

Research Papers

Perceptual Learning Exercises: An adjunct to balance exercises for normal healthy geriatric population

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ABSTRACT

In older adults, falls commonly lead to injury, loss of independence, associated illness, and early death. The purpose of this study was to investigate the effects of perceptual learning exercises on static balance in a normal healthy geriatric population. A total of 28 healthy elderly subjects (19 female and 9 male) participated in this randomized two-group parallel controlled trial. The whole population was divided into control (group A) and experimental (group B) using the convenience sampling method. Static balance in terms of postural sway of all subjects was measured with the help of a trivially-made swaymeter, before and after the treatment protocol. The experimental group received perceptual learning exercises, i.e. hardness discrimination task, using three different levels of hardness of rubber sponges for 10 days while the control group received conventional physiotherapy exercises for postural control such as maintenance of standing balance with forward and backward perturbations, shifting of weight load from one foot to the other on the health metre, and tandem walking. The multivariable 't' test (dependent and independent) showed that the group that received the hardness discrimination tasks showed a remarkable decrease in postural sway, meaning intervals. The results of the analyses revealed a significant difference between pre-treatment and post-treatment antero-

posterior and mediolateral sway ($P < 0.05$) in the experimental group. However, no significant difference was recorded between pre-treatment and post treatment anteroposterior and mediolateral sway ($P > 0.05$) in the control group.

Key words: *Perceptual learning exercises, balance exercises, geriatric*

INTRODUCTION

As our population ages, a stronger interest in the issue of balance control has emerged. Previous research has shown that postural stability declines with age, and that this decline may be due to a multitude of factors that increase the likelihood of serious falls in older adults. Among these is an age-related deterioration in the three sensory systems contributing to postural control (somatosensory, vestibular, and visual system).¹ There is a marked decline in vibratory sensation, number of vestibular hair cells, and visual acuity.²⁻³ On the output side, there is an age-related slowing of peripheral nerve conduction velocity, a reduction in the number of motor units, and a reduction of muscle mass.⁴⁻⁶ Furthermore, central processing abilities also decrease with age, as revealed by a reduction in the speed with which older people react and move.⁷

It is well established that maintaining and controlling an upright posture requires a certain amount of attention. The relation between attentional resources and the processing of information from somatosensory, visual, and vestibular systems is readily apparent in cases of reduced or conflicting sensory information.⁸⁻⁹ On the one hand, the degree of attention, or cognitive involvement, required for controlling posture increases with task difficulty. This has been (indirectly) illustrated that the reaction time of a verbal response to an auditory stimulus increased with the difficulty of the postural task.¹⁰⁻¹¹ On the other hand, the amount of attention required to perform a secondary suprapostural task is known to influence posture.¹²

It is believed that the perception of the plantar sole is the most influential factor in maintaining posture during standing.¹³⁻¹⁶ By requiring trainees to stand on shotgun balls spread all over the floor, Okubo et al.¹⁷ found a decrease in postural sway and also noted the importance of foot pressure receptors in the control of standing posture. Also, in a recent study, it was found that standing balance was improved by increasing sensory input from the passive sole in subjects standing on a rubber mat.¹⁸ Thus, it appears that sensory input from the plantar influences the control of posture, emphasizing the proprioception role of the sole.

In a recent experiment, the ability of young and older adult subjects to maintain an upright posture under changing visual and surface conditions, while simultaneously performing a reaction-time task, was tested. The reaction-time task involved the subjects pressing a button when an auditory cue was randomly presented as the subjects were standing. The results demonstrated that a decrease in available sensory information significantly disturbed both the young and the older adults' ability to maintain balance. It was concluded that with this decrease in sensory information, the postural task required an additional allocation of attentional resources for older adults.¹⁹

One method used to evaluate the contribution of proprioceptive inputs to postural control and the integrity of the integrative mechanisms within the CNS is to measure changes in postural sway during or

following vibration applied over the muscle belly or tendon.²⁰ This technique directly targets the primary muscle afferents contributing to proprioception and may effectively reflect a perturbation of this system.

The purpose of this study is to investigate the possibility that static balance in geriatrics can be improved by physical means, i.e. exercises that particularly concentrate on perceptual learning from the exploratory action of a subject's sole during discrimination of hardness of sponge rubber.

METHODOLOGY

Population and Sampling

Twenty-eight healthy elderly subjects of both sexes; 19 females (housewives), 9 males (retired) in the age group of 60-70 years were recruited from the Out Patient Department of Hydrabadi Hospital, Panipat. They subjects were divided into a control (Group A) and an experimental (Group B) group using the convenience sampling method.

