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Original Research Article

Efficacy of Balance Scales in Fall Risk Identification in Elderly with Breathing Pattern Dysfunction - An Observational Study

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ABSTRACT

Background: Many studies have confirmed the efficacy and effect of postural system training on fall risk prevention but in this present study focus is on respiratory pattern variations and its relation to balance and fall risk, and to find out the sensitivity and applicability of scales in evaluation of balance and fall risk identification in elderly with breathing pattern dysfunctions.
Methods: Out of 247 subjects, 50 subjects were enrolled in this study, if they met the inclusion criteria. The subjects were assessed for breathing pattern disorders, and balance issues. Breathing and balance parameters were assessed using Nijmegen Questionnaire, Self-evaluating breathing questionnaire, Hi-lo breathing assessment, seated lateral expansion, respiratory rate, breath hold time, single breath count, Fullerton Advanced Balance Scale, Berg Balance Scale. All the parameters were measured at baseline, before the intervention. The interventions were Supine Breathing, Crocodile Breathing Seated Breathing, 90/90/90 breathing, and Breathing with Thera -band. After the intervention, parameters of respiratory rate, single breath count, Fullerton advance balance scale, and berg balance were measured.
Results: there was statistically significant difference in the parameter score, before and after the intervention. There was also a positive correlation between all the measured respiratory and balance parameters.
Conclusion: The result of this study shows that breathing pattern disorders have an effect on balance. Both Berg Balance Scale and Fullerton advanced balance can document fall risk identification in subjects with breathing pattern disorders, but Fullerton advanced balance scale appears to be more sensitive.

Key words: Balance, Elderly, FABS, BBS, breathing pattern dysfunction, BPD.

INTRODUCTION

Normal breathing, also known as diaphragmatic breathing, involves synchronized motion of the upper rib cage, lower rib cage, and abdomen. [(1)] Additionally, normal breathing requires adequate use and functionality of the diaphragm muscles. [(2,3)]

Abnormal breathing, involves breathing from the upper chest, characterized by greater upper rib cage motion, compared to the lower rib cage. [(4)]

Breathing pattern disorders (BPD) is defined as inappropriate breathing that is persistent enough to cause symptoms with no apparent organic cause, are present in a variety of individuals with musculoskeletal dysfunction. [(3)]

Thomas et al. have suggested that DB (Dysfunctional breathing) affects up to 10% of the general adult population and about

30% of adults with asthma. [5] Dysfunctional breathing is more prevalent in women than in men.

The mechanisms underlying disordered breathing involve physiological, psychological and biomechanical components, and these cannot be completely separated. [6]

Women are at higher risk due to hormonal influences, and stress. Studies have shown that women have higher respiration rate which is exaggerated during progesterone phase of menstrual cycle, [7] therefore BPD is dominant in females with a ratio of 2:1 to 7:1. [8]

According to WHO, fall is defined as, "An event which results in a person coming to rest inadvertently on the ground or floor or lower level."The normal ageing process involves alteration in the normal physiological systems which result in loss of independent living by decrease in the physical capacity, mobility and endurance. Globally falls are a major public health problem.

An estimated 6,46,000 fatal falls occur annually, the death rates due to falls are highest amongst adults over the age of 60.

Tripping, slipping over bathroom or toilet floors, falling on road and indulging in ambulatory activities, bathing has been identified as the most prevalent risk factors The most common predictor of falls are balance and gait abnormalities.

Control of balance involves maintaining postures, movements and equilibrium achieved by integration and coordination of vestibular, visual, auditory, motor, and pre motor system.

Biomechanically to achieve balance the center of gravity (COG) of the body should be perpendicular to the base of its support. This is achieved by feeding the information received through sensory organs and hence executing the coordinated and synchronized movements. Breathing has destabilizing effect on posture. [9]

These destabilizing effects are counteracted by the postural respiratory synergy. [10]

Studies show that hyperventilation leads to elevated reports of somatic symptoms, including disorientation, the central changes that accompany hyperventilation may influence balance system functioning. [11]

Muscle imbalances, postural balance disturbance are associated with anxiety, anxiety being linked to breathing pattern disorders. [12] Habitual, chronic, breathing pattern disorders interfere with normal function stabilizers like the transversusabdominis and the diaphragm. [13]

Many studies conducted have shown an interdependency of breathing and postural control Diaphragm and transversusabdominis play an important role in core stability, however movement of the diaphragm and ribcage displace the center of mass. [9]

Also, parasternal inter-coastal are involved in respiration as well as torso rotation, [14] thereby activating the same motor unit pools. Studies also suggest that there is activation of erector spinae during breathing and stance. [15]

The Berg Balance Scale (BBS) and Fullerton Advanced Balance Scales (FABS) can predict fall risk, when used for independently functioning community-dwelling older adults. [16]

As the age increases the Neuro-musculoskeletal and cardio-respiratory systems of the elderly will undergo age related changes, thereby leading to functional variations. Respiratory muscles have crucial role in postural control also; if there is any respiratory pattern variation this will have impact on stabilization system. Postural system integration is vital for respiration and balance, hence training of postural system and respiratory system can be considered for preventing balance and fall risk.

