行政院國家科學委員會專題研究計畫　期中進度報告

使用輔具對腦中風病患站立與步行時之動態平衡及維持動態平衡所需注意力之影響(1/3)

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執行期間： 91 年 08 月 01 日至 92 年 07 月 31 日
執行單位： 國立臺灣大學醫學院物理治療學系暨研究所

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行政院國家科學委員會專題研究計畫成果報告

使用輔具對腦中風病腦中風病患站立與步行時之動態平衡及維持動態平衡時所需注意力之影響(1/3)

(Influence of Assistive Devise Use on Dynamic Balance and the Associated Attentional Demands during Standing and Walking in Patients with Stroke (1/3))

計畫編號：NSC 91-2314-B-002-365
執行期限：91 年 8 月 1 日至 92 年 7 月 31 日
主持人：湯佩芳助理教授　台大醫學院物理治療學系暨研究所
共同主持人：林光華教授　台大醫學院物理治療學系暨研究所

Abstract

The specific aim of this year-one part of the three-year research project was to compare the differences in the influence of assistive device use on dynamic balance and the associated attentional demands during voluntary stepping in standing between patients with stroke and age-matched healthy individuals. Subjects were asked to step forward, sideways, or backward, in response to a stimulus light signal with the left or right leg under a cane-free and a cane (regular type)-assisted condition. In the cane -assisted condition, healthy subjects used the dominant hand and patients with stroke used the unaffected hand to hold the regular cane. To date, 8 (6 young and 2 older) healthy subjects have participated in this study. Reaction time, movement time, step length, and the force dynamics of the cane were calculated. The results showed that older adults benefited from using the cane by decreasing the reaction time and increasing the movement time of the stepping responses. The force dynamics of the cane were task-specific, suggesting that even for healthy adults, the use of a cane still provides additional physical support for the completion of the stepping movement. These preliminary results will serve as important reference information to be compared with as we collect more data on hemiparetic patients following stroke.

Keywords: hemiplegia, ambulation assistive device, attention, stepping during standing, dynamic equilibrium, reaction time, movement time, force dynamics

Background and Aims

Restoration of independent standing and walking ability is one of the most common ultimate goals of stroke rehabilitation. Ambulation assistive devices (or ambulation aids) are thus important training or supporting tools in stroke rehabilitation. Although the use of an assistive device increases the base of support and decreases postural sway for stroke patients in standing, the use of an assistive device may also inevitably aggregate weight bearing asymmetry between the affected and unaffected lower extremities (Milczarek et al., 1993). Brunt et al (1995) has shown that asymmetric stance led to greater difficulty with gait initiation than symmetric stance for stroke patients. Therefore, it remains an important issue to investigate how the use of an assistive device influences dynamic balance, rather than static balance, in standing for these patients. Furthermore, research using dual-task paradigm has also shown that the use of an assistive device increased attentional demands during standing for healthy individuals (Wright & Kemp, 1992). The verbal reaction time for a secondary verbal task was found longer when healthy individuals walked with standard walker or rolling walker compared to when they walked without any devices (Wright & Kemp, 1992). It remains unknown whether the use of an assistive device also increase attentional demands to perform a motor tasks for stroke patients. The specific aim of this study was to compare differences in the influence of assistive device use on dynamic balance and the associated attentional demands during voluntary stepping in standing between patients with stroke and age-matched healthy individuals.

Methods

Subjects. Eight (6 young and 2 older) healthy adults have participated in this study. The mean age, body weight, and body height were 25.3 ± 3.2 yr, 54.8 ±12.3kg, 163.0 ± 7.2cm for young subjects and 62.5± 0.7 yr, 69.0 ±9.9kg and 179.0 ±1.4cm for older subjects, respectively. All of these subjects were right-foot dominant, had normal muscle strength and full score (56) on the Berg Balance Scale, indicating that none of these subjects have balance problems in daily activities. Because of the outbreak of SARS disease in Taipei metropolitan area in the past several months, we had great difficulty recruiting volunteers, especially stroke patients, from the National Taiwan University Hospital or the communities in the surrounding to participate in this study. Therefore, to date, only healthy subjects have been tested. After the outbreak of the SARS disease in under better control in the Taipei area, we will continue to recruit more stroke and healthy subjects to participate in this study.

