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Gait due to difference in Intravenous pole position on the healthy participants

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Abstract—**Introduction: The gait while using an intravenous (IV) pole is close to the gait of the elderly and fallers. Additionally, one survey has reported that the diagonal position is optimal for transporting an IV pole with a light load. However, in clinical practice, carrying a heavier load may be possible. Therefore, this study clarifies the optimum operation position using an IV pole with a weight closer to that in actual clinical practice.**

Method: Using image analysis software, we investigated several variables indicating gait, such as stride length. Participants walk with an IV pole in three ways: sideways, in front, and diagonally. We investigated two types of IV pole loads, which are 0.5 kg and 5.0 kg.

Results and Discussion: In 0.5-kg settings, the sideways position is a way to suppress the narrowing of the heel–floor angle. No significant difference in the subjective appraisals was observed between the sideways and diagonal positions. In addition, the sideways position is as optimum as the diagonal position. In 5.0-kg settings, only the sideways position suppressed the narrowing of the step length. Therefore, the sideways position is optimal. However, the participants' impressions suggested that arm strength is required for the sideways position. If a patient has weak arms and cannot maintain the sideways position, the patient may choose the diagonal position. Moreover, the front position is the way to hold the trunk most forward. However, there is a possibility that it is easy for a specific person, such as a rollator user, to choose. Therefore, further investigate of the optimum operation position depending on the walking abilities is needed.

Conclusion: It was suggested that the sideways position is optimal for walking with an IV pole when transporting with a total load of approximately 5.0 kg.

Clinical Relevance— **The results of this study help to prevent people from gait like fallers and the elderly when using IV poles in clinical settings.**

I. INTRODUCTION

Intravenous (IV) poles are one of the most widely used instruments to administer drugs continuously in the hospital. Patients usually walk in the ward on their own with an IV pole [1]. A study has analyzed patients' behaviors on risk factors for falls and reported that medical devices, such as IV tubes and stands, impede patient movement and cause patients to fall [2]. Falls cause fractures and accidental death, resulting in poor physical activity and quality of life (QOL). In addition, the mortality rate due to falls increases exponentially as age increases [3]. Several nurses are careful not to let the patients fall. However, to date, no consensus exists on how patients should carry and use an IV pole.

A study has reported that posture and gait while using an IV pole resemble those of the elderly and fallers [4]. The gait of the elderly is characterized by decreased gait speed, step length, and heel–floor angle [5]. Moreover, compared to young adults, older adults exhibited greater trunk flexion angles [6]. In addition, it has been highlighted that the decrease in gait speed is an internal (age-related deterioration) contributor to falls in older adult [7]. Such changes in the gait of the elderly increase their risks of falls.

Hachigasaki has shown that gait with an IV pole reduced the step length and resulted in the trunk angle leaning forward compared with normal gait [4]. However, the heel–floor angle has not been investigated. The decrease in the heel–floor angle during a heel strike is a characteristic of elderly gait [5]. By investigating the heel–floor angle, clarifying the changes in gait when using an IV pole is possible in more detail.

Another study has reported that the optimal operation position of an IV pole is diagonally forward compared with sideways, in front, and diagonally forward [8]. This study has indicated that the diagonally forward position is the best position in terms of suppressing the reduction of the step length and subjective evaluation. The weight of the IV pole used in this study was 0.5 kg. However, in clinical practice, infusion pumps, among others, are also often transported with the IV pole. From the questionnaire study, more than half of the clinical nurses answered that they use up to two infusion pumps, and the total volume of infusion was 1001-2000 mL regarding to the carried load [9]. Additionally, in heavy load settings, patients may carry their weight on the IV pole compared with patients in light load settings of approximately 0.5 kg. The relationship between heavy load and gait has not been strongly established. The impact of a heavy load settings, such as an IV pole with infusion pumps attached, on gait and subjective appraisals of patients is largely unknown.

We hypothesized that carrying additional weight on the IV pole changes the gait and optimal operating position of the patients. Therefore, considering the optimum operating position with a setting closer to actual clinical practice is necessary. Thus, this study determines the optimal operation position that minimizes the effect of an IV pole at heavy load settings on the gait of the patients. Additionally, this study clarifies the effect of operation position when using an IV pole on the heel–floor angle.

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II. METHODS

A. Participants and setting

Participants were recruited on campus using a snowball sampling method. This is because there were limitations on who could come to the lab under COVID-19 situations. Thirty three participants who could walk without aids, such as canes, and were 20 years old or older were recruited. This study was approved by the Ethical Committee of the Graduate School of Nursing, Chiba University (#28-65). All participants provided written informed consent.

