J. Phys. Ther. Sci. 29: 405–408, 2017

The Journal of Physical Therapy Science

Original Article

Effect of a modified grip angle of a walker on the wrist deviation angle, muscle activation and palmar load during walker-assisted gait in elderly people

Sang-Yeol Lee, PT, PhD[1)], Seon-Chill Kim, PhD[2)*], Young-Ik Lee, PhD[3)]

[1)] *Department of Physical Therapy, College of Science, Kyungsung University, Republic of Korea*
[2)] *Department of Biomedical Engineering, School of Medicine, Keimyung University: 1095 Dalgubeol-daero, Daegu 42601, Republic of Korea*
[3)] *Department of Oriental Sports Medicine, College of Health and Therapy, Daegu Haany University, Republic of Korea*

Abstract. [Purpose] The aim of this study was to develop a new handle holder by modifying the inclination of the existing handle holder to reduce load on the wrist joints. [Subjects and Methods] The subjects of this study consisted of 25 elderly people aged 65 years or older accustomed to a walker-assisted gait. Two types of handle holders ((1) standard handle holder (2) inclination handle holder) were applied to all subjects and their wrist joint movement and muscle activity were measured while they conducted 10 cycle walker-assisted gait. [Results] The use of an inclination handle holder during the walker-assisted gait decreased considerably the extensor carpi radialis longus activity and angles of the ulnar deviation and wrist extension. [Conclusion] Improvements in the overall structure of a walker may be a new tool for improving existing walker users but the replacement cost will be expensive. The inclination handle holder presented in this study decreases the burden on the wrist joints of walker users without any overall structural changes in the walker, thereby reducing the occurrence of musculoskeletal diseases of the wrist joint during the walker-assisted gait of elderly people.

Key words: Walker assisted gait, Walker handle, Wrist load

(This article was submitted Sep. 21, 2016, and was accepted Nov. 22, 2016)

INTRODUCTION

Owing to ongoing progression of the aging population, the quality of life of the elderly is becoming a serious concern. Elderly people feel a sense of discomfort due to degeneration. For safe movements, elderly people utilize diverse gait aiding instruments in their ordinary life. Among them, walkers are gait-assisting tools used by many elderly people that provide base of support (BOS) widely and maintain a stable gait[1)]. A walker comprises 40% of the humans' gait cycle and a base of support is obtained during the swing phase when the risk of falling down is highest, thereby reducing the risk of falls and assisting in a stable gait[2, 3)].

The use of a walker has the merit of obtaining stability during movement but imparts excessive pressure on the upper limb joints, such as the wrists where the pressure is not delivered during gait[4)]. The handle of most walkers consists of two horizontal bars[1)], which significantly affects how the walker grasps the holder and pressure is delivered to the ground by the angles[5)]. The holder of the horizontal bar type causes excessive wrist deviation, resulting in cumulative repetitive motion to the wrists while using the walker, which adversely affects the wrist joints[6)]. A walker has the potential to trigger secondary

*Corresponding author. Seon-Chill Kim (E-mail: sunchil2@naver.com)

diseases, such as carpal tunnel syndrome. According to existing research, those accustomed to a walker have smaller ulnar deviation and wrist extension angles than those who are not[7]. This suggests that a wrist injury is likely to result from cumulative repetitive motions when the elderly are not accustomed to the gait using a walker when they use the holder of existing horizontal bar type. In many studies, a walker has the advantage of increasing the gait stability while failing to maintain a neutral position in the wrists, which highlights the need to develop a handle to adjust the posture and reduce the pressures on the wrist joints[8]. Accordingly, this study evaluated a handle holder that may decrease the load on the wrists during gait using a walker by improving the existing horizontal bar type handle.

SUBJECTS AND METHODS

The subjects of this study consisted of elderly people aged 65 or older who had used a walker for at least one year. They were accustomed to walker gait. In addition, their walker gait was longer than 50 m. Their mini-mental state examination score was 24 point or higher. Their right hand and foot were their dominant side. They had not experienced surgery to the upper and lower limbs in the recent six months or suffered a stroke. The average age of the subjects was 72.9 years (age range: 67 to 80 years old). The average weight and height of subjects was 69.8 kg and 169.9 cm. All procedures in this Institutional Review Board-approved project were explained to the participants prior to their involvement in the study. We declare that the abovementioned manuscript was approved by Ethics Committee of Kyungsung University according to approval number KSU-16-08-001 and that an Informed Consent Form was signed by the participants.

This study utilized a standard walker to examine the effects on the wrist deviation angle, muscle activation, and palmar load during the walker-assisted gait using two types of walkers. This study measured the right hand on all subject.

To make the area where the handle holder contacts the hand with contact forms, an inclination handle holder type (inclination of 15° (IH holder)) and standard handle holder type (inclination of 0° (SH holder)) were produced and employed (Fig. 1). The handle diameter of the standard walker used in this study was 2 cm. The holder diameter and length of the walker were 4 cm and 13 cm, respectively. The height of the holder was adjusted to become the greater trochanter height of the subjects.

