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Using walker during walking：a pilot study for health elder

Yeh Po-Chan [a], and Leung Cherng-Yee [b]
[a]*The Graduate Institute of Design Science, Tatung University, 40, Chungshan N. Rd., Sec. 3 Taipei, 104, Taiwan*
[b]*Department of Industrial Design, Tatung University, 40, Chungshan N. Rd., Sec. 3 Taipei, 104, Taiwan*

Abstract. Walker operation completely relies on the walker handle, however most marketed walkers possess two horizontal handles. Several researchers have suggested that horizontal handles might lead to wrist injury. Therefore, the purpose of this study is to assess the relevant design aspects of walker for elderly people. 28 elders participated in this study; when the experiment was started, subject walked on the tile for 3 meter distance twice by using walker. Data for analysis were selected at the corresponding wrist deviation and vertical force. The results showed that during walker using, the mean wrist deviation was greater than zero. The largest vertical force is significantly larger than the smallest one, and different wrist deviation occurred at three phases, the largest wrist deviation while raising walker is larger than the smallest one, however, no significant different was found between the largest and smallest wrist deviation while pressing walker. No significant correlation occurred between weight and wrist deviation. The correlation between weight and vertical force was significantly positive. With wrist deviation walker use may cause injury to upper-limb, however wrists remain in a neutral position during hand movement to prevent damage. The findings of this study should improve the design of walker handles to reduce the wrist deviations of users.

Keywords: walker; aging; wrist deviation; handle design

1. Introduction

Nowadays, the proportion of older people in population is expanding faster than younger ones [1]. In Taiwan, the proportion of the population older than 65 has increased from 8.8 % in 2001 to 10.4 % in 2008 [2]. Huang [3] estimated that almost 31.2% of the Taiwanese population will be 60 years or older in 2050.

Literatures also showed more and more people turn into limb / trunk handicapped because of aging [4-5]. In Taiwan 34% of 650 thousand disabilities are older than 65 years old [6]. Elders have dysfunction and lives on their own could bring up much more dangerous [7], therefore it becomes a very important issue of elders having independent life.

Walking is a general movement that is often seen in daily life [8]. However, during walking, elders who gradually lose their physiological function might encounter accident and get injured [5], therefore the medical costs have been increasing for elder life [9-10]. As a consequence, elders have to rely on ambulatory devices such as canes, crutches or walkers to assist in completing routines [11]. Carolyn & Urs [12] found that when a cane is used, 16% to 19% of body weight is transferred to the cane for support. In Taiwan, the average weight of males and females is 67.35 and 54.22 kg, respectively [13], so male might exert more vertical force larger than female does.

Walker is one of the most popular ambulatory devices by elders with gait disorders [14-15], and is expected to help elders function normally [5][11][16-17]. Most marketed walkers possess two horizontal handles [18] which are the main parts in operating walker. Several researchers [19-20] have suggested that horizontal handles might lead to wrist injury, especially when cumulatively repetitive movements are performed. Once the injury happened, the elder's independence would be reduced. The operation of walker is indeed a cumulatively repetitive movement. Designers should design appropriate and practical assistant device for elders to improve their independence [7]. *

*Corresponding author e-mail: leung@ttu.edu.tw.

The purpose of this study is based on the following four hypotheses: 1) Users exhibit wrist deviation with walker use during the movements of walking; 2) gender have significant effects on wrist deviation and vertical force; 3) wrist deviation have significant difference between raising and pressing walker; 4) the relationships among weight, wrist deviation, and vertical force are significant. The results might help to assess the relevant design aspects of walker for elderly people and to indentify possible product improvement.

2. Method

2.1. Participants

Thirteen male between 65 and 84 years of age (M = 74, SD = 6.55) and fifteen female between 67 and 82 years of age (M = 71.06, SD = 6.77) were recruited by an advertisement posted at Taipei Shilin Senior Center. They were retirees and reported no neural, sensorial or musculoskeletal impairments, medical conditions or medication use affecting control of balance or limb movement. Each person was given a gift for his / her participation.

2.2. Experimental device

Experimental walker — A standard walker (Fig. 1) made by aluminum alloy with a width of 52 cm, adjustable height of 72 to 82 cm, and weight of 4 kg was adopted to perform the experimental tasks.

