CONTROL OF STABILITY DURING SLOPE LATERAL WALKING

[1]Chien-Ju Lin, [1, 2]Lin-Hwa Wang, [3]Yi-Wen Chang and [1]Fong-Chin Su
[1]Institute of Biomedical Engineering and [2]Department of Physical Education, National Cheng Kung University, Tainan, Taiwan, [3]Department of Exercise and Health Science, National Taiwan College of Physical Education, Taichung, Taiwan;
email: fcsu@mail.ncku.edu.tw

INTRODUCTION

Nowadays, the workers' occupational safety is highly emphasized for all the developing countries. Tubular steel scaffolding, which is regulated not to be narrow than 30 centimeters is commonly used in Taiwan as construction false work and finishing structure of high headroom buildings. In this condition, the workers need to walk laterally on a narrow slope while lateral walking is not a usual gait pattern in our daily life. Center of pressure (COP) is the point where the ground reaction force is collectively exerted at the surface [1], and it has been wildly used to analyze the control of stability [2,3].Very little research concerns gait pattern in lateral walking and slope walking. Kawamura, et al. determined step length, width, time factors and deviation in the COP during upslope and down slope walking, and found that walking speed, deviation in COP and the ratio of stance phase to stance phase were different between level and slope walking [2]. Lerous, et al. investigated postural adaptation to walking on inclined surface. They concluded that it was necessary to modify trunk and pelvis alignment during slope walking [4]. The purpose of this study was to investigate the COP trajectory in level and slope lateral walking. Hopefully the results will provide useful information on improving labors' working safety.

METHODS

Five normal subject (three males and two females, ages: 25±4.8 years, height: 166.9±7.2 cm and weight: 62.0±11.6 kg) participated in this study.

Two Kistler force plates (Kistler Instrument Corporation, NY, USA) were used in this experiment to collect the data of ground reaction force for further computation of COP. Foot switches (Motion Lab System, LA, USA) were synchronized with the force plates to identify gait phases during walking. The entire lateral walking cycle can be divided into two double support phases and two single support phases (right and left). The first double support phase started with the leading foot contact, and ended with the trailing foot off. The second started with the contact of trailing foot and ended with the leading foot clearing off from the floor. Slope inclinations were set at 5 degree. The subjects were instructed to walk with right leg leading from the bottom of the slope to the top at self-selected speed.

RESULTS AND DISCUSSION

According to the COP trajectories (Figure 1), we found these subjects performed two kinds of gait patterns. Four subjects performed toe contact with their leading foot while only one subject performed heel contact. Those who walked with toe contact had a U-shaped COP trajectory. The COP moved backwards after contact and then turned left before trailing foot contact. At this moment, COP moved laterally until the leading foot off. After that, COP kept moving to the left and turned forwards when the leading foot was performing hip abduction for next stride. However, the S-shaped trajectory indicated that the subject performed heel contact thus the COP moved forwards after contact.

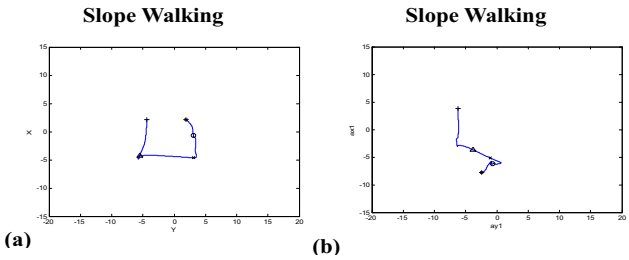

Figure 1: (a) U-shaped COP and (b) S-shaped COP (*: right foot contact; o: left foot off; x: left foot contact; Δ: right foot off; +: 2nd right foot contact)

Besides, the mean single-to-double support ratio (single support phase/double support phase) for level lateral walking and slope lateral was 0.31±0.04 and 0.24±0.03, respectively. The single support phase had a trend to be shorter during slope walking because walking on the slope was more unstable. Furthermore, the maximum velocity of the shift of COP during each phase is shown in Table 1. The result showed that during second double support phase the maximal velocity of COP shift during slope lateral walking was significantly larger than that during level lateral walking.

Table 1: Maximal sway velocity during four phases (unit: m/s)

	1st Double Phase	Right Single Phase	2nd Double Phase	Left Single Phase
Level	1.02±0.50	0.65±0.28	0.97±0.18	0.71±0.10
Slope	1.10±0.67	0.74±0.19	0.95±0.18	0.83±0.14 *

* $p<0.05$

CONCLUSIONS

The most obvious difference in maximal COP shift velocity happened in the second double support phase. It is unstable for human to walk laterally on a slope. Therefore, the muscle activation and joint adaptation of lower extremities will be important to control the movement.

REFERENCES

1. Winter DA. *Gait Posture* **3**, 193-214, 1995.
2. Kawamura K, et al. *Acta Medica Okayama* **45**, 179-184, 1991.
3. Hass J, et al. *Arch Phys Med Rehabil* **85**, 1593-1598, 2004.
4. Leroux A, et al. *Gait posture* **15**, 64-74, 2002.

ACKNOWLEDGEMENTS

Support from grant NSC 91-2316-B-006-002-CC3, Taiwan