International Journal of Otorhinolaryngology and Head and Neck Surgery
Ismail N et al. Int J Otorhinolaryngol Head Neck Surg. 2017 Jan;3(1):17-24
http://www.ijorl.com
pISSN 2454-5929 | eISSN 2454-5937

DOI: http://dx.doi.org/10.18203/issn.2454-5929.ijohns20164804

Original Research Article

Postural control among normal population of different age groups

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Received: 29 August 2016
Revised: 26 September 2016
Accepted: 04 October 2016

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ABSTRACT

Background: Postural control continues to change in later stages of life. Age-related changes may occur within or between sub-systems involved in postural control. It is thought clinically that these changes are important as they often result in falls & injury. The aim of the work was to compare the balance characteristics among different age groups using computerized dynamic posturography to provide clinicians with normal references.
Methods: Inclusion criteria were study group consisted of (30) normal healthy individuals, age range 16-79 years, with neither hearing nor vestibular complaints. It was divided into 3 age groups, each group consisted of 10 patients. Group (A) young- 16-39 years, group (B) middle- 40-59 years and group (C) elderly- 60-79 years. Exclusion criteria were history of neuromuscular or neuroskeletal disease, symptoms of unsteadiness, dizziness or vertigo, symptoms of impaired sensory function, symptoms of arthritis or lower limb problem, symptoms of uncorrected visual problems, symptoms of postural hypotension or diabetes, medication intake such as sedatives, hypnotics, anxiolytics & antidepressants. All participants were subjected to full history taking, otologic examination, basic audiologic evaluation, computerized dynamic posturography which included sensory organization test, limits of stability and rhythmic weight shift.
Results: Sensory organization test: The elderly group (C) had lowest equilibrium score with eyes open, closed & with conflicted visual cues on swayed surface (condition 6) and also this group have lowest percentage of SOT strategy. There was a statistically significant difference among A & C groups when using sensory organization test strategy in all conditions. Limits of stability test: The elderly group has higher overall reaction time. There was statistically significant difference in all conditions of limits of stability as regards directional control. Rhythmic weight shift right and left test: There was a statistically significant difference between groups A & C in low & medium speed on on-axis velocity & directional control. Rhythmic weight shift front & back test: There was no statistically significant difference between all groups as regards on-axis velocity. There was highly statistically significant difference between all groups in all trials as regards directional control.
Conclusions: Postural instability occurs frequently in healthy elderly subjects. Sensory organization test is the most effective test to compare balance function among different age groups.

Keywords: Posturography, Postural sway, Age effect, Sensory organization, Cognitive function

INTRODUCTION

Postural sway increases with age. Hence, it is important to study the changes in postural balance that occur with aging. Deterioration in postural control in elderly populations can be proved or explained by impaired cognitive function.[1-3] Also, decline in sensory inputs such as visual, vestibular, and somatosensory input lead to decline in motor responses with deterioration in sensory integration systems and other musculoskeletal and neuromuscular systems. These result in decreased muscle strength, impaired knee or plantar reflexes, slow reaction time, and decreased efficacy of protective movement.[2-4] Computerized dynamic posturography (CDP) is used to quantify an individual's change in body position and movement control when maintaining static and dynamic balance. This done by eliminating or sway referencing one's visual surround or conflicting somatosensory input by using a swaying support surface to evaluate the ability to maintain an upright posture.[5]

CDP has become an important tool for comprehending standing balance in clinical setting. The key test in dynamic posturography system is SOT which provides information about integration of multiple components of balance.[6]

The aim of the work was to compare between balance characteristics among different age groups using computerized dynamic posturography to provide clinicians with normal reference values.

METHODS

This study was carried out in Audiology and Vestibular Units of Hearing and Speech Institute, Giza, Egypt.

Subjects

The study group consisted of (30) healthy individuals that were divided into 3 age groups, each group consisted of 10 patients. Group A: Young age: 16-39 years; Group B: Middle age: 40-59 years; Group C: Elderly: 60-79 years.

Inclusion criteria

This study included 30 normal healthy individuals. Their age ranged from 16 to 79 years. They had no hearing or vestibular complaints, they were fully conscious well oriented to time, place & persons, cooperative & with normal mentality.

