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Research Report

Comparison of the Effects of Balance training on Foam V/S Sand in individuals with Stroke

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Abstract: Background: Individuals with Stroke often present with somatosensory deficits. Improvement in balance has been reported with exercises using surface manipulation; such as on Foam surface in Stroke subjects, and on textured as well as sandy surface in elderly. The textured and shifting nature of sand is expected to enhance somatosensory inputs from the foot and it is also an unstable surface. Hence comparison of the efficacy of balance training on foam v/s sand in individuals with Stroke is proposed. **Aim:** To compare the effects of balance training on foam v/s sand in individuals with stroke. **Design:** Prospective experimental study comparing 2 types of interventions in 53 adults with stroke of duration > 3 months **Methods:** After random allocation, subjects underwent 6 weeks of balance training using task oriented exercises on either: Foam (26) or Sand (27). Outcome measures used were a) BESTest, b) instrumented mCTSIB done pre-training, after 6 weeks of training & at 9th week. **Results:** Significant change in BESTest mean scores after 6 weeks of training in Foam group (p <0.001) and in sand group (p <0.001). Significant change in mCTSIB COG sway velocity after 6 weeks of training in Foam group (p <0.001) and in sand group (p <0.001). Comparison between outcomes at 6th & 9th week, not significant (p >0.05) indicating the carryover of training effects in both foam and sand groups. On comparison between both groups, no significant difference in mean change of BESTest and m-CTSIB scores obtained at 6th & 9th week (p >0.05), indicating that training on sand was as effective as training on foam

Conclusion:
Balance training using task-oriented exercises on sand is as effective as on foam in individuals with Stroke. The carryover effects persisted in both groups similarly for next 3 weeks.

KEYWORDS: Stroke, balance training, foam, sand

Introduction

Stroke is the most common cause of neurological disability in adult Indian population.[1] About 83% of the affected individuals have balance disabilities.[2] The decreased ability to maintain static and dynamic balance after Stroke could be related to the inability to select reliable sensory information (visual, vestibular and somatosensory) in order to produce proper motor action necessary to maintain postural stability.[3,4]

Since Stroke subjects often present with somatosensory deficits, the adaptation of regular exercises with use of surface and vision manipulation to challenge balance have improved the process of somatosensory integration along with postural stability.[4,5] Exercise interventions, in the form of task-oriented exercise programs, have improved the functional status of chronic stroke survivers.[6,7,8,9] Following 4-8 weeks of functional training, patients with stroke have shown significant improvements in functional mobility,8,9 walking speed and endurance,[6,7,8] and in clinical measures of balance.[6,8,9,10]

Surface manipulation using foam disperses foot pressure, thus affecting the reliability of somatosensory information received from these receptors.[11] Hence individual has to rely on visual or vestibular system for balance. This shift in emphasis between the different sensory systems depending upon the availability and validity of sensory information is called "sensory reweighting"[12].

Somatosensory inputs to the feet can be enhanced by changing the surface characteristics like texture. Texture is used on the basis that it can stimulate peripheral receptors that are otherwise not being stimulated.[13] Studies in elderly using different types of textures like spikes, gravel, sandpaper have reported significant reduction in mediolateral sway in comparison to anteroposterior sway when standing on textured surfaces.[13,14]

Sand is easily available and cheap, is non toxic and has a rough texture. Shifting nature of sandy surface deforms it on loading, thus making it an unstable surface for standing and walking. Rough texture of sand is expected to enhance cutaneous somatosensory information from sole of foot and unstable nature of sandy surface is expected to stimulate vestibular system.

Studies on task oriented training on foam in Stroke [6,7,8,9,10,] standing on textured surfaces[14,15] and walking on sand surface in elderly have reported to improve balance.[16,17] Hence there is a need to compare the efficacy of task oriented training on foam and sand for improving balance functions in individuals with Stroke.

Methods

Study design: Prospective experimental study comparing 2 types of interventions was performed with study duration of 9 weeks at physiotherapy department of All India Institute of Physical Medicine & Rehabilitation, Mumbai.