Data was collected while the subjects conducted walker-assisted gait of 10 cycles using the two types of handle holders. The mean value of the middle 6 cycles was used for statistics. To observe the period when the fore and back feet of the walker contacted the ground, a wireless footswitch (Noraxon Inc., USA) was attached to the fore and back feet of the walker. Muscle activation was measured using a Noraxon DTS system (Noraxon Inc., USA) and wrist movement was measured using a myoMotion system (Noraxon Inc., USA) with an Inertial Measurement Unit (IMU) sensor. An adjustable thin F-Scan sensor (Tekscan Inc., USA) was used to measure the palmar load.

For the electromyography (EMG) (Noraxon Inc., USA) data, the sampling ratio was set to 1,000 Hz. The band filter and notch filter were set to 20–500 Hz and 60 Hz, respectively, and the electrodes (IWC-DTS, 9113A-DTS) were used. The signals collected were processed using the root mean square (RMS) values. For EMG data, a normalized % maximum voluntary contraction (MVC) was utilized. For muscle activation, the mean value of each cycle was used for statistics. A hair shave was conducted when necessary to reduce the skin resistance and fix the electrodes well onto the skin before using the surface electrodes, and the cleanness was maintained using alcohol cotton swabs[9]. For the measurements of the wrist movement using myoMotion (Noraxon Inc., USA), the sampling rate was 200 Hz. The inertial measurement unit sensor was attached to the back of the subject's hand to measure the values that changed during gait with the anatomical position as the standard. The palmar load was measured by attaching a thin F-Scan sensor of 0.2 mm to the proximal ulnar part and the proximal radial part of the palm with double-sided tape.

To measure the wrist movement, the average value of max angle of the walker-assisted gait's middle angle cycle was used for statistics. The muscle activation and movement data were analyzed simultaneously using myoResarch biomechanical analysis software (Noraxon Inc., USA). The palmar load was analyzed using the F-Scan program.

A paired sample t-test was conducted to compare the wrist movement, muscle activation, and palmar load measured during walker-assisted gait using a handle holder. The statistical significance was set to $\alpha=0.05$. Unless otherwise noted, all data are reported as the mean ± standard deviation (SD). The SPSS statistical package was used for data analysis.

RESULTS

An examination of the wrist movement and muscle activity during walker-assisted gait using an SH holder type and a IH holder type showed that the use of the IH holder type triggered significantly lower ulnar deviation and wrist extension than that using the SH holder type (Table 1) ($p \leq 0.05$). The flexor carpi radialis activity was also lower when an SH holder type was used than when an IH holder type was employed (Table 1) ($p \leq 0.05$). For the palmar load, the pressure on the proximal ulnar part decreased when the IH holder type was used compared to when an SH holder type was employed (Table 1) ($p \leq 0.05$).

DISCUSSION

This study was conducted to develop a handle holder aimed at reducing the excessive use of the wrist joints while maintaining a stable walker structure for elderly people who used a walker for a long time. The gait is generally a behavior

Fig. 1. Experimental walker using two type of handle holder

Table 1. The comparison of SH holder and IH holder on muscle activation and wrist movement

	SH holder	IH holder
Wrist movement (°)		
Ulnar deviation*	33.86 ± 3.35	24.00 ± 3.12
Radial deviation	17.61 ± 4.87	16.61 ± 4.84
Wrist extension*	24.90 ± 3.54	22.20 ± 3.82
Muscle activation (%MVC)		
Extensor carpi radialis longus*	40.98 ± 4.50	31.77 ± 4.72
Flexor carpi ulnaris	33.86 ± 3.35	24.00 ± 3.12
Palmar load (kg)		
Proximal ulnar part*	5.52 ± 1.76	4.47 ± 1.39
Proximal radial part	7.70 ± 2.19	7.23 ± 1.74
Comfortable level		
Modify VAS*	3.48 ± 0.51	2.96 ± 0.46

*p≤0.05, Mean ± SD
SH holder: Standard handle holder; IH holder: inclination handle holder

performed repetitively in ordinary life and provides elderly people with an excessive load and instability, which carries the risk of triggering many musculoskeletal system disorders[10]. To reduce this risk, the load is distributed using a gait-assistance tool, such as a walker. Nevertheless, the horizontal handle type of a standard walker triggers repetitive and excessive ulnar deviation and extension of the wrist joints during gait, with the possibility of triggering secondary diseases and pain in the wrist joints[6].

In this study, the use of an IH holder decreased the angle of ulnar deviation during walker-assisted gait. This suggests that the Guyon's canal pressure and excessive use may prevent secondary disorders[11]. In addition, the angle of extension in the wrist joints decreased together with ulnar deviation. The repetitive use of wrist extension may generate carpal tunnel syndrome and secondary diseases resulting from its overuse[11]. In walker-assisted gait, wrist extension is the excessive movement of the joints occurring in a walker user not accustomed to extension[7]. An increase in wrist extension and ulnar deviation occurs due to a dependence of the weight load on the upper limbs, not the lower limbs, which is characterized by repetitive motion away from a normal gait pattern. In addition, the risk of carpal tunnel syndrome (CTS) increases when the activity of the flexor is great with the wrist joints extended[12]. An IH holder is considered to reduce the risk of wrist joint syndrome because the walker handle is held and maintained with the extension reduced in walker-assisted gait. Moreover, the use of an IH holder decreases the range of repetitive motion of the wrist joints, thereby decreasing the activity of the extensor carpi radialis longus. This is believed to be because the occurrence of ulnar deviation decreases the extensor carpi radialis longus while the weight is moved to the wrist joints. Therefore, use of an SH holder is more likely to trigger a problem, such as 'tennis elbow' in the elbow joints as well as the wrist joints compared to the use of an IH holder[13].