Exclusion criteria

History of neuromuscular and musculoskeletal diseases such as stroke, Parkinson's disease. Patients with symptoms of unsteadiness, dizziness or vertigo, impaired sensory function, arthritis or lower limb problem, uncorrected visual problems, postural hypotension and diabetes, medication intake such as sedatives, hypnotics, anxiolytics, and antidepressants.

Equipment

Two channel audiometer (Interacoustics, model AC40) with air & bone conduction facilities; sound treated room (I.A.C model 1602); middle ear analyzer (Interacoustics model Az26); computerized dynamic posturography long forceplate: (Neurocom version 8, Smart Balance Master).

All participants in this study were subjected to full history taking, otological examination and basic audiological evaluation in the form of-

Pure tone audiometry

- Air conduction thresholds were tested at the following frequencies 0.25, 0.5,1,2, 4 & 8 KHz.
- Bone conduction thresholds were tested at the following frequencies 0.5, 1, 2 & 4 KHz.

Speech audiometry

This included speech reception threshold testing (SRT) using Arabic spondee words and word discrimination score test using Arabic phonetically balanced (PB) words.[7]

Acoustic immittance testing

It included tympanometry and acoustic reflex threshold measurements.

Computerized dynamic posturography (CDP)

CDP provides quantitative assessment of both sensory and motor components of postural control along with how the sensory inputs to the brain interact.[8]

Sensory organization tests (SOT)

SOT provides an extremely sensitive objective assessment of the main sensory systems involved in balance and stability.[8] It objectively identifies problems with postural control by assessing the patient's ability to make effective use of (or suppress inappropriate) visual, vestibular, and proprioceptive information.[9]

Limits of stability (LOS)

This test quantifies the furthest distance in any direction a person can lean away from midline (vertical) without altering the original base of support (either by stepping, reaching ,or falling).[9]

Rhythmic weight shift (RWS)

The RWS test quantifies the patient's ability to rhythmically move their center of gravity (COG) from left to right (lateral) and forward to backward (anterior/posterior) between two targets at three distinct speeds: slow (3 second peak to peak pacing), medium (2 second pacing), and fast (I second pacing).

Statistical methods

IBM SPSS statistics (V. 22.0, IBM Corp., USA, 2013) was used for data analysis. Date was expressed as Mean ±SD for quantitative parametric measures. The following tests were done:

Comparison between more than 2 patient groups for parametric data using Analysis of Variance (ANOVA).

The multiple comparisons (Post-hoc test or least significant difference, LSD) were also followed to investigate the possible statistical significance between one group and other 2 groups. The probability of error at 0.05 was considered significant, while at 0.01 and 0.001 were highly significant.

RESULTS

Sensory organization test

Table 1 showed no statistically significant difference between all groups in conditions 1 to 5 and statistically significant difference in condition 6 of SOT as regards equilibrium score.

Table 2 showed that there is non-statistically significant difference between all groups from condition 1 to 4 and statistically significant difference between group B&C and A&C in condition 5 & 6.

Table 3 showed high statistically significant difference in conditions 1-3-6 and statistically significant difference in conditions 2-4-5 between all groups as regards to sensory organization test strategy.

Table 4 showed that there is statistically significant difference between group A & C in all conditions. There is no statistically significant difference between groups B &C in all conditions. There is statistically significant difference between groups A & B in condition 6 only.

Table 1: ANOVA Table showing comparison of different age groups as regard equilibrium score of sensory organization test.

SOT (Equilibrium) Deg/sec		Age group			F value	p value
		A	B	C		
C1	X	95.65	94.6	94.6	2.29	0.121
	SD	0.8835	1.5951	1.2202		
C2	X	92.65	91.6	91.6	3.947	0.31
	SD	1.7958	1.9972	1.8529		
C3	X	92.76667	92.4	91.13333	2.166	0.134
	SD	1.555952	1.608619	2.272759		
C4	X	86.63333	85.86667	85.2	0.31	0.736
	SD	4.489906	4.894441	2.389276		
C5	X	70.9	69.46667	67.166	0.949	0.4
	SD	5.479592	5.5848	7.137538		
C6	X	77.46667	71.26667	71.3	3.751	0.037*
	SD	4.169851	7.284009	5.611826		

$P < 0.01$ = HS $P < 0.05$ = S $P > 0.05$ =NS

Table 2: Multiple comparison using least significant difference in SOT (equilibrium score).

