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ORIGINAL ARTICLE

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Examining directional changes when walking with an intravenous pole: A comparison of turning methods with and without stopping

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Abstract

Aim: This study aimed to examine safer turning methods by focusing on and comparing gait and turn methods in relation to stopping when executing a turn while walking with an intravenous (IV) pole.

Methods: The study participants included 33 healthy men. A situation was recreated in which an IV drip was placed in the peripheral vein of the left forearm of the participants and the IV pole was maneuvered using the left hand. A series of six movements was executed, including turn left and right, stopping. Gait was measured (by observing turning motion, stride, walking speed and head tilt angle), and subjective assessments were performed.

Results: Compared with walking normally, walking with an IV pole and executing turns resulted in a decrease in the walking speed, an increase in the time required for walking, a decrease in the stride and a forward tilting in the head angle. Turning left without stopping was mostly accompanied by a spin turn, and the probability of the pole legs coming into contact with participants' legs (15.2%) was higher than that in other assessed movements of walking with a pole. In the subjective assessment, turning left without stopping displayed a lower sense of security ($p < .05$) than turning left with stopping.

Conclusions: When turning while using an IV pole, the pole itself poses a risk of falling. Therefore, momentary stopping and checking the safety of one's footing is a preventive measure against falling.

KEYWORDS
fall, gait, IV pole, turning, walking

1 | INTRODUCTION

Over 21% of Japan's population is aged >65 years, which is the highest proportion worldwide. Additionally, the number of hospitalized patients has increased, and the proportion of inpatients among individuals aged ≥65 years has increased from 52.1% in 1996 to 71.1% in 2014. The promotion of early postoperative ambulation and shortened hospital stay has recently increased, and an upward trend can be observed in the percentage of patients using intravenous (IV) poles on a daily basis. According to Hiyama and Nakamura (2017), medical instruments, such as IV drip routes, tubes, and IV poles, restrict patient movement and increase the risk of falling during hospitalization. Moreover, in a nationwide survey conducted by Hachigasaki (2015) on 629 nurses with a minimum of 3 years of experience, 85.7% of respondents felt there is a risk of falling when patients use IV poles.

The survey respondents indicated that 18.6% of patients fell and 39.0% almost fell when using an IV pole. Thus, over half the nurses had experienced either a patient falling or the danger of near misses while using an IV pole. Moreover, despite the high risk of falling when walking with an IV pole, the poles are not created with the premise of being used by the physically weak or elderly, and no maneuvering or handling methods have been established for these individuals.

Walking with an IV pole can influence an individual's gait. Research conducted by Hachigasaki (2012) on healthy individuals in their 60s showed that walking in a straight line while using an IV pole shortens stride, reduces speed, and diminishes arm swing compared with walking normally. These results indicate that when walking with an IV pole, even a healthy individual's walk approaches that of an elderly individual or someone who has fallen.

The halls of a hospital ward are not always linear and with good visibility; moreover, there are places with obstructed views, such as entrances to patient rooms and corners. In addition, medical staff, patients, wheelchairs, stretchers, and other traffic frequently traverse the halls. Patients using an IV pole must walk while constantly taking care not to bump themselves or the IV pole against objects and individuals in their way. There is also the danger of stumbling against the legs of the IV pole and falling over.

Several studies have assessed turning while walking normally. Glaister, Bernatz, Klute, and Orendurff (2007) used a video analysis to study turn rate and straight walking during daily activities in 11 healthy adults. Turns comprised 8–50% (average, 34.5%) of movement in the four locations assessed (cafeteria, office, convenience store, and parking lot). These results suggest the necessity of considering both straight walking and turning in the clinical setting. According to Cumming and Klineberg (1994), an interview survey conducted at nursing homes showed the risk of femoral neck fractures was 7.9 times greater when turning than that when walking in one direction. Furthermore, Yamaguchi, Yano, Onodera, and Hokkirigawa (2012) conducted an experiment on 15 healthy men (average age, 22.7 years) that compared the rate of falling between straight walking and turning at 30°, 45°, and 60° on a slippery floor. The frequency of falling was approximately 3-fold higher with a turning angle of 60° with the right foot (55.6%) than that of straight walking (13.3%). The mean frequency of falling significantly increased as the turning angle increased ($p < 0.001$). Taken together, turning carries a risk of falling independent from the use of IV poles and even when walking normally.

In addition to the limited data on walking with an IV pole, there are no findings that address the fact that turning is more dangerous than straight walking; furthermore, there is no clarification on safe turning methods. Therefore, there is a need to explore the factors that lead to falling when turning while using an IV pole and to examine safe turning methods to avoid falls.

