The Effect of Light Touch Cue on The First Step Length and Step Time in Patients with Parkinson's Disease: A Pilot Study

การศึกษานำร่องผลของการใช้การสัมผัสแผ่วเบา ต่อความยาวก้าวและระยะเวลาของการเริ่มต้นการก้าวเดินในผู้ป่วยพาร์กินสัน

Suthida Ditthaphongphakdee (สุธิดา ดิษฐพงศ์ภักดี)* Chitanongk Gaogasigam (จิตอนงค์ ก้าวกสิกรรม)**

ABSTRACT

Patients with Parkinson's disease (PD) degrade balance control during locomotion especially gait initiation. Light touch cue from external object could increase spatial reference. The aim of this pilot study was to investigate the effects of light touch cue on the first step length and step time in patients with PD. Five participants (Hoehn & Yahr 1-3) were tested the first step length and step time by using the motion analysis and force platforms under two random conditions, including No touch (NT) and Light touch (LT). Participants with LT presented significantly longer step length than NT condition ($p<0.05$) but there was no statistically significant difference of the step time between both conditions ($p>0.05$). We concluded that light touch cue could improve step length but could not improve step time in patients with PD.

บทคัดย่อ

ผู้ป่วยพาร์กินสันมีความเสื่อมของความสามารถในการทรงตัวในขณะที่มีการเคลื่อนไหว โดยเฉพาะอย่างยิ่งขณะเริ่มต้นการก้าวเดิน การใช้การสัมผัสแผ่วเบาโดยรับความรู้สึกสัมผัสจากวัตถุภายนอกจะสามารถเพิ่มข้อมูลเกี่ยวกับการรับรู้สภาพและตำแหน่งของร่างกายมากขึ้น วัตถุประสงค์ของการศึกษานำร่องนี้คือ ศึกษาผลของการใช้การสัมผัสแผ่วเบาต่อความยาวก้าวและระยะเวลาของการเริ่มต้นการก้าวเดินในผู้ป่วยพาร์กินสัน โดยผู้ป่วยพาร์กินสันทั้งหมด 5 คน (Hoehn & Yahr 1-3) จะได้รับการตรวจประเมินด้วยเครื่องวิเคราะห์การเคลื่อนไหว 3 มิติและแผ่นวัดแรงกดจากเท้าภายใต้สองสถานการณ์สุ่ม ได้แก่ ไม่มีการสัมผัสและมีการสัมผัสแผ่วเบา ซึ่งผลการศึกษาพบว่าสถานการณ์ที่มีการสัมผัสแผ่วเบาทำให้ผู้ป่วยมีความยาวในการก้าวมากกว่าสถานการณ์ที่ไม่มีการสัมผัสอย่างมีนัยสำคัญทางสถิติ แต่ไม่พบความแตกต่างของระยะเวลาของการเริ่มต้นการก้าวเดินระหว่างสองสถานการณ์ ดังนั้น การสัมผัสแผ่วเบาสามารถเพิ่มความยาวก้าวในการเดิน แต่ไม่สามารถลดระยะเวลาในการก้าวเดินในผู้ป่วยพาร์กินสันได้

Keywords: Parkinson's disease, Light touch cue, Gait initiation

คำสำคัญ: พาร์กินสัน การสัมผัสแผ่วเบา การเริ่มต้นการก้าวเดิน

** Student, Master of Science Program in Physical Therapy, Faculty of Allied Health Sciences, Chulalongkorn University*

*** Assistant Professor, Department of Physical Therapy, Faculty of Allied Health Sciences, Chulalongkorn University*

Introduction

Instabilities of balance and gait are major problems in patients with Parkinson's disease (PD) (Bryant et al., 2012). Gait initiation is a volitional move from a static steady base of support to a continuously unsteady base of support. Therefore, gait initiation had been shown to be a sensitive indicator of balance dysfunction, which occurs with age-related declines and disability such as patients with PD (Martin et al., 2002; Hass et al., 2004). About 50-68% of patients with PD had fall occurrences during locomotion i.e., walking and gait initiation (Martin et al., 2002; Brauer et al., 2011). Gait initiation cycle starts with center of pressure (COP) located between the feet while quiet standing to the ends at toe-off of the stance limb (Taweetanalarp et al., 2011). Gait initiation features in patients with PD are prolonged anticipatory postural adjustment (APA), decreased gait speed, longer total time of initiation cycle, and decreased step length (Mille et al., 2012). Gait initiation is the complex integration between locomotion and postural stability. Accordingly, sensory inputs from visual system, vestibular system, and somatosensory system are involved to provide the appropriate task and maintain postural stability (Hass et al., 2005; Shumway-Cook, Woollacott, 2012). All of the major sensory systems degenerate with age advancing and disability such as PD. Compensatory strategies benefit for declining sensory abilities in elderly, stroke, and patients with PD (Tremblay et al., 2004; Boonsinsukh et al., 2009; Boonsinsukh et al., 2012). So, initiation and achievement the movement of patients with PD depend on external stimuli such as visual cue, auditory cue, and somatosensory cue (Konczak et al., 2009; McCandless et al., 2016).