Age groups	C1	C2	C3	C4	C5	C6
Groups A&B	0.075	0.408	0.66	0.677	1	0.99
Groups A&C	0.075	0.604	0.058	0.433	0.022*	0.025*
Groups B&C	1	0.183	0.136	0.717	0.022*	0.025*

Table 3: ANOVA Table showing comparison of different age groups as regards sensory organization test strategy.

SOT (Strategy) deg.		Age group			F value	p value
		A	B	C		
C1	X	99.95	99.45	99.15	5.9	0.007**
	SD	0.1581	0.4972	0.7472		
C2	X	99.9	99.35	99.2	3.485	0.045*
	SD	0.3162	0.6687	0.7888		
C3	X	99.96667	99.26667	98.8	7.838	0.002**
	SD	0.105409	0.624599	0.958394		
C4	X	84.73333	81.36667	78.23333	2.801	0,049*
	SD	4.88333	5.984445	7.314876		
C5	X	75.8	69.16667	64.26667	4.388	0.022*
	SD	7.348805	7.83353	10.66412		
C6	X	79.36667	69.7	65.73333	7.635	0.002**
	SD	3.386429	10.254117	8.752848		

Table 4: Multiple comparison using least significant difference in sensory organization test strategy.

Age group	C1	C2	C3	C4	C5	C6
Groups A&B	0.43	0.059	0.056	0.231	0.101	0.012*
Groups A&C	0.002**	0.018*	0.001**	0.025 *	0.006**	0.001**
Groups B&C	0.213	0.596	0.127	0.264	0.221	0.279

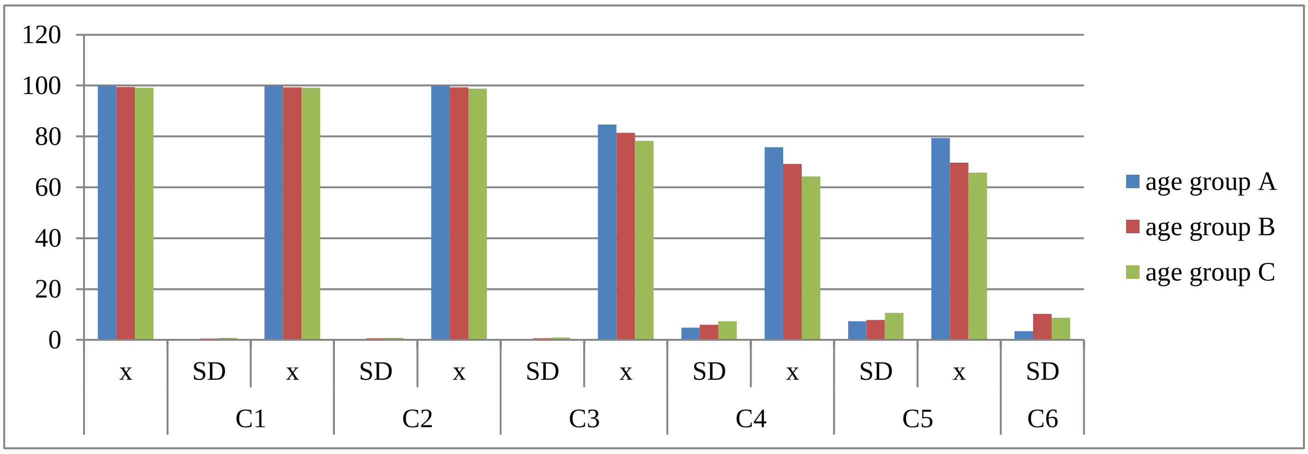

Figure 1: Showing comparison of different age groups as regards sensory organization test strategy.

Limits of stability

Reaction time

Table 5 showed non-statistically significant difference in all conditions as regards reaction time of limits of stability. (F=front, RF=right front, R= right, RB=right back, B=back, LB=left back, L=left, LF=left front).

Directional control

Table 6 showed that there is high statistically significant difference in conditions (RF-RB-LB), statistically significant difference in condition (LF) and non-statistically significant difference in conditions (F-R-L) as regards to directional control of limits of stability.

Table 5: ANOVA table showing comparison between different age groups as regards reaction time of limits of stability.

