

Changes in the Postural Stability and Balance in Multitasking with Increasing Task Demands in Normal Healthy Individuals of Different Ages: A Hypothesis

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Abstract

Background: Balance and postural instability disorders become more prevalent with age. The three sensory modalities responsible for normal balance and steadiness, viz. vision, vestibular system and proprioception, can become compromised as a result of normal aging process as well as age-related disease or pathology leading to increased risk of falls and related injury. The elderly fall more often and with greater consequence as a result of balance and postural instability issues, leading to huge personal costs as well as large health care costs. 1 in every 3 adults over the age of 65 will suffer from a fall, and these numbers are expected to rise making balance disorders a major healthcare crisis. But there is a dearth of literature in understanding the activities or specific tasks which may lead to falls, especially tasks having dual or multitasking components in our day to day activities which may be precursors of falls. Thus, there is a need to evaluate the changes occurring, if any, related to balance impairments with an increasing age or with relation to increasing in the difficulties in the levels of tasks performed and their relation with the falls.

Hypothesis: There will be a reduction in balance and stability parameters with an increase in the levels of difficulty of the task demands which will be enhanced with an advancing age.

Clinical Importance: The evaluation of specific tasks leading to impairments of balance with an advancing age can help us form optimum strategies for fall prevention and also may help us give functional balance training in accordance with the task demands in the varied ages.

Future Research: The effects of balance training on the variations of tasks can be evaluated to specify exercises which may help the higher age groups cope up in the dynamic challenges of the daily activities. Also environmental influences on these activities can be studied in order to improvise and enhance the quality of life in this population.

Key Words: Postural instability, Balance, Multitasking, Aging, Falls.

THESIS SUMMARY

Introduction

Aging is an extremely complex process which is characterized by the degeneration of organs and tissue [1]. There are multiple theories of ageing. But broadly, ageing process is physiologically characterised into 3 groups. The first group comprises of the cellular homeostatic mechanism such as blood pressure, body temperature. The second

group characterises of the decreasing organ mass while the third and most important mechanism consists of the loss of functional body system which contributes in maintenance of the functional status of the body [2]. As aging occurs, there will be a concurrent deterioration in the other systems of the body as well [2]. The three sensory modalities responsible for normal balance and steadiness,

viz. vision, vestibular system and proprioception, can become compromised as a result of normal aging process as well as age-related disease or pathology leading to increased risk of falls and related injury[2].

Balance is defined as a state in which weight is evenly distributed enabling a person or thing to remain steady and upright[3]. Balance is of two types: 1. Static balance/ static postural control, which is the ability to maintain a steady position in a weight bearing, anti-gravity postures. Impairments of static postural control are instability or increased postural sway in sitting/ standing, episodes of loss of balance and risk of falls. 2. Dynamic balance/ dynamic postural control, which is the ability to alter a position or change position while maintaining stability[3]. Impairments of dynamic postural control are difficulty in maintaining balance during weight shifting or rocking within a posture (e.g. sitting) and the inability to assume a posture independently. This activity requires movement against gravity through a large range of motion.

Postural control depends on the integration and co-ordination of three body systems; Sensory, central nervous (CNS) and neuromuscular systems. The sensory system gathers essential information about the position and orientation of the body segments. CNS integrates, coordinates and interprets the sensory input and directs the movements while the neuromuscular system responds to the orders provided by the CNS[3].

The prime concern in geriatric rehabilitation is fall prevention. Studies have proved that falls are the leading cause of accidental death over 65 years of age[4]. Although there are intrinsic and extrinsic factors for the causes of fall but the authors believe that the prime reason of falls can be the challenges to the balance system, especially during the dual tasking and multitasking which are somehow not emphasized upon during the assessment and rehabilitation processes.

