



Effect of light finger touch in balance control of individuals with multiple sclerosis



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ABSTRACT

Deficit in balance control is a common and often an initial disabling symptom of multiple sclerosis (MS). The purpose of this study was to investigate if a light finger touch contact with a stationary surface is effective in improving upright postural stability in MS. Eleven individuals with relapsing–remitting MS were standing on a force platform with eyes open and closed, feet shoulder width apart and together, and with a light touch contact of the right index finger with a stable surface and without any contact. Balance was evaluated using center of pressure measures. Individuals with MS demonstrated significant postural instability in the absence of visual inputs and with reduced base of support ($p < 0.05$). The availability of a light finger touch contact with a stable surface was effective in reducing postural sway in both, the sagittal and frontal planes, in all experimental conditions ($p < 0.05$). Light finger touch contact is effective in improving postural control in people with MS and can be considered as a useful balance rehabilitative strategy.

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1. Introduction

Balance control deficit is a common and often an initial disabling symptom of multiple sclerosis (MS) [1–4]. During the course of the disease about 75% of people with MS exhibit postural instability [2]. Furthermore, poor balance control is a significant contributor to the increased risk of falling in people with MS [1,5–7] and is also associated with lower engagement in physical activity [8]. In a study on falls in MS, transfers and ambulation related tasks were the most commonly reported activities being performed at the time of a fall with 35% of people also reporting falling while performing everyday tasks in standing [9]. Incipient balance and gait impairments are known to be detected early on in MS when disability levels are mild [1,3,4] and even in those with no clinically assessable impairments but with subjective symptoms of instability [2]. Laboratory studies have also demonstrated excessive postural sway in people with MS during standing with a regular base of support (BOS), which is further accentuated under conditions of reduced BOS and no vision [6,10].

Light touch contact of a finger tip with a stable surface is known to enhance postural stability [11]. In healthy individuals, light

touch contact was found to improve stability in the sagittal and frontal planes during upright standing [12] as well as during tandem and single limb stance [11,13–15]. These contact forces are typically less than 1 N and considerably smaller than those required for significant physical stabilization of the body. In fact, in the absence of vision, light touch contact resulted in improvements in balance to a level equal to or better than that during conditions with full vision [12]. Additionally, light finger touch on one's own body reduces postural sway as does interpersonal light touch [16], albeit by small amounts in comparison to contact with a fixed object. Likewise, while standing on a firm surface and foam, application of a passive stimulus to the skin of the leg or shoulder (that provides sensory information about body movement) significantly reduces postural sway in healthy young and old individuals, and in people with peripheral neuropathy [17]. Thus, availability of additional active as well as passive sensory inputs causes adaptation of the postural control processes resulting in body stabilization. Furthermore, haptic contact with a stable surface was found to suppress the ongoing and after effects of postural destabilization and disorientation induced by continuous leg muscle vibration [18]. Similarly, improvements in postural stability with light touch contact have been reported in older adults [19], individuals with vestibular impairments [20], and in those with congenital blindness [21]. Haptic supplementation by light touch contact also enhances postural stability in individuals with balance impairments due to peripheral neuropathy [22] and during standing [23] and walking in individuals with stroke [24].

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The ability to integrate sensory inputs is found to be severely compromised in people with MS; with 75% of people showing abnormal scores even when standing with eyes open [25]. Moreover, it has been suggested that balance control in MS may be more correlated to the number of reliable sensory inputs than the nature of the sensory input itself [25]. As such, light finger touch contact may play an important role in providing additional and reliable sensory information about body sway. However, the role of light finger touch in balance control of people with MS has not been investigated. The current study was thus aimed at drawing on the application of this simple strategy in improving balance control of individuals with MS. It was hypothesized that in individuals with MS, light finger touch contact with a stationary flat surface will be effective in improving upright postural stability. It was also hypothesized that under challenging visual and BOS conditions, the light touch postural response would be scaled with the balance task difficulty.

2. Methods

2.1. Participants

Eleven individuals with relapsing–remitting MS (9 females and 2 males, age 52 ± 13 years, height 169.8 ± 10.3 cm, weight 68 ± 12 kg), an Expanded Disability Status Scale (EDSS) score of 2.3 ± 0.9 (indicating mild disability and fully ambulatory status), and average disease duration of 17.24 ± 11 years participated in the study. Hand dominance was determined using the Edinburgh Handedness Inventory: all the subjects were right hand dominant. The participants had normal or corrected to normal vision and were able to stand independently without any aid or orthosis for at least 1 min. Patients were excluded if they had cognitive impairments, any other neurological condition, any kind of pain that interfered with their daily activities, or if they were unable to perform the experimental tasks. The experimental procedure was approved by the university's Institutional Review Board and the participants provided their informed consent.