Many studies have confirmed the efficacy and effect of postural system training on fall risk prevention but in this present study focus is on respiratory pattern variations and its relation to balance and fall risk, and to find out the sensitivity and applicability of scales in evaluation of balance and fall risk identification in patients with BPD in elderly.

Participants:

Ambulatory elderly subjects aged above 65 years, subjects with breathing pattern disorders, subjects having nondependent respiration (without mechanical support) subjects having adequate vision, hearing, and understanding ability. Exclusion criteria subjects who weren't interested in giving consent, subjects having problems which have a role in balance, and stability, neuromuscular, skeletal or respiratory system diseases which had an impact on balance, posture (recent fractures, dislocations, etc.,), vestibular, metabolic, or neurological diseases (Stroke, Parkinson's, etc.,), cardiac in-competencies, orthostatic hypotension, and other diseases. All the subjects were informed about the nature of the study and written informed consent was obtained. The study was approved by the ethical committee of Nizam's Institute of Medical Sciences.

Study Procedure:

Balance Testing: The postural balance was evaluated using the Fullerton's advanced balance (FAB) scale and Berg balance scale (BBS). In addition to evaluating the multiple dimensions of balance in both static and dynamic environments, the FAB scale challenges the balance abilities of independently functioning older adults.

The scale grades all the activities from 0 to 4, with a maximum score of 40 (FABS) and 56 (BBS). The cut-off score of FABS scale is 25/40, which indicates moderate to high risk of falls.

Breath holding time: Participants were asked to hold their breath until they experience a definite sensation of discomfort or recognizable difficulty in holding the breath (BHT-DD). And further, until the first involuntary movement of the respiratory muscles (BHT-IRM). Participants were then instructed to sit quietly and breathe normally.

They were asked to breathe gently and at the end of a normal exhalation to pinch their noses and hold the breath. Measurement was done with a stopwatch. All breath holding procedures were repeated three times.

The Hi Lo breathing assessment: This technique involves simple observation by the practitioner of chest and belly motion. During the Hi Lo assessment, patients were asked to breathe in slowly and a little bit deeply into the belly. The examiners hands were placed on the anterior central upper chest and clavicular area (Hi) and the anterior upper abdomen (Lo). From this hand position the examiner determined whether abdominal motion is "paradoxical", i.e., whether it moved inward towards the spine, during inspiration despite the patients attempt to breathe into and expand their belly.

Seated lateral expansion: Place hands on lower thorax and monitor motion while breathing. Observe for symmetrical lateral expansion.

Intervention:

Repetitions: Each breathing exercises for 5 minutes.

Supine Breathing: Patients were instructed to lay supine, knees bent with arms wherever it felt comfortable. They were also cued to focus on breathing with their diaphragm, the breath filling into their lower abdomen and posterior chest wall, and cued to keep their ribs depressed and thoraco-lumbar junction supported and to keep their shoulders and neck relaxed.

Crocodile Breathing: Patients were instructed to lay prone with their hands in a diamond shape supporting their forehead. They were cued to try and focus on pushing their ribs out laterally and trying to breathe all the way down to the sacrum.

Seated Breathing: Patients were seated on a hard surface with their knees, hip, and ankles bent at 90°. They were told to sit tall, as if a "string is pulling them up from the top of their head," while maintaining all previously discussed breathing cues.

90/90/90 Breathing: Patients were made to the 90/90/90 assessment position, and were asked to hold their legs while maintaining all previously discussed breathing cues.

Breathing with Thera-band: A Thera-band was added around the lower ribs to help promote lateral excursion.

Statistical Analysis: The SPSS software (version 21.0) and Excel 2016 were used to analyze all the data. Pearson's correlation coefficient was used to test the correlation of balance and respiratory variables. Student's t-test was used for sample statistics of the variables. There was statistically significant difference between the respiratory parameters, and balance scales before and after the intervention. The descriptive statistics of NQ were (mean ± SD: 25.18 ± 5.09; Std. error mean: 0.72); one sample test for NQ (t: 3.02; df: 49; sig: 0.004; mean difference: 2.18). The descriptive statistics of SEBQ were (mean ± SD: 20.84± 4.20; Std. error mean: 0.59); one sample test for SEBQ (t: 16.58; df: 49; sig: 0.00; mean difference: 9.84). Sensitivity of the scales was established using the formula given below:

Sensitivity/TPR (True Positive Rate) = Σ True positive divided by Σ Condition positive.