LOS (RT) sec		Age group A	Age group B	Age group C	F value	p value
F	X	1.153	1.232	1.778	1.893	0.17
	SD	0.77629	0.36064	1.05036		
RF	X	0.76	0.942	0.878	0.526	0.597
	SD	0.47067	0.41384	0.30524		
R	X	0.866	0.907	1.451	7.989	0.061
	SD	0.36142	0.33863	0.39388		
RB	X	0.989	0.833	1.349	3.063	0.36
	SD	0.32288	0.35141	0.67691		
B	X	0.779	1.038	1.212	1.233	0.307
	SD	0.39543	0.48412	0.87444		
LB	X	0.988	0.713	1.171	2.692	0.086
	SD	0.26038	0.45891	0.56017		
L	X	1.112	1.025	1.338	1.017	0.375
	SD	0.31499	0.60185	0.55561		
LF	X	1.081	0.724	1.002	1.857	0.176
	SD	0.46417	0.48525	0.34214		

Table 6: ANOVA table showing comparison between different age groups as regards to directional control of limits of stability.

LOS (DCL)%		Age group A	B	C	F value	p value
F	X	81.6	79.8	77.2	0.112	0.894
	SD	29.3455	18.7427	9.9085		
RF	X	73	75.8	51.7	12.357	0.000**
	SD	15.9095	9.7502	8.5771		
R	X	88.9	80.6	77.7	1.873	0.173
	SD	4.9092	4.5265	22.2863		
RB	X	77.2	68.8	46.6	14.056	0.000**
	SD	14.7558	9.8635	14.7814		
B	X	76.4	80.1	57.5	3.38	0.049*
	SD	19.3115	5.6853	29.9824		
LB	X	77.4	71.6	52.9	5.807	0.008**
	SD	17.1088	14.4699	18.5679		
L	X	87.4	84.8	80.4	2.37	0.113
	SD	7.8909	7.1616	6.7032		
LF	X	83.5	75.5	63.5	4.133	0.027*
	SD	10.4907	14.2614	20.544		

Table 7: Multiple comparison using least significant difference as regards to directional control of limits of stability.

Age groups	F	RF	R	RB	B	LB	L	LF
Groups A&B	0.849	0.602	0.178	0.17	0.695	0.447	0.431	0.263
Groups A&C	0.642	0.00**	0.073	0.00**	0.053	0.003**	0.04*	0.008**
Groups B&C	0.783	0.00**	0.633	0.001**	0.022*	0.019*	0.187*	0.098

Table 8: ANOVA table showing comparison between different age groups as regards to directional control of rhythmic weight shift (right & left).

Age group	DCL in % Low		Medium		Fast	
	X	SD	X	SD	X	SD
A	80.4	4.55	87	3.86	89	2.94
B	76.3	9.14	80.8	5.37	82.9	9.0
C	67.3	9.41	79.3	4.85	84.6	5.56
f value	6.989		7.428		2.465	
p value	0.004**		0.003**		0.104	

Table 9: Multiple comparison using least significant difference as regards to directional control of rhythmic weight shift (right & left).

Age groups	Low	Medium	Fast
Groups A&B	0.263	0.007 **	0.041 *
Groups A&C	0.001 **	0.001**	0.132
Groups B&C	0.018 *	0.485	0.554

Table 7 showed non statistically significant difference between group A&B in all conditions, high statistically significant difference between group A&C in all conditions except (B) and statistically significant difference between group B&C in all conditions except (F&LF) as regards to directional control of limits of stability.

Rhythmic weight shift

Table 8 showed high statistically significant difference in low and medium speed and non-statistically significant difference in fast speed as regards to directional control of rhythmic weight shift (right & left).

Table 9 showed that there is statistically significant difference between groups A&B in medium speed and between A&C in low & medium speed, and between B&C in low speed as regards to directional control of rhythmic weight shift (right & Left).

Table 10 showed that there was high statistically significant difference in all conditions of directional control of rhythmic weight shift (front & back).

Table 10: ANOVA table showing comparison between different age groups as regards to directional control of rhythmic weight shift result (front & back).

Age group	DCL (%)					
	Low		Medium		Fast	
	X	SD	X	SD	X	SD
A	83	6.98	6.98	7.16	87.8	5.53
B	78.9	3.54	3.54	5.27	80	6.09
C	67.5	8.78	8.78	11	76.3	9.93
f value	13.984		8.593		6.213	
p value	0.000**		0.001**		0.006**	

Table 11: Multiple comparison using least significant difference as regards to directional control of rhythmic weight shift (front & back).