Participant Characteristics: 53 adult individuals with stroke were selected for the study. Age range was from 27-70 yrs with stroke duration of 6 months to 5 yrs. Inclusion criteria consisted of adult medically stable ambulatory individuals with hemiparesis due to stroke episode, of more than 3 months duration, having MMSE score > 24. Causes of hemiparesis other than stroke eg. cerebral palsy, infection, tumour etc, those who are medically unstable and those having associated painful orthopaedic conditions of trunk and lower limbs, congenital anomalies, vestibular conditions, nerve/muscle blocks to lower limb in previous 6 weeks were excluded.

Outcome measures: A) Clinical test: BESTest[30] and B) Instrumented test: m-CTSIB on long force platform. The Balance Evaluation Systems Test (BESTest) consists of 36 items grouped into 6 categories or sections. The maximum BESTest score is of 108 points. Score is then converted to percentage; higher score indicate better balance performance.

Modified Clinical Test for Sensory Interaction on Balance (m-CTSIB) was performed on long forceplate (NeuroCom balance master ver.8.6). The subjects stood on force platform with feet parallel and arms at sides under the following 4 conditions: 1) Eyes open (EO), firm surface; 2) Eyes closed (EC), firm surface; 3) Eyes open (EO), foam surface; 4) Eyes closed (EC), foam surface. Assessment of COG alignment and COG sway velocity was done for every condition. 3 trials of 10 secs each were taken, and the mean of the 3 trials was recorded.

Materials used: Medium-density Foam of 6ft x 4ft and 6″ height, Sand pit of 6ft x 4ft and 6″ height with beach sand, Wooden stool of 20″ height, Shoe boxes for obstacles (4-6″ height)

Procedure: Study was commenced after approval from institutional ethics committee. The selected 53 subjects were explained about the nature and implications of the study and a written consent was taken. Subjects were randomly assigned to the 2 groups viz. Foam group (n=26) & Sand Group (n=27) Assessment of each individual's static and dynamic balance was done prior to initiating training program, after 6 weeks of training and at 9th week using a) clinical test- BESTest and b) instrumental test measuring COP parameters on long force platform- mCTSIB,.

Training protocol: Subjects underwent regular stretching and strengthening program for trunk and lower limbs as a part of conventional rehabilitation regime, followed by these task oriented activities on either foam or sand:

1. Standing, feet shoulder width apart with eyes open
2. Standing, feet shoulder width apart with eyes closed
3. Standing, feet together with eyes open
4. Standing, feet together with eyes closed
5. Tandem standing with eyes open
6. Tandem standing with eyes closed
7. Single leg standing
8. Sit to stand from a stool (20 inch height)
9. Walking forwards along the length of foam or sandpit
10. Walking backwards along the length of foam or sandpit
11. Walking sideways along the length of foam or sandpit
12. Tandem walking along the length of foam or sandpit
13. Stepping over obstacles (4-6 inch height) on foam/sand surface.

The therapist stood besides the subjects to ensure their safety at all times. Each activity was performed with 10 repetitions with adequate rest periods between the activities. Activity (1-7) was performed with maximum of 60 secs hold. Each training session was for 1 hour/day, twice a week for a period of 6 weeks. There was 1 dropout in Foam group at 4th week of training and 2 dropouts in Sand group at 3rd and 4th week of training respectively. Hence a sample size of 50 was available for statistical analysis.

Statistical Analysis:

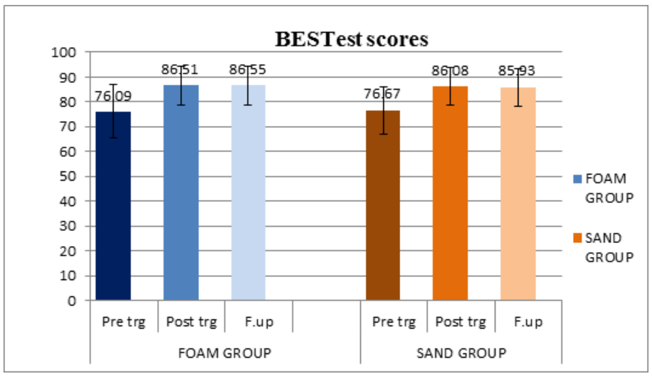
Analysis of data for this study was done using software Graphpad Instat version 3.10. Using normality test (KS) test, it was found that BESTest parameters in both groups followed normal distribution pattern; while m-CTSIB parameters in both groups did not follow normal distribution pattern.

