

# Motor Learning in the Community-dwelling Elderly during Nordic Backward Walking

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**Abstract.** [Purpose] The aims of this study were: 1) to confirm the motion learning process of Nordic backward walking (NBW) in older adult community-dwelling volunteers and, 2) to check the change in psychological condition resulting from NBW. This study examined whether the learning process and psychological condition become more efficient after repeated sessions of NBW. [Methods] The subjects were 19 community-dwelling elderly individuals between the ages of 64 and 78 years. [Results] Significant differences in walking speed during NBW were only found between the first and second sessions and between the second and third sessions. The walking speed in the sixth session, measured one hour after the fifth session, was decreased in comparison with that in the fifth session. Significant differences in stride length during NBW were only found between the first and second sessions and between the second and third sessions. The stride length in the sixth session, measured one hour after the fifth session, was decreased in comparison with that in the fifth session. Significant differences in VAS score (sense of fear) after NBW were found for each session. VAS score for the sixth session, measured one hour after the fifth session, was decreased in comparison with that for the fifth session. [Conclusions] The findings in the present study suggest that NBW is indeed a novel task and that motor learning occurs as a result of practice, leading to a more efficient recruitment of motor units.

**Key words:** Nordic backward walking, Motor learning, Community-dwelling elderly

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## INTRODUCTION

Nordic walking is a physical activity consisting of walking with poles similar to ski poles. It has evolved from an off-season form of ski training. The poles are designed for the purpose of activating the upper body during walking. They are equipped with rubber or spike tips, and the walking itself resembles Nordic-style skiing. Beginners are asked to walk in an upright position, not leaning forward or backward. The head should be up and facing forward, and the poles are held close to the body. When the leading foot is moving forward, the opposite arm swings forward to waist height. The opposite pole strikes the ground level with the heel of the leading foot. Beginners are reminded not to plant the pole in front of their feet. The poles remain pointing diagonally backward and are pushed as far back as possible. The arm straightens and the hand opens, coming off the grip by the end of the arm swing. Nordic walking is not expensive and can be performed throughout the year.

But handling of the poles is difficult, the technique required to handle them cannot be easily acquired by community-dwelling elderly individuals.

An intriguing phenomenon is the extent to which the human motor system can transfer relevant strategies learned in one context to other similar situations. Experimental paradigms using upper limb tasks show the ability of the nervous system to generalize learned motor skills to similar movements, contexts, or workspaces and even to the opposite limb<sup>1-4)</sup>. Such studies have yielded valuable insights into how the nervous system codes and generalizes motor skills. Walking is a motor task that is highly flexible in its adaptation to different situations. Such flexibility is important for effective navigation through different environments and unpredictable circumstances. Extensive work has shown the ability of the locomotor system to adapt to changes in sensory input from the limbs<sup>5-7)</sup>. In addition, the walking pattern is easily modified to accommodate different external constraints, for example, navigating over or around obstacles<sup>8)</sup> or different slopes of the walking surface<sup>9, 10)</sup>.

Falls are a social problem affecting 10–30% of elderly individuals. Therefore, it is important for elderly individuals to train with movements in the backward direction to prevent falling forward. Nordic backward walking (NBW) is a very difficult form of walking for beginners, and we do not currently know the effect of repetition of NBW on

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movement in the backward direction in the elderly.

The aims of this study were: 1) to confirm the motor learning process of NBW in older adult community-dwelling volunteers and 2) to check the change in psychological condition resulting from NBW.

## SUBJECTS AND METHODS

This study utilized a single-group, repeated-measures design. We evaluated 19 older adult community-dwelling volunteers (11 female and 8 male; mean age  $64\pm 4$ ) (Table 1). The volunteers ( $n=19$ ) were included based on the following criteria: 1) self-report of good health and 2) absence of a history of psychiatric or neurological disorder. All participants gave informed consent, and the study was approved by the Ethics Committee of Kansai University of Welfare Sciences.

Nordic backward walking was measured using a 10 m instrument. We measured NBW consecutively five times and then measured it a sixth time one hour later. Participants were given adequate rest time and allowed to sit between trials. No participants reported fatigue, likely because of the short walking distance and limited number of trials. The results from the trials for each direction were averaged. The primary variables of interest were walking speed, stride length, and visual analogue scale (VAS). The VAS was used as an index of sense of fear for walking backward.

A paired t-test was used to compare the mean front and back scores. The alpha level for statistical significance was set, a priori, at 0.05. All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 19.