Data on age, height, current and past fall experiences, reasons for falling, and effects on the body were collected and analyzed. The following five anatomical landmarks were marked: the acromion, outer ankle, toe, heel, and sacrum (Fig. 1).

B. Procedure

The seven survey patterns were as follows (Fig. 2). The IV pole was gripped by the arm opposite to the dominant hand.

(0) Normal walking: Walking as usual without an IV pole

(1) Sideways 0.5: Walking while holding an IV pole with a load of 0.5 kg in a lateral position against the body

(2) Sideways 5.0: Walking while holding an IV pole with a load of 5.0 kg in a lateral position against the body

(3) Front 0.5: Walking while holding an IV pole with a load of 0.5 kg in front of the body with both hands

(4) Front 5.0: Walking while holding an IV pole with a load of 5.0 kg in front of the body with both hands

(5) Diagonal 0.5: Walking while holding an IV pole with a load of 0.5 kg in a diagonally forward position

(6) Diagonal 5.0: Walking while holding an IV pole with a load of 5.0 kg in a diagonally forward position

The participants walked while using IV pole for practice. In this study, we prepared two types of IV pole load; therefore, the participants practiced walking using either setting. The participants were instructed to walk at a comfortable and free speed.

First, survey pattern (0), which is normal walking without an IV pole, was measured. Next, the participants were put on a simulated infusion set and measured gait in survey patterns (1) to (6). Subjective appraisals of walking were obtained from each survey pattern. The participants were informed of the survey pattern for each measurement and instructed the operation position. The order of survey patterns (1) to (6) was randomly chosen. After conducting all survey patterns, we obtained answers from each participant using a questionnaire asking their impressions of the entire survey.

The survey was conducted in a corridor with vinyl floor tiles that can set a flat straight walking path of 12 m. A video was taken of the section where three steps after the start of walking and three steps before the end were excluded.

Following a previous study, the height of the IV stand was set to 110% of the height of the participants, and the grip of the IV stand was set to 60% of the height of the participants [4]. The orientation of the handle was horizontal to the ground.

Two types of loads were prepared. The first load was assumed to be an IV pole with one infusion bottle (approximately 0.5 kg), and the load is 0.5 kg. Alternatively, the second load was assumed to be an IV pole with two infusion bottles (approximately 0.5 kg each) and two infusion pumps (approximately 2.0 kg each), and the total load was 5.0 kg.

A simulated infusion set was used to reproduce the condition during peripheral IV infusion. In the simulated infusion set, the tip of the infusion line connected to the infusion bottle was taped to the nondominant forearm.

Image analysis was performed using a still frame created from a video. Using HERO5 (GoPro, Inc., California, USA), the video from the direction of the sagittal plane was taken. A picture was taken so that at least one cycle of gait was always included. Using Dartfish (Dartfish Japan Co., Ltd., Tokyo, Japan), a still frame was cut out from the video, and the step length, stride length, heel–floor angle, and trunk lean angle were measured. All images were taken from the left side when the IV pole was on the right and from the right side when the IV pole was on the left. In addition, the researcher measured the walking time to reach 12 m and calculated the gait speed (m/min).

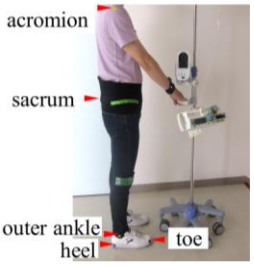

Figure 1. Anatomical landmarks

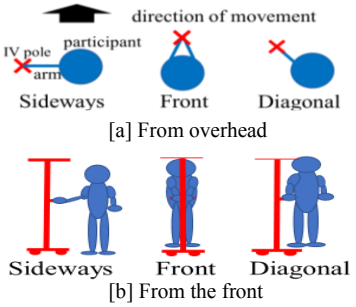

Figure 2. Position of the IV pole and participant from [a]overhead and [b]the front

C. Variables

・*Stride length*

The step length is the distance between the left and right heels when the heel of the front foot contacts the ground (Fig. 3).

・*Stride length*

The stride length is the distance moved when the same foot contacts the ground again (Fig. 3).

・*Heel–floor angle*

The heel–floor angle is the angle between the line connecting the toes and heel and the ground on the still image during heel strike (Fig. 4).