Age groups	Low	Medium	Fast
Groups A&B	0.188	0.272	0.027*
Groups A&C	0.00**	0.00**	0.002**
Groups B&C	0.001**	0.007**	0.276

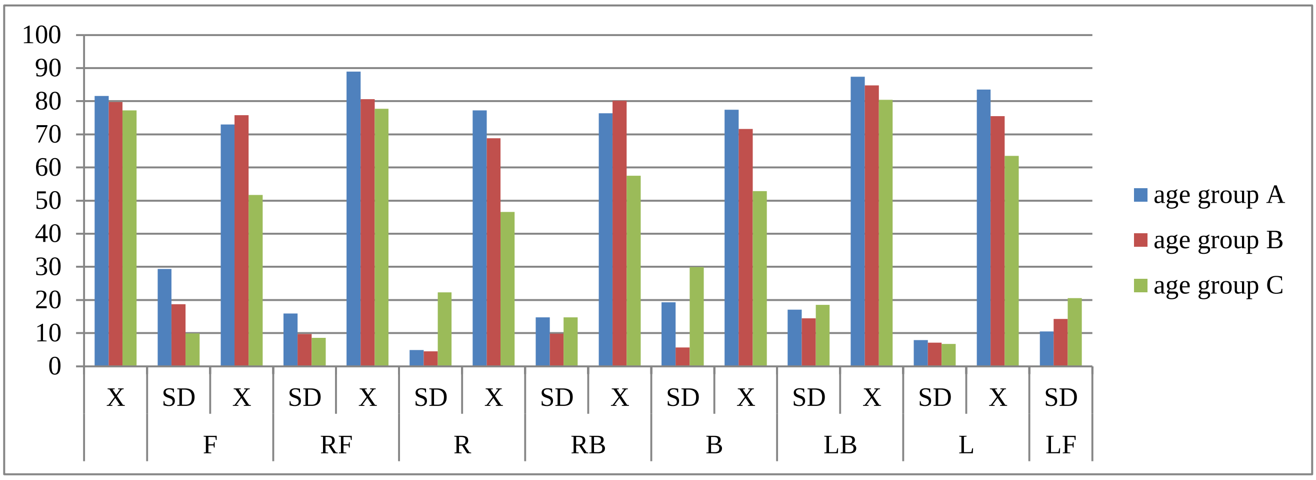

Figure 2: Showing comparison between different age groups as regard to directional control of limits of stability.

Table 11 showed that there was statistically significant difference between groups A&B in fast speed, between A&C in all conditions and between groups B&C in low & medium speed conditions as regards to directional control of rhythmic weight shift (front & back).

DISCUSSION

CDP is used to quantify an individual's change in body position and movement control when maintaining static and dynamic balance by eliminating or sway- referencing one's visual surround, or conflicting somatosensory input by using a swaying support surface to evaluate the ability to maintain an upright posture.[5]

Sensory organization test (SOT)

In the present study, regarding equilibrium scores Table (1) showed that the elderly group (C) had the lowest equilibrium score with eyes open and closed & with conflicted visual cues on a fixed support surface (condition 3). There was no statistically significant difference between all age groups in (condition1 to 5) and statistically significant difference was present in swayed support surface with conflicted visual cues (condition 6). However, similar results were obtained by, who found no age-related increase in postural sway of subjects standing on a fixed support surface with their eyes open or closed.[10] In the present study, multiple comparisons using least significant difference was done and showed statistically significant differences between groups A & C and also between groups B & C on swayed support surface with absent or conflicted visual cues (conditions 5&6). Meanwhile, there was no statistically significant difference between groups A& B in all conditions as shown in Table 2. This is also in agreement with other authors who reported that the elderly group had the lowest average maximal stability with eyes open and closed, and with conflicted visual cues on a fixed support surface than young and middle age groups.[5,11] This may be attributed to that all age groups are depending more on proprioception than on vision to maintain balance. However, in the absence of reliable pressoreceptor information, dependence on vision is increased.