Experimental Apparatus. A Reaction Time Timer (Lafayette Instrument, USA) was used to provide a stimulus light to the subject. Two force plates (AMTI OR6-7, Advanced Mechanical Technology, Inc., USA) were used to record ground reaction forces of the subjects, which then were used to derive center of pressure data. One instrumented cane (Model Z-CT6-500, Advanced Mechanical Technology, Inc., USA) was used to record the horizontal and vertical reaction forces on the cane in the cane-assisted conditions. Six foot switches (Motion Lab Systems, Inc., USA) were used to signal the time the heel and the 1st and 5^{th} metatarsal heads of each foot were in contact with or off the floor. The stimulus light, force and foot switch signals were all recorded on a PC computer using the DATAPAC A/D acquisition board and acquisition software (Run Technologies, USA). The DATAPAC2000 software (Run Technologies, USA) was used to analyze the light, force and foot switch data. A video camera (Video Hi8 SONY) was used to record subject's behaviors during the experiment. A custom-written software is now being programmed and will be used to quantitatively analyze the center of pressure data. Behavioral analysis using the video data was performed to characterize subject's balance behaviors before, during, and after the stepping movements.

Stepping Tests. Each subject was standing on one of the force plates with symmetric stance initially. The stimulus light of the reaction timer was positioned 1 meter in front of the subject at the eye level. Each subject was instructed to make a quick step with comfortable step length toward the other force plate after a red stimulus light was lit. Twelve stepping conditions were tested on each subject in random order, including stepping forward, sideways, and backward with the right and left leg, respectively, under a cane-free and a regular cane-assisted condition. In the regular cane -assisted condition, healthy subjects used the dominant hand and patients with stroke used the unaffected hand to hold the regular cane.

There were a total of 36 trials with 3 trials in each condition.

Results

Figure 1 shows the reaction time for making a stepping movement in all tested conditions for the young subjects. In the forward and backward stepping conditions, young subject presented longer reaction time in the cane-assisted conditions than in the cane-free conditions. In sideway stepping condition, the reaction time increased in the cane-assisted rightward stepping condition, but decreased in the cane-assisted leftward stepping condition, compared to the corresponding cane-free conditions. Figure 2 presents the movement time of completing the stepping movement in all tested conditions for the young subjects. The results showed that the movement time decreased in the cane-assisted forward and backward stepping conditions, but increased in the rightward stepping condition, compared to the corresponding cane-free conditions. Figure 3 illustrates the reaction time for making a stepping movement in all tested conditions for the older subjects. Different from the reaction time results on young subjects, the reaction time of older adults decreased in all cane-assisted conditions except for the cane-assisted backward stepping with the right leg condition. Also contrary to the results of movement time on young adults, older adults presented longer movement time in most of the cane-assisted conditions, except for the cane-assisted backward stepping conditions (Fig. 4).

Figures 5 and 6 present the effects of cane use on normalized step length in all stepping conditions for the healthy young and older adults, respectively. It appears that the use of cane did not cause significant changes in step length for both age groups.

Figures 7, 8, 9 and 10 illustrates the typical dynamics of the horizontal and vertical reaction forces on the cane in the forward stepping with the left leg, backward stepping with the left leg, leftward stepping with the left leg, and rightward stepping with the right leg conditions, respectively, in one young subject. In all of these conditions, the subject held the cane with his right hand.

Regarding the medio-lateral (ML) force trajectories, the results showed no significant change in the ML forces prior to and during the stepping movement in both forward and backward cane-assisted stepping conditions (Figs 7 & 8), whereas this force was directed rightward as the subject stepping leftward (Fig. 9) and directed leftward as the subject stepped rightward (Fig. 10).

Regarding the antereo-posterior (AP) force trajectories, the results showed that in the forward stepping condition, this force was directed forward and then backward (Fig. 7). In the backward and leftward stepping conditions, this force was directed anterior throughout the stepping movement (Figs. 8 & 9). In the rightward stepping condition, this force was directed posterior first and then change to be anterior (Fig. 10).

In terms of the vertical force trajectories of the cane, the data showed that in forward, backward, and leftward stepping movement, the vertical force on the cane first decreased, that is the subject unloaded the cane momentarily, in the early phase of the stepping response, then the vertical force increased (loading on the cane) afterwards (Figs. 7, 8, & 9). On the other hand, during the rightward stepping movement, the subject loaded the cane directly in the early phase of the reaction and thus the vertical force on the cane increased immediately (Fig. 10).

Discussion and Conclusions

1. The preliminary results on reaction and movement times showed that differential effects of cane use between healthy young and older adults. In young adults, it appears that the use of the cane may change their programming of a stepping movement, therefore the reaction time increased with the use of a cane. On the other

hand, the use of a cane may provide older adults with extra physical support and therefore older adults were willing to spend more time in the single stance phase of the stepping movement, which resulted in a longer movement time in the cane-assisted condition.

2. The dynamics of the force patterns on the cane were rather task-specific. It appears that although these healthy adults do not need to use the cane for making a stepping movement on a regular basis, when they do hold a cane to perform the stepping movement, the forces they generate on the cane still play a complementary role in assisting the completion of the stepping movement.
3. These preliminary data will serve as important reference information to be compared with as we collect more data on stroke patients.