Therefore, this study focused on turning methods and examined safe methods of executing directional changes when using an IV pole. This study aimed to examine safer turning methods by focusing on and comparing gait and turn methods in relation to stopping when executing a turn while walking with an IV pole.

2 | METHODS

2.1 | Participants

The participants were adult men aged 60–69 years, which is the age group of many hospitalized patients. To increase the safety of the study, male participants were chosen with the idea that they have a higher physical ability and lower possibility of falling. The participation criteria were as follows: absence of motor dysfunction, height of up to 178 cm, right-handed, and no experience of walking using an IV pole on a daily basis in the past 6 months. The exclusion criteria were as follows: use of a walking aid such as a cane; serious vision/hearing disabilities; history of hypertension, cardiovascular disease, or cerebrovascular disease; categorization as "weak" (a person who in the last year has naturally lost ≥4.5 kg weight, has a grip strength of ≤30 kg, and has exhibited fatigue within the past month) in the Frailty Model (Fried et al., 2001); and alcohol allergy or skin problems.

Participants were selected using convenience sampling. A request was raised to the local Silver Human Resources Center to enlist the cooperation of registered men. The enlisted men's intent to participate was confirmed, and those who cooperated in the experiment were given remuneration.

2.2 | Experimental conditions

In a room with level flooring made of vinyl chloride material, an 86-cm wide, L-shaped walkway was created with a 301-cm simulated corner, an 86 × 86 cm turning zone, and a 301-cm stopping zone (Figure 1). Cameras were placed on both sides of the walkway. Cameras 1 and 2 were placed outside the walkway at a height of 99 cm above the floor, with their lenses aimed in a horizontal direction. Camera 3 was placed obliquely upward from the participants at heights of 215.5 and at 192.5 cm above the floor, with the lens angled downward at 50°.

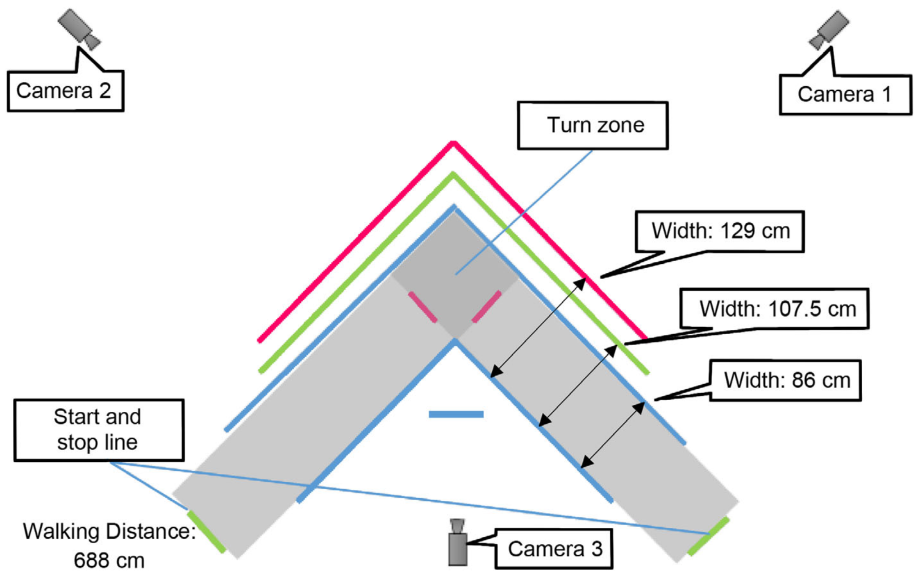

FIGURE 1 Layout of the experiment site. Participants walked along the gray road. The total walking distance was 688 cm. For a left turn, participants started walking from the right starting line. They turned to the left at the turning zone and stopped at the left stop line

Participants wore rubber-soled shoes and clothes that allowed the contours of their arms and legs to be viewed. Markers with a diameter of 20 mm were placed with double-sided tape at 14 sites: (a) highest point of the shoulders (acromia), (b) bony tip of the elbows (olecranon), (c) styloid process of the ulna, (d) trochanter, (e) head of the fibula, (f) toes, and (g) left and right heels. A peripheral vein IV drip was simulated on the left forearm, and the length of the infusion line from the infusion bottle to the arm was approximately 200 cm.

A five-legged IV pole KC-508 (Paramount Bed Co., Ltd.) was utilized. Based on previous research (Hachigasaki, 2012), the height of the pole was adjusted to 110% of the user's height, and the grip was horizontally attached at a height equal to 60% of the user's height (Figure 2).

