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AGE RELATED CHANGES IN POSTURAL STABILITY

DIGANTA BORAH*, SANJAY WADHWA**,
UPINDERPAL SINGH***, SHIV LAL YADAV***,
MANASI BHATTACHARJEE# AND SINDHU V##

*Departments of *Orthopaedics and #Physiology,*
Jawaharlal Institute of Postgraduate Medical Education and Research,
Pondicherry – 605 006,

***Department of Physical Medicine and Rehabilitation,*
Postgraduate Institute of Medical Education and Research,
Chandigarh – 160 012,

****Department of Physical Medicine and Rehabilitation,*
All India Institute of Medical Sciences,
New Delhi – 110 029

and

##Department of Physical Medicine and Rehabilitation,
Safdarjung Hospital, New Delhi – 110 029

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Abstract : Postural instability is a commonly encountered problem in elderly population. In a large number of persons this can be attributed to the physiological changes associated with aging. To investigate the changes in postural stability with aging this study was conducted in 64 healthy volunteers aged eight to seventy years using dynamic posturography. Three tests, namely sensory organization test, limits of stability and rhythmic weight shift which included a total of ten parameters were done. Of these, equilibrium score, strategy score, reaction time, movement velocity and on axis velocity showed statistically significant deterioration with progression of age. Disturbances in postural stability were detected from the fourth decade onwards in the population studied. This instability was not related to any disease process and possibly reflects the process of aging. Adequate precautionary measures should be taken by elderly persons to avoid the possible adverse consequences of postural instability.

Key words : posturography balance age

INTRODUCTION

For various day-to-day activities, an ability to balance and maintain a stable posture is very important. Postural control may have different goals under different circumstances. The functionally important components of balance are maintenance of

*Corresponding Author : Diganta Borah, Department of Orhtopaedics, Jawaharlal Institute of Postgraduate Medical Education and Research, Pondicherry – 605 006; Tel. No. 0413-2272380-390, Ext- 4151; Fax : 0413-2272067; E-mail: diganta29@yahoo.com

posture, postural adjustments in anticipation of and during a self initiated movement and adjustments in response to an external perturbation (1).

Balance emerges from a complex interaction between sensory and musculoskeletal systems. The sensory component includes the vestibular, proprioceptive and visual systems (2). The various inputs are integrated and modified within the central nervous system in response to changing internal and external conditions (1). This close interaction of various systems to maintain balance adequately may be disturbed in various conditions (3–11). The process of aging is one such example. There may be numerous causes for age related postural changes. With increasing age there is an increased probability for developing specific pathologies, which lead to accelerated degeneration in neural and/or musculoskeletal systems (12). A relatively inactive lifestyle may also result in disuse related changes in the neuromuscular system, including muscle weakness and slowed response time. In elderly persons weaker muscles impose a relatively higher demand during muscular activity leading to early fatigue and postural imbalance (13). A combination of reduced sensation, leg muscle weakness and increased reaction time appear important factors associated with postural instability in elderly (14).

Falls in elderly is a major health problem (15, 16, 17). This may be due to some disease process or to age related deterioration of postural stability. There are some reports evaluating age related changes in postural stability (16–28). However, similar studies have not been conducted in the Indian population. Therefore, this study was conceptualized in order to have a better understanding of age related postural changes in the Indian population.

METHODS

The subjects were recruited from the persons accompanying patients attending Physical Medicine and Rehabilitation OPD, All India Institute of Medical Sciences (AIIMS) and staff members of AIIMS. 64 subjects aged 8 to 70 years weighing 18 to 94 kg with height of 76 to 174 cm were studied. The subjects were divided into seven (7) age groups (Table I).

Each subject was evaluated in detail including Mini mental status examination. The subjects having significant visual, vestibular and sensory impairment, any musculoskeletal, central nervous system or cognitive disorder and subjects on chronic medications were excluded from the study.

Suitable subjects were enrolled in the study after signing informed consent forms. Balance was assessed using the Smart Balance Master (version 7). This is a rehabilitation tool designed to provide quantitative assessment of static and dynamic balance performance and visual feedback of the excursion and position of centre of gravity. The system utilizes force plate technology to determine the location of centre of gravity (COG) within predefined 75% limits of stability while adjusting for an individual subject’s height (COG=0.55x height). The software provides measure of the subjects’ postural sway and the ability to maintain the centre of gravity within a predefined targeted area. Before the procedure each subject was explained about the nature of the test and clear instructions were given to all the subjects while

conducting the test. Three tests were conducted.