Light touch cue is somatosensory cue from a stable external object which not offering physical support (threshold of 1 Newton) (Chen, Tsai, 2015). Somatosensory system converges sensory information from proprioception, kinesthesis, pressure, and touch to provide body segments location and motion, contact with material objects, and orientation comparative to the environment (Boonsinsukh et al., 2009; Chen, Tsai, 2015). Accordingly, somatosensory inputs from light touch enhance spatial reference about body and trunk orientation from the external object to a body part. Then, the information is sent to the cortical areas which could adjust postural muscles to control posture leading to attenuate postural sway and increase postural stability (Boonsinsukh et al., 2009; Rabin et al., 2013). Rigidity of axial muscles will lead to motor disability such as incoordination between inter-segment during walking and slowness of gait speed (Van Emmerik et al., 1999; Franzén et al., 2009). Nevertheless, rigidity of axial muscle in patients with PD could be attenuated by light touch that helped patients with PD to control movement easily (Van Emmerik et al., 1999; Franzen et al., 2012). However, it is unclear whether the effect of light touch cue can improve the first step length and step time in patients with PD or not. Therefore, this study aimed to evaluate the effect of light touch cue on the first step length and step time in patients with PD.

Objectives of the study

To investigate whether the effects of light touch cue can improve the first step length and step time in patients with PD.

Methodology

Participants

Five participants were recruited (4 males and 1 females). Inclusion criteria were diagnosed PD patient who was treated with dopaminergic medication, Hoehn & Yahr stage 1-3 (Hoehn, Yahr, 1967), independent walking>10 meters without using a walking aid (ON medication), understand and follow simple commands. Participants who were unable to complete the procedures, had cognitive impairment (Thai Mental State Examination□23), had other neurological diseases that affected sensory impairment in the extremities such as stroke, had musculoskeletal conditions that affected the ability to walk such as fracture and arthritis, had sensory system pathology affected walking or communication such as blindness, deafness, had surgical treatment for PD such as deep brain stimulation were excluded. The anthropometric data, Thai Mental State Examination (TMSE), 10-meter walk test (10MWT) were administered to all participants.

Procedures

The participants were tested during the period of "ON" medication (60-120 minutes after dopaminergic medication intake). There were two randomly conditions; no touch (NT) and light touch (LT) conditions. Before data collection, a researcher attached heel marker on both heels of each participants. The starting position, the participants began with standing barefoot outside force platforms. After they received instruction "step", they stepped on the force platforms and continued quite standing for 1 minute. Adhesive tape was used to mark the feet position on each force platform so the same starting position was repeated for all gait initiation trials.

The trials with a touch condition was illustrated in figure 1. A touch device consisted of load cells which was used to monitor the fingertip force. The touch device was calibrated with standard weight. Pearson Correlation was used to evaluate validity of touch device and standard weight (Pearson correlation = 1). The device beeped if the participants touch exceeded the threshold of 1 Newton. The touch device was put on a camera tripod and could adjust the height at the level of the grater trochanter of each participant. The touch device was placed beside at dominant hand of participant. Their dominant index finger touched the device before initiating gait with the contralateral leg of the dominant hand. The trial with no touch condition was illustrated in figure 2, the participants placed the arm in a comfortable hanging. After participants received instruction "start", they began walking as quickly as possible and continued walking to the end of the walkway. Each condition was collected in 3 successive trails, and there was a 30 seconds rest period between each trail and 5 minutes rest period between each condition.