Evaluation of the Outcomes of the Present Study

1. In this project, we originally had a dual-task design and proposed to purchase a commercial verbal reaction time machine (Lafayette Instrument, USA) to record subjects' performance on a secondary verbal task. However, it was later found that the function of the commercial machine is not adequate for fulfilling the purpose of the current project. Therefore, we later decided to have this machine custom-made by a local company instead. Because this machine was not ready until late April of 2003, we therefore conducted this study using the single task design first and report the results on single task design here. We will continue to conduct the dual-task design part of this study and further investigate the attentional changes associated with cane use in healthy subjects and stroke patients.
2. Because of the outbreak of SARS disease in Taipei metropolitan area in the past several months, we had great difficulty recruiting volunteers, especially stroke patients, from the National Taiwan University Hospital, where our laboratory is located, or from the communities in the surrounding to participate in this study. Therefore, to date, only healthy subjects have been tested. After the outbreak of the SARS disease in under better control in the Taipei area, we will continue to recruit more stroke and healthy subjects to participate in this study.
3. We will continue to work on the custom-written software and use it to complete our quantitative analysis of the COP data.
4. Our preliminary results on the effects of cane use on reaction times, movement times, step lengths, and force dynamics on the cane are highly important for understanding the influence of cane use on the dynamic balance control mechanisms during stepping movement in healthy adults and in hemiplegic patients. These results also have significant clinical implications and will provide some important guidelines for balance and gait training regimens in hemiparetic patients following stroke.
5. Results of this study are suitable to be published in an internationally peer-reviewed journal. We will write it up for publication after the completion of this project.

References

1. Brunt, D., Linden, D. W. V., & Behrman, A. L. (1995). The relation between limb loading and control parameters of gait initiation in persons with stroke. Archives of Physical Medicine and Rehabilitation, 76, 627-634.
2. Chang, H.-A., & Krebs, D. E. (1999). Dynamic balance control in elders: gait initiation assessment as a screening tool. Archieves of Physical Medicine and Rehabilitation, 80, 490-494.
3. Milczarek, J. J., Kirby, R. L., Harrison, E. R., & Macleod, D. A. (1993). Standard and four-footed canes: their effect on the

standing balance of patients with hemiparesis. Archieves of Physical Medicine and Rehabilitation, 74, 281-285.
4. Tyson, S. F. (1994). Hemiplegic gait symmetry and walking aids . Physiotherapy Theory and Practice, 10, 153-159.
5. Tyson, S. F. (1999). Trunk kinematics in hemiplegic gait and the effect of walking aids. Clinical Rehabilitation, 13, 295-300.
6. Tyson, S. F., & Ashburn, A. (1994). The influence of walking aids on hemiplegic gait. Physiotherapy Theory and Practice, 10, 77-86.
7. Wright, D. L., & Kemp. T. L. (1991). The dual-task methodology and assessing the attentional demands of ambulation with walking devices. Physical Therapy, 72, 306-315.

