transmitted to sensory brain areas[23] that are connected to prefrontal brain regions[24], passive WBV may acutely increase neurotransmission in the prefrontal cortex and in regions around the inferior frontal sulcus by sensory stimulation. WBV with 30 Hz frequency and approximately 0.5 mm amplitude improved attention. This may be explained by the specific sensitivity of Meissner corpuscles in the skin. Meissner corpuscles are especially sensitive to 30–40 Hz vibration. Therefore, passive WBV with 30 Hz frequency and approximately 0.5 mm amplitude may induce a relatively strong stimulation of Meissner corpuscles in the skin, subsequently improving executive functioning.

Conclusion

This study demonstrated that whole body vibration has positive effects on balance and attention in normal individuals. Results showed that short session of 4 mins with 30 Hz frequency has a positive effect on balance and attention in normal individuals for 30mins with a high level of cognitive functions and balance.

Clinical implication

Balance and attention are the most commonly affected functions in any neurological case, whole body vibration could be used as an adjunct therapy before a session of physiotherapy as it can give better outcome to it. It can be used in elderly as it is known that attention (external focus) helps in improving balance, as it is shown in the present study that whole body vibration helps in improving balance and attention it could be used to prevent falls. As whole body vibration is cheap and a feasible intervention it could be used for patients with balance and attention disorders.

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