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RESEARCH ARTICLE

Decreased Cervical Kinesthesia in Elderly Do Not Impair Their Balance Abilities

Juliana Lopes Aguiar[1], Delmas Luis Freitas Rodrigues[2], Givago da Silva Souza[3] and André dos Santos Cabral[4*]

[1]*Physiotherapist Course, Department of Human Movement Sciences, University of State of Pará, Santarém, Pará, Brazil*

[2]*Academic of Physiotherapy Course, University of State of Pará, Santarém, Pará, Brazil*

[3]*Professor Ph.D., Federal University of Pará, Belém, Pará, Brazil*

[4]*Professor Ph.D., Pará State University, Belém, Pará, Brazil*

***Corresponding author:** *André dos Santos Cabral, Department of Human Movement Sciences, Biological Science and Health Center, Pará State University, Tv. Perebebuí, 2623 - Marco, 66087-670, Belém, Pará, Brazil, E-mail: ascfisio@gmail.com*

Abstract

Objective: To correlate the cervical kinesthesia and the level of balance ability in elderly subjects.

Methods: Sixty healthy elderly subjects, with sedentary life style (71.12 ± 6.92 years-old), performed test for positioning error of cervical joint, Romberg test (RT), Sensitized Romberg test (SRT), and Timed Up and Go test (TUG).

Results: The positioning error of cervical joint was less than 5 cm in 13% of the sample. We observed no impairment in the static balance of the subjects; however, the SRT with visual aid demonstrated that 75% of the sample had balance disorders and 80% had balance disorders without visual support. All subjects performed TUG with duration smaller than 20 s, demonstrating preservation of dynamic balance. The correlation between cervical joint position sense and decrease static balance was higher than others associations with and without visual aid. The correlation between decrease static balance and impaired cervical joint position sense without visual aid and with bilateral impairment was higher than observed in unilateral deficit. The prevalence of these associations without visual aid was higher than those observed with visual support. The prevalence ratio to parameters association was not significant.

Conclusion: There was a high prevalence of decreased cervical kinesthesia in healthy elderly people; however, this fact does not determine a clinical balance disorder.

Keywords

Proprioception, Cervical kinesthesia, Balance, Aging

Introduction

The perception of position and joint movement, muscular tension and length, adjacent static structures strength and compression such as dermis and epidermis are important variables utilized by central nervous system, both to elaborate and to correct the voluntary motor act, as well as to start motor patterns already set in neural engrams in ontogenetic development of central nervous system [1].

Many studies have been demonstrated how factors, such as senescence [2-4], muscular fatigue [5-7], vibratory stimuli [8,9], the cold [10,11] and the pain [12-15] affect in proprioceptive perception. The chronic neck pain impairs the perception of neck position, and his motor coordination [12,13,15-19]. This repercussion is a common finding in patients with whiplash syndrome, which is evidenced by the loss of accuracy in cervical joint repositioning volunteer movement [13,17-19].

The possible reasons for the loss kinesthetic sense are the interference of pain in processing of cervical sensations [12,14-19] as well as changes in intrinsic muscle structure accompanied by fat infiltration [20-23]. However, because a neuroanatomical and functional relationship between the sensorial system in level of the first cervical vertebrae and central nervous system responsible for corporal balance, it was observed that

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exist a balance impairment in patients with chronic neck pain [24-28].

Many physiological changes by senescence process are very close to those evidences on whiplash pain development and their repercussions, such as muscular hypotrophy, infiltration of fat and conjunctive tissues and decreased cervical kinesthesia [4,19,29]. These changes impair the balance abilities in elderly people [29,30].

In the present study, we investigated the association between decreased cervical kinesthesia in healthy elderly people and impairment of balance in this population.

Methods

The present study was performed in three steps: Sample composition, evaluation of cervical kinesthesia and evaluation of balance. To compose the sample, the blood pressure was checked and a form with questions about cervical pain, and vestibulopathy (Dizziness Handicap Inventory) [31] was applied. Furthermore, the Dix-Hallpike test and vestibulo-ocular reflex was tested. We evaluated sixty healthy elderly subjects, with no habit of regular physical activity (30 males, 73.33 ± 6.1 years-old; and 30 females, 70.10 ± 7.4 years). People unable to ambulate, with any neurological and vestibular diseases, neck pain, alcoholism history, diabetes, systemic arterial hypertension or casual arterial hypertension and visual impairments were excluded. We used a sphygmomanometer and a stethoscope to check the blood pressure, a pen and a clipboard to relevant data notes, a blindfold, a fixed target with scale, an arch to head with laser pen coupled and a professional stopwatch. The evaluation of cervical kinesthesia was performed following the clinical test described by Reis [27].