## RESULTS

Our results demonstrated that following repeated sessions of backward walking, the walking speed during NBW in the first, second, third, fourth, and fifth sessions were 73 m/min, 80 m/min, 86 m/min, 88 m/min, and 91 m/min, respectively. Significant differences were only found between the first and second sessions and between the second and

third sessions. The walking speed in the sixth session (86 m/min), measured one hour later, was decreased in comparison with that in the fifth session. The stride lengths during NBW in the first, second, third, fourth, and fifth sessions were 0.52 m, 0.56 m, 0.58 m, 0.59 m, and 0.59 m, respectively. Significant differences were only found between the first and second sessions and between the second and third sessions. The stride length in the sixth session (0.56 m), measured one hour later, was decreased in comparison with that in the fifth session. The VAS scores after NBW for the first, second, third, fourth, and fifth sessions were 4.03 cm, 3.46 cm, 2.95 cm, 2.47 cm, and 2.00 cm, respectively. A significant difference was found between each session and the one preceding it. In addition, the VAS score for the sixth session (2.00 cm), measured one hour later, was increased compared with that for the fifth session (Table 2).

## DISCUSSION

This study investigated the learning process in beginners learning how to perform NBW using Nordic poles. Our results demonstrated that following repeated sessions of backward walking, the walking speed during NBW showed significant differences only between the first and second sessions and between the second and third sessions. The walking speed in the sixth session, measured one hour later, was decreased in comparison with that in the fifth session. Unlike the subjects studied by Lake and Cavanagh<sup>11)</sup>, our subjects demonstrated a clear increase in efficiency, likely as a result of increased efficiency of motor unit recruitment due to practice. The differing results can most likely be explained by considering the differences in the type of exercise used. Backward walking is truly a novel task, whereas even individuals who do not specifically train with forward running do engage in forward walking. Therefore, the motor pathways used for any forward locomotion are at least somewhat trained, whereas those used for backward locomotion are untrained.

Significant differences in stride length during NBW were only found between the first and second sessions and between the second and third sessions. The stride length in the sixth session, measured one hour later, was decreased in comparison with that in the fifth session. Specifically, the increase was significant between the fourth and sixth week of training. Schwane et al.<sup>12)</sup> suggested that a novel activity may require increasingly greater motor unit recruitment in order to complete a task. Although we did not specifically examine muscle activity, backward walking requires greater sustained EMG activity of the quadriceps than forward walking<sup>13, 14)</sup>. Thus, we believe our findings are the first to demonstrate that an individual may perform

**Table 1.** General characteristics of participants ( $n=19$ )

Indexes	Mean $\pm$ SD
Age (years)	64 $\pm$ 4
Gender (male/female)	11/11
Functional reach test (cm)	28.1 $\pm$ 7.5
Bone density (g/cm <sup>2</sup> )	2.4 $\pm$ 0.2
Mini-mental state examination (point)	29 $\pm$ 1

**Table 2.** Motor learning during Nordic backward walking ( $n=19$ )

	1st	2nd	3rd	4th	5th	6th
Backward walking speed (m/min)	73 $\pm$ 21	80* $\pm$ 20	86* $\pm$ 21	88 $\pm$ 24	91 $\pm$ 28	86 $\pm$ 23
Stride length (m)	0.52 $\pm$ 0.10	0.56* $\pm$ 0.12	0.58* $\pm$ 0.11	0.59 $\pm$ 0.13	0.59 $\pm$ 0.12	0.56 $\pm$ 0.11
Visual analogue scale (cm)	4.03 $\pm$ 2.39	3.46* $\pm$ 2.35	2.95* $\pm$ 2.25	2.47* $\pm$ 2.39	2.00* $\pm$ 2.29	1.66 $\pm$ 2.04

Values are presented as the average $\pm$ SD. \*Versus the previous session ( $p<0.05$ )

backward walking more efficiently after repeated sessions of backward walking training.

Significant differences in VAS score after NBW were found for each session. In addition, the stride length in the sixth session, measured one hour later, was decreased in comparison with that in the fifth session. If the energy cost decreases as a person learns a new motor skill, as suggested by Schwane et al.<sup>12)</sup>, the prescribed exercise workload, per the regression equations reported by Myatt et al.<sup>15)</sup> and Clarkson et al.<sup>16)</sup>, may not have the intended training effect. Our findings are consistent with the hypothesis that efficiency increases when a task is no longer novel.

Therefore, it is important for elderly individuals to train with backward movements to prevent falling forward. The skill of the subjects in performing NBW rose with every repetition, but they learned at a slow pace. Also, their level of skill tended to decrease when they took a break between sessions. However, their sense of fear did not worsen even if they took a break. This finding suggests that NBW is indeed a novel task and that motor learning occurs as a result of practice, leading to a more efficient recruitment of motor units. Therefore, NBW was a form of training that matched with the preferences of the elderly and was thought to be useful as a backward walking exercise for the elderly. NBW can be performed anywhere and anytime, and therefore, widespread clinical application of NBW is possible.

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