1. Sensory organization test (SOT): During this assessment somatosensory and visual environments were altered systematically and the patient's responses were measured and recorded. To create such an altered environment, the force plate, the visual surround or both were sway referenced. The subjects were exposed to 3 consecutive 20 seconds trials for each of the 6 combinations of visual and support surface conditions (Fig. 1).

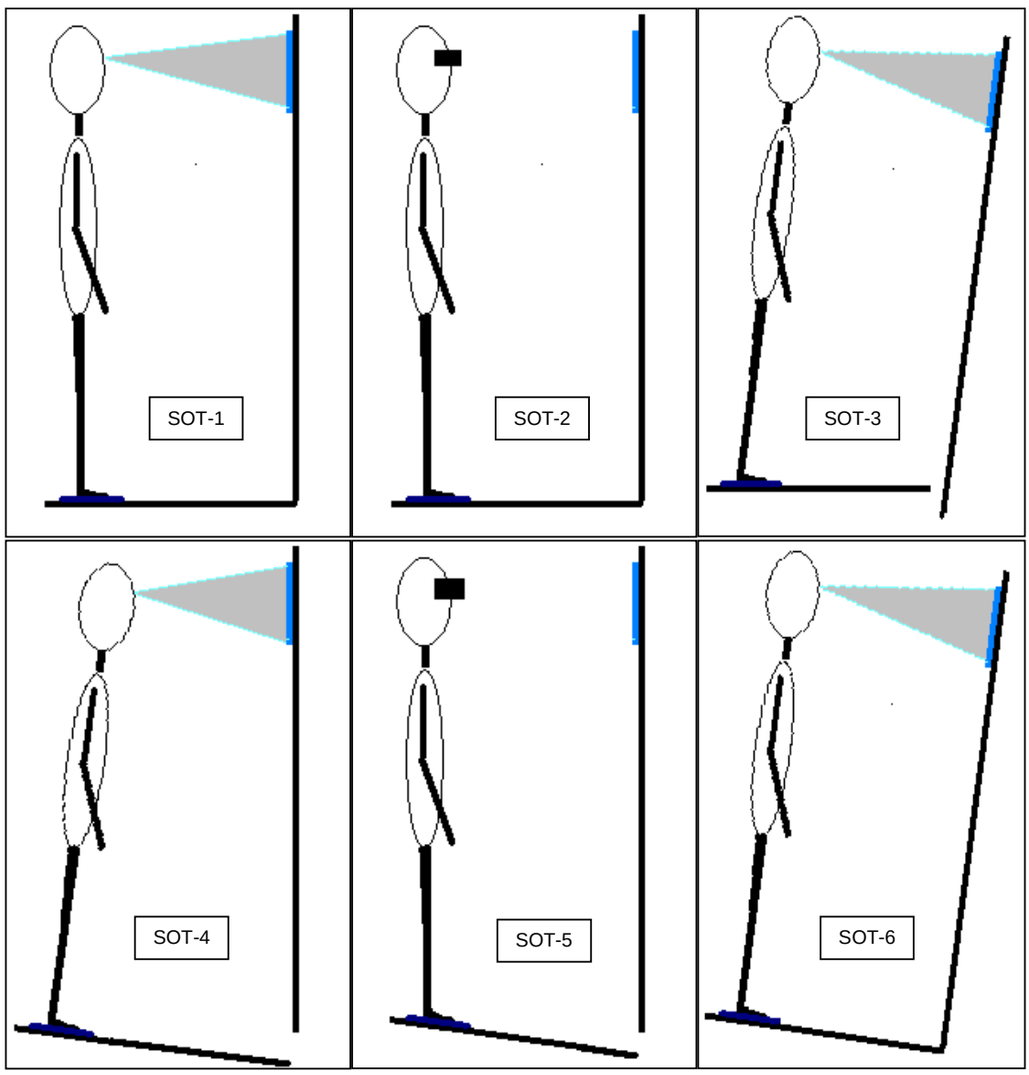

Fig. 1: Figure showing six different visual and support-surface conditions used in the Sensory Organization Test (SOT). SOT1: eyes open, fixed support and surround; SOT2: eyes closed, fixed support and surround; SOT-3: eyes open, fixed support and moving surround; SOT4: eyes open, moving support and fixed surround; SOT5: eyes closed, moving support and fixed surround; SOT6: eyes open, moving support and surround.

Align eyes open (SOT 1): Measured the subjects' average position and amount of anterior-posterior sway with eyes open.

