

# Change of Gait Pattern According to Type of Perpendicular Vision and Speed

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## Abstract

Walking speed and the field of view is clinical element of gait. Previous studies saw mainly visual feedback effects. The purpose of this study was to see the change of gait pattern according to speed and the kinds of vision which are fixed vertically. This study recruited healthy 15-male and 16-female. The subjects walked 3 minute on the treadmill in 5km, 3km, and 1km each session. The vision of subjects fixed the front, the bottom and the top. Gait pattern (step length, stride length, speed, and cadence) collected using OPTOGait. The data was analyzed by one-way ANOVA. There were significant differences in the gait pattern of speed ( $p < 0.05$ ). However, there are no significant difference in the sight which is fixed vertically ( $p > 0.05$ ). Gait speed was related to the stability associated with falls. Because of decreasing step length, stride length and cadence. Slow speed gait was helpful to prevent from fall-down, and useful to control to posture control. In normal subjects, the vision will be considered as not affecting the gait pattern.

**Keywords:** Gait Pattern, Gait Speed, Treadmill Training, Vision

## 1. Introduction

Gait is an important part of Activity of Daily Living (ADL). The importance of walking is not limited by age, gender, race, health condition<sup>1,2</sup>. Gait is a good indicator to assess the health. There was a correlation abnormal gait with high mortality, unhealthy condition, and risks associated with the fall<sup>3-5</sup>. The walk was required coordination with upper extremity and lower extremity movement of the body, each segment was a continuous and complex operation consisting of repetitive motion. Coordination between these segments was essential for the functional gait<sup>6</sup>. Because of these factors, we can walk. When gait was measured, gait pattern and gait speed are mainly used<sup>5-8</sup>. Gait pattern was consisted of stance phase, swing phase, stride length, step length, velocity, and cadence<sup>7-10</sup>. Normal walking cycle was classified as stance phase which was the feet on the ground and swing phase which was the feet were off the ground. Stance phase of normal walking cycle was 60 percent (double stance phase takes

25 percent) and swing phase of it was 40 percent. Stance phase was consisted of heel strike, foot flat, mid stance, and toe off. Swing phase was consisted of acceleration, mid swing, and deceleration.

Gait speed was an important indicator to measure the health status<sup>11</sup>. The walking speed was a factor that affects the gait and movement. When the speed was increased, the change in the body's movement was shown a change in the walking pattern<sup>12</sup>. When the walking at a faster rate than the preferred velocity increased the risk of falls, and when the walking speed to a lower speed than preferred required a lot of attention<sup>13-15</sup>. Sloot et al<sup>28</sup>. reported walking speed compared to the speed with randomly fixed rate preference<sup>16</sup>.

Walking was the balance and posture control ability and relationships, it was important to maintain the sensory input integration equilibrium during walking<sup>17</sup>. There were many factors on balance. Those factors were consisted of vestibule function, visual, auditory, proprioceptor and sensory receptor<sup>18</sup>. Visual

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system provided information about the distance, plays an important role in maintaining stability during walking<sup>19</sup>. Visual information which was given while walking affected changing the strategy of walking<sup>20</sup>. The visual perception of the environment during walking contributed reaching the destination through adjusting the direction and avoiding obstacle<sup>21</sup>. The visual recognition of the position and motion of the body was important to adjust the step length and an issuing position, and controls the walking pattern<sup>22</sup>. Ridge and Richards<sup>23</sup> was used in the posture control or speed control during walking to a visual stimulus by applying the visual feedback effects. Many articles had used the visual feedback effects to control the posture adjustment and the gait speed adjustment.

A number of studies have been done that walking speed on the subject took place many studies about the effects on the muscles of the activity according to the speed and gait pattern. Research walking speed on gait patterns were compared to most fast and comfortable speed, the study of changes in the gait pattern when walked at a slow speed is lacking. Visual stimulation has been a lot of progress in the research on the effect of walking, was achieved the visual feedback effects much research on the theme. However, there was a study of the gait pattern of the straight vision limits. This study aimed to describe changes in the gait pattern according to walking speed if the gait is changing how the vertical as would limit the field of view.