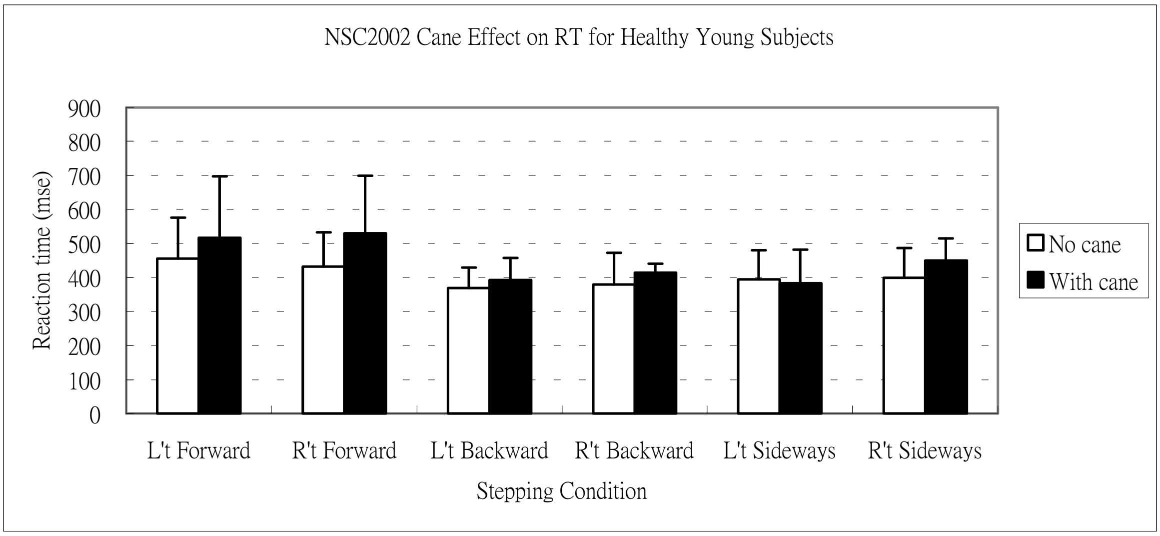


Fig. 1

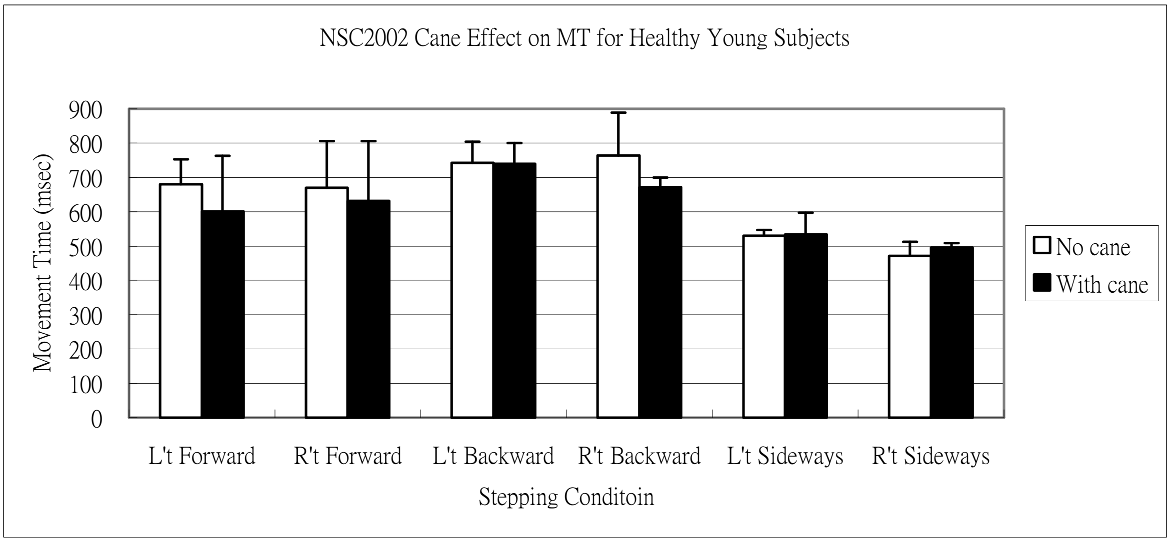

NSC2002 Cane Effect on MT for Healthy Young Subjects
Movement Time (msec)
900
800
700
600
500
400
300
200
100
0
No cane
With cane
L't Forward
R't Forward
L't Backward
R't Backward
L't Sideways
R't Sideways
Stepping Conditoin

Fig. 2

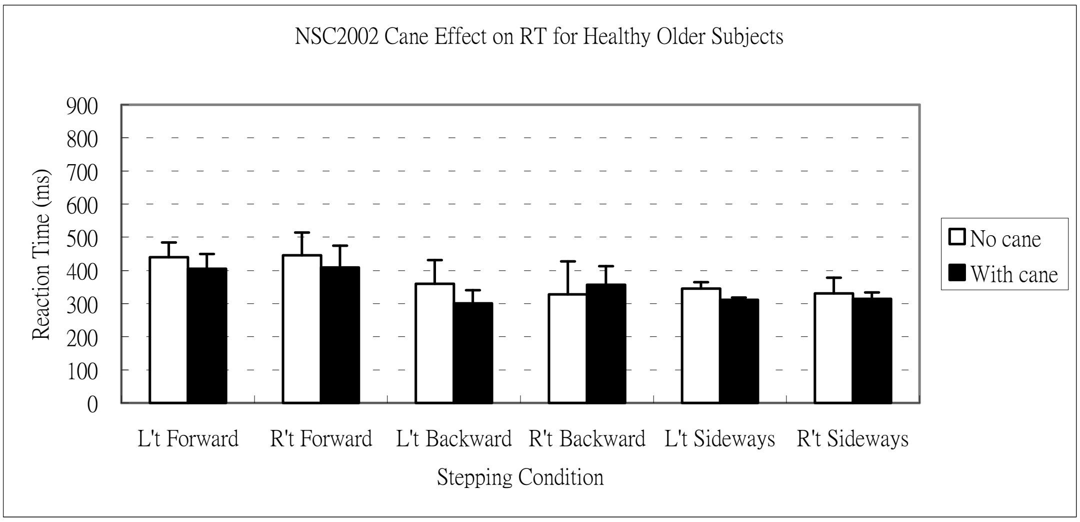

NSC2002 Cane Effect on RT for Healthy Older Subjects
Reaction Time (ms)
900
800
700
600
500
400
300
200
100
0
No cane
With cane
L't Forward
R't Forward
L't Backward
R't Backward
L't Sideways
R't Sideways
Stepping Condition