2.3 | Movements

Participants executed six different turns. They implemented (a) a right turn using natural movements and (b) a left turn using natural movements while walking normally without an IV pole. Next, while maneuvering an IV pole with the left hand, they changed direction by (c) turning right and stopping, (d) turning right without stopping, (e) turning left and stopping, and (f) turning left without stopping. Participants were asked to maintain their natural walking speed and movements. The location at which the stop was to be executed was not stipulated but was determined by the participants. To minimize the influence of execution order, the order of right turns (c) and (d) and left turns (e) and (f) were alternated.

2.4 | Measurement items

2.4.1 | Participant attributes

Participants were enquired about their age, gender, number of falls in the past year, and experience of using an IV pole. In addition, their height, weight, and grip strength (left and right) were measured.

2.4.2 | Analysis of two-dimensional movements

Three digital video cameras (cameras 1 and 2, Sony HDR-PJ800; camera 3, Sony HDR-CX670) were used to film the participants' movements. The video was set to standard mode, and a progressive system with a shutter speed of 1/250 and frame rate of 60 frames per second was used. The recorded video was separated for each turn using the Sony image management software Play Memories Home. Then, still images of the targeted movement were created. The frame width was 1920 pixels, and the frame height was 1,080 pixels. The still images were 2,304 × 1,296 pixels with a resolution of 96 dpi. Image analysis software (ImageJ) was used to measure the variables of the created still images.

2.4.3 | Gait

The turning methods during normal walking and walking with an IV pole were observed by focusing on the foot movement. Average walking speed, stride before executing a turn, anterior inclination of the body trunk, and head tilt angle were measured. Average walking speed was

FIGURE 2 A participant prepares to walk with an IV pole. The height of the attached pole is 110% of the user's height, and the grip was placed at a height equal to 60% of the participant's height. A peripheral vein IV drip was simulated on the left forearm

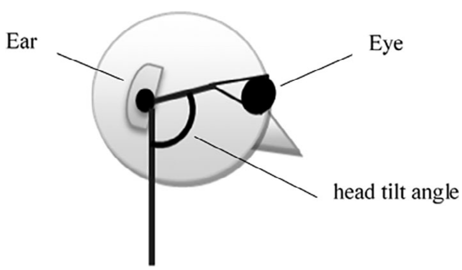

FIGURE 3 Head tilt angle

calculated based on the walking distance of the entire space (688 cm) and the time required between marked positions that were directly programmed into Electromyogram by the researcher at the initiation and conclusion of the walk. Stride was defined as the distance between the left and right heels at the moment the preceding heel touched the floor. Head tilt angle was formed by a straight line and vertical line linking the corner of the eye and ear hole (Figure 3).

Turns were classified using a previous study by Kaijo, Hashiba, Hirayama, Kazahari, and Tanaka (2014) as a reference. The extended linear line linking the markers for the heel of the front supporting leg that initiated a turn (L1) and the opposite heel (R) were used as a basis. When the opposite leg exceeded the line with the next step to become the subsequent basis (L2), it was considered a spin turn (a directional change in which the left and right legs are crossed). When it did not exceed the line (L2'), it was considered a step turn (a directional change in which the left and right legs are not crossed; Figure 4).

2.4.4 | Subjective assessment

We compared the differences in participants according to each turning motion while using an IV pole for eight items: (a) ease of maneuvering the IV pole, (b) sense of stability of the IV pole, (c) ease of turning, (d) sense of security when turning, (e) sense of burden on the upper limbs, (f) sense of burden on the lower limbs, (g) sense of psychological burden in terms of the IV pole coming into contact with the legs, and (h) sense of burden in terms of swinging of the infusion bottle. Participants were asked whether stopping or not stopping was more applicable for each of these items. Applicable and nonapplicable responses were given two and zero points, respectively. When the actions were equally applicable, each was given one point. The participants were asked which turning method was the easiest and any other thoughts about executing a turn.

2.5 | Analysis method

Turning motions were primarily classified according to the type of turn and were compared between normal walking and walking with an IV pole. For variables concerning gait, a one-way analysis of variance and multiple comparisons using the Scheffe method were implemented for each measurement item. The Scheffe method was used to compare the six types of direction changes. The *t* test was performed to analyze the subjective assessment questions. A significance level of 5% was used for both types of analyses. The participants' thoughts regarding turning motion when using an IV pole and gait were analyzed.