Human Multi-tasking means dealing with more than one task by an individual at a time[5]. Multitasking trains the untrained part of the brain. Researchers have shown that adding cognitive demands to the performance will enhance the functional performance of the person, which is very necessary for maintaining a good functional status[6]. Multi-tasking is extremely essential component during ambulation and locomotor activities as this is the phase wherein there can be maximum falls due to impaired ability to maintain normal gait while simultaneously performing cognitive task or any other activity which leads to postural instability[6]. Also performance of daily activity requires a concurrent performance of multiple tasks as per the needs of the situation. Hence it is absolutely crucial to evaluate the balance specifically while doing multitasking activities; which can help the rehabilitation specialists to focus on the training of the multitasking in functional activities.

Hypothesis

Humans are bipedal for their locomotive needs and need to maintain balance on single leg during stepping forward or while running[7]. Hence balance maintenance is crucial in our day to day activities. Falls have short term and long term consequences which can be difficult to manage further. It is commonly assumed that balance would be impaired only in elderly due to physiological status of the body and hence the young and middle age population is neglected for assessment of balance. Study done by Chony NL et al suggest that the balance can be impaired from any age, even from 40 years onwards, which is considered as the

middle age[8]. Hence, variations in balance need not be only physiological, but even the environmental factors and task demands can contribute towards maintenance of balance and hence there is the need to understand the variations in balance, if any, in the various ages. Thus, there is a need to evaluate the changes occurring, if any, related to balance impairments with an increasing age or with relation to increasing in the difficulties in the levels of tasks performed and their relation with the falls. Thus, the study is based on the hypothesis that there will be a reduction in balance and stability parameters with an increase in the levels of difficulty of the task demands which will be enhanced with an advancing age with the objectives of measuring the static and dynamic balance in varied levels of task demands in normal healthy population from 10-80 years of age. To meet this purpose, an analytical cross sectional study will be conducted, the approval for which has been obtained from the institutional review board. The sampling will be done by the stratified sampling method wherein the sample will be collected from all the 7 legislative zones of Pune city, the single legislative zone being strata. This is to eliminate any potential confounders in the study based on demographic and geographic variations. The data collection, assessment and analysis shall be done as per STROBE statement guidelines. There will be 7 groups with the age group of from 10 to 80 years, having 100 subjects in each decade wise age group which has been calculated by the formula of the sample size $(Z\text{-VALUE})^2 \times p \times (1-p)/c^2$, wherein, Z-value: 1.96 (for 95% confidence interval), p: 0.5 (% picking a choice, expressed as decimal (0.5 is used for sample size needed)) c: confidence interval, expressed as decimal based on the 2011 census report for Pune city for the above mentioned age group.

The study shall include normal healthy individuals from 10 to 80 years of age who will be screened for physical fitness based on no history of any clinical complains and assessed by the PAR Q and YOU questionnaire. The individual with Visual problem (non – correctable), Vestibular disorder, Neurological disorder which leads to balance problem, Lower limb musculoskeletal problems (RA, recent fracture) etc., will be excluded from the study. The written informed consent form will be signed by the participants. Balance assessment shall be done by 5 outcome measures viz., 1. Bergs balance scale (BBS), 2. Dynamic gait index (DGI), 3. Time up and go test (TUG), 4. Star excursion balance test (SEBT) and 5. Single leg stance time (SLS). After this, the subjects will be asked to hold a glass of water filled with 80% of water and perform the above tests. Further, subjects will be asked hold a glass of water filled with 80% of water and to count numbers reverse from 100 to 1 (odd or even numbers) thus adding multitasking including cognitive task. Balance of each subject will be measured by the varied outcome measures to understand the variations in these tests and to understand which clinical tool can be most appropriate to evaluate the minute variations in balance parameters. Statistical analysis for inter group variations, if any, shall be done with on way ANOVA Test for TUG, SEBT and SLS and Kruskal Wallis Test for BBS and DGI measures with alpha set at $p < 0.05$ at 95% confidence interval.