Fig. 3

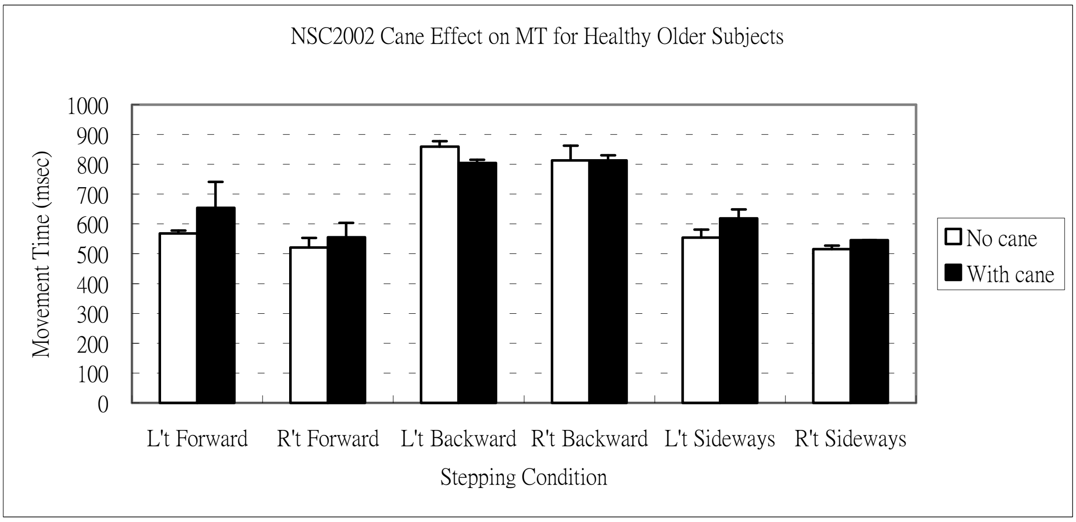
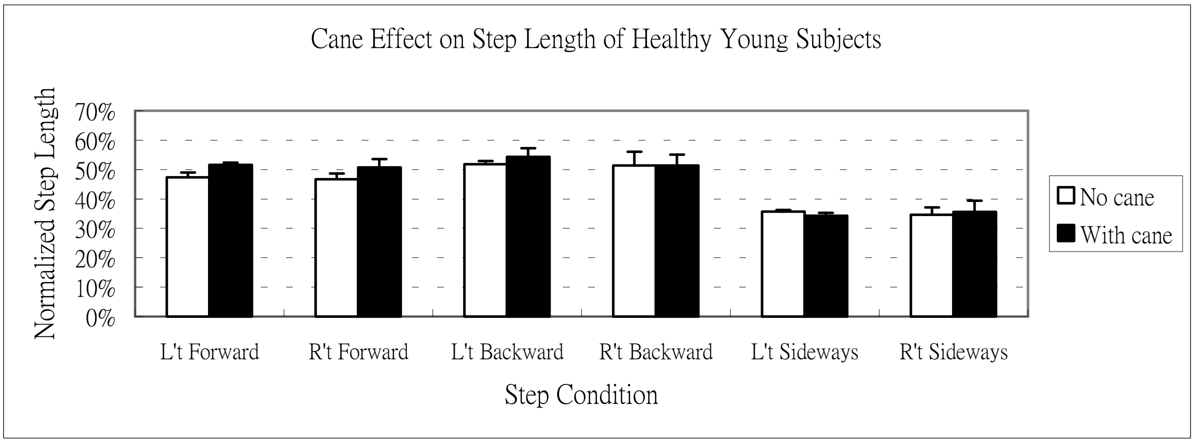
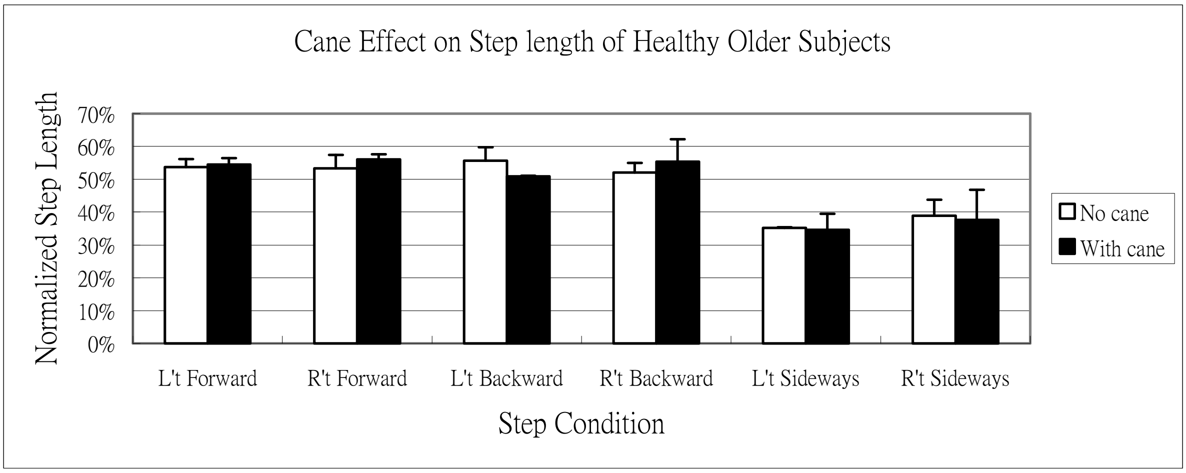