Align eyes closed (SOT 2): Measured the subjects' average position and amount of anterior-posterior sway with eyes closed.

Sway vision (SOT 3): Surround moved in direct relation to subjects' anterior-posterior sway.

Eyes open, sway support (SOT 4): Surface moved in direct relation to subjects' anterior-posterior sway.

Eyes closed; sway support (SOT 5): Surface moved in direct relation to subjects' anterior-posterior sway.

Sway vision; sway support (SOT 6): Surface and surround moved in direct relation to subjects' anterior-posterior sway.

From this assessment the following parameters were obtained:

- Equilibrium score
- Centre of gravity alignment
- Strategy score

2. Limits of stability (LOS): This assessment quantifies several movement characteristics associated with subject's ability to voluntarily sway to various locations in space and briefly maintain stability at those positions. A limit of stability is the perimeter around the COG. It is approximately 12.2 degrees in the anterior-posterior and 16 degrees in the lateral dimension. It was assessed by 8 trials of 8 seconds each. In each trial the subject assumes a standard position and controls a cursor on the computer monitor to 8 fixed targets by shifting his body weight.

From this assessment the following parameters were obtained:

- Reaction time in seconds
- Movement velocity in degrees per second
- Endpoint excursion as a percentage
- Maximum excursion as a percentage
- Directional control as a percentage

3. Rhythmic weight shift: This assessment quantifies two movement characteristics associated with the subject's ability to voluntarily move his/ her centre of gravity or sway from left to right and forward to backward in a rhythmic manner. It consists of 6 trials with 3 different speeds (slow, medium and fast).

From this assessment the following parameter were obtained:

- Velocity in degrees per second
- Percentage of normative directional control

Statistical analysis:

All the data were expressed in means ± standard deviations. Comparison of each parameter between groups was done by using appropriate *post hoc* test following Kruskal-Wallis test. P value 0.05 was considered as level of statistical significance.

RESULTS

The various parameters assessed were compared between the different age groups. The number of subjects in each age group is shown in Table I.

TABLE I: Subject distribution in different age groups.

Age Groups		*Number of subjects*
Group I	8 to 10 years	6
Group II	11 to 20 years	10
Group III	21 to 30 years	10
Group IV	31 to 40 years	10
Group V	41 to 50 years	10
Group VI	51 to 60 years	10
Group VII	61 to 70 years	8

1. Sensory organization test:

(a) Equilibrium score:

In SOT1 overall difference in the mean values of groups I to VII was significant with P value less than 0.05 (Table II). The lowest value was found in group I. On comparison between individual groups, significant difference was found between group I and II ($P<0.05$). In SOT2 overall difference between groups was significant ($P<0.05$) and the lowest value was recorded in group-VII. Similarly in SOT3 overall difference in mean values was significant ($P<0.01$). The lowest value was obtained in group-I and significant difference was found on comparing group-I with groups-II to VI and group-II with group VII. In SOT4 the overall difference was significant ($P<0.05$). Comparison of group I with II to IV also revealed significant difference. In this support surface condition the lowest value was found in group-I. In SOT5 the P value was <0.01 while comparing all the groups, with lowest value in group VII. Significant difference was found between groups III and VI and groups III and VII. In SOT6 the P value was <0.01 on overall comparison, the lowest value being recorded in group VII. Significant difference was observed while comparing group VII with groups II, III and IV. In addition to individual support surface conditions a composite equilibrium score was also calculated and compared among the different age groups. The lowest value was found in group VII. The difference was highly significant with P value <0.001 and significant difference in the composite equilibrium score was observed

TABLE II: Sensory organization test (SOT): Equilibrium score.

Tests	*Gr. I*	*Gr. II*	*Gr. III*	*Gr. IV*	*Gr. V*	*Gr. VI*	*Gr. VII*	*P value*
SOT 1	87.44±3.26	94.06±1.98	92.00±3.92	92.23±4.78	92.57±3.88	93.07±1.82	90.33±4.01	.045
SOT 2	87.44±3.25	92.10±4.15	92.00±2.81	92.10±2.24	90.00±4.47	88.60±5.16	86.96±5.34	.019
SOT 3	82.78±6.14	93.70±1.81	90.87±4.05	91.50±3.11	89.33±4.36	90.20±3.80	85.79±4.48	.001
SOT 4	70.78±12.63	85.03±5.75	84.13±3.87	85.90±6.42	81.53±9.03	79.23±8.96	76.79±5.53	.012
SOT 5	60.11±9.62	64.00±8.41	70.43±6.19	64.97±7.45	58.73±4.89	55.80±13.23	54.29±10.52	.002
SOT 6	53.11±12.33	65.53±5.44	67.33±7.58	63.30±7.67	55.60±12.83	56.97±13.66	44.12±9.67	.001
CES	72.50±8.38	79.40±3.47	80.00±2.49	78.60±3.66	74.10±3.28	73.90±6.61	68.75±1.67	.000

Values are shown as means±SDs.

between groups I and III, groups II and VII, groups III and VII and groups IV and VII.