## 2. Subjects and Method

### 2.1 Subjects

After preliminary research subjects as the body healthy men and women were elected to those who agree to participate in this study. Participants were selected as subjects for a total of 31 people (male; 15, female; 16). To participate in the study prior to the purpose of the study participants, explain the procedure was fully gave consent for research participation. Based on the subjects was excluded from the nervous system in the past, and musculoskeletal surgery was caused by damage to the physical balance undamaged character defects and visual, auditory, no participants were excluded due to these factors. This study was approved by the Ethics Review Committee of Sun Moon University IRB.

### 2.2 Research Procedure

This experiment was conducted for 2 days on a single group. On the first day, participants were recruited for prior training, and measurement of height and weight using the body composition analyzer (Inbody 570, Biospace, Korea, 2013). On the second day, participants walked 5km/h, 3km/h, 1km/h while looking straight ahead, down, up for 3 minutes respectively. The distance between the ground and the ceiling is 3.5m and looking straight ahead was 1.7m, looking up 3.4m, and looking down 0.1m in height. Participants walked on the treadmill at the speed of 5km/h with their eyes straight ahead for 3

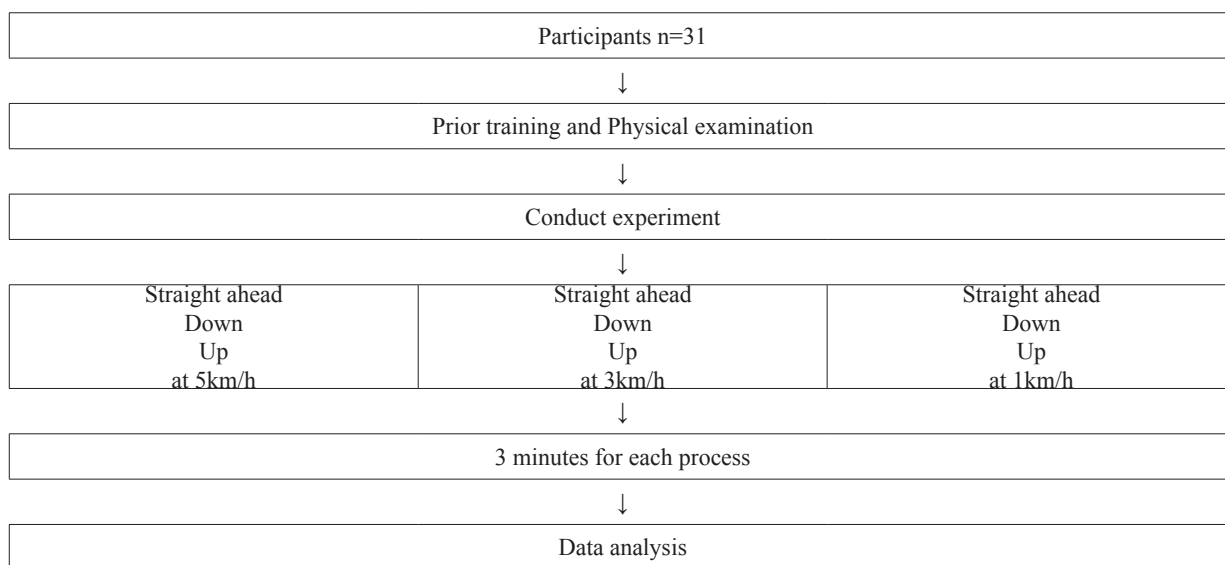


Figure 1. Research procedure.

minutes, after 3 minutes of rest. They walked at the speed of 5km/h with their eyes close, another 3 minute rest, walked at the speed of 5km/h with their eyes open. After 3 minutes of rest, they walked on the treadmill at the speed of 3km/h with their eyes straight ahead, after 3 minutes of rest they walked at the speed of 3km/h with their eyes close, another 3 minute rest, walked at the speed of 3km/h with their eyes open. After 3 minutes of rest, they walked on the treadmill at the speed of 1km/h with their eyes straight ahead, after 3 minutes of rest they walked at the speed of 1km/h with their eyes close, another 3 minute rest, walked at the speed of 1km/h with their eyes open. Data is collected by gait analysis equipment while the participants were walking (Figure 1, Figure 2 and Figure 3).



Figure 2. Gait analysis equipment.