Discussion

The degeneration of the balance control system and many

pathology in elderly has forced researchers and clinicians to understand more about how the System works and how to quantify its status at any point in time[7]. Due to sedentary and busy lifestyle now-a-days, few considerations are given to the physical fitness of the body. Postural stability (balance) is one of the very prime concerns for staying fit. Falls are one of the major problems in the elderly and are considered one of the "Geriatric Giants"[9]. Recurrent falls are an important cause of morbidity and mortality in the elderly and are a marker of poor physical and cognitive status[9]. Due to various changes that takes place in the body due to aging process, consideration for postural instability or balance while doing dual or multitasking is not given. The ability to control our body's balance may be impaired due to changes in the sensory, motor, and neurological system. Usually balance assessment gives us the purpose of scoring balance in the quantitative way such as scores for the scales. Many other technical aids such as balance platform which measures the balance in a very accurate form can be used[10]. But the functional component of the balance or the activities which is performed in day to day activities is neglected hence the functional component is missed which can be impaired in all the ages. It has been suggested that the balance impairment of the all the ages can be overcome by giving the balance training which include all the exercises of the body[10]. Task which challenges Balance while multitasking is observed in our day to day activities. Multitasking increases the work load on the mental system[11]. One form of multitasking, impaired ability to maintain normal gait while performing other cognitive tasks, may predispose individuals to postural instability while walking and to falls by reducing obstacle avoidance and ability to recover from a postural perturbation independent of neuromuscular function[12]. Hence it will be very important to assess and at the same time the treatment should be given in the functional way so that the post intervention the balance score is improved. There are many scales which asses the balance and give us the very accurate score in the functional form. The scales or the outcome measures which will be used in this research study are Bergs balance scale (BBS), Dynamic gait index (DGI), Single leg stance (SLS), Star excursion balance test (SEBT) and Time up and go test (TUG). These tests are used to assess the balance score in different ages. But there is no scale which can help us understand the complexities of dual-tasking to multi-tasking. According to literature, the rising awareness for maintenance of balance is taken into consideration and strategies to improve balance while doing multitasking specially for the elderly population should be developed. Damage to the prefrontal cortex (PFC) is associated with impaired Multitasking performance[13]. Neuroscientific findings showed that, like other externally directed attention-demanding tasks such as working memory tasks, networks mainly consisting of the lateral frontal cortex and parts of the inferior and superior parietal lobes are activated during Multitasking[13]. Studies have investigated the effects of Multitasking training on cognitive functions and neural systems, and this training has been shown to lead to improvements in untrained Multitasking task[14]. Functional activity has been found to undergo changes during Multitasking in regions such as dorso lateral pre frontal cortex. A study by Julia Karbach et al

(2013), suggest that the activity was decreased in most of the areas involved in task performance, but training given will increase changes in dorso Lateral Prefrontal cortex[15]. These changes suggest that adaptation to Multitasking leads to increased efficiency in task execution as well as learning to rely on cognitive processes involving dorsolateral prefrontal cortex[15-17]. Hence due to all this process which takes place in the gray matter in the brain, multitasking training can be started at any age so that we can avoid the risk of falls and create enhanced body balance. Thus, the study hypothesizes that there would be changes in balance in form of reduced balance scores as measured with the performance based balance tests in the higher age groups and in relation to the increase in the task demands.

Clinical Importance

Reaching tasks are commonly performed during daily activities and require anticipatory postural adjustments (APAs) to ensure a stable posture during movement execution. Age-related changes may impact dynamic balance and cause postural instability during functional activities. Older adults are more likely to fall while performing concurrent tasks such as walking while performing other motor or cognitive tasks. Thus doing dual tasking while walking will add up to more risk of fall. This study may help the readers understand the exact functional components which need to be trained with an advancing age and with relation to the variations in task demands. This may help the rehabilitation specialists to focus on specific tasks and functional training demands in the rehabilitation process and may help in formation of task specific rehabilitation guidelines and protocols.

Future Direction

The effects of balance training on the variations of tasks can be evaluated to specify exercises which may help the higher age groups cope up in the dynamic challenges of the daily activities. Also environmental influences on these activities can be studied in order to improvise and enhance the quality of life in this population.

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