Evaluation of cervical kinesthesia

The evaluation of cervical kinesthesia was performed with the subject in seated position gazing in a target at 90 cm of nasal base. A laser pointer was fixed over subject head, with the light focusing at the center of target. So, we requested to the subject to rotate the neck in approximately 45° of cervical spine, for later return to starting position. This procedure was performed three times for each side (right and left) with and without the visual aid followed by repositioning error corrections for each subject.

The accuracy of joint repositioning test was represented by the average of absolute positioning error of cervical joint (APECJ). The limit of 5 cm of absolute error average was established how normal value [27].

Evaluation of balance

The static balance was evaluated using *Romberg test* (RT) and *Sensitized Romberg test* (SRT), both with and without visual aid. The dynamic balance was evaluated using *Timed Up and Go test* (TUG) [32].

The subjects who failed to maintain RT position during at least 30 s was marked with a static balance deficit. We considered dynamic balance deficits were shown to those people that finished TUG more than 20 s [32].

Results

The values of cervical kinesthesia right (R) and left (L) to each gender have a normal distribution (*D'Agostino test*). There was significant difference of APECJ between male R and L rotation (RR an LR) with higher values to the LR (*Student's t-test, $P < 0.05$*). Also, female group had higher APECJ values than the male group for RL (*Student's t-test, $P < 0.05$*). Table 1 is shown the values of APECJ estimated from the present study.

The data was analyzed without gender distinction. We observed that 50% of the sample had alterations for bilateral rotation, 36.66% of the sample had alterations for unilateral rotation and 13.33% of the sample showed no kinesthesia alterations (Table 2).

Furthermore, the mean APECJ values in those subjects that showed no alterations was 3.86 ± 0.71 cm for RR and 3.81 ± 0.53 cm for LR; 5.08 ± 1.31 cm for RR and 5.42 ± 2.11 cm for LR in subjects that showed unilateral alterations, and; 7.74 ± 1.73 cm for RR and 6.64 ± 1.03 cm for LR in subjects that showed bilateral alterations. There are significant differences between those values (*$P < 0.05$*). With application of linear correlation,

Table 1: APECJ minimum and maximum values (cm), APECJ average (cm), APECJ standard deviation (SD) and prevalence rate of subjects with decreased cervical kinesthesia for each gender and total sample.

		Amplitude (cm)	Average (cm)	SD (cm)	Amplitude (degrees)	Average (degrees)	DP (degrees)	(%)
Male group	**RR**	2.77-11.72	6.44*	2.33	1.76-7.46	4.10	1.48	20 (n = 06)
	LR	2.03-7.73	5.11*	1.53	1.29-4.92	3.25	0.98	10 (n = 03)
	Bilateral	-	-	-	-	-	-	53.33 (n = 16)
Female group	**RR**	3.2-1.12	6.05	1.91	2.04-7.08	3.85	1.22	16.67 (n = 05)
	LR	3.45-10.30	6.19*	1.68	2.19-6.54	3.94	1.07	26.67 (n = 08)
	Bilateral	-	-	-	-	-	-	46.67 (n = 14)
Total	**RR**	2.77-11.72	6.24	2.12	1.76-7.46	3.97	1.35	18.33 (n = 11)
	LR	2.03-10.03	6.19	1.68	1.29-6.54	3.93	1.07	18.33 (n = 11)
	Bilateral	-	-	-	-	-	-	50 (n = 30)

*$p > 0.05$.

Table 2: Agreement and disagreement condition of kinesthesia evaluation.

Condition	Evaluation	n = 60	%
Agreement	↓ R/L kinesthesia	30	50
	Normal kinesthesia	8	13.33
Disagreement	↓ Right kinesthesia	11	18.33
	↓ Left kinesthesia	11	18.33

Table 3: Relation with cervical kinesthesia and static balance evaluated with and without visual aid.

Association	↓CK + ↓B	↓CK + B	CK + ↓B	CK + B
EO	66.67%*	20%*	8.33%	5%
EC	71.67%**	15%**	8.33%	5%

(*and **) *Chi-squared Test* ($p < 0.05$).

Table 4: Percentage of Unilateral (Uni.) or bilateral (Bi.) cervical kinesthesia (CK) condition associated with balance conditions (B).