2.6 | Ethical considerations

The participants voluntarily cooperated in this study, their anonymity was rigorously maintained, and considerations were made to avoid placing them at a disadvantage. In addition, they were informed of their ability to withdraw at any point. Before and after the implementation of this study, participants were given health checks according to the New Physical Fitness Test (for individuals aged 65–79 years) from the Ministry of Education, Culture, Sports, Science and Technology (1999). Participation of individuals whose systolic blood pressure exceeded 180 mmHg was suspended. Personal information was restricted to name and age, and all the data were managed using an ID. This study was implemented after receiving approval from the ethics review board of St. Luke's International University (Approval No. 15–045).

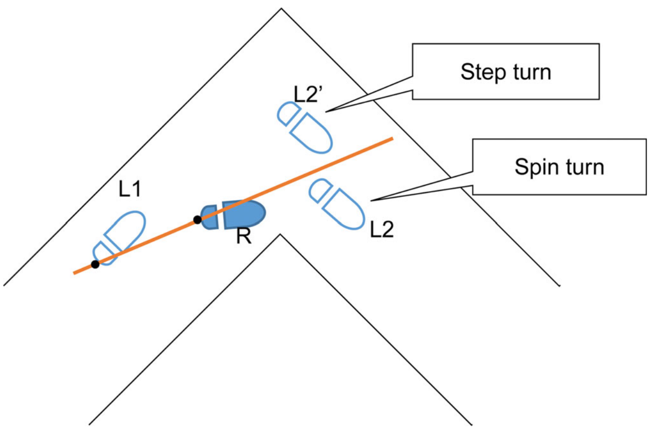

FIGURE 4 Step and spin turns (while turning right). Spin turn: left and right legs are crossed. Step turn: left and right legs are not crossed

3 | RESULTS

3.1 | Basic attributes of participants

Thirty-six individuals participated in this study. However, only 33 subjects were included in the analysis after the exclusion of subjects who had a grip strength of <30 kg and whose momentary stopping execution was unclear. The average age of participants was 66.9 years (*SD*, 1.7; age range, 63–69 years), and their average body mass index was 22.9 kg/m^2 (*SD*, 2.5; range, 18.4–28.6 years). In the past year, 30 individuals (90.9%) had not fallen and three individuals (9.1%) had fallen once. Twenty-one subjects (63.6%) had never used an IV pole, eight (24.2%) had used once, and two (6%) had used twice and thrice, respectively. None of the participants were susceptible to falling or accustomed to handling an IV pole.

3.2 | Turning methods when changing direction

Table 1 shows turning methods while walking normally and with an IV pole. The spin turn was often used when walking normally, and the step turn when stopping. The step turn was often used when turning right without stopping, whereas the spin turn was often used when turning left without stopping (Table 1).

TABLE 1 Turning methods for right and left turns. Walking normally (without an IV pole), walking with an IV pole and stopping, and walking with an IV pole without stopping

	Walking normally		Walking with an IV pole				
	Right turn	Left turn	Turning right and stopping	Turning left and stopping	Turning right without stopping	Turning left without stopping	Overall
Step turn	12 (36.4%)	15 (45.5%)	23 (69.7%)	23 (69.7%)	21 (63.6%)	14 (42.4%)	108 (55.0%)
Spin turn	21 (63.6%)	18 (54.5%)	10 (30.3%)	10 (30.3%)	12 (36.4%)	19 (57.6%)	90 (45.0%)
n	33	33	33	33	33	33	

Units: participants (%).

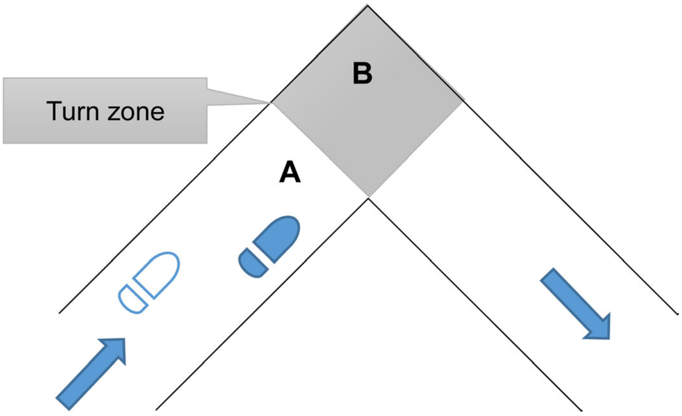

FIGURE 5 Stopping point (while turning right)

3.3 | Turning when walking with an IV pole and the stopping point

When instructed to stop when executing a turn, the stop was divided into two positions (Figure 5):

Position A: stopping before the turn zone and executing the turn after resuming walking.

Position B: stopping after executing the turn in the turn zone and walking straight ahead after resuming walking.

Position AB: stopping before and after turning and executing a turn between A and B.