NSC2002 Cane Effect on MT for Healthy Older Subjects
Movement Time (msec)
1000
900
800
700
600
500
400
300
200
100
0
L't Forward
R't Forward
L't Backward
R't Backward
L't Sideways
R't Sideways
Stepping Condition
No cane
With cane

Fig. 4



Cane Effect on Step Length of Healthy Young Subjects
Normalized Step Length
70%
60%
50%
40%
30%
20%
10%
0%
L't Forward
R't Forward
L't Backward
R't Backward
L't Sideways
R't Sideways
Step Condition
No cane
With cane

Fig. 5



Cane Effect on Step length of Healthy Older Subjects
Normalized Step Length
70%
60%
50%
40%
30%
20%
10%
0%
L't Forward
R't Forward
L't Backward
R't Backward
L't Sideways
R't Sideways
Step Condition
No cane
With cane

Fig. 6

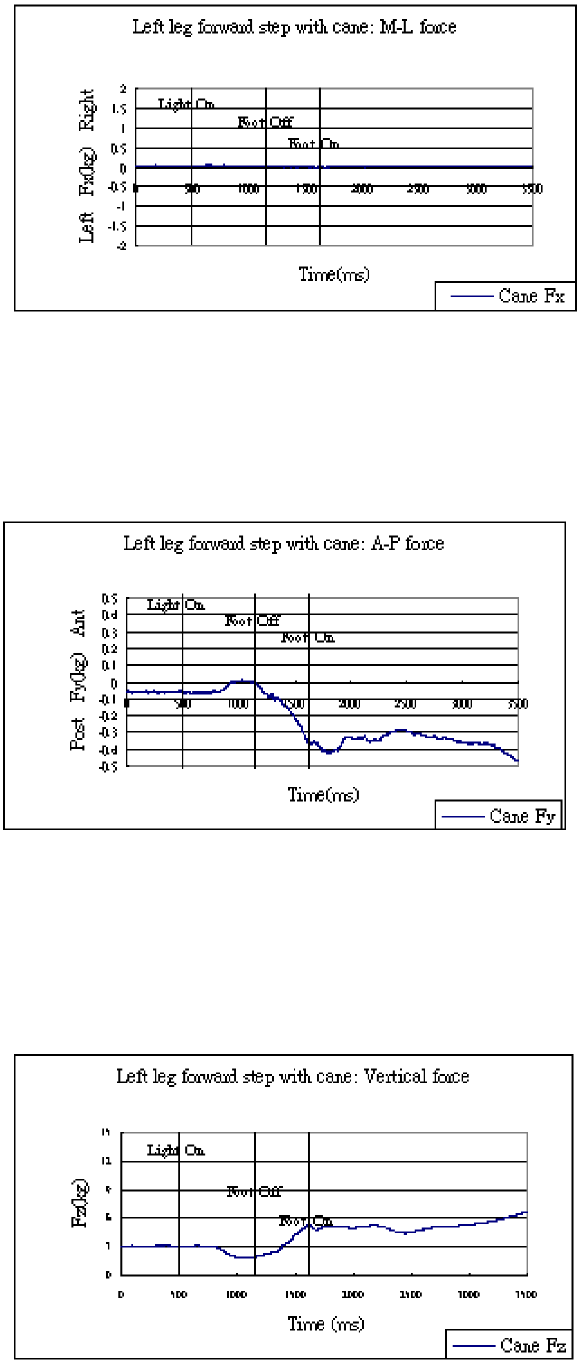

Left leg forward step with cane: M-L force
Left Fx(kg) Right
Light On
Foot Off
Foot On
Time(ms)
Cane Fx
Left leg forward step with cane: A-P force
Post Fy(kg) Ant
Light On
Foot Off
Foot On
Time(ms)
Cane Fy
Left leg forward step with cane: Vertical force
Fz(kg)
Light On
Foot Off
Foot On
Time (ms)
Cane Fz