	↓CK Bi. + ↓B	↓CK Uni. + ↓B	↓CK Bi. + B	↓CK Uni. + B	CK + ↓B	CK + B
EO	41.67*	25*	8.33	11.67	8.33	5
EC	45*	26.67*	5	10	8.33	5

**Chi-squared Test ($p < 0.05$).*

relating degree of impaired cervical kinesthesia (No impaired kinesthesia, unilateral impaired kinesthesia and bilateral impaired kinesthesia) with the prevalence of these conditions (%), the R value was 0.95. The same occurred when the mean APECJ values were connected with mean TUG values between normal classification, unilateral alterations and bilateral alterations.

No alterations were found in RT, performed with eyes open (EO) and eyes closed (EC), for both gender. During the SRT done with EO, 76.67% of the sample presented balance alterations. On the other hand, 83.33% of the sample presented SRT alterations with EC. The male group had 17.62 ± 9.08 s (EO) and 11.72 ± 10.21 s (EC) of mean SRT time. *Student's t-test* demonstrated statistical difference ($P < 0.05$) between these values.

For the female group, 73.33% had balance alterations during SRT done with EO and 76.67% had balance alterations for the same test done with EC. The mean duration was 17.75 ± 9.05 s (EO) and 12.33 ± 11.21 s (EC) with statistical difference between this two conditions ($p < 0.05$). Comparing both variations of SRT (EO/EC), there are no statistical differences between the male and female groups.

Changes in TUG duration were not found (duration < 20 s), which means that functional mobility and balance were preserved. The mean TUG duration was 11.22 ± 2.35 s for the male group and 13.21 ± 2.78 s for the female group. *Student's t-test* demonstrated that mean duration of the female group was higher than that from male group ($p < 0.05$). The mean duration for both genders was 12.22 ± 2.74s. Therefore, 63.33% of men executed TUG until 10 s and 36.67% between 11 to 20 s. In the group of women, 23.33% executed TUG until 10 s and 76.67% between 11 to 20 s.

When we analyzed the relation between cervical kinesthesia and static balance with EO, 66.67% of the sample had decreased (↓) cervical kinesthesia (CK) and decreased balance (B), 20% just decreased cervical kinesthesia, 8.33% only decreased balance and 5% had no alterations. The *chi-squared test* checked that ↓CK and ↓B association was higher ($p < 0.05$) than other associations (Table 3).

The same relation of previous paragraph, but done with EC, demonstrated that 71.67% of the sample had decreased cervical kinesthesia and decreased balance, 15% just decreased cervical kinesthesia, 8.33% only decreased balance and 5% had no alterations. ↓CK and ↓B association was higher ($p < 0.05$) than other associations (Table 3).

There was no statistical difference ($P < 0.05$) between the relation with cervical kinesthesia and static balance for the EO and EC variations (Table 3).

We observed that 41.67% of the sample had decreased bilateral cervical kinesthesia and decreased static balance, 25% had decreased unilateral cervical kinesthesia and balance alterations, 8.33% had no alterations in cervical kinesthesia and decreased balance and 5% had no alterations. The *chi-squared test* checked statistical difference ($p < 0.05$) between decreased bilateral cervical kinesthesia associated with decreased balance in relation to unilateral alteration associated with decreased balance, when that is tested with EO (Table 4).

There were no changes when we analyzed the association of unilateral or bilateral cervical kinesthesia with balance alterations when that is tested with EC. It was found that 45% of the sample had decreased bilateral cervical kinesthesia and decreased static balance, 26.67% had decreased unilateral cervical kinesthesia and balance alterations, 5% had decreased unilateral cervical kinesthesia and normal balance, 10% had decreased bilateral cervical kinesthesia and normal balance, 8.33% had no alterations in cervical kinesthesia and decreased balance and 5% had no alterations.

The *chi-squared test* demonstrated statistical difference ($P < 0.05$) between the prevalence of decreased bilateral cervical kinesthesia associated with decreased balance in relation to unilateral alteration associated with decreased balance. This test also proved statistical difference of decreased bilateral cervical kinesthesia associated with decreased balance between EO and EC.

The prevalence ratio (PR) and odds ratio (OR) demonstrated association between kinesthesia alterations in elderly people with decreased static balance when that is tested in a sensitized way, with EO or EC. But, these

Table 5: PR and OR values to decreased kinesthesia (unilateral and/or bilateral) associated with static balance conditions.