While turning right, 20 participants (60.6%) stopped at position A, eight (24.2%) at position B, and five (15.2%) at position AB. While turning left, 17 participants (51.5%) stopped at position A, 11 (33.3%) at position B, and five (15.2%) at position AB. For both the right and left turns, many participants stopped before turning at position A.

3.4 | Contact between the IV pole and participants' legs

The number of times the participants' legs came into contact with the pole while walking was counted (Table 2) and were compared before and after turning; we found that contact was usually made before turning. Moreover, contact was most often made while turning left without stopping.

3.5 | Walking features

3.5.1 | Comparison of walking speed over the entire walkway

Table 3 shows walking speed over the entire 688-cm walkway. A significant difference was observed in the walking speed, including the three types of turns executed while walking normally, walking with an IV pole and stopping, and walking with a pole without stopping.

TABLE 2 Number of times the participants' legs came into contact with the IV pole according to turning methods (turning right and left). Walking with an IV pole and stopping; walking with an IV pole without stopping

	n	Before turning	After turning	Total no. of times (%)[a]	
Turning right and stopping	33	2	0	2	(12.1%)
Turning left and stopping	33	2	1	3	(9.1%)
Turn right without stopping	33	1	0	1	(3.0%)
Turning left without stopping	33	2	3	5	(15.2%)
Total	132	7	4	11	(9.8%)

[a]Percentage of n.

3.5.2 | Stride before the turn zone

The stride length before executing left and right turns is shown in Table 4.

Stride before the turn zone when turning right

When turning right, the longest stride for both the left and right legs occurred while walking normally, whereas the shortest stride was reported when walking with an IV pole and stopping. For the right stride in which the right leg leads, a significant difference was observed among walking normally, walking with a pole and stopping, and walking with a pole without stopping. For the left stride, a significant difference was observed between walking normally and walking with a pole (with and without stopping). Comparing left and right strides showed that while walking with a pole, the stride was shorter on the left side where the IV pole is maneuvered both with and without stopping.

Stride length before the turn zone while turning left

When turning left, the longest stride for both the left and right legs occurred when walking normally, whereas the shortest stride was reported when walking with an IV pole and stopping. For both the left and right strides, a significant difference was observed among walking normally, walking with a pole and stopping, and walking with a pole without stopping.

TABLE 3 Multiple comparisons between groups based on the walking speed over the entire walkway

n = 33 items	Average (m/s)	*SD*	95% CI of the mean: Min	Max	*F* value[a] (*p*)	*p* value of multiple comparison between the groups[b]: Walking normally left turn	Turning right and stopping	Turning left and stopping	Turning right without stopping	Turning left without stopping
Normal right turn	0.92	0.13	0.87	0.96	61.713 (0.000)	.915	.000**	.000**	.000**	.000**
Normal left turn	0.95	0.13	0.91	1.00			.000**	.000**	.000**	.000**
Turning right and stopping	0.59	0.11	0.55	0.62				.971	.001**	.005**
Turning left and stopping	0.56	0.10	0.52	0.59					.000**	.000**
Turning right without stopping	0.73	0.15	0.68	0.78						.996
Turning left without stopping	0.71	0.11	0.67	0.75						

[a]*F* value according to one-way analysis of variance; min is the *p* value.
[b]*p* value of multiple comparison according to the Scheffe method.
$^{**}p < .01$.

TABLE 4 Multiple comparisons between groups according to stride length (cm) before turning left and right

n = 33 items	Average	*SD*	Left/right stride (%)[a]	95% CI of the mean: Min	Max	*F* value[b] (*p*)	*P* value of multiple comparison between the groups[c]: Turning right and stopping R	Turning right without stopping R
Right turn: Right stride								
Walking normally right turn R	64.6	9.3	—	61.3	67.9	31.692 (0.000)	.000**	.000**
Turning right and stopping R	44.7	12.1	—	40.4	49.0			.004**
Turning right without stopping R	53.2	8.9	—	50.0	56.4			
Right turn: Left stride								
Walking normally right turn L	64.0	10.3	99.0	60.3	67.6	59.637 (0.000)	.000**	.000**
Turning right and stopping L	40.4	7.8	90.4	37.7	43.2			.050
Turning right without stopping L	46.0	9.2	86.5	42.8	49.3			
Left turn: Right stride								
Walking normally left turn R	65.8	7.2	—	63.2	68.3	28.918 (0.000)	.000**	.000**
Turning left and stopping R	49.8	9.3	—	46.5	53.1			.003**
Turning left without stopping R	57.2	8.9	—	54.0	60.3			
Left turn: Left stride								
Walking normally left turn L	66.9	7.9	101.7	64.1	69.7	43.717 (0.000)	.000**	.000**
Turning left and stopping L	45.6	10.7	91.5	41.8	49.4			.017*
Turning left without stopping L	52.4	9.5	91.6	49.0	55.7			

[a]Percentage of left stride against right stride.
[b]*F* value according to one-way analysis of variance; min is the *p* value.
[c]*p* value of multiple comparison according to the Scheffe method.
$^{*}p < .05$.
$^{**}p < .01$.

