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Effects of Nordic walking on gait parameters on leveled ground (0°) and inclined slope (30°) in healthy individuals

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Abstract
Background: Nordic poles was used for skiing and later evolved for support and balance. The study is carried with European style Nordic walking to know its effect on gait parameters.
Materials and Methods: The study included 30 participants, which were categorized into two groups with 15 participants in each group. They were asked to walk on levelled ground and inclined slope and their stride length, step length and walking velocity was measured.
Result: Walking with Nordic poles on both the surfaces was extremely significant but when compared to inclined slope and levelled ground, inclined slope was more significant.
Conclusion: Walking with Nordic poles on inclined surface was more significant than on levelled ground.

Keywords: nordicpoles, stride length, step length, walking velocity

1. Introduction

Walking is the simple act of falling forward and catching oneself. "Winter" felt gait performs five main functions. First, it helps to support head, arms, and trunk by maintaining a semi rigid lower limb. Second, it helps to maintain upright posture and balance. Third it controls the foot to allow it to clear obstacles and enables gentle heel or toe landing through its eccentric muscle action. Fourthly, it generates mechanical energy by concentric muscle contraction to initiate, maintain, and if desired, increase forward velocity. Finally, through eccentric contraction of muscles, it provides shock absorption and stability and decreases forward velocity of the body [1]. It is the most basic movement of humans and said to be one of the good methods to maintain and promote health [2]. Humans can lead efficient daily lives by adjusting their walking patterns in various ways during exercise. However walking for long hours consumes energy and may cause fatigue [3].

Gait is normal human locomotion. The alternating movements of the lower extremities essentially support and carry along the heads, arms and trunk. The heads, arms and trunks constitute about 75% of total body weight, with the head and arms contributing about 25% of total body weight and the trunk contributing the remaining 50%. A gait cycle spans two successive events of the same limb, initial contact of the lower extremity with the supporting surface [4]. During one gait cycle, each extremity passes through two phases: A stance phase, when some part of the foot is in contact with the floor, which consists of 60% of gait cycle, and a swing phase when the foot is not in contact with the floor, which makes up remaining 40% [5].

Stance phase is divided into sub phases by a number of events that mark the start and end of the sub phases. Events of stance phase are: Initial contact which refers to the instant foot of the leading extremity which strikes the ground. In normal gait, the heel is the point of contact, and the event is referred to as heel contact or heel strike. Foot flat is the first instance during when foot is flat on the ground. Mid stance is the point where the bodyweight is directly over the supporting lower extremity, usually about 30% of the gait cycle [5]. Heel–off is the point where the heel of the reference extremity leaves the ground, usually about 40% of the gait cycle. Toe-off is the instant at which the toe of the foot leaves the ground, usually about 60% of the gait cycle. Sub phases of stance phase are: Heel strike phase which begins with initial contact and ends with foot flat and occupies only small percentage of gait cycle. Mid stance phase begins with foot flat at 7% of gait cycle and ends with heel-off at about 40% of gait cycle. Push-off phase begins with heel-off at about 40% of the gait cycle and ends with toe-off at about60% of gait cycle [6].

Swing phase consist of phases in which early swing phase begins once the toe leaves the ground and continues until mid-swing, or the point at which extremity is directly under the body, this phase is also referred to as initial swing, or the acceleration phase. Mid swing occurs approximately when the extremity passes directly beneath the body or from the end of acceleration to the beginning of deceleration. Late swing occurs after mid swing when the limb is decelerating and preparation for heel strike. It is also known as terminal swing, or the deceleration phase.

Time and distance are two basic parameters of motion, and measurements of these variables provide a basic description of gait. Temporal variables include: Stance time- It is the amount of time that elapses during the stance phase of one extremity in a gait cycle. Single-limb support time is the amount of time that elapses during the period when only one extremity in a gait cycle. Double support time is the amount of time spent

with both feet on the ground during one gait cycle. Swing time, stride time –it refers to the amount of time taken to accomplish one stride and step time-refers to the amount of time spent during a single step. Cadence is the number of steps taken by a person per unit time, and walking velocity is the rate of linear forward motion of the body, which can be measured in meters or centimeters per second, meters per min or miles per hour.