	Associations prevalence	PR	CI (95%)	OR	CI (95%)
EO	**↓CK Uni. and Bi. + B**	1.23	0.71 - 2.15	2	0.41 - 9.61
	↓CK Bi. + ↓B	1.31	0.76 - 2.33	**2.76***	0.49 - 5.52
	↓CK Uni. + ↓B	1.13	0.63 - 2.05	1.46	0.27 - 7.8
EC	**↓CK Uni. and Bi. + B**	1.32	0.76 - 2.3	2.87	0.57 - 14.22
	↓CK Bi. + ↓B	1.44	0.83 - 2.5	**5.4***	0.83 - 34.8
	↓CK Uni. + ↓B	1.16	0.64 - 2.11	1.6	0.28 - 8.85

*Change in OR value to without visual aid condition for ↓CK Bi. + ↓B association.

results did not demonstrate statistical difference ($p > 0.05$).

The prevalence ratio of decreased bilateral or unilateral cervical kinesthesia associated with decreased balance was 1.23 (CI95%: 0.71-2.15) times higher in our sample and demonstrate us a chance of occurrence of 2 (CI95%: 0.41-9.61) times more in people with decreased kinesthesia (Table 5).

The reduction of bilateral kinesthesia and balance presents an RP of 1.31. The odds ratio was 2.76 (CI95%: 0.49-15.52) times reduced balance when compared those subjects without decreased kinesthesia. For this association with decreased unilateral kinesthesia, the RP of 1.13 (CI95%: 0.63-2.05) and the odds ratio was only 1.46 (CI95%: 0.27-7.8) (Table 5).

We also observed smaller confidence intervals (CI) for the prevalence ratios, suggesting more reliable estimates. However, analyzing CI, both ratio results between EO variables did not present statistical significance ($P > 0.05$). These same parameters, analyzed from balance evaluation with EC, demonstrated prevalence ratio of decreased kinesthesia (unilateral and bilateral) associated with decreased balance were 1.32 (CI95%: 0.76-2.3) and this relation had 2.87 (CI95%: 0.57-14.22) times more chances of occur in those individuals with decreased kinesthesia (Table 5).

The decreased bilateral cervical kinesthesia associated with decreased balance presents PR = 1.44 (CI95%: 0.83-2.5). The odds ratio demonstrated 5.4 (CI95%: 0.83-34.8) times more chances of occur in elderly subjects with decreased kinesthesia. People with only unilateral dysfunction presents PR = 1.16 and odds ratio demonstrate 1.6 (CI95%: 0.28-8.85) times more chances of occur in association (Table 5).

Although these values call enough attention, the confidence intervals did not demonstrated statistical significance to categorize evaluated associations (Table 5).

Discussion

In the present study, we evaluated cervical kinesthesia in elderly people with mean age (71.72 ± 6.92) and sample size (n = 60) higher than other studies [4,19,26,28,32].

Just a few studies in literature investigated cervical kinesthesia in elderly people and only three of then considered the age a predisposing factor for decreased kinesthesia [4,19,28]. One of them [19] investigated a group of 11 subjects with neck pain and mean age of 41.1 ± 13.3 years-old and control group with 11 subjects with mean age of 39.3 ± 10.3 years-old. Another study [4] included 20 middle aged adults without history of neck pain and mean age of 54.5 ± 5 years-old, 20 subjects with neck pain and mean age of 58.8 ± 5.7 years-old and a young people control group with mean age of 21.9 ± 3.9 years-old. The most likely work [28] investigate eighteen young (mean age = 23 yrs) and 18 older healthy adults (mean age = 68 yrs). Our research agreed with these studies that concluded that the age has direct influence in cervical kinesthesia, however none investigate any influence in the balance ability in elderly.

The normal data distribution and insignificant gender differences allowed main points, such as kinesthesia and balance, were analyzed together, without sample division; however some peculiarities were highlighted separately per gender.

Cervical kinesthesia in the elderly is decreased independent of gender

The APECJ average values measured was above normal (5 centimeters) for sample studied, which means that the most of sample (86.66%) has cervical kinesthesia alterations, even with a previously training before the procedure. There were differences between RR male average values and LR female average values, however this fact has no relevance because it is related to some kind of learning occurred in orientations or some test procedure, considering that the tests started with RR and RE demonstrated a lower average value.

Because of similarity of values between genders and because of cervical kinesthesia differences not influenced in categorical interpretations (normal or abnormal), these data were analyzed together, without sample division between genders.

A small part of the sample demonstrated alterations only for one side, without prevalence between right and left sides, however, half of the evaluated sample demonstrated decreased cervical kinesthesia to both sides, confirming that kinesthetic alteration is more related with a physiological aging process than any other type of change [30].