Within group analysis of pre & post tests and follow-up was done using repeated measures ANOVA with post-test for BESTest parameters; and Friedman's test with post-test for m-CTSIB parameters. Comparison between 2 groups was done using unpaired t-test.

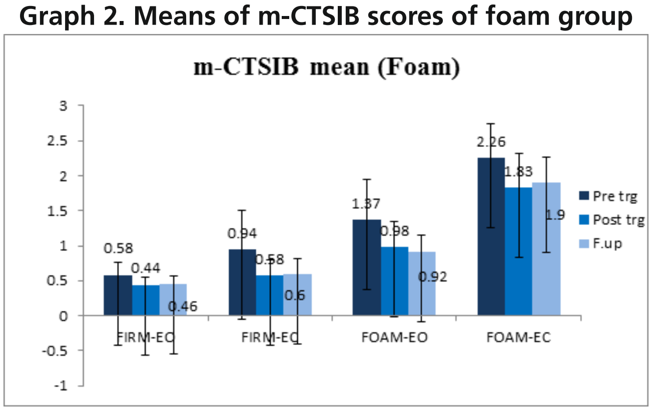
Results: Analysis of the baseline data revealed that both groups are similar at baseline p> 0.01. There is significant change in BESTest mean scores after 6 weeks of training in Foam group (p <0.001) and in sand group (p <0.001). No statistically significant change between post training and follow-up (p> 0.01) in both groups. There is significant change in m-CTSIB mean scores after 6 weeks of training in Foam group (p <0.001) as well as in sand group (p <0.001). While post training v/s follow up shows no significant change in both groups (p<0.01). On comparison between two groups, no significant difference in mean change of scores obtained for BESTest & mCTSIB at 6th week & 9th week (p >0.05), indicating that training on sand was as effective as training on foam.

Therefore, training on both sand and foam is equally effective.

Graph 1: Means of BESTest scores of Foam and sand groups



Graph 2. Means of m-CTSIB scores of foam group



Graph 3. Means of m-CTSIB scores of sand group

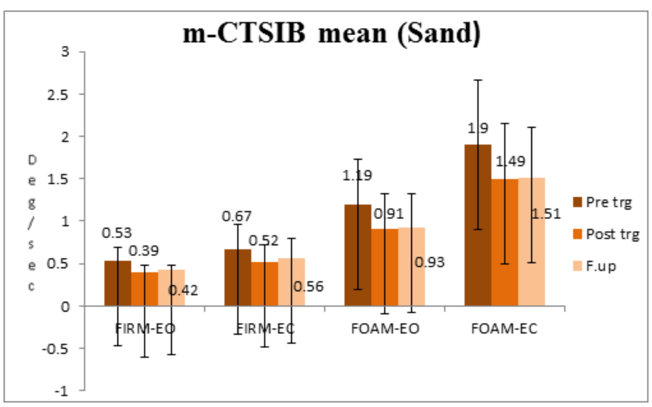


Table 1: Comparison of BESTest scores for pre-training, post training & follow up in a) foam group & b) sand group:

BESTest score (%)	a) Foam Group				
	Mean change (SD)	95 % CI	Effect size (δ)	P value & Significance	
Post trg (6th wk) v/s Pre trg	10.43 (4.23)	8.77, -12.09	1.11	<0.001	ES
F.up (9th wk) v/s Post trg (6th wk)	0.04 (0.91)	-0.31, -0.4	0.01	>0.05	NS
	b) Sand Group				
Post trg (6th wk) v/s Pre trg	9.41(3.57)	8.01, -10.80	1.088	<0.001	ES
F.up (9th wk) v/s Post trg (6th wk)	0.15 (0.83)	-0.18, -0.5	0.02	>0.05	NS