Criteria for Sample Selection

Subjects were included in the study if they fulfilled the following inclusion criteria:

1. Aged 60-70 years.
2. Do not have any known neurological symptoms which affect balance.
3. Can achieve independent standing for more than half an hour.

Criteria for Exclusion

1. Preexisting major lower limb pathology like chronic ankle instability or severe osteoarthritis.

INSTRUMENTS AND TOOLS USED

The instruments and tools used include: three different thicknesses of rubber sponge i.e. 4cm, 6 cm, and 8 cm (fig. 1); a swaymeter (fig. 2), i.e., a postural sway assessment tool for measuring postural disturbances mainly in forward and sideway reaching activity; graph sheets with millimetre markings; a ballpoint pen to record the spontaneous movements of the body at waist level; and a table on which graphs were plotted.

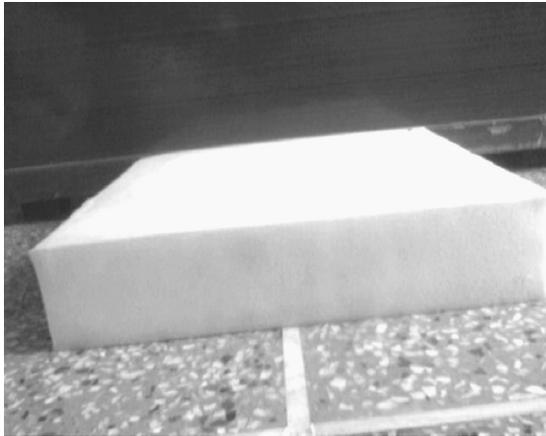


Figure 1. A rubber sponge (8cm thick).

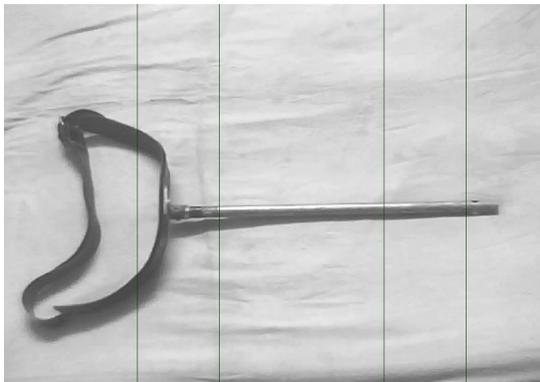


Figure 2. A trivially-made swaymeter.



Figure 3. Techniques of taking postural.

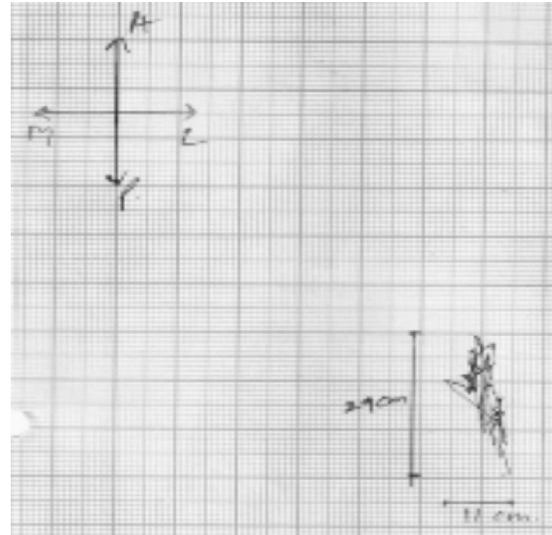


Figure 4. Sample postural graph.

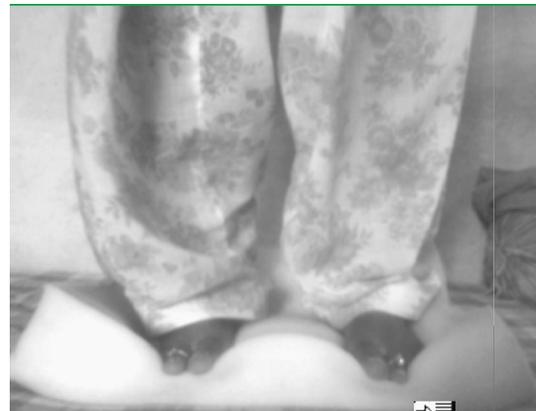


Figure 5. An aged person standing on an 8cm rubber sponge.