2.2. Experimental procedure

A force platform (AMTI, OR-5, USA) was used to record the ground reaction forces and the moments of forces. Subjects were required to stand upright and maintain steady stance under different sensory and BOS conditions (Fig. 1). The BOS conditions included feet shoulder width apart (regular, R) and feet close together

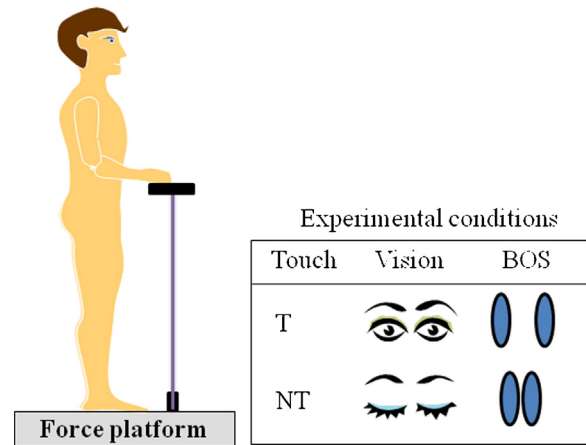


Fig. 1. Schematic representation of the experimental setup. Subjects were required to maintain steady stance with eyes open and eyes closed, with regular and narrow base of support, and with and without a light finger touch contact. A total of eight task conditions were performed.

2.3. Data processing

All signals from the force platform were processed offline using Matlab software (MathWorks, Natick, MA). The vertical component of the ground reaction force (F_z), the horizontal components in the anterior–posterior (AP) direction (F_y) and in the medial–lateral (ML) direction (F_x) and the moments of forces around the frontal axis (M_x) and the sagittal axis (M_y) were filtered with a 20 Hz low-pass, 2nd order, zero-lag Butterworth filter. Time-varying COP_{AP} and COP_{ML} displacements were calculated using the following approximations [26]:

$$COP_{AP} = \frac{M_x - (F_y \cdot dz)}{F_z} \quad \& \quad COP_{ML} = \frac{-M_y - (F_x \cdot dz)}{F_z}$$

where dz pertains to the distance from the surface to the platform origin.

Subsequently, the displacements of COP_{AP} and COP_{ML} were used to calculate the mean excursion, the maximum distance between any two points on the COP path (range), the length of COP trajectory and the mean velocity in the AP and the ML directions using following equations [27]:

$$\begin{aligned} excursion_{AP} &= \frac{1}{N} \sum_{n=1}^N |COP_{AP}[n]| \quad \& \quad excursion_{ML} = \frac{1}{N} \sum_{n=1}^N |COP_{ML}[n]| \\ range_{AP} &= |\max(COP_{AP}) - \min(COP_{AP})| \quad \& \quad range_{ML} = |\max(COP_{ML}) - \min(COP_{ML})| \\ trajectory_{AP} &= \sum_{n=1}^{N-1} |COP_{AP}[n+1] - COP_{AP}[n]| \quad \& \quad trajectory_{ML} = \sum_{n=1}^{N-1} |COP_{ML}[n+1] - COP_{ML}[n]| \\ velocity_{AP} &= \frac{trajectory_{AP}}{T} \quad \& \quad velocity_{ML} = \frac{trajectory_{ML}}{T} \end{aligned}$$

(narrow base, N); each of these tasks was performed with eyes open (EO) and with eyes closed (EC). Furthermore, all the above conditions were performed with a light touch contact of the right index finger with a stable, flat instrumented surface (touch, T) and without any contact (no touch, NT). During the light touch contact condition, subjects were instructed to maintain their right arm by the side of their body, forearm pronated and at 90° of elbow flexion, wrist in neutral position, and the index fingertip in contact with a rigid and stable metal surface to which was attached a force transducer while the other fingers were flexed to form a light fist. Participants were instructed to merely contact the surface with a very light touch and exert no pressure at all. The left upper limb remained hanging loosely by the side of the body but not in contact with it. In the EO conditions, subjects were instructed to focus on a point marked in front of them at eye level and in EC conditions, they were asked to keep their neck and head in neutral position while their eyes were covered with a mask. During the NT conditions, subjects were required to keep their index finger just above the contact surface, but not touching it. All subjects were tested bare feet. A total of eight task conditions were performed and two trials were collected per condition, each lasting for 30 s. The conditions were randomized for each subject. The assessment protocol was carried out in one session and subjects were allowed to rest during testing if necessary. Subjects were tested in the morning to minimize the effects of fatigue commonly reported in MS later in the day.

where N is the number of data points included (30,000) and T is the period of time (30 s) selected in the present analysis. These variables were calculated for each trial and averaged across two trials in each condition.

2.4. Statistical analysis

Three-way repeated measures ANOVAs were performed with factors: vision (2 levels: EO and EC), BOS (2 levels: R and N), and touch (2 levels: T and NT) for each outcome measure (excursion, range, trajectory and velocity) in the AP and the ML directions. A post hoc comparison was done using Tukey's honestly significant difference test for significant interactions and main effects. Statistical difference was set at $p < 0.05$. Means and standard errors are presented.

3. Results

3.1. Effect of vision

Fig. 2 illustrates excursion, trajectory, range and velocity in the AP and ML directions for the EO and EC conditions, averaged over

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