・*Trunk lean angle*

The trunk lean angle was the angle formed by the vertical line and the line connecting the acromion and sacrum on the still image during heel strike (Fig. 5).

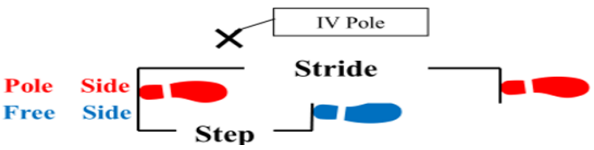

Figure 3. Step and stride.

Figure 4. Heel–floor angle.

Figure 5. Trunk lean angle.

・*Individual subjective appraisals*

The variables of subjective evaluation of walking were the feeling of strain from the forearm to the shoulder joint, the feeling of strain on the lower back, the stability of the IV pole, the ease of operation of the IV pole, and the ease of walking compared with normal walking. The aforementioned five variables were investigated using a visual analog scale (VAS). After investigating all walking patterns, the overall impression of the survey was obtained from each participant using open-ended questions.

D. Statical analysis

Data analyses were performed using repeated-measures analysis of variance (ANOVA) and Bonferroni multiple comparisons among seven groups including normal walking pattern for each variable. For subjective appraisals, repeated-measures ANOVA and Bonferroni multiple comparisons among six groups were performed for each subjective evaluation variable. Additionally, for subjective appraisals, we created three groups—sideways position, front position, and diagonal position—and analyzed them in the same way. In these three groups, each group contained 5.0 kg and 0.5 kg. All statistical analyses were performed using Statistical Package for the Social Sciences version 24.0 (IBM Corp., Armonk, NY, USA). Probability (p) values less than 0.05 were used to denote statistical significance (*).

III. RESULTS

A. Participant

Thirty-three participants attended, consisting of 12 males (36.4%) and 21 females (63.6%) (Table 1). Of the 33 participants, three (9.1%) had experienced falls in the past year, but none of them had difficulty walking on the day of the experiment. Thirty participants were right-handed and only three were left-handed.

TABLE I. PARTICIPANT CHARACTERISTICS

	Mean ± SD, n (%)
Number of participants	33
Age (year)	41.2 ± 22.9
Sex Male	12 (36.4)
Female	21 (63.6)
Height (cm)	162.4 ± 8.6

B. Gait speed

The gait speed in all patterns was significantly slower than that in normal walking. No significant difference in gait speed was found between the sideways and diagonal positions under both 5.0 kg and 0.5 kg loads ($p = 1.00$, $p = 1.00$, respectively). In the 5.0-kg load setting, the gait speed in the front position was significantly slower than those in the sideways and diagonal positions ($p < 0.05$).

C. Step length

Only (2) Sideways 5.0 and (5) Diagonal 0.5 did not have a significant difference in the step length on the free side compared with normal walking (Fig. 6).

D. Stride length

Only (5) Diagonal 0.5 did not have a significant difference in the stride length on the pole side compared with normal walking (Fig. 7).

E. Heel–floor angle

Only (1) Sideways 0.5 did not have a significant difference in the heal–floor angle compared with normal walking (Fig. 8).

F. Trunk lean angle

Regardless of the load, walking using the front position made the participant significantly lean forward compared with normal walking, walking using the sideways position, and walking using the diagonal position (Fig. 9). The average value of the front position was higher than that of normal walking (Fig. 9).

G. Individual subjective appraisals

Comparing each load setting, no significant difference in any question was observed between the sideways and diagonal positions. However, comparing the three groups (sideways, front, and diagonal) regarding the feeling of burden on the lower back and ease of walking, the front position resulted in a significantly greater burden and more difficulty in walking than the sideways and diagonal positions.

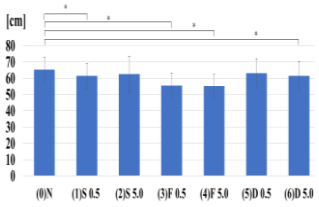

Figure 6. Step length.

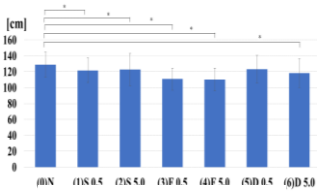

Figure 7. Stride length.

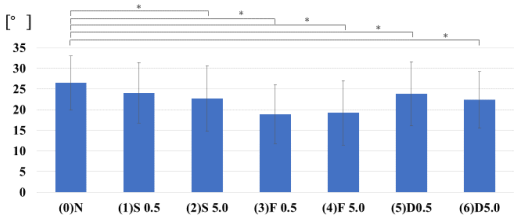

Figure 8. Heel–floor angle.

