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# Comparison of the Effects of Walking with and without Nordic Pole on Upper Extremity and Lower Extremity Muscle Activation

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**Abstract.** [Purpose] The aim of this study was to assess the effect of Nordic pole walking on the electromyographic activities of upper extremity and lower extremity muscles. [Subjects and Methods] The subjects were randomly divided into two groups as follows: without Nordic pole walking group (n=13) and with Nordic pole walking group (n=13). The EMG data were collected by measurement while the subjects walking on a treadmill for 30 minutes by measuring from one heel strike to the next. [Results] Both the average values and maximum values of the muscle activity of the upper extremity increased in both the group that used Nordic poles and the group that did not use Nordic poles, and the values showed statistically significant differences. There was an increase in the average value for muscle activity of the latissimus dorsi, but the difference was not statistically significant, although there was a statistically significant increase in its maximum value. The average and maximum values for muscle activity of the lower extremity did not show large differences in either group, and the values did not show any statistically significant differences. [Conclusion] The use of Nordic poles by increased muscle activity of the upper extremity compared with regular walking but did not affect the lower extremity.
**Key words:** Nordic pole walking, Upper extremity muscle, Lower extremity muscle

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## INTRODUCTION

Walking is the most basic movement of humans and is said to be one of the good methods to maintain and promote health[1)]. Among the good walking methods that promote health, Nordic pole walking has been recently used. It is an exercise frequently performed in Northern Europe[2)] that remarkably increases calorie and oxygen consumption compared with regular walking exercise due to the use of poles carried in both hands, which results in many muscles in the upper body, such as the arms, shoulders, and chest, being used simulatenously[3)]. According to Church et al. (2002)[4)], oxygen and calorie consumption remarkably increase when walking forward using Nordic poles. This indicates that use of Nordic poles greatly affects human bodies.

Exercises using Nordic poles increase stability compared with regular walking because the upper extremities are used together with the lower extremities during exercises using Nordic poles, and they have been said to be particularly useful for persons with disorders in body balance ability[4)]. It was reported that the use of Nordic poles reduced loads imposed on the lower extremities[5)] and that reducing loads imposed on the lower extremities could prevent damage to the knee joints[6)]. In studies of walking using Nordic poles, it was reported that oxygen consumption and heart rates remarkably increased during walking using Nordic poles[4, 7, 8)] and that these effects were very effective not only in arthritis patients but also in subjects with cardiovascular or nervous diseases[9)].

This exercise method enables exercises of the whole body because use of Nordic poles increases the use of the upper extremities and reduces loads on the lower extremities. According to a paper written by Kim & Shim (2012)[1)], when movements before and after using Nordic poles were observed, normal movements appeared when Nordic poles were used that made foot pressure pass through the feet. Given this result, it can be assumed that symmetric movements of the upper extremities positively affected normal movements of the feet. According to Shim (2012)[10)], the use

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of Nordic poles increases step lengths and reduces the ratio of time from foot flat, at which the feet come into contact with the ground, to heel off because the use of the poles increased stability. Therefore, it can be assumed that use of the upper extremities' force using Nordic poles affected the lower extremities.

On reviewing previous studies, it can be seen that the use of muscles in the upper extremities affects the lower extremities. However, studies on differences in muscle activity between the upper extremity and lower extremity are quite insufficient.

Therefore, in the present study, subjects were divided into a group that used Nordic poles and a group that did not use Nordic poles to examine differences shown by the biceps brachii, triceps, deltoid, and latissimus dorsi in the upper extremity and the rectus femoris, lateral hamstring, tibialis anterior, and gastrocnemius in the lower extremity between the two groups. The aim of the present study was to provide accurate information on the effects of use of Nordic poles on the muscles in the upper and lower extremities.

## SUBJECTS AND METHODS

The participants were twenty-six subjects who voluntarily consented to participate in the study. They were randomly divided into two groups as follows: walking with Nordic poles group (with NPW group's, n=13) and walking without Nordic poles group (without NPW group, n=13). The with NPW group`s average age was 21.38±0.87 years, average height was 168.85±8.05 cm, and average weight was 65.23±14.14 kg. The without NPW group's average age was 21.46±0.77 years, average height was 169.15±7.66 cm, and average weight was 63.00±11.88 kg. The exclusion criteria were past or present musculoskeletal, neurological and cardiopulmonary disease that could hamper with or without NPW. Prior to the start of this study, all subjects signed an informed consent form. This study was approved by university institutional review board.