Table 2: Comparison in m-CTSIB scores for pre-training, post training & follow up in a) foam & b) sand group

	a) Foam Group									
Mean COG sway velocity (Deg/sec)	Post trg v/s pre trg					F.up v/s Post trg				
	Mean change (SD)	95% CI	Effect size (δ)	P value & significance		Mean change (SD)	95% CI	Effect size (δ)	P value & significance	
FIRM-EO	-0.14 (0.17)	-0.20, -0.07	0.9	<0.001	ES	0.02 (0.11)	0.02, 0.06	0.18	>0.05	NS
FIRM-EC	-0.30 (0.40)	-0.46, -0.14	0.83	<0.001	ES	0.02 (0.10)	0.02, 0.06	0.09	>0.05	NS
FOAM-EO	-0.39 (0.39)	-0.54, -0.23	0.9	<0.001	ES	-0.06 (0.35)	-0.2, -0.07	0.19	>0.05	NS
FOAM-EC	-0.02 (0.11)	-0.06, 0.02	0.89	<0.001	ES	0.02 (0.33)	-0.15, 0.11	0.16	>0.05	NS
	b) Sand group									
FIRM-EO	-0.14 (0.13)	-0.19, -0.09	1.07	<0.001	ES	0.03 (0.08)	-0.001, 0.06	0.39	>0.05	NS
FIRM-EC	-0.15 (0.14)	-0.2, -0.1	0.6	<0.001	ES	0.04 (0.10)	-0.028, 0.08	0.18	>0.05	NS
FOAM-EO	-0.28 (0.25)	-0.37, -0.18	0.58	<0.001	ES	0.02 (0.22)	0.10, 0.07	0.04	>0.05	NS
FOAM-EC	-0.41 (0.35)	-0.56, -0.26	0.57	<0.001	ES	0.02 (0.20)	-0.06, 0.09	0.03	>0.05	NS

Table 3: Comparison of mean change in BESTest scores between Foam group and Sand group

BESTest scores	Foam group: Mean change (SD)	Sand group: Mean change (SD)	Effect size (δ)	P value	Significance
Post trg v/s Pre trg	10.43 (4.23)	9.41(3.57)	0.262	0.36	NS
F.up v/s Post trg	0.04 (0.91)	0.15 (0.83)	0.12	0.44	NS

Table 4. Comparison of mean change in m-CTSIB scores between foam group and sand group

Mean change in COG sway vel (Deg/ sec)	Post trg v/s Pre trg			F.up v/s Post trg		
	Effect size (δ)	P value and significance		Effect size (δ)	P value and significance	
FIRM-EO	0	>0.99	NS	0.10	0.72	NS
FIRM-EC	0.5	0.09	NS	0.19	0.34	NS
FOAM-EO	0.3	0.24	NS	0.13	0.10	NS
FOAM-EC	1.5	0.83	NS	0	>0.99	NS

Discussion

This study was conducted to compare the effects of 6 weeks of balance training on foam surface v/s training on sand surface in individuals with Stroke.

From the results, it is evident that after 6 weeks of balance training, improvement in the scores of clinical and instrumental outcome measures was statistically significant from their baseline scores in both groups($p<0.001$), ES>0.8. To verify the carryover effects, on comparison of the scores of post-training to follow-up at 9 weeks, no statistically significant change was observed in both foam and sand group ($p >0.05$), ES<0.2. On comparison of effects of training between the two groups, there was no statistically significant difference, indicating that training on sand was as effective as training on foam ($p >0.05$),ES <0.2, thus supporting the null hypothesis (Ho).

The Balance training exercise protocol used in this study aimed to improve sensorimotor integration, which focussed on use of task oriented exercises with vision and surface manipulations on foam or sand. When balance exercises are more task oriented, they have shown to also improve functional mobility of the individuals.[6,7,8,9,10]
When standing on foam surface, somatosensory inputs from cutaneous mechanoreceptors on the plantar soles are reduced due to dispersion of foot pressure and alteration of the ankle torque, thus making somatosensory information less relevant for maintenance of balance.[18,19] With addition of closure of eyes, visual inputs are also cut-off, thus forcing the individuals to "sensory re-weight", and rely on vestibular inputs for maintenance of balance.