The distance variables include stride length which is the linear distance between two successive events that are accomplished by the same lower extremity. Step length is the linear distance between two successive points of contact of opposite extremities. Step width is the linear distance between the midpoint of the heel of one foot and the same point of the other foot and degree of toe out represents the angle of foot placement and can be found by measuring the angle formed by each foot's line intersecting the centre of the heel and the second toe [6].

Among the walking methods that promote health, Nordic pole walking has been recently using [2]. The history of Nordic walking, a specialized form of physical activity, is quite short, in its current form it dates back only a dozen years. The sources must be found in the form of summer training, cross country skiers, called Ski walking. Many advantages of "March with sticks" resulted in unprecedented development in relatively ephemeral time, not only in Finland-where it originated, or the Scandinavian Peninsula, but throughout Europe. There are unquestionable advantages of Nordic walking, such as: the simplicity of the movement-running, accessibility for people of all ages and different fitness levels, relatively low cost, and safety during practice [7]. Nordic walking is a walking style that uses two specially designed walking poles [8]. It involves walking with two poles using a reciprocal arm leg action [9]. It was divided into two, Japanese style Nordic walking and European style Nordic walking by the Japan Nordic walking league. The Japanese style Nordic and European style Nordic walking is the use of two poles. In Japanese style Nordic walking the walker plants the pole vertically on a ground like a cane and in European style Nordic walking the walker thrusts each pole in diagonal angle, creating driving force for a more active walking style [8]. It has become a wide established leisure sport in middle and northern Europe. It offloads lower extremities and loads the upper extremities [9].

Exercises using Nordic poles increases stability compared with regular walking because the upper extremities are used together with the lower extremities during exercises using Nordic poles, and they are noted useful for persons with disorders in body balance ability. It was reported that the use of Nordic poles reduced loads imposed on the lower extremities and that reducing loads imposed on the lower extremities could prevent damage to the knee joint [10].

Material and Methodology

- **Research Design:** The research design used for the study was Prospective and Comparative Study
- **Source of Data:** The source of data was students from Dr. A.P.J. Abdul Kalam, College of Physiotherapy, Loni, Taluka - Rahata, District- Ahemdnagar-413736, Maharashtra.
- **Type of Data:** The data was primary which was collected by the primary investigator.
- **Place of Study:** The study was conducted in the campus of Pravara Institute of Medical Sciences.
- **Duration of Study:** The study was conducted from August 2016 to November 2016.
- **Intervention Period:** Participants received training for 4 days per week for a period of 4 weeks. Each training session lasted for 30 minutes.
- **Participants:** Both Males and Females were included for the study.
- **Sample:** The sample included participants who fulfilled the inclusion and the exclusion criteria and were willing to participate.
- **Sample Size:** The sample size was 30.
- **Sampling Design:** Simple Random Sampling.
- **Equipment:** Nordic Poles.

Selection Criteria

1. Healthy young individuals both Males and females who were willing to participate within the age group of 20-25years were included in the study
2. Individuals with cognitive disorders, past history of cardio-respiratory disease, past history ogneuro-muscular disorders. History of fracture in past 6 months, balance impairments, recent infections and recent operative wounds were excluded from the study.

Procedure

The study received ethical approval from Institutional Ethical Committee of Dr. A.P.J. Abdul Kalam College of physiotherapy, Loni.

The participants were screened and after finding suitability according to the inclusion and exclusion criteria, they were requested to participate in the study. They were explained about the study and the intervention. The participants were briefed about the nature of the study, the duration of intervention and the intervention being used was explained in the language best understood by the participants. They were encouraged to clarify queries regarding the study, if any. An informed written consent form, previously approved by ethical committee was then obtained from the participant's. The demographic data was obtained and a detailed assessment was done. After the assessment they were randomly divided in two groups, one which was walking on Leveled ground (Group A) and another on Inclined slope (Group B).

The participants were asked to dip their feet in red ink which was diluted with water after which they were asked to walk and then with the help of their footprints, study variables like stride length and step length was measured. They were then asked to walk 10.8 meters which was same for both Leveled and Inclined slope, and while their walking duration was noted, which later helped in calculating walking velocity. The post readings were taken similarly for progression.