Alterations in cervical kinesthesia correlate with APECJ values and performance in TUG

Significant difference was observed between APECJ average values measured in subjects with normality condition and with unilateral or bilateral alterations. There was a highest mean APECJ value for those who had bilateral alterations than only unilateral alterations, which in turn had highest average than those within normal. We also observed a linear correlation (R^2 = 0.95) between kinesthetic condition and mean APECJ values, as well as this values and kinesthetic conditions and mean TUG values, suggesting that kinesthetic cervical condition is intimately linked to tests performances, may be a general functional condition of the individual.

The static balance of elderly is not clinically impaired; however, there is a relation between cervical kinesthesia and SRT performance

The fact of no abnormalities found in RT means that decreased cervical kinesthesia demonstrated by elderly does not impair clinically the balance like in neck pain [12,15,19,26] or whiplash syndrome [13,18,24,25]; however, increased difficulty of SRT demonstrate to us important adaptive mechanisms that central nervous system is able to perform to compensate the decrease of this proprioceptive ability, that can occur in all body during aging.

Vision is a compensatory adaptive mechanism for balance maintenance; however, other mechanisms also be involved

We checked a kind of visual aid to posture, direction of movement and positioning of body segments, but other mechanisms should be most important considering that visual acuity also affected by age [33]. This fact was observed when we took out the visual aid and some results changed. This was evidenced in evaluation of performance of SRT with EO (75%) and EC (80%); in evaluation of length of stay in SRT position with EO compared with EC (17.68 ± 8.98 s and 12.02 ± 10.63 s respectively, with $p < 0.05$ under review of *Student's t-test*); and in evaluation of prevalence of decreased kinesthesia associated with balance alterations, demonstrated in Table 4, where we observed that the condition without visual aid increases prevalence of this association (41.67% with EO and 45% with EC). This may be the probable explanation of no alterations found in dynamic balance test, since the test is done with visual aid.

Other fact that proves that there were other compensatory mechanisms beyond vision during aging process was, although there was a higher prevalence of the association between cervical kinesthesia and impaired balance with EC (71.67%), this was similar ($p > 0.05$) to that observed with EO (66.67%). In other words, the vision was important but was not determinative as a compensatory mechanism.

When we observed the unilateral or bilateral kinesthetic impairment, the kinesthetic variable defined increased prevalence of association higher than when we took out the visual aid (Table 4). Those with bilateral alteration have highest prevalence of association with worse performances in SRT so with EO (41.67%) as with EC (45%), when compared with those who have only unilateral kinesthetic deficit (EO: 25% and EC: 26.67%). Comparing the differences, considering the vision, the prevalence of association of decreased cervical kinesthesia and bad performance in SRT is 3.33% for EC and 1.67% for EO ($p < 0.05$) whereas the bilateral kinesthetic impairment in relation to unilateral promotes a difference of 16.67% with EO and 18.33% with EC ($p < 0.05$).

In TUG, we noted a significant difference in performance between genders. The male gender had better performance when compared to female gender (11.22 ± 2.35 s and 13.21 ± 2.78 s, respectively, with $p < 0.05$ under review of *Student's t-test*). The most of men (63.33%) that had better accuracy indices in kinesthetic evaluation, performed TUG in less than 10 s, whereas this score was achieved only by a minority of the women (23.33%) that had worse performance in kinesthetic evaluation. This can be explained by the difference of physiological aging between males and females. Women naturally have a small number of muscle fibers as compared to men [34].

There was no significant association between cervical kinesthetic deficit and balance alterations

Cross-sectional studies have limited analysis to establish associations between phenomena; however, PR was a good parameter for this type of study [35]. PR and OR demonstrated certain association between kinesthesia alteration in elderly associated with static balance decrease when it was tested in a sensitized way, with EO and EC, and we can also observe that these ratios were higher when proprioceptive deficit is higher, increasing to 5 times more likely to occur when the individual has bilateral kinesthetic deficit and test was performed without visual aid. This result showed no statistical significance. It was not possible in this study to categorize the association analyzed ($p > 0.05$).

Conclusion

This present study concluded that cervical kinesthesia was decreased in healthy elderly that not practicing physical activity, independent of gender. The APECJ impairment level may be an indicator of functional performance of the individual. In despite of the high prevalence of elderly people with decreased cervical kinesthesia, this fact did not affect elderly balance. Our results demonstrated that the vision was an important compensatory mechanism to maintaining balance but was not the only one. So, although higher prevalence of association between decreased cervical kinesthesia and bad performance in balance tests, there was no significant association between decreased cervical kinesthesia and impairment of balance in elderly.

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Ethical Statement

All the procedures in the present study agreed with guidelines for research involving humans of the Brazilian National Council of Health, 196/96 Resolution, being approved by Ethics Committee for Human Research of the Universidade do Estado do Pará.

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