Comparing left and right strides showed that when walking with a pole, the stride was shorted on the left side where the IV pole is maneuvered, both with and without stopping.

Head tilt angle before turning

Head tilt angle prior to turning was compared according to the turning method (Table 5). The head tilt angle was the widest while turning right in normal walking, and a significant difference was observed among all instances of walking with an IV pole. The head tilt angle was the narrowest while turning left and stopping, and a significant difference was observed between left and right turns during normal walking.

3.5.3 | Subjective assessments

Comparison of subjective assessments for turns with and without stopping

The participants were asked whether it was more applicable to stop or not stop. Applicable responses were given two points and nonapplicable responses were given zero points. When the actions were equally applicable, each was given one point. When turning right, a significant difference was observed for "(7) sense of psychological burden regarding coming into contact with legs" with a higher score for turning and stopping (1.42) than for turning without stopping (0.58) ($p < .01$). When turning left, a significant difference was observed for "(4) sense of security when turning" with a higher score for turning and stopping (1.33) than for turning without stopping (0.67) ($p < .05$). In addition, a significant difference was observed for "(6) sense of burden on lower limbs" with a higher score for turning and stopping (1.18) than for turning without stopping (0.82) ($p < .05$).

Comparison of ease of turning left and right

Participants were asked whether it was easier to turn right or left and which was more difficult when using an IV pole (Table 6). Most participants responded that turning right without stopping was the easiest and that turning left without stopping was the most difficult. A higher number of participants (11 persons) indicated that turning without stopping was more difficult than turning with stopping.

Other thoughts

Individuals who chose to stop when turning stated that it gave them a sense of safety and security. Individuals who chose to turn without stopping stated that the movement was smoother and provided better control.

The advantages when turning right included having a wider space to move the IV pole and a wide angle at the turning point. The disadvantages mentioned included using arm muscles, feeling that the IV pole was being swung around due to centrifugal force, and the necessity of a wide turn.

The advantages when turning left included having a tight turning circle and being accustomed to a counterclockwise rotation. The disadvantages mentioned included difficulty turning due to the wall, a sharp-angled turning point, and a narrow space for moving the IV pole.

4 | DISCUSSION

4.1 | Examining safe turning methods when walking with an IV pole

4.1.1 | Risk of falling when turning

Our data suggested that there is a high risk of falling while turning when walking with an IV pole. This can be attributed to reduced walking speed, shortened stride before turning, and a forward-tilted head angle (Tables 3–5).

TABLE 5 Multiple comparisons between groups according to the head tilt angle (°) before turning

			95% CI of the mean		F value[a]	p value of multiple comparison between the groups[b]				
n = 33 items	Average	SD	Min	Max	(p)	Walking normally left turn	Turning right and stopping	Turning left and stopping	Turning right without stopping	Turning left without stopping
Walking normally right turn	84.2	10.1	80.6	87.8	8.011 (0.000)**	.993	.025*	.000**	.043*	.030*
Walking normally left turn	82.6	8.2	79.7	85.6			.127	.001**	.191	.146
Turning right and stopping	75.8	9.5	72.4	79.2				.754	1.000	1.000
Turning left and stopping	72.0	10.2	68.4	75.7					.643	.720
Turning right without stopping	76.3	8.1	73.4	79.2						1.000
Turning left without stopping	76.0	10.0	72.4	79.5						

[a]F value according to one-way analysis of variance; min is the p value.
[b]p value of multiple comparison according to the Scheffe method.
*$p < .05$.
**$p < .01$.

TABLE 6 Subjective assessments on turning methods. Walking with an IV pole and stopping; walking with an IV pole without stopping

	Most easy turn	Most difficult turn
Turning right and stopping	5	7
Turning left and stopping	6	8
Turning right without stopping	12	6
Turning left without stopping	7	11
Other	3	1
Total	33	33

Unit: person.

Several studies have evaluated the differences between individuals who fall and do not fall; the latter have a slower walking speed and shorter stride (Guimaraes & Isaacs, 1980; Imms & Edholm, 1981). According to Yamada et al. (2012), compared with the elderly with a low risk of falling, the line of sight in the elderly with a high risk of falling is near their feet when walking. It is thought the study participants had a tendency to watch their feet because they were taking care to avoid contact between the IV pole legs and their own legs.