Fig. 7

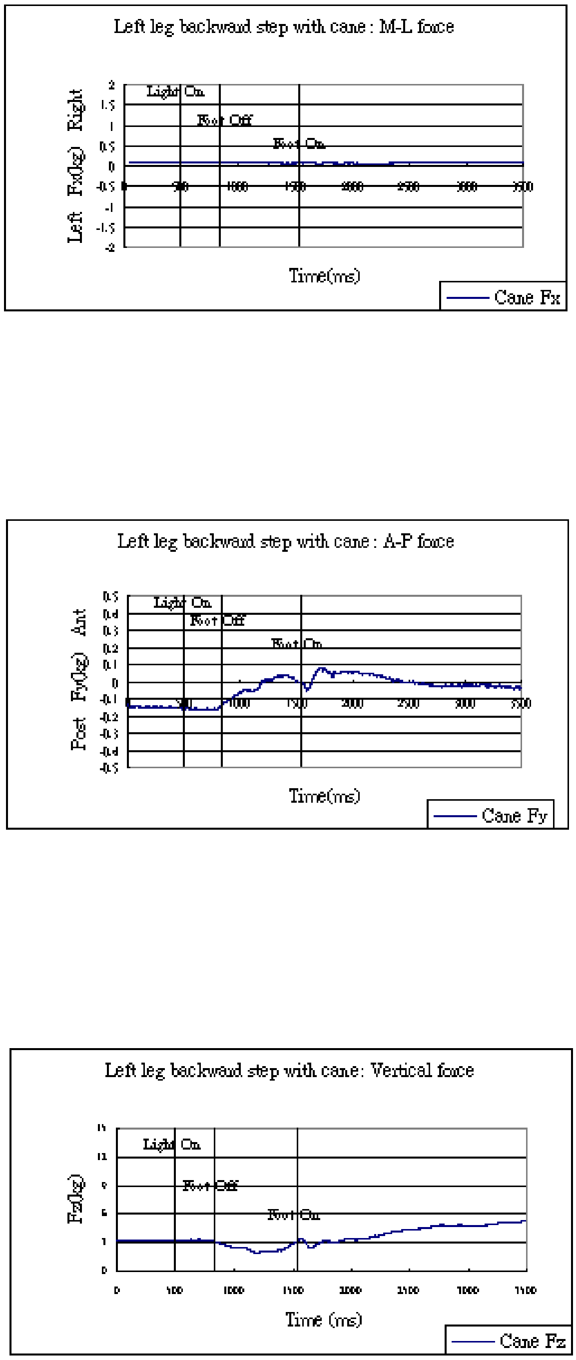

Left leg backward step with cane : M-L force
Left Fx(kg) Right
Light On
Foot Off
Foot On
Time(ms)
Cane Fx
Left leg backward step with cane : A-P force
Post Fy(kg) Ant
Light On
Foot Off
Foot On
Time(ms)
Cane Fy
Left leg backward step with cane: Vertical force
Fz(kg)
Light On
Foot Off
Foot On
Time (ms)
Cane Fz