The subjects were asked to walk in an upright posture, with the head upright and looking forward. In Nordic pole walking, the Nordic poles are held close to the body. When a foot is moved forward, the arm on the other side lifts the Nordic pole and moves it forward. The pole comes into contact with the ground first, followed by the foot. Then, the pole and the foot move by turns to push the body forward while pushing backward against the ground. When pushing backward, the arm is completely extended at the farthest point that can be reached. At this point, the hand holding the pole is spread to push the body forward[11)]. When walking forward using Nordic poles, the body utilizes more calories[12)], and the upper extremities become to act so that the walking becomes exercises of the whole body and thus more physical activities appear unavoidably[13)].

Before examinations using EMG, the dominant arms and legs of the study subjects were first examined. In the case of the arms, the subjects were examined to determine the arm used for writing; in the case of the feet, they were examined to determine the foot used to kick a ball[14)]. The activities of the lower extremity muscles were measured using surface EMG (TeleMyo 2400T G2, Noraxon U.S.A., Inc., Scottsdale, AZ, USA). Collected surface EMG signals were converted into digital signals in a TeleMyo 2400T G2, and the converted signals were processed using the Myoresearch XP 1.07 software. The EMG signal sampling rate was set to 1000 Hz. The sampled EMG signals were filtered at 20–500 Hz using 60 Hz notch filters as band-pass filters.

Electrodes were placed on each muscle (biceps brachii, triceps long head, deltoid medius, latissimus dorsi, rectus femoris, lateral hamstring, tibialis anterior, gastrocnemius) in the standard places[15)]. After attaching EMG electrodes to each muscle, the values of maximal voluntary contraction were obtained three times in total from the manual muscle-testing position, and the average of the values was obtained[16)]. Based on these values, muscle activity was measured in each member of the with NPW and withoutNPW groups, and %MVIC values were obtained by substituting the muscle activity values.

First, all the subjects were present at the laboratory and educated on the NPW technique for approximately 30 minutes. Then, they were educated on the use of Nordic poles so that they could sufficiently use the poles by practicing walking with them[17)]. They did not wear any shoes during walking, and the speed of the treadmill was set to the average of the speeds at which the subjects could comfortably walk in both groups. The average treadmill speed was 4.56 km/h. EMG data were collected by measurement while the subjects walked on the treadmill for 30 minutes by measuring the time from the right leg's heel strike to the next heel strike of the same leg. The values were measured at 10, 15, 20, and 25 minutes during walking and the averages of the values were calculated. The ratio of contraction during waking of each muscle to the maximal voluntary contraction of the muscle was calculated to obtain the percentage of maximal voluntary contraction.

All the statistics were analyzed using the Statistical Package for the Social Sciences (SPSS Statistics for Windows, version 17.0, SPSS Inc., Chicago, IL, USA), and the significance level α for all the statistics was 0.05. To examine the general characteristics of the subjects, means, standard deviations, and frequencies were calculated. To compare the without NPW and with NPW groups, the data were analyzed with the independent sample t-test.

## RESULTS

A comparison of the muscle activities of the upper extremity during walking between the with NPW group and the without NPW group is shown in Table 2.

The average and maximum values for the muscle activities of the biceps, triceps, and deltoid muscles in the upper extremity increased in the without NPW group, and differences were statistically significant ($p<0.05$).

The average value for the muscle activity of the latissimus dorsi increased, but the difference was not significantly significant, although there was a statistically significant increase in the maximum value ($p<0.05$).

A comparison of the muscle activities of the lower extremity during walking between the with NPW group and

**Table 1.** EMG activity of each muscle during walking with and without Nordic poles in the upper extremity (n=26)

| | | Without NPW | With NPW | |
|---|---|---|---|---|
| Biceps brachii | Mean | 0.64±0.54 | 4.69±3.55 | * |
| | Max | 3.49±2.35 | 12.29±7.77 | * |
| Triceps | Mean | 1.58±0.56 | 11.23±11.09 | * |
| | Max | 6.59±6.45 | 32.00±18.83 | * |
| Deltoid medius | Mean | 1.38±0.62 | 3.81±3.72 | * |
| | Max | 5.49±3.60 | 15.22±11.50 | * |
| Latissimus dorsi | Mean | 5.81±5.86 | 9.28±5.43 | |
| | Max | 14.88±13.29 | 33.69±21.55 | * |

*p<0.05
Unit: %MVIC

**Table 2.** EMG activity of each muscle during gait with and without Nordic poles in the lower extremity (n=26)

| | | Without NPW | With NPW |
|---|---|---|---|
| Rectus femoris | Mean | 11.18±7.53 | 11.08±6.49 |
| | Max | 28.98±15.81 | 32.30±26.32 |
| Lateral hamstring | Mean | 21.47±16.48 | 22.93±19.43 |
| | Max | 41.89±22.54 | 45.50±32.72 |
| Tibialis anterior | Mean | 13.90±6.20 | 12.40±3.79 |
| | Max | 37.87±17.31 | 36.66±14.39 |
| Gastrocnemius | Mean | 19.30±3.34 | 17.61±3.19 |
| | Max | 65.67±13.89 | 61.62±13.17 |

*p<0.05
Unit: %MVIC

the without NPW group is shown in Table 1.