Sensitivity = number of true positives/ number of true positives+ number of false negatives.

All the parameters showed improvement post intervention evident from the mean difference ± SD values Table 2.

Table 1 shows the descriptive statistics of outcome measures. Table 3 shows correlation between different parameters, before and after the intervention, using Pearson's correlation coefficient. (Table) shows sensitivity of FABS, and BBS changes before and after the intervention, at different cut off rates. The overall change percentage between Pre and Post FABS across all the cut off values, was 12%; whereas BBS change was 8%.

RESULTS

Out of the 50 subjects, 2 subjects (1 male, and 1 female) had deep breathing type; 8 females, 7 males had rapid type, and 24 females, and 19 males were shallow breathing. There were 0 female and 1 male abdominal breather, and 1 female and 4 male abdomino-thoracic breathers, 13 female, and 12 male thoraco-abdominal breathers, and 9 female and 10 male thoracic breathers. 19 females and 24 males showed unequal/asymmetrical seated lateral expansion. 22 females and 23 males showing Hi breathing, and 1 female and 4 males showing Lo breathing.

Table 1: Descriptive statistics of SBC, RR, BBS, FABS, before and after intervention.

	Mean	N	Std. Deviation	Std. Error Mean
Pre SBC	13.76	50	5.004	0.71
Post SBC	18.06	50	4.858	0.69
Pre RR	18.36	50	2.220	0.31
Post RR	14.70	50	2.072	0.29
Pre BBS	26.18	50	5.910	0.83
Post BBS	26.80	50	5.887	0.83
Pre FABS	23.80	50	5.503	0.78
Post FABS	24.70	50	5.607	0.79

The findings of the present investigation indicates that RR has improved significantly in the subjects, evident by the mean values of the baseline, before and after the intervention, are 18.36, and 14.70 respectively. The findings of the present investigation indicates that SBC has improved significantly in the subjects, evident by the mean values of the baseline, before and after the intervention, are 13.76, and 18.06 respectively. The findings of the present investigation indicate that BBS has mildly improved in the subjects, evident by the mean values of the baseline, before and after the intervention, are 26.18, and 26.80 respectively. The findings of the present investigation indicates that FABS has improved significantly in the subjects, evident by the mean values of the baseline, before and after the intervention, are 23.80, and 24.70 respectively. The study showed improvement in all the respiratory and balance parameters.

TABLE 2 - Paired Samples Test for SBC, RR, FABS, BBS

		Paired Differences			t	Df	Sig. (2-tailed)
		Mean	SD	S.E. Mean			
Pair 1	Pre SBC – Post SBC	-4.300	.789	.112	-38.539	49	.000
Pair 2	Pre RR – Post RR	3.660	1.042	.147	24.833	49	.000
Pair 3	Pre FABS – Post FABS	-.900	.863	.122	-7.374	49	.000
Pair 4	Pre BBS – Post BBS	-.620	.567	.080	-7.725	49	.000

TABLE 3- Correlations of Pre SBC, POST SBC, RR PRE, RR POST, FABS PRE, FABS POST.

		Pre SBC	Post SBC	Pre BBS`	Post BBS	RR PRE	RR POST	FABSPRE	FABSPOST
Pre SBC	Pearson Correlation	1	.988**	.203	0.194	-.205	-.277	.240	.270
	Sig. (2-tailed)		.000	.157	.176	.153	.052	.093	.058
	N	50	50	50	50	50	50	50	50
Post SBC	Pearson Correlation	,998**	1	0.174	0.169	-.186	-.270	0.204	0.237
	Sig. (2-tailed)	.000		.226	.239	.197	.058		
	N	50	50	50	50	50	50	50	50
Pre BBS	Pearson Correlation	.203	0.174	1	0.995	-.154	-.135	.833**	.837**
	Sig. (2-tailed)	.157	.226		.000	.284	.348	.000	.000
	N	50	50	50	50	50	50	50	50
Post BBS	Pearson Correlation	0.194	0.169	0.995	1	-0.156	-0.145	0.829	0.829
	Sig. (2-tailed)	.176	.239	.000		.277	.313	.000	.000
	N	50	50	50	50	50	50	50	50
RR PRE	Pearson Correlation	-.205	-.186	-.154	-0.157	1	.884**	-.191	-.201
	Sig. (2-tailed)	.153	.197	.284	.277		.000	.184	.162
	N	50	50	50	50	50	50	50	50
RR POST	Pearson Correlation	-.277	-.270	-.135	-0.145	.884**	1	-.127	-.140
	Sig. (2-tailed)	.052	.058	.348	.313	.000		.379	.334
	N	50	50	50	50	50	50	50	50
FABSPRE	Pearson Correlation	.240	0.204	.833**	0.829	-.191	-.127	1	.988**
	Sig. (2-tailed)	.093		.000	.000	.184	.379		.000
	N	50	50	50	50	50	50	50	50
FABSPOST	Pearson Correlation	.270	0.237	.837**	0.829	-.201	-.140	.988**	1
	Sig. (2-tailed)	.058		.000	.000	.162	.334	.000	
	N	50	50	50	50	50	50	50	50
	**. Correlation is significant at the 0.01 level (2-tailed).								