Fig. 8

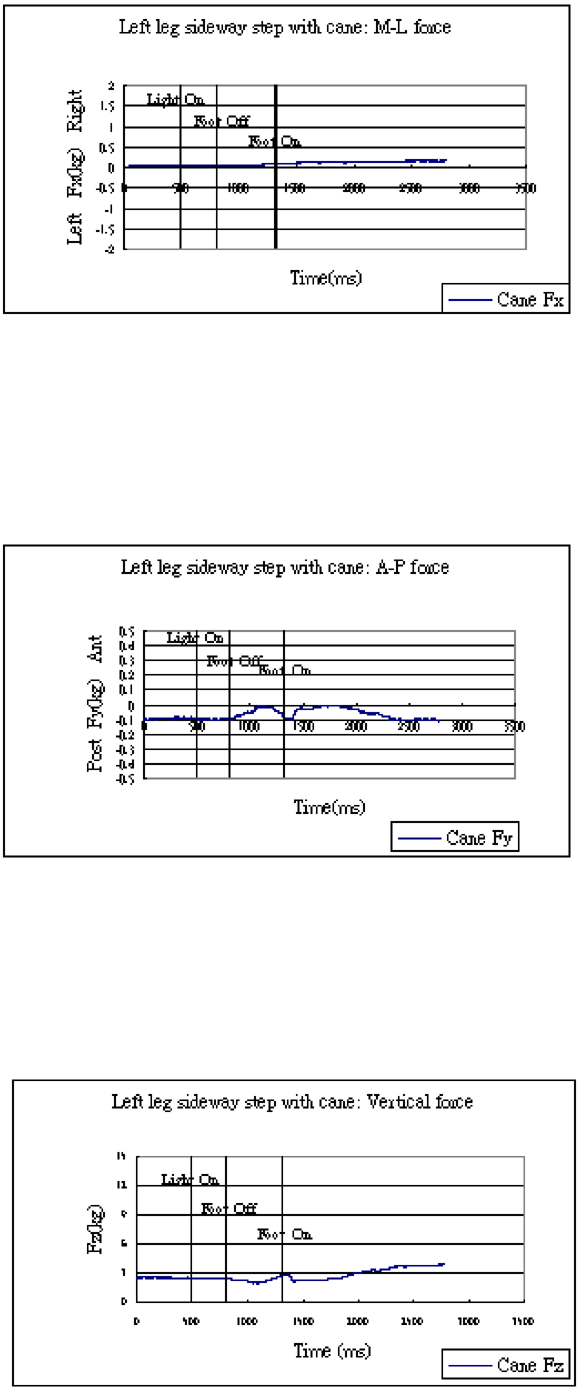

Left leg sideway step with cane: M-L force
Left Fx(kg) Right
Light On
Foot Off
Foot On
Time(ms)
Cane Fx
Left leg sideway step with cane: A-P force
Post Fy(kg) Ant
Light On
Foot Off
Foot On
Time(ms)
Cane Fy
Left leg sideway step with cane: Vertical force
Fz(kg)
Light On
Foot Off
Foot On
Time (ms)
Cane Fz

Fig. 9

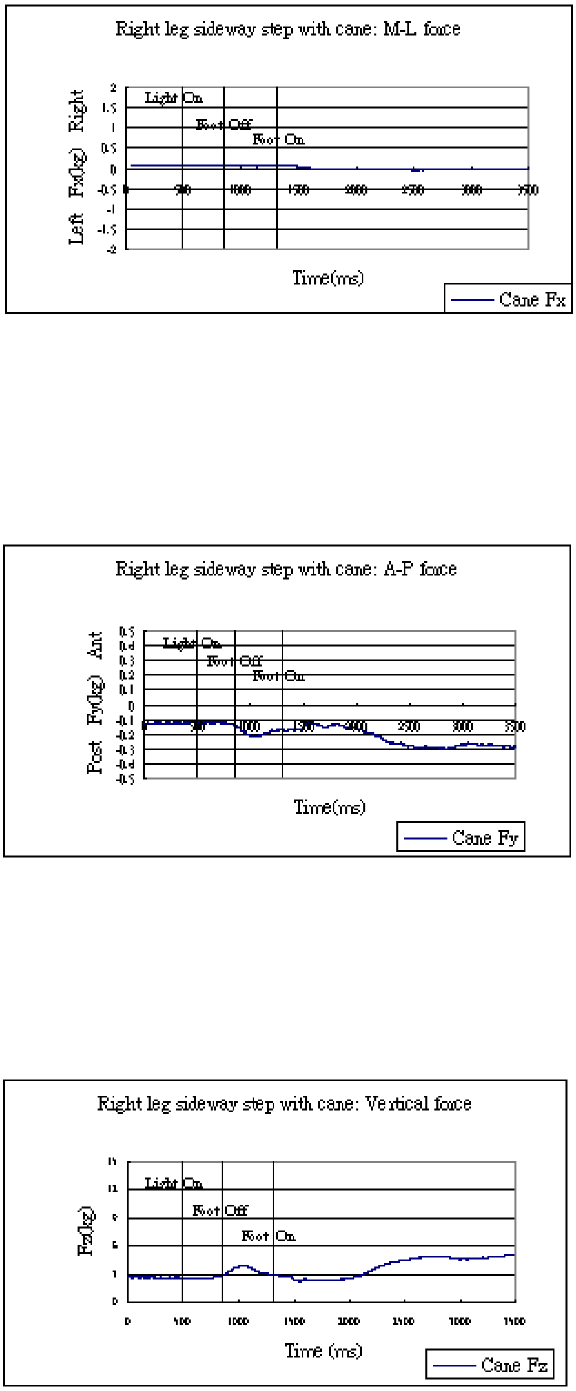

Right leg sideway step with cane: M-L force
Left Fx(kg) Right
Light On
Foot Off
Foot On
Time(ms)
Cane Fx
Right leg sideway step with cane: A-P force
Post Fy(kg) Ant
Light On
Foot Off
Foot On
Time(ms)
Cane Fy
Right leg sideway step with cane: Vertical force
Fz(kg)
Light On
Foot Off
Foot On
Time (ms)
Cane Fz

Fig. 10