The study suggests that when turning while using an IV pole, the elderly choose to move cautiously by slowly walking with short steps and watching their feet. Moreover, when walking with an IV pole, their legs come into contact with the IV pole 9.8% of the time before and after turning (Table 2). In addition to slipping, tripping is a major factor in falls. Since the legs (casters) of the IV pole are constant obstacles at their feet, they are easily collided with and tripped over. Moreover, recovering from tripping requires the leg opposite the one that collided with the obstacle to be placed forward to support the body, but when using an IV pole, the pole's legs are always at the user's feet and are highly likely to interfere with the compensating action. Furthermore, the subject is toting along the IV pole, which is unable to follow sudden directional turns, which makes it more likely for the user to lose their balance and stagger. An experiment by Cao, Ashton-Miller, Schultz, and Alexander (1997) in which subjects executed turns on cue demonstrated that men in their 70s have a higher failure rate than men in their 20s when the time provided after the cue was short. Even when turning while walking naturally, if the time allowed for judgment is short, the body's response cannot keep up, and movements are not smoothly executed. Responding to a sudden incidence is even further delayed when turning while using an IV pole. In other words, it is easy to lose balance and fall. One way to prevent falling when turning is to take time to sufficiently confirm safety and avoid sudden movements.

4.1.2 | Turning methods when changing direction

The step turn and spin turn are two types of turning methods used both when walking normally and when walking with an IV pole (Table 1). When walking normally, the spin turn was often used for both left and right turns, but the percentage of individuals who used a step turn increased when walking with a pole. The participants in this study were healthy men in their 60s, and the spin turn was often employed when walking normally for both right and left turns; it comprised 59.1% of the overall turns.

According to Taylor, Dabnichki, and Strike (2005), the nature of the strategies for the step turn and spin turn are quite different. There are more advantages to the step turn than the spin turn because it has a wide base of support, small angle variations and turning force (requiring muscle), and is more similar to straight walking. Additionally, the shortest distance between the toes is smaller in the spin turn than in the step turn, and there is a greater danger of tripping when lower limb coordination is impaired (Taylor et al., 2005). Since both legs are crossed in the spin turn, it is easy for the base of support to be reduced. Given that the body's orientation is considerably changed when turning, a small support base makes it easier for the center of gravity to fall outside that base of support and for balance to be lost. Therefore, the spin turn method facilitates falls. Research by Yamada et al. (2012) indicated that seven out of 11 (63.6%) elderly subjects with a high risk of falling employed a spin turn, but in contrast, many elderly subjects with a low risk of falling (22 out of 26) did not choose to execute a spin turn. Employing a spin turn requires a longer stride than the step turn because both legs are crossed and step width (the gap between left and right legs) is eliminated. Step width in a step turn is greater than it is during straight walking, and the stride is shortened (Strike & Taylor, 2009). Hase and Stein (1999) stated that the step turn is a simpler and more stable method than the spin turn. Yamaguchi, Okamoto, Hokkirigawa, and Masani (2018) stated that spin turning is a safer turning strategy for preventing lateral slips. Their research examined slipping when changing direction, but this study focuses on tripping. This is because the IV pole is continually at a person's feet when walking and conceivably there is a high risk of the pole and the person's feet coming into contact, causing that person to trip and fall.

When walking with an IV pole and executing a left turn, a spin turn causes the right leg to cross and increases the risk of the leg making contact with the pole that is on the left side. When turning right, a spin turn makes it difficult for the IV pole to follow the sharp turn of the body's movement. Therefore, when changing direction while using an IV pole, choosing to execute a spin turn solely to prevent slipping is not thought possible.

One reason for employing a step turn when walking with an IV pole is a shortened stride due to concern over the user's legs coming into contact with the legs of the IV pole. This outcome is supported by the fact that the stride of the left leg is smaller than that of the right leg when walking with a pole, regardless of the direction of the turn or whether the user stops (Table 4). A second reason is the reduced walking speed and shortened stride produced by stopping while turning. The stride length is reduced with a step turn compared to a spin turn since the legs are not crossed during a step turn. Therefore, a step turn is preferred to a spin turn from a safety standpoint because a person can slowly and steadily walk while ensuring safety. Crossing the legs during a spin turn requires a longer stride and more speed than a step turn. A longer stride results in a swing phase where the body is supported by lengthening one leg, which makes walking less steady and may cause loss of balance. More careful movements are necessary while walking with an IV pole. Therefore, the step turn is a safer and more efficient method of turning. In summary, a method of turning direction that encourages natural selection of the step turn is recommended.