PROCEDURE

During the initial session, history was taken and subjective and objective examinations and thorough neurological evaluation were performed. The twenty-eight healthy elderly subjects (19 females and 9 males) were divided into a control (Group A) and an experimental (Group B) group, using the convenience sampling method. Their demographic profile and detailed medical history regarding ailments, if any, were collected through individual interviewing. A signed consent was obtained from each of the subjects. Their postural graphs were taken with a trivially-made swaymeter on the same day i.e. assessment day.

Sway is said to be anteroposterior or mediolateral when the body is displaced in anteroposterior or mediolateral direction respectively. In this study, a swaymeter that measures spontaneous displacement of the body at waist level (in between the anterior superior iliac spine (ASIS) and the greater trochanter (GT) level) was used to take postural graphs.

The swaymeter consisted of a 40cm long rod with a vertically-mounted pen at its end to record the lines traversed in anteroposterior or mediolateral direction on a millimetre graph sheet. The rod was attached to the subject by a firm belt that extended posteriorly. While the subject attempted to stand as still as possible, the pen recorded the anteroposterior (AP) and mediolateral (ML) sways on a sheet of millimetre graph paper fastened to the surface of an adjustable height table. Testing was performed with the eyes open. Total pre-treatment sway (number of millimetre squares traversed by the pen) in the 30-second periods was recorded once for the tests on the day of assessment. Patients were guarded by the therapist and one helper during the whole procedure.

Subject's Positioning and Stabilization

Control (Group A)

Group A received conventional physiotherapy exercises for postural control, chiefly:

1. Maintenance of standing: Subjects were instructed to maintain a standing, erect position in front of a postural mirror and were perturbed forwards and backwards. The exercise was performed for 15 minutes.
2. Shifting of weight load to either foot: Subjects were made to stand and instructed to shift their body weight alternatively from one foot to the other for 15 minutes.
3. Standing on the wobble board: Subjects were instructed to maintain their balance on the wobble board in standing position for 15 minutes.
4. Tandem walking and walking along a line over a painted floor: Subjects were instructed to walk by placing the heel of one foot directly in front of the toe of the other foot and walking over a straight

line painted on the floor. Both exercises were administered for 15 minutes.

Frequency of the Conventional Physiotherapy Protocol

The conventional physiotherapy exercises were administered daily for 10 consecutive days.

Experimental (Group B)

Group B received perceptual learning exercises along with the conventional physiotherapy exercises mentioned above.

Perceptual learning exercises consisted solely of discrimination of hardness of a sponge rubber placed under the sole of the foot, i.e. hardness/thickness discrimination tasks.

Three 30cm square sponge rubbers (8cm, 6cm, 4cm thickness) of identical shape and material were each placed under the sole of the foot daily for 10 consecutive days. Subjects were in standing position and were blindfolded. The examiner verbally explained the thickness of the sponge placed under the foot or simply explained the ascending or descending arrangement of the different sponge rubbers under the foot. The examiner's job was to habituate the subjects to the different thicknesses of sponge rubbers placed under the sole of the foot.

Furthermore, the subjects were made to participate in three trials during which they were instructed to estimate the thickness of different sponges. A verbal response regarding the correct or incorrect thickness of the sponge was given, aiming at memory formation regarding the thickness of the sponges. Thirty seconds later, 10 trials were administered during which the subject had to estimate the thickness of the sponge. No verbal response regarding correct or incorrect answer was given during these 10 trials. The number of incorrect answers was used as the score for the hardness discrimination task.

Frequency of the Protocol

This hardness discrimination task was administered daily for 10 consecutive days.

The physical characteristics of the subjects are presented in table 1. Both control and experimental groups were comparable in age and physical characteristics.

Table 1. Physical characteristics of the subjects

	Control group Mean ± SD	Experimental group Mean ± SD
Age (years)	65.2 ± 2.22	64.8 ± 1.69
Height (cm)	167.3 ± 5.02	167.3 ± 3.96
Weight (Kg)	72.3 ± 5.28	71.3 ± 5.20

Table 2. Comparison of anteroposterior and mediolateral sways at pre- and post-treatment intervals for the control group

	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	t-cal	p-value
AS (mm)	19.25 ± 2.86	18.43 ± 2.44	2.98	0.75
MS(mm)	9.12 ± 2.21	9.37 ± 2.96	1.11	0.65

Key: AS – anteroposterior sway; MS – mediolateral sway

Table 3. Comparison of anteroposterior and mediolateral sways at pre-treatment and post-treatment intervals for the experimental group