All the parameters showed improvement post intervention, with a mean difference ± SD of 4.3±0.79 for SBC, 6.62±0.9 for BHT, and 3.66±1.04 for RR following intervention, and 0.62± 0.57 for BBS, 0.9±0.86 for FABS (Table 2).

Table 4: Sensitivity of FABS, and BBS at different cut-off scores.

Cut-off values	Pre FABS	Pre BBS	Post FABS	Post BBS
≤ 21	40%	24%	36%	24%
≤ 25	64%	54%	58%	50%
≤ 30	84%	72%	82%	66%
≤ 35	98%	90%	98%	88%
≤ 40	100%	100%	100%	100%

The overall change across all the cut off values between Pre and Post FABS was 12%; whereas BBS change was 8%.

DISCUSSION

There were significant statistical changes between the pre and post intervention values in respiratory, as well as balance parameters. This demonstrated an overall clinical and statistical improvement in the balance and respiration variables, after the intervention.

Respiratory parameters

The findings of the present investigation indicates that SBC and BHT have improved significantly in the subjects, evident by the mean values of the baseline, before and after the intervention, are 13.76, and18.06 for SBC, and 14.06 and 20.68 for BHT respectively. There was significant improvement in RR, evident by the mean values of the baseline, before and after the intervention, 18.36, and 14.70 respectively.

These findings are consistent with the finding of Poonam Nariyani, et.al, the study showed a decrease in the respiratory rate, pulse rate, SpO2 and an increase in the breath holding time, after a five minute session of deep breathing exercises. The improvement was significant statistically too. [17]

Balance parameters

The FABS scale appears to be more sensitive to changes, post intervention, it is evident by changes in the mean differences of FABS, in comparison to BBS (mean difference of Post FABS – Pre FABS = 0.900; Post BBS – Pre BBS = 0.620). Also, the overall change across all the cut off values between Pre and Post FABS was 12%; whereas BBS change was 8%.

The findings of the present investigation indicates that BBS has improved in the subjects, evident by the mean values of the baseline, before and after the intervention, 26.18, and 26.80 respectively, and FABS has improved in the subjects, evident by the mean values of the baseline, before and after the intervention, are 23.80, and 24.70 respectively. This finding is supported by a study done by Boulgarides LK, et.al, which BBS has been shown to be a poor predictor of falls. [18]

This study intended to find a correlation between balance and breathing pattern dysfunctions. The study shows that an improvement in the respiratory parameters correlated with an improvement in the balance variables too. This finding correlates well with the study conducted by RinaCzapszys, et. al., which suggests that diaphragmatic breathing exercises, would reduce the occurrence of injury, in the elderly. The study also suggested that abdominal breathing increases the stability. [19]

It is believed that increase in the diaphragmatic strength may have caused an increase in proprioception, which in turn might have contributed to an increase in balance, which correlates well with the study conducted by Stephan, et.al, whose preliminary study gave proof of concept evidence that, there may be a relationship between balance and breathing. [20] However, as the intervention was for a short duration, the effects can be temporary.

Limitations: Study sample was limited to those who were able to attend department of physiotherapy, NIMS. Major percentage of subjects were observed to have left side asymmetrical seated lateral expansion, but as this study was not directed towards it, the reason for the same, couldn't be found, it could have been due to diaphragmatic excursion, or related to hand dominance, or other reasons, which hasn't been established in this study.

Further scope: This study was done in older age group, younger age group can also be considered for the same. This is an observational study, with intervention being given once, and hence the physiological changes can be temporary, and needs to be taken as a follow up study, for adaptable improvement in the physiological respiratory, and balance functions. Psychometric properties of these scales can be tested for other conditions that affect balance. A more exclusive study can be done with multi-centers approach, for sample collection.

CONCLUSION

In conclusion, there was significant improvement in outcome measures of single breath count, breath hold time, respiratory rate, and Fullerton advanced balance scale, in comparison to berg balance scale, statistically. This study shows that there is a correlation between breathing pattern dysfunctions, and balance, as improvement in the breathing parameters, also documented improvement in the balance variables. Though both the scales documented changes, Fullerton advanced balance scale showed more sensitivity to changes, than Berg Balance Scale.

Conflict of interest: None.

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