4.1.3 | The impact of the IV pole when turning

The corner established in that experiment was 90°, and the angle for left and right turns was identical. However, when walking with an IV pole, the test subjects felt that the angle of the left turn was sharp and the angle of the right turn was wide. This was not due to the angle of the trajectory followed by the subjects but rather the angle of the trajectory drawn by the IV pole. This feeling is believed to be a sensation generated by maneuvering the IV pole. When maneuvering the pole with the left hand, the pole is inside when turning left, making it necessary for the subjects to turn wide with the pole as the axis. Conversely, when turning right, the pole is on the outside, making it necessary for the subjects to turn wide with the IV pole using themselves as the axis. This disparity was expressed in the different sensations between turning left and right.

Although the step turn was chosen when turning right while walking with an IV pole regardless of whether the participant stopped, the spin turn was used when the participants turned left without stopping (Table 1). This is because when executing a spin turn without stopping during a right turn, the movement of the IV pole does not keep up with the rotation speed when changing the body's orientation. Therefore, centrifugal force conceivably comes into play, and a greater burden is placed on the arm. It is surmised that the body naturally chooses to execute a step turn when turning right because of the resistance transmitted from the IV pole. Conversely, when turning left, the body attempts to change direction using the IV pole as an axis, and the user walks forward with the shortest distance. It is reasonable that when trying to travel the shortest distance, the body naturally chooses a spin turn, which is efficient since the trunk of the body is forced into a more rapid rotation.

There is a need to consider whether the IV pole is maneuvered on the left or right side when walking with a pole. In this study, maneuvering the IV pole on the left requires the subject to stop more concretely when turning left compared to turning right. This response occurs for two reasons. First, the IV pole is oriented in the same direction as the turn, and visibility past the corner is poor. Second, the IV pole is ahead of the user's body. When the IV pole is on the side of the turn, it obstructs the view, and visual confirmation of safety is insufficient. Furthermore, when moving forward without sufficiently confirming safety by momentarily stopping, there is risk of the IV pole, which is ahead of the user, coming into contact with an approaching person.

4.1.4 | Differences in safety depending on whether the user stops prior to turning

Turning without stopping has advantages that include being able to turn with momentum, smooth progression, and moving forward without breaking speed. Conversely, when turning and stopping, the law of inertia does not come into play, and the driving force produced from the rotation of the body when turning cannot be used. Thus, the efficiency of movement declines because movement is interrupted and walking rhythm is broken. However, the ability to check on the path ahead when stopping also has the advantage of a sense of security since an individual can calmly turn and take a cautionary moment.

This experiment instructed the participants to stop at the corner, resulting in two stopping points—stopping before turning and stopping after turning. However, since an individual stops before turning a corner and initiates walking after confirming safety on an ordinary road, it is thought that stopping prior to turning is more natural. In particular, when turning left, walking with an IV pole inhibits visibility at the corner and makes it difficult to check for safety. Being able to see past the direction of movement before turning enables an individual to walk with a sense of security because the state of the path forward can be anticipated. This study recommends that one checks for safety by temporary stopping before turning at the corner.

Based on the above discussion, a turn executed toward the same side as the side on which the IV pole is being maneuvered should be made after stopping. When turning in the opposite direction, stopping is unnecessary. However, in either case, subjects should check for safety and cautiously move forward.

4.2 | Limitations and future directions

The study participants were healthy men in their 60s. This study selected men as subjects believing them to have higher physical function and a lower risk of falling than women. Because bone density in women considerably declines following menopause, it becomes easier to sustain a distal radius fracture and cervical fracture of the femur from an impact when falling. Therefore, male subjects were selected to boost the safety of the study in consideration of the possibility of falling. However, to reflect the circumstances of hospital patients, in future studies it will be necessary to consider including women, older persons, and men with a grip strength of 30 kg or less who are considered to possess a physical condition similar to hospital patients.

In addition, although the experiment was conducted with an IV pole considered the most widely used in Japan, many hospitals and facilities have older types of IV poles that are heavy. Future studies should use various types of IV poles to examine shapes and weights that are even safer and impose less of a burden.

5 | CONCLUSION

While turning, the IV pole poses a risk for the user to fall. Therefore, momentary stopping and checking the safety of one's footing should be implemented as a preventive measure.

When a right-handed person holds an IV pole in their left hand and turns left, which is the side on which the pole is being maneuvered, it is advisable to stop when turning. When turning right to the opposite side, stopping is unnecessary.

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CONFLICT OF INTEREST

The author has no conflicts of interest directly relevant to the content of this article.

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