Measurement Devices

Load cell — Four load cells, which were installed on each foot of the experimental walker, were used. A load cell (JIHSENSE S100) is an electronic device (transducer) used to convert force into an electrical signal. This conversion is indirect and occurs at two different points. Through a mechanical arrangement, the force being sensed deforms a strain gauge.

Shape sensor — A shape sensor was placed on the wrist of each participant to measure wrist deviation (Fig. 1). The shape sensor (Synapse S700) is a 1-degree-of-freedom sensor. It consists of two plastic enclosures, each attached to one end of a 200-mm vinyl-covered metal cantilever. One enclosure contains the electronics that convert the light signal from the sensor to an electrical output. The angle between the two plastic enclosures determines the amount of light traveling through the fiber.

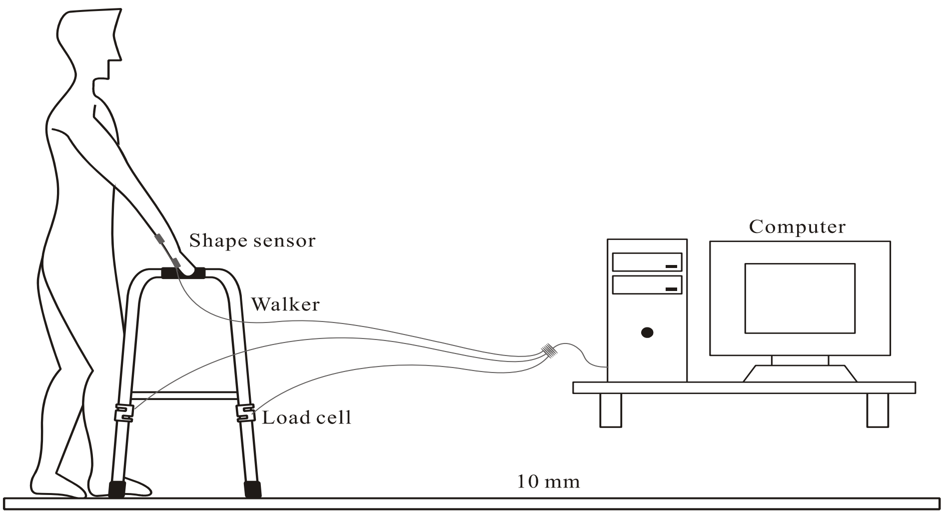

Fig. 1 The layout of experimental setting

All participants were tested one by one in a quiet room with room temperature approximately at 25 °C. Before experiment each participant's stature, weight, height of popliteal fossa, and height of greater trochanter were measured. Then the researchers adjusted the height of walker according to each individual greater trochanter height respectively, and asked he/she to practice the sequence twice. The experiment was conducted in two repeated sessions each taking approximately 10 minute duration. When the experiment was started, the researcher instructed subject walking on the tile for 3 meter distance twice by using walker. After the first experiment was finished, participant took a two minutes rest. Then participant repeated the same experiment. A personal computer simultaneously recorded the data of wrist deviations (°) and vertical force (N) at 1000 Hz obtained from the shape sensors and the load cells, respectively. During all trials, a registered nurse presented for safety.

2.3. Data analysis

Data for analysis were selected at the following 3 points: (1) When the largest and (2) the smallest vertical force occurred while pressing walker, the corresponding wrist deviation (°) and then vertical force (N) were chosen; and (3) the largest wrist deviation (°) was chosen while raising. The selected data were input into the SPSS statistical software package (Version 12.0) for analysis.

The single-mean *t*-test was used to determine whether users would exhibit wrist deviation with walker use during the movement of walking. MANOVA was used to detect the effects of gender on wrist deviation and vertical force. Paired *t*-test was used to determine whether vertical force have significant difference during press walker, and one-way ANOVA with blocking was used to determine whether wrist deviation have significant difference between raising and pressing walker. Finally, the Pearson product-moment correlation was adopted to determine the correlations among weight, wrist deviation, and vertical force. The significance level was set at 0.05.

3. Results and analysis

Table 1 presents the means and standard deviations of vertical force and wrist deviation during walking.

3.1. Wrist deviation

Table 1 shows the results of the single-mean t-test. During walker using, the mean wrist deviation was greater than zero ($p < 0.0001$); i.e., with walker use, on average, participants exhibited significant wrist deviation during walking.

When the two gender groups were compared, a multivariate analysis of variance (MANOVA) revealed that men and women did not differ significantly in terms of vertical force or in terms of wrist deviation while operating walker in walking (Table 2).