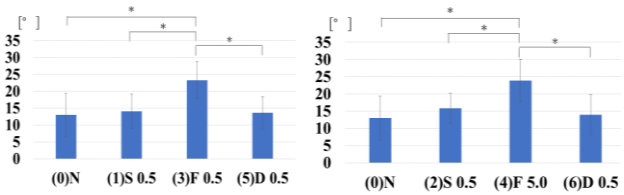

Figure 9. Trunk lean angle
Left is the 0.5 kg setting, and right is the 5.0 kg setting.

(0)N, normal; (1) S 0.5, Sideways 0.5 kg; (2) S 5.0, Sideways 5.0 kg;
(3) F 0.5, Front 0.5 kg; (4) F 5.0, Front 5.0 kg;
(5) D 0.5, Diagonal 0.5 kg; (6) D 5.0, Diagonal 5.0 kg

IV. DISCUSSION

It was clarified that step and stride length, and heel-floor angle changed with the position and weight of the IV stand. The respective threshold indicating the risk of falling for these gait parameters hasn't been clarified. However, the gait with the IV pole tended to the same characteristics of the gait of the elderly and fallers: short step and stride, slow speed, small heel-floor angle, and greater trunk flexion angles [5] [6] [7]. Therefore, it was shown that the ease of falling may differ by the position and load of the IV pole.

A. Comparison between 0.5 kg load settings

In stride length and stride, only the diagonal position wasn't significantly different from normal walking. This result conforms to the results of a study by Hachigasaki [8]. Additionally, regarding the heel–floor angle, only the sideways position was not significantly different from normal walking. Therefore, it is possible that the sideways position is close to normal walking. The operation position close to normal walking is the diagonal position in terms of suppressing the narrowing of the step and stride lengths and the sideways position in terms of suppressing the decrease in the heel–floor angle.

In the subjective appraisals, we received the answers that "Sideways position requires strength in the arm" and "It is difficult to start walking". These results suggest that if you start walking diagonally and switch to the sideways position after the third step, you can suppress the narrowing of the stride length and reduce the burden on the arm.

B. Comparison between 5.0 kg load settings

Regarding the step length, only the sideways position was not significantly different from normal walking. It was clarified that by setting the load to 5.0 kg, the step and stride lengths in the diagonal position are significantly shorter than that in normal walking. To sum up, these results regarding the step and stride lengths were different from those observed in the 0.5 kg load setting. This result suggests that carrying weights on the IV pole changes the gait. Additionally, the sideways position is significantly close to normal walking. It is because the operation position close to normal gait is the sideways position in terms of suppressing the narrowing of the step length in the free side.

However, comments from the participants regarding the sideways position were "Sideways position requires strength in the arm", suggesting that the sideways position requires arm strength. Additionally, no significant difference between the sideways and diagonal positions in terms of gait speed, heel–floor angle, trunk lean angle, and subjective evaluation. Therefore, those who have difficulty in maintaining the sideways position may choose the diagonal position.

C. The danger of the front position

Focusing on the trunk lean angle, walking using the front position made a participant to significantly lean compared with normal walking and walking using the sideways and diagonal positions, regardless of the load. However, selecting the front position for those who use walking aids including rollators and rolling walkers constantly may be easier. In addition, for those who have an unstable trunk or who use walking aids, the front position may be the most stable and safest. Therefore, further study more focused on them should be conducted to investigate the optimal position depending on each usual gait.

D. Limitation and future work

We haven't been able to clarify the extent of the risk of falling related to the change in gait. Further research is still needed, including the evaluation of risk related to the change of gait with the IV pole.

V. CONCLUSION

This study evaluated the effect of the operation position with an IV stand on the gait and determined the optimal operation position, especially when load is heavier.

When transporting only approximately 500 mL of infusion, the sideways or diagonal position is optimal. If you switch to the sideways position at the beginning of walking diagonally and after the third step, you can suppress the narrowing of the step length and reduce the burden on the arm.

When transporting approximately 1,000 mL of infusion and two infusion pumps (a total load of approximately 5.0 kg), the sideways position is optimal. Those who have difficulty in maintaining sideways may choose the diagonal position.

The front position was the position in which gait changed most, regardless of the load, and it makes an individual easy to fall. However, selecting this position may be easy for those who use walking aids. Thus, a further study with more focus on persons who use walking aids should be conducted.

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