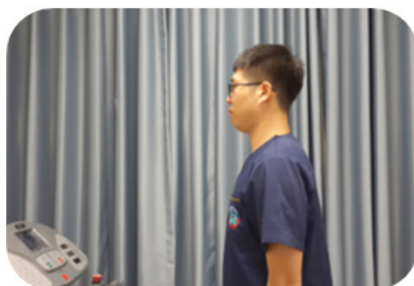
The data was collected by gait analysis equipment (Optogait, Microgata, Italy, 2010) and 31 participants were analyzed walking on a treadmill with a 0° slope. The gait analysis equipment used in this experiment is composed of a reception rod and a transmission rod, arranged parallel to the treadmill. Kinematic gait variables are cadence, gait cycle, step length, and stride length (Figure 2).

### 2.3 Method of Analysis

All measurements are statistically processed using the SPSS 18.0 for Windows. Measurements of looking straight ahead, down, and up at the same speed of gait, and of 5km/h, 3km/h, 1km/h looking at the same direction were compared. The one-way ANOVA method was used for analysis. The Bonferroni method was used for post-hoc to compare the differences between respective variables. The level of significance of statistical analysis was set  $p < 0.05$ .

## 3. Results

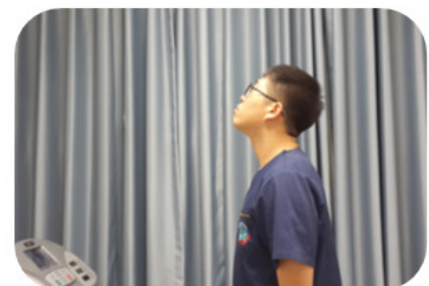
Walking looking straight ahead at 5km/h, 3km/h, 1km/h was significant in step, stride, speed, cadence ( $p < 0.05$ ). Walking looking down at 5km/h, 3km/h, 1km/h was significant in step, speed, cadence ( $p < 0.05$ ). In contrast, there was no significant difference for stride ( $p > 0.05$ ). Walking looking up at 5km/h, 3km/h, 1km/h were significant in step, stride, speed, cadence ( $p < 0.05$ ). In addition, post-hoc result of walking looking straight ahead in step,



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Figure 3. Direction of eyes.

**Table 1.** The gait pattern depending on the perpendicular line of sight and gait velocity

		Straight ahead	Down	Up	P
Step (unit cm)	5Km/h	39.00 ± 3.40	40.03 ± 3.69	38.81 ± 2.96	0.309
	3Km/h	44.13 ± 3.84	42.97 ± 3.63	42.97 ± 3.61	0.365
	1Km/h	41.35 ± 3.48	40.74 ± 3.27	40.19 ± 2.89	0.369
	P	0.000	0.004	0.000	
Stride (unit cm)	5Km/h	77.77 ± 6.65	78.94 ± 10.43	77.29 ± 5.90	0.703
	3Km/h	86.29 ± 7.51	84.06 ± 7.04	83.87 ± 7.02	0.343
	1Km/h	82.55 ± 6.71	81.35 ± 6.24	80.42 ± 5.85	0.412
	P	0.000	0.050	0.000	
Speed (unit m/s)	5Km/h	0.98 ± 0.14	0.97 ± 0.12	0.95 ± 0.09	0.638
	3Km/h	0.70 ± 0.10	0.68 ± 0.10	0.66 ± 0.08	0.230
	1Km/h	0.16 ± 0.02	0.16 ± 0.03	0.16 ± 0.02	0.631
	P	0.000	0.000	0.000	
Cadence (unit steps/min)	5Km/h	143.26 ± 13.41	140.35 ± 12.80	141.94 ± 9.36	0.634
	3Km/h	93.29 ± 8.98	94.16 ± 8.87	90.97 ± 7.80	0.321
	1Km/h	22.52 ± 4.47	23.25 ± 2.18	23.28 ± 1.71	0.542
	P	0.000	0.00	0.000	

speed, cadence at 5km/h and 3km/h, 5km/h and 1km/h, 3km/h and 1km/h were significantly different ( $p < 0.05$ ). In stride, there were significant difference at 5km/h and 3km/h, 5km/h and 1km/h ( $p < 0.05$ ). Walking looking down at 5km/h and 3km/h, 5km/h and 1km/h, there were significant difference in step, stride, speed ( $p < 0.05$ ). In cadence, there were significant difference at 5km/h and 3km/h, 5km/h and 1km/h, 3km/h and 1km/h ( $p < 0.05$ ). Walking looking up at 5km/h and 3km/h, 3km/h and 1km/h, there were significant difference in step ( $p < 0.05$ ). In stride, there was significant difference at 5km/h and 3km/h ( $p < 0.05$ ). In speed, cadence there were significant difference at 5km/h and 3km/h, 5km/h and 1km/h, 3km/h and 1km/h ( $p < 0.05$ ). Walking at 5, 3, and 1km/h, looking ahead, down, up was no significant in step, stride, speed, cadence ( $p > 0.05$ ) (Table 1).