In addition, an IH holder decreases the pressure by the proximal ulnar part of the palms, thereby reducing the load on the ulnar part of the wrist joint and complementing the problems of the standard walker. Previous research on crutch handle design showed that CTS could be prevented by the overall dispersion of the pressure distribution through structural changes of the crutch handle[14]. An IH holder also decreased the pressure on the proximal ulnar part while decreasing the pressure on the radial part from 7.70 ± 2.19 to 7.23 ± 1.74. Nevertheless, the F-Scan system measures the data on the vertical force only; therefore, continuous research on the shear force will be necessary.

According to the result of this study, during walker-assisted gait, an IH holder causes smaller ulnar deviation and wrist extension compared to a SH holder and decreases the extensor carpi radialis longus activity and pressure on the proximal ulnar part. On a long-term basis, use of an IH holder by elderly people utilizing a walker is expected to decrease the possibility of triggering secondary lesions in the wrist joints and elbow joints without a cost burden according to the replacement of

a walker.

This study is a limited study on handle holders with a 15 degree inclination. The study did not investigate the pressure on detailed parts on the palm but measured the vertical force on the palms only. In addition, this study failed to measure the gait variables of users when using a new handle type. In the future, research on effective walker-assisted gait by decreasing the load on the upper extremities through diverse structural changes of the walker handle will continue.

During walker-assisted gait, an IH holder decreased the excessive movement and muscular use of the wrist joints compared to an SH holder. In addition, an IH holder presented in this study decreased the burden on the wrist joint of the walker users without any overall structural changes in the walkers, which is likely to decrease the occurrence of musculoskeletal diseases on the wrist and elbow joints during walker-assisted gait.

Conflict of interest

There are no conflicts of interest to declare.

Financial disclosure

None

REFERENCES

1) Joyce BM, Kirby RL: Canes, crutches and walkers. Am Fam Physician, 1991, 43: 535–542. [Medline]
2) Goodpaster BH, Park SW, Harris TB, et al.: The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging and body composition study. J Gerontol A Biol Sci Med Sci, 2006, 61: 1059–1064. [Medline] [CrossRef]
3) Burnfield JM, Few CD, Mohamed OS, et al.: The influence of walking speed and footwear on plantar pressures in older adults. Clin Biomech (Bristol, Avon), 2004, 19: 78–84. [Medline] [CrossRef]
4) Koh ES, Williams AJ, Povlsen B: Upper-limb pain in long-term poliomyelitis. QJM, 2002, 95: 389–395. [Medline] [CrossRef]
5) Haque S, Khan AA: Effects of ulnar deviation of the wrist combined with flexion/extension on the maximum voluntary contraction of grip. J Hum Ergol (Tokyo), 2009, 38: 1–9. [Medline]
6) Giuliani CA, Gruber-Baldini AL, Park NS, et al.: Physical performance characteristics of assisted living residents and risk for adverse health outcomes. Gerontologist, 2008, 48: 203–212. [Medline] [CrossRef]
7) Leung CY, Yeh PC: Vertical force and wrist deviation angle in a sample of elderly people using walkers. Percept Mot Skills, 2013, 116: 223–232. [Medline] [CrossRef]
8) Pachi A, Ji T: Frequency and velocity of people walking. Struct Eng, 2005, 83: 36–40.
9) Hermens HJ, Freriks B, Disselhorst-Klug C, et al.: Development of recommendations for SEMG sensors and sensor placement procedures. J Electromyogr Kinesiol, 2000, 10: 361–374. [Medline] [CrossRef]
10) Shurr DG, Cook TM: Prosthetic and orthotics. New York: Appleton and Lange, 1990.
11) Claiborne DK, Reynolds-Lynch K, Powell NJ: Ergonomics and cumulative trauma disorders: a handbook for occupational therapists. San Diego: Singular Publishing, 1999.
12) Veeger HE, Meershoek LS, van der Woude LH, et al.: Wrist motion in handrim wheelchair propulsion. J Rehabil Res Dev, 1998, 35: 305–313. [Medline]
13) Lieber RL, Ljung BO, Fridén J: Sarcomere length in wrist extensor muscles. Changes may provide insights into the etiology of chronic lateral epicondylitis. Acta Orthop Scand, 1997, 68: 249–254. [Medline] [CrossRef]
14) Sala DA, Leva LM, Kummer FJ, et al.: Crutch handle design: effect on palmar loads during ambulation. Arch Phys Med Rehabil, 1998, 79: 1473–1476. [Medline] [CrossRef]