Sensory organization strategy as ankle strategy, is used to correct small amounts of postural sway that occur as a result of slow, small perturbations on a firm wide surface. Hip strategy is usually used for quick postural adjustment needed to correct larger, more rapid perturbations or when the support surface is small. Stepping strategy is also used when the ankle and hip strategies are inadequate, where an individual realigns the base of support during rapid or large perturbations.[12] In the present study, Table 3 showed statistically significant differences among 3 groups when using SOT strategy in all conditions of sensory organization test. Multiple comparison using least significant difference was done and showed that there was statistically significant difference between groups (A) & (C) in all conditions of sensory organization test. This may be due to age difference. There was no statistically significant difference between groups (B) & (C) and between groups (A) & (B) except in condition 6 as shown in Table 4. This may be due to that the condition (6) is very difficult where visual and somatosensory cues were conflicted and normal persons needed to use more hip strategy to a greater extent under variable visual & proprioception cues (conditions 5 & 6).

This in agreement with who reported that there was a significant difference in the average percentage of strategy between the elderly and young groups in conditions 5 and 6 and between the elderly and middle aged groups in condition.[5,13] Elderly subjects use hip strategy to a greater extent to maintain their postural balance when visual cues were absent and the reference support swayed as in condition.[5] Also they use it when visual surround was conflicted and the reference support swayed as in condition.[6]

Limit of stability (LOS)

As shown in Table 5 there were no statistically significant difference between groups as regards reaction time which is the time in seconds between the command to move and the patient's first movement. The elderly group had the longest reaction time. This increase of reaction time with progression of age suggests slower processing of information in the CNS in elderly subjects. However it doesn’t reach statistical significant value may be due to small sample size & difficult task. Meanwhile, same finding was previously reported by Lord et al.[14] Also similar results were obtained by Borah et al who found that shortest reaction time was found in 1st decade whereas the longest reaction time was recorded in the 7th decade.

In the present study, Table 6 showed that there was statistically significant difference in almost all conditions of limits of stability as regards directional control. This is a comparison of the amount of movement in the intended direction (towards the target) to the amount of extraneous movement (away from the target). Multiple comparisons using least significant difference was done and showed non-statistically significant difference between groups (A&B) in all conditions. A statistically significant difference was present between groups (A&C) in all conditions and between groups (B&C) in 5 out of 8 conditions as shown in Table 7. This may be due to delay in CNS processing in old age, as cerebral cortex & cerebellum are key structures in modifying actions through constant analysis of information & comparing one movement with target movement.[15]

Rhythmic weight shift (RWS)

Table 8 showed a high statistically significant difference between groups in low & medium speed regarding rhythmic weight shift results of directional control. This is a comparison between the amount of movement in the intended direction (toward the end line) to the amount of extraneous movement (away from the end line) to right and left test. Multiple comparison using least significant difference was done and showed that there was a high statistically significant difference between groups (A&C) in low & medium speed & a statistically significant difference between groups (B&C) in low speed and between groups (A&B) in medium & fast speed regarding directional control as shown in Table 9. Table 10 showed highly statistically significant difference between groups in all trials as regards directional control of front & back test. Multiple comparisons using least significant difference was done and showed that there was high statistically significant difference between groups (A&C) in all trials, between groups (B&C) in low & medium speed and also between groups (A&B) in fast speed in directional control as shown in Table 11. This may be due to age related changes as there is a slow processing of visual-vestibular- somatosensory inputs or conflict of one of them. So, postural control becomes more challenging, filtering, integration & interpretation of the conflicting inputs. Similar results were obtained by Liaw et al who reported a lower average percentage of directional control in the right/left test forward/backward RWS test than the young group.

The effect of different modes of therapy on vestibular and balance dysfunction in Parkinson's disease using CDP for balance assessment was investigated by and they reported that the highest percentage of affection was in the sensory organization test (SOT).[16] So organization protocols are useful for the assessment of postural control under various sensory conditions and generally accepted as a reliable paradigm of measuring the capacity of the central nervous system to prioritize and reintegrate sensory information.

CONCLUSION

Postural instability occurs frequently in healthy elderly subjects. Sensory organization test is the most effective test to compare balance function among different age groups.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Ismail N, Abd El-Salam GS, Fathi A. Postural control among normal population of different age groups. Int J Otorhinolaryngol Head Neck Surg 2017;3:17-24.