The results of Paired *t*-test showed the mean of the largest vertical force (M = 125.442 N, SD = 73.088) is significantly larger than the smallest one (M = 96.815 N, SD = 66.691) ($p < 0.0001$). One-way ANOVA with blocking showed different wrist deviation occurred at three phases (Table 3). Further analysis by using LSD method divided 3 phase into 2 groups, the largest wrist deviation while raising walker (M = 27.264°, SD = 10.856) is larger than the largest (M = 23.691°, SD = 10.362) and the smallest wrist deviation (M = 23.175°, SD = 10.629) while walking with walker, however, no significant different was found between the largest and smallest wrist deviation while pressing walker.

Table 1
Means, Sd, and one-sample t-test

Variable	Vertical force (N)		Wrist deviation (°)			
	M	SD	M	SD	t_0	P
The largest wrist deviation	125.442	73.088	23.691	10.362	12.098*	0.0000
The smallest wrist deviation	96.815	66.691	23.175	10.629	11.538*	0.0000
The largest wrist deviation while raising	-	-	27.264	10.856	13.289*	0.0000

$p < 0.05$

Table 2
MANOVA Table for Gender on Wrist Deviation and Vertical Force

Source	SS	*af*	MS	F	*P-Value*
The largest vertical force	18528.899	1	18528.899	3.832	0.061
The smallest vertical force	15140.078	1	15140.078	3.751	0.064
The largest wrist deviation	85.338	1	85.338	0.78	0.383

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The smallest wrist deviation	65.327	1	65.327	0.569	0.457
The largest wrist deviation while raising	363.744	1	363.744	3.356	0.078

$p < 0.05$

Table 3
One-way ANOVA with blocking for wrist deviation

Source	SS	*df*	MS	F	*P-Value*
Phase	277.625	2	138.812	4.541	0.015
Error	1650.697	54	30.568		
Total	1928.322	56	169.38		

$p < 0.05$

3.2. Correlations among weight, wrist deviation, and vertical force

The results of Pearson's correlation test showed no significant correlation between weight and wrist deviation: the largest wrist deviation (r = -0.193, p = 0.324), the smallest wrist deviation (r = -0.205, p = 0.294) and the largest wrist deviation while raising walker (r = 0.033, p = 0.867). The correlation between weight and vertical force was significantly positive: the largest vertical force (r = 0.564, p = 0.002), and the smallest vertical force (r = 0.536, p = 0.003). That is a heavier user exerts more vertical force during walking.

4. Discussion

This study revealed that walkers cause wrist deviation in users' wrists (average = 24.70°) during usage, However, there is no significant differences on wrist deviation and vertical force between genders, therefore, we can inferred that male and female operate the walker in similar way.

Most walker users who are elders with low limb injured [11], expect to use walkers in order to help them function normally. In the literature, many studies [5] have stated that walking which is a highly repetitive movement, with similar hand operation. However, the results of this study show that horizontal handles might cause wrist deviation during walker use whether raising or pressing, therefore, this study can infer that the user's wrist in the bad position to operate walker.

We can conclude that weight affects vertical force, which means if a participant is heavier, their hands exert more vertical force. However, while operating the walker whether raising or pressing the horizontal handles cause wrist deviation, so this kind of handle design might be the reason why there is no significant correlation between vertical force and wrist deviation. The up limbs have to be raised up in order to raise walker. This raising gesture with horizontal handle might increase the wrist deviation. Furthermore, while pressing walker, the wrist have to support the body weight, so that the wrist deviation presented 23° or so.

This study showed that horizontal handles can cause wrist deviation during walker using, however with wrist deviation walker use may cause injury to upper-limb, e.g., carpal tunnel syndrome (CTS) [21]. Several studies [22-24] have noted that wrists should remain in a neutral position during hand movement to prevent damage. Therefore, minimizing wrist deviation among walker users is important.

Even through this body of research has the undeniable merit of offering valuable insights into walker design, it has some limitations. Future research is necessary to determine with certainty the extent of wrist deviation, including flexion/extension and radial/ulnar deviation, and should include situations with experienced participants. The findings of this study should be helpful to product designers and elderly welfare researchers, and should improve the design of walker handles to reduce the wrist deviations of users and it is hoped that it can serve as a basis for further study in walker design.

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