## 4. Discussion

This research described the change of gait pattern depending on the gait velocity and line of sight set perpendicularly. Change of gait pattern was noted according to different gait velocities, while distinct change of gait pattern was not observed according to the change of eye direction.

Previous researches were done at comfortable speed<sup>24</sup>. They suggested that gait analysis at various speed was necessary to understand gait pattern profusely and guide it<sup>25</sup>. The 3km/h was set as the normal gait, 5km/h fast gait, 1km/h slow gait velocity in this research and the objective was to study the change of gait pattern in various speeds. Hallmans et al<sup>26</sup>. reported that velocity and length of stride were deeply related, that when velocity increased length of stride increased and when velocity decreased length of stride decreased. According to research by Andriacchi et al<sup>27</sup>. as velocity increased, stride length and rate of gait increased. In this study, the stride length showed different outcomes and the rate of gait the same. Previous researches measured gait patterns walking on flat land using the VICON MX System, while this research measured gait patterns walking on the treadmill using OPTOGait. According to research by Sloom et al<sup>28</sup>., walking in a favorable speed of gait results in more increased stride length and rate of gait than walking in a fixed velocity, and when walking in a fast pace it was shorter in stride length to walk in a fixed pace like on a treadmill than to walk in a favorable speed of gait, and when walking in a slow pace it was shorter in stride length to walk in a fixed pace like on a treadmill than to walk in favorable speed of gait. When walking on a treadmill

change of gait pattern was restricted by the length of belt. In previous studies it was described that stride length and rate of gait decreased, and importance of double-limb support and stance phase increased in a slow gait in comparison to normal speed gait<sup>23,27,29</sup>. Slow gait resulted in the decrease of stride length, velocity, and similar rate of gait in this research. This was considered a resistance to prevent falling by lengthening the time of feeling and enhanced the stability of gait<sup>30</sup>.

Sight was an important factor in regulating posture and movement. Many research described that posture control involves vestibule, proprioception and vision system<sup>31,32</sup>. Posture control and gait was closely related and sight has substantial influence on gait<sup>33</sup>. The vision system provided information of the street and walking circumstance which changed the gait pattern<sup>19-22</sup>. Hallemans et al<sup>30</sup>. have reported that visually handicapped people were slow in gait, short in stride length, and long in stance phase. Friedman et al<sup>34</sup>. reported that glaucoma patients' speed of gait and stride length decreased over time. There was no significant difference in this research. Previous researches were on children while in this experiment was conducted on adults. Adult speed of gait was faster than elderly people and children<sup>35</sup>. Natural increase of speed was observed using the VICON MX System in previous researches but in this research the change of speed is not significant because the velocity was fixed. They shorten their stride length and slow down their gait to maintain stable posture and prevent falling<sup>26,30,34,36</sup>. In this research of fixing their eyes straight ahead, down, up there were no significant differences in stride length, gait, speed, and rate of gait. According to Siler's research, there was no significant difference of stride length and double stance phase between holding the handle on the treadmill or not<sup>37</sup>. It was considered that psychological factors about falling do not influence the pattern of gait. Looking up while walking restricts information of the street and the circumstance of walking and this was considered a similar psychological environment as those who are visually handicapped. Although sight is influential to gait, it was not considered to have significant influence on gait pattern.

The limitation of this research was that the experiment was restricted to healthy people, rendering it difficult to generalize on patients. Furthermore, the age of participant was restricted to the twenties, similar to the previous studies. It is difficult to generalize it to children and elderly people. The line of sight was fixed without taking

account of difference in height, angle of the neck. It is expected to have high academic value when participants are diversified and the line of sight set considering neck angle.

## 5. Conclusion

The objective of this research was to study the gait pattern in the perpendicularly set line of sight and the change of gait pattern depending on the speed of gait. Conclusively, there was no change of gait pattern in the perpendicularly set line of sight, however, there was depending on the speed of gait. Thus clinically, slow gait is effective for posture control and is likely to help prevent falling accidents.

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