(b) Strategy score :

The second parameter of the SOT analyzed and compared was the strategy score. This was also evaluated under 6 different support surface conditions. The mean and standard deviation of the strategy score of all the groups is given in Table III. In all the 6 conditions the lowest value was found in group-VII and the difference in mean values of all age groups was highly significant (P<0.001). In SOT1 significant difference was found on comparing group VII with groups I to VI. In SOT2 significant difference existed on comparing group VII with groups I to VI and group VI with groups II, III, IV and V. In SOT3 groups-VI and VII significantly differed from groups I to V. In SOT4 the values were significantly different on comparing groups VI and VII with groups I to V. In SOT5 and SOT6 significant difference was found on comparing mean values of groups- VI & VII with groups I to V and on comparing group I with group V. The difference in the average strategy score between all the groups was also highly significant with (P<0.001) and significant difference was found on comparing groups VI and VII with groups I to V and group VI with group VII.

(c) Centre of gravity alignment :

This too was evaluated in 6 different support surface conditions. At the beginning of each SOT the COG position was recorded as the initial COG and the average was calculated. Similarly the average of final COG was also calculated from the COG position at the end of each SOT. On comparing both the initial and final COG values among different age groups, no significant difference was found.

2. Limits of stability :

(a) Reaction time :

The mean values of reaction time in different age groups were compared and the difference was found to be significant with P value less than 0.01. The value gradually increased with the highest value in group VII. Significant difference of mean values

TABLE III : Sensory organization test (SOT): Strategy score.

Tests	*Gr. I*	*Gr. II*	*Gr. III*	*Gr. IV*	*Gr. V*	*Gr. VI*	*Gr. VII*	*P value*
SOT1	98.50±2.34	98.50±1.00	98.40±1.33	98.80±0.99	98.70±1.18	98.53±4.33	85.04±6.50	<.001
SOT2	96.33±4.90	98.83±0.65	98.77±1.17	98.73±1.03	98.27±2.74	91.30±5.00	82.50±5.81	<.001
SOT3	98.05±2.32	98.90±0.52	97.90±1.99	99.03±0.76	98.27±1.82	89.13±8.06	83.62±9.06	<.001
SOT4	91.61±3.16	92.83±4.29	89.40±5.33	92.17±3.46	89.83±3.86	79.80±6.61	78.88±6.36	<.001
SOT5	87.22±5.65	78.80±10.18	77.04±6.51	78.03±4.64	74.50±8.03	63.33±8.00	60.33±3.76	<.001
SOT6	83.28±7.64	79.40±8.48	74.57±10.38	74.60±8.31	73.07±6.90	62.37±6.76	56.33±5.72	<.001
ASS	92.51±2.04	90.14±4.65	88.80±3.73	90.40±2.49	88.24±2.34	80.22±1.59	74.45±3.66	<.001

Values are shown as means±SDs.

TABLE IV: Limits of stability.

Tests	*Gr. I*	*Gr. II*	*Gr. III*	*Gr. IV*	*Gr. V*	*Gr. VI*	*Gr. VII*	*P value*
RT	0.62±0.11	0.78±o.26	0.72±0.09	0.98±0.30	1.10±0.41	1.01±0.34	1.03±0.14	.003
MV	5.20±1.76	4.72±1.11	4.73±0.93	3.52±1.05	3.19±1.18	3.65±1.33	3.19±0.56	.008

Values are shown as means±SDs.

TABLE V: Rhythmic weight shift.

Tests	*Gr. I*	*Gr. II*	*Gr. III*	*Gr. IV*	*Gr. V*	*Gr. VI*	*Gr. VII*	*P value*
OAV	5.09±0.71	5.71±1.10	5.43±0.58	4.38±0.68	4.34±0.55	4.64±0.58	3.38±0.28	<.001

Values are shown as means±SDs.

was found on comparing group I with groups IV, V, VI and VII (P<0.05) (Table IV).