	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	t-cal	p-value
AS (mm)	18.1 ± 1.83	14.8 ± 2.56	2.96	0.05
MS (mm)	10.8 ± 2.34	8.33 ± 1.82	3.5	0.05

Table 4. Comparison of mean values for anteroposterior and mediolateral sways between the control and the experimental group at pre- and post-treatment intervals

	Anteroposterior Sway		Mediolateral Sway	
	t-cal	p-value	t-cal	p-value
Pre treatment	1.23	0.05	-1.87	0.05
Post treatment	3.86	0.05	1.07	0.05
MD (Pre-Post)	-1.65		-2.79	

There was no significant difference between pre-treatment and post-treatment anteroposterior and

mediolateral sway ($P > 0.05$) in the control group, but there was a significant difference between pre-treatment and post-treatment anteroposterior and mediolateral sway ($P < 0.05$) in the experimental group. However, there was no significant difference found for anteroposterior and mediolateral sway ($P > 0.05$) between the control and the experimental group.

Table 5. Paired sample test for the control and experimental group for both anteroposterior and mediolateral sways

	Mean ± SD	t-cal	df	p-value
Control Group				
Pre-Post AP sway	0.81 ± 4.06	0.79	15	0.437
Pre-Post ML sway	-0.25 ± 2.56	-0.38	15	0.703
Experimental Group				
Pre-Post AP sway	3.33 ± 3.89	2.96	11	0.013*
Pre-Post ML sway	2.41 ± 2.39	3.5	15	0.005*

*Significant at $p < 0.05$

DISCUSSION

The present study was conducted to investigate the effect of perceptual learning exercise on static balance in a normal geriatric population. The motive behind this study was to train and improve the static balance of elderly people which normally diminishes with the normal ageing process.

Maintaining balance is a complex process involving sensory detection of postural changes, integration of sensorimotor information within the central nervous system, and execution of appropriate musculoskeletal responses. Loss of balance implies that the system failed in some respect. One possible cause for failure could be a deficit in the higher brain centre's ability to allocate appropriately the attention resources necessary for postural stability.²⁰

The reason for the improvement in motor performance, such as standing balance, due to improved perceptive ability may be inferred from the following. Because changes in somatic sensation has been sustained in geriatrics due to the normal ageing process, perceptual and motor learning through the

conscious control stage is mediated via the cerebral cortex and pyramidal tract. Thus, the hardness discrimination exercise was transferred to the achievement stage of reflective control.²⁰

The use of sponge rubber for the task of hardness discrimination is convenient and easy in clinical applications to balance dysfunction in elderly people. In addition, it is suggested that there was an immediate effect on the exercise. Therefore, this relatively inexpensive form of sensory feedback may be of clinical value.

It may be argued that enhanced signals arising at the level of the proprioceptive receptors account for the postural improvements. Researchers recently demonstrated that this mechanism is not likely to be the substrate for change.²¹ With only 1 of 3 proprioceptive measures indicating improvement with training, it was difficult to ascribe a training effect at the peripheral level. However, without sufficient physiological evidence from receptor isolation techniques, such as microneurography, the possibility of an increase in the discharge of these receptors cannot be discounted.

A more probable explanation for these results is an increase during the training intervention in the attention allocated to proprioceptive cues (explicit learning), which eventually led to a less attention-demanding recovery of postural stability (implicit learning). Improvements in postural control in the exercise group support this theory. As the accuracy of peripheral input declines with age, attentional resources become more focussed on the control of posture. Thus, the introduction of a sufficiently challenging secondary task or postural condition often results in reduced task performance or instability. Because the specific instructions provided to participants in the present study were to maintain focus on the task, evidence that stability was increased suggests an implicit learning effect.

Several authors have proposed that the explanation for impaired postural responses in older adults lies in age-related changes in the central integration mechanisms. During the exercise intervention in the present study, sensory inputs were manipulated by altering the thickness or hardness of

the sponge placed under the sole of the foot or by reducing the sensory redundancy of the visual and vestibular systems; these manipulations forced participants to effectively re-weigh the remaining inputs within the CNS. The direct beneficial consequences of these tasks were reflected in the ability of the participants to regain stability or decreased postural sways on the postural graphs, likely by taking advantage of the restored proprioceptive information and integrating it with vestibular inputs and other sensorimotor cues. Evidence of similarly enhanced central integration following sensory training has been found in studies demonstrating improved stability during the manipulation of proprioceptive, vestibular, or visual systems or all of these by use of the Sensory Organization Test (SOT).

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