The average and maximum values for the muscle activities of the quadriceps, hamstring, tibialis anterior, and gastrocnemius muscle in the lower extremity did not show any large differences in either the with NPW group or the without NPW group, and the values did not show any statistically significant differences (p>0.05).

## DISCUSSION

The results of the present study indicated that compared with regular walking, walking with Nordic poles can prevent damage to the lower extremity joints[18] and relatively reduce loads on the knee joints[6]. Unlike regular walking exercises, Nordic pole walking exercises induces the mobilization of all upper and lower extremity muscles because poles are used, and so they show higher oxygen consumption by the body compared with regular walking[19]. Bumgardner (2010)[20] said that Nordic pole walking could easily increase cardiac outputs and heart rates without increasing exercise fatigue thereby increasing the effects of exercises. Church (2002)[4] reported that when adult males and females were instructed to walk 1 mile and oxygen consumption during the exercises was measured, Nordic walking exercises showed higher oxygen consumption. He also reported that, when compared with regular walking, Nordic pole walking enabled faster walking. Nordic pole walking exercises are aerobic exercises that can increase muscle mass even when only they are performed, so muscle strength can be improved and the poles can play a role as supports to improve stability. According to Kim and Shim (2012)[1], the use of Nordic poles can enable exercises closer to normal walking and provide positive effects of foot pressure distribution during walking. According to Shim (2012)[10], when compared with walking without using Nordic poles, walking using Nordic poles increased step length and the time from heel contact to foot flat while reducing the time from foot flat to heel off. The reason for the increase in the time from heel contact to foot flat can be assumed to be the fact that the Nordic pole comes down to the ground together with the heel at heel contact, and the reason for the reduction in the time from foot flat to heel off can be assumed to be the fact that the Nordic pole pushes against the ground to make heel off happen faster in the gait cycle. Therefore, the use of Nordic poles can relieve pain in the lower extremity, increase the amount of exercise, improve cardiovascular system functions, help patients with arthritis or diabetes during walking, and help improve the gait and normal walking in relation to foot pressure.

This means that the use of Nordic poles greatly affects the human body. Therefore, this researcher conducted the present study to examine the effects of use of Nordic poles during walking on muscles of the upper and lower extremities.

In the present study, EMG was used to observe the activities of muscles of the upper and lower extremities. On reviewing the movements made during walking with Nordic poles in the hands and walking without Nordic poles, it can be seen that when the arms move back and forth, the feet also move back and forth. The muscles mainly used for these movements are the biceps brachii, triceps, deltoid, and latissimus dorsi in the upper extremity and the rectus femoris, lateral hamstring, tibialis anterior, and gastrocnemius in the lower extremity[10]. Therefore, in the present study, those muscles were measured. A treadmill was used in order to maximally reduce changes in muscle activity due to changes in speed, since subjects can find speeds suitable to them and continuously walk at those speeds when they walk on a treadmill[1].

On reviewing the results of the present study with regard to the upper extremity, it can be seen that the activities of the biceps brachii, triceps, deltoid medius, and latissimus dorsi increased remarkably when Nordic poles were used compared with when Nordic poles were not used. In particular, it can be seen that the biceps brachii and the triceps were exercised in turns as the elbow joints were moved when Nordic poles were used. The deltoid and lattissimus dorsi were frequently used when the body moved forward while pushing against the ground using a Nordic pole and when the poles were moved. The results of the present study were similar to the results of a study conducted by Evans et al. (1994)[3] indicating that when Nordic poles are used, many muscles in the arms, shoulders, chest, and back are used and energy consumption is increased. The results of the present study were also similar to the results of a study conducted by Anja et al. (1999)[21] indicating that when many office workers performed Nordic pole walking exercises for 12 weeks, their upper body muscles were improved.

However, the results of the present study with regard to the lower extremity indicated that the muscle activities of the rectus femoris, lateral hamstring, tibialis anterior, and gastrocnemius did not show big differences between when Nordic poles were used and when Nordic poles were not used. These results indicate that the use of Nordic poles by the upper extremities did not greatly affect the muscle activity of the lower extremity muscles. On reviewing these results, it can be seen that walking with Nordic poles has the added benefit of exercise of the arms compared with walking without Nordic poles, resulting in larger exercise effects[22]. However, the results of the present study indicated that although walking using Nordic poles increased use of the upper extremity, the activities of the muscles in the lower extremity were not greatly affected.

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