Texture can enhance the somatosensory inputs to the feet by changing the characteristics of the support surface in contact with the feet. Sand is a textured material and its rough texture is expected to enhance cutaneous somatosensory information from sole of foot. Texture can stimulate peripheral receptors that are otherwise not being stimulated.[14] The proposed mechanism involves an increase in the rate of discharge from stimulated groups of cutaneous receptors. Indentation or stretch at sufficient intensity provides information about characteristics of the material, such as roughness, spatial resolution and orientation.[14] When standing on sand, there is an increase in the area of foot in contact with the support surface. Therefore more number of cutaneous receptors will be stimulated. Effect size of 1.5 obtained between the two groups in m-CTSIB in foam EC condition, probably indicates enhancement of proprioceptive function detected only as reduction of sway velocity; A verification on a larger sample is suggested. In addition, the subjects performed exercises with eyes closed like the subjects who were trained on foam, hence requiring sensory re-weighting from somatosensory and vestibular systems. Probably the texture of sand provided somatosensory information additionally for sensory re-weighting.

Both foam and sand are unstable surfaces challenging the COG towards its limits of stability. Unstable nature of foam is attributed to the mechanical properties of the foam surface, viz; the foam surface density, its visco-elasticity and modulus of elasticity i.e. the extent to which the foam material compresses under a given force. These properties are significantly related to the resulting stability challenge. [20,21] Berardino and colleagues suggested that using foam of higher stiffness and preferably medium density was best for clinical use.[22]

The sand also has a shifting nature and it deforms the surface on loading, making it unstable for standing and walking. Sand procured was dry sand from the one of beaches along the Mumbai coast. Beaches along the western coast of India have sand particles of medium size (0.2-0.63mm).[23,24] Sand found in the desert is generally of finer size (0.063-0.2mm)[23]. The sand particles used in this study were of medium size, the instability of the surface may be lesser as compared to fine sand.

An unstable surface increases the external swing which more effectively encourages postural orientation by forcing faster modifications of sensory and motor systems.[25] Balancing exercises on an unstable surface sensitize the muscle spindle through gamma motor neurons, thereby improving the motor output which influences the stability of the joints.[26] With practice of the exercises, there is treatment-induced cortical reorganization in brain.[27,28] This occurs due to plasticity of the central nervous system. Plasticity occurs due to several reasons like unmasking of silent synapses, regenerative synaptogeneis or regeneration of damaged neurons and reactive synaptogenesis or collateral sprouting from neurons of intact adjacent areas.[29]

Study on walking program on sand have shown a greater improvement in hip strength which could be related to the role of the muscles acting around the hip, especially the hip extensors, in controlling posture and stability of the body. This improvement in strength has implications for the risk of falls, since lower limb muscle weakness is an important predisposing factor to falls.[17] It also showed an increased electromyographic activation & proposed higher levels of muscle co-contraction to stabilize the joints of lower limbs. Another study proposed that soft sand walking may improve or maintain better balance, by requiring more proprioception input than firm ground exercise.[16]

Sand is a natural, readily available material. It has properties of both texture and unstable surface which improved the balance in individuals with Stroke. The effects were similar to those obtained after training on foam surface. Hence exercises on sand can be used to train balance in individuals with Stroke.

Conclusion

The improvement in static and dynamic balance measures in upright posture, after balance training using task-oriented exercises, on either foam or sand for 6 weeks in individuals with Stroke are similar. The carryover of the improvement persisted in both groups for next 3 weeks.

Clinical Implication

Sand is easily available, non toxic material and provides benefits of textured and unstable surface and can be used for training balance in individuals with Stroke. Exercises on sand can be advised as a home exercise program for individuals with Stroke. Balance training on sand for individuals with Stroke can provide training under a natural outdoor environment as opposed to training on foam in indoor set-up. Patient acceptance and compliance is also expected to be better on sand.

Limitations

The degree of instability of the foam or sand surface could not be measured and compared unlike wobble boards or instrumented stability platforms which measures instability in terms of angulation of the surface or speed of movement.

Suggestions

Sand has been found to be effective in improving balance in stroke. Its effects of balance training in other neurological conditions like cerebral palsy, Parkinson's disease, cerebellar and vestibular conditions can be studied.

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