(b) Movement velocity

The mean values of movement velocity in different age groups were compared and significant difference was observed (P<0.01) and the lowest values were observed in groups V and VII. On comparing the individual groups significant difference was found between groups I and V and groups I and VII (Table IV).

The other three parameters assessed as a part of LOS were endpoint excursion, maximum excursion and directional control. The mean values of these three parameters were also compared among different age groups. However, no significant difference was found (Table IV).

3. Rhythmic weight shift:

(a) On-axis velocity:

The mean values of velocity in different age groups were compared and found to be significant on overall comparison with p value less than 0.001. The lowest value was recorded in group VII. The mean values were found to be significantly different on comparing group I with group VII, group II with groups IV, V, VI and VII, group III with groups IV, V and VII and group VI with group VII (Table V).

The other parameter of rhythmic weight shift, directional control was also compared among different age groups, but no significant difference was found.

DISCUSSION

Age related deterioration of postural stability adversely affects the quality of life in the elderly, especially due to increased incidence of falls (29). In elderly persons balance disturbance may be due to obvious disease of the sensory components and/or effector apparatus or the CNS. On the other hand it may merely be a reflection of the

process of aging. In healthy elderly persons, functionally evident progressive age-related quantitative balance changes have been reported (24).

The present study was designed on the basis of the reported postural changes in elderly persons and a lack of knowledge of the same in the Indian population. In this study, the pattern of changes in stability with increasing age was assessed. The parameters obtained from the posturographic assessment were compared between the groups.

Sensory organization test: The overall change in composite equilibrium score with age was highly significant. The score was highest in 3rd decade, followed by a gradual decline with the lowest value in the 7th decade. This is indicative of minimum sway during the third decade and maximum sway during seventh decade of life in the subjects included in the study. A similar finding was earlier reported by Whipple et al (30). Although the minimum sway in different support surface condition was observed in different age groups, we found a similar trend of variation of sway in all the conditions. Sway was decreasing from the 1st decade (group I) of life up to a certain age group after which it started increasing till the 7th decade. Our results also indicate that sway increases significantly when any two sensory inputs are compromised simultaneously. This has also been reported earlier by Woolacott et al (31) and Peterka et al (32) in their studies on age related postural changes.

On comparing the strategy score of SOT highly significant overall difference was found in each support surface condition including the average strategy score. We found that the mean value of strategy score was lowest in 7th decade in all the 6 support surface condition as well as in average strategy score. A strategy score of 100 means a total use of ankle strategy while a score of zero means total use of hip strategy by a subject for maintaining balance. In our study the strategy score in most of the support surface conditions and average strategy score were found to be highest in the 1st decade followed by a decrease, with the lowest value in the seventh decade. From the results of the present study it is evident that the subjects in group- VII used more hip strategy in comparison to the other groups. This finding is in accordance with similar report by Manchester et al (33).

Limits of stability: All the 5 parameters of limits of stability were compared among different age groups in the study. But significant difference was found only in reaction time and movement velocity. The shortest reaction time was found in 1st decade whereas the longest reaction time was recorded in the 7th decade. This increase of reaction time with progression of age suggests slower processing of information in the CNS in elderly subjects. This finding was previously reported by Lord et al (34). Therefore, in the elderly an increase in reaction time may hamper a person’s response to any destabilizing factor, which may result in impaired balance performance with an increased probability of falls. Movement velocity in LOS test was found to be declining from the first decade up to the fifth decade (Table V) followed by slight increase in 6th decade with a lower value in the seventh decade. This indicates that the

subjects of the seventh group of the study were slower in comparison to preceding groups.

Rhythmic weight shift : Only on-axis velocity of this test showed significant difference among the groups. No definite pattern of changes could be identified with increasing age from first to seventh decade. However, the lowest value was found in the seventh decade indicating that the subjects belonging to the seventh group were much slower in shifting their body weight from side to side and antero-posteriorly than the younger subjects.

The findings of this cross sectional study are similar to earlier reports on age related postural deterioration. Thus, postural instability is not uncommon in healthy elderly Indians. This occurs in the absence of any disease and may be attributed to the process of aging *per se*. Although, it may not manifest during day to day activities, this instability may have adverse consequences in certain conditions which demand high degree of postural adjustments. Keeping in mind the possibility of postural deficits in the absence of obvious disease, this section of population should be screened routinely to detect such inapparent postural deficits, followed by implementation of preventive measures to avoid adverse consequences.

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