Figure 1 LT condition (Left) **Figure 2** NT condition (Right)

Data processing and data analysis

The characteristics of gait initiation were recorded using 8 camera motion analysis system (Motion analysis CO., Santa Rosa, CA) at 120 Hz and cleaned up and smoothed data by low-pass Butterworth filter with a cutoff frequency of 12 Hz. Outcome measure of this study was the first step length and step time. The first step length was defined as the maximum anterior sagittal displacement of the initial swing limb heel marker from initial resting position until heel strike of the first swing limb (Dibble et al., 2004). Force data were collected by three Bertec force platforms at 1,200 Hz. The first step time was defined as the period between the onset of COP displacement and heel contact of the first step (Yohei Okada et al., 2011). Descriptive statistics were performed for age, gender, height, weight, dominant hand. The Shapiro-wilk test showed normal distribution of the data. The outcome measures in this study were compared between no touch and light touch condition using paired t test. All statistical analyses used a level of significance of 0.05.

Results

The anthropometric data, TMSE, 10MWT of participants were showed in table 1. The mean and standard deviation of the first step length and step time were presented in table 2. As shown in table 2, patients with PD had statistically significant difference of the first step length between no touch and light touch conditions ($p<0.05$). When the participants touched the device, they had a longer distance of the first step length than no touch condition or initiate by themselves (NT=30.49±11.55 cm, LT= 33.04±7.35 cm). However, the first step time in no touch condition were not statistically difference from the light touch condition ($p>0.05$).

Table 1 Characteristics of participants

Variables	Participants (n=5)
Age (Year: Mean±SD)	73.4±13.52
Gender (Male/Female)	4/1
Height (Centimeter: Mean±SD)	161.98±11.56
Weight (Kilogram: Mean±SD)	66.36±15.24
Dominant hand (Right/Left)	5/0
Body Mass Index (Kg/m^2)	24.98
Thai Mental State Examination (Score: Mean±SD)	26.00±2.35
Hoehn & Yahr stage	
Stage 1	1
Stage 2	2
Stage 3	2
10-meter walk test (Meter/second: Mean±SD)	0.75±0.24

Table 2 Mean±SD of the first step length (cm) and step time (s) between no touch and light touch conditions

	NT	LT	*p*-value
Step length (cm)	30.49±11.55	33.04±7.35	0.002*
Step time (s)	2.38±0.82	2.65±0.55	0.27

* = Significant difference at p-value<0.05

Discussion and Conclusions

The purpose of this study was to investigate the effects of light touch cue on the first step length and step time in patients with PD. The finding of this study showed that participants with LT presented significantly longer step length as compared to participants with NT. The increasing of step length might be benefit from light touch cue which added sensory feedback from external object to enhance postural stabilization (Chen, Tsai, 2015). The postural stabilization could be corrected by a local trunk reference frame instead of a global reference frame (Franzen et al., 2012). The data of previous studies showed light touch decreased axial muscle tone from the exceeding to the optimal level of axial muscle tone (Franzen et al., 2012). For walking, exceeding muscle tone leaded to incoordination between pelvic and thoracic rotation, slower walking velocity, shorter step length (Van Emmerik et al., 1999; Franzén et al., 2009). In order to explain those findings, Franzen and co-worker found light touch could decrease rigidity of axial muscle in patients with PD (Franzen et al., 2012). Therefore, decreasing of rigidity could improve the first step length in patients with PD. However, these results were in contrast to the previous study that found light touch cane could not improve step length during walking 10 meter in patients with PD. The different results might be due to the magnitude of force applied by the participants. The previous study used a light touch cane, which allowed the average force of 21 N but this study used the touch device regulated fingertip force only 1 N. Moreover, the touch device had stable support more than light touch cane which was hold by the participants (Boonsinsukh et al., 2012).

The first step time in LT and NT conditions were similar. Nevertheless, our results were in agreement with the study of Bryant and co-worker which reported no difference in stride time between free walk and cane walk (Bryant et al., 2012). The equal time between NT and LT conditions showed that LT could not reduce step time. On the other hand, LT could improve step length in patients with PD. This outcome may be correlated with the ability to move a greater COP displacement during gait initiation. Participants with LT might be able to extend the weight shifting to the initial stance limb support more than NT condition so the first step length of the initial swing limb increased. Halliday and colleague reported that patients with PD who had a greater COP displacement and shifting of weight would have a longer step during initiation of gait (Halliday et al., 1998). However, the small sample size used in this pilot study limits our ability to find statistically significance of step time between both conditions. Thus, future research is necessary to clarify the kinetics of gait initiation especially COP displacement and velocity in each phase of gait initiation cycle, increase number of participants, and specify degree of pathology in patients with PD.

In conclusion, the results of this study showed that light touch cue could increase the first step length but not step time in patients with PD. Based on these findings, it is recommended that clinicians could use light touch cue to improve the first step length in patients with PD.

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