The Nordic pole walking was given for the duration of 4 days a week for 30 minutes and for four week with a break of five minutes. Participants received and training session of 4 days per week for 4 weeks. Each session lasted for 30 minutes with 5 to 10 minutes of break if required.

Stride length: It is the linear distance between two successive events that are accomplished by the same lower extremity.

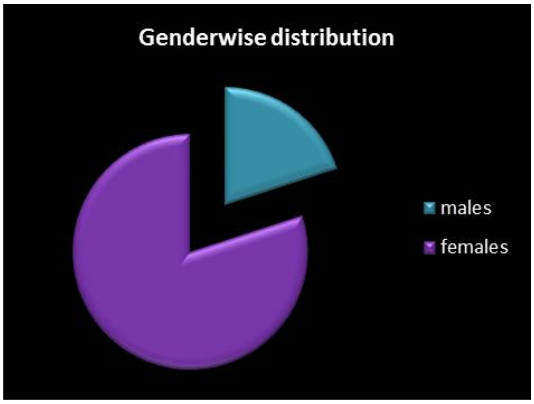
Step length: It is the linear distance between two successive points of contact of opposite extremities.

Walking velocity: It is the rate of linear forward motion of the body, which can be measured in meters or centimeters per second, meters per min or miles per hour.

Data analysis, interpretation and result

Table 1: Data representation of gender distribution of participants

Gender	No of participants
Male	6
Female	24



Graph 1: Shows demographic representation of gender

Result no 1: Represents no of participants, in which 24 were females and 6, were males.

Table 2: Data representation of gait parameters on Leveled ground

Parameters	Pre (mean+-SD)	Post (mean+-SD)	p value	T value
Stride length	116.2+-11.39	118.6+-11.55	< 0.0001	11.457
step length	57.8+-6.57	60.33+-7.17	<0.0001	8.718
Walking velocity	1.08+-0.23	1.152+-0.25	0.0006	4.492

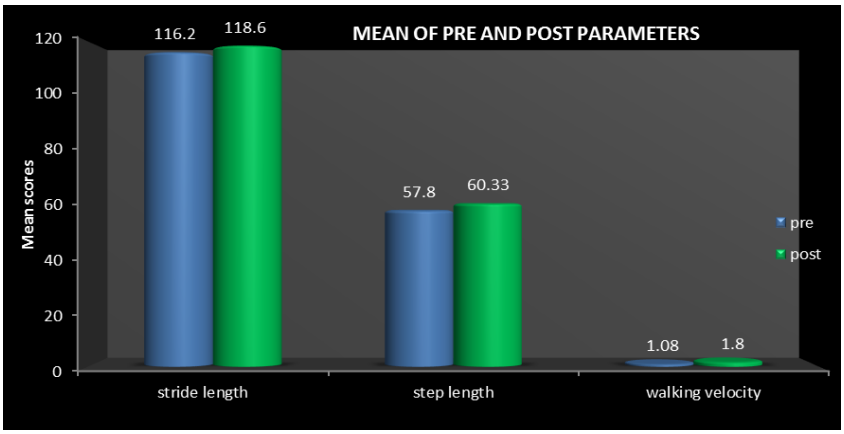


Fig 2: Represents pre and post gait parameters on Leveled ground

Result no 2: The above graph shows the comparison of mean value of pre and post stride length, t value was 11.457, df=14 and p<0.0001 using student paired t' test within the group which shows extremely significant difference. Comparison of mean value of pre and post step length, t value was 8.718, DF=14and p<0.0001using student paired't' test within the group which shows extremely significant difference. Comparison of mean value of pre and post stride length, t value was 4.492, df =14 and p is 0.0006 using student paired't' test within the group which shows extremely significant difference.

Table no 3: Data representation of gait parameters on inclined slope.

Parameters	Pre (mean+-SD)	Post(mean+-SD)	p value	T value
Stride length	117.6+-16.62	133.6+-18.27	<0.0001	13.155
Step length	57.93+-11.18	71.4+-11.48	<0.0001	15.068
Walking velocity	0.976+-0.21	1.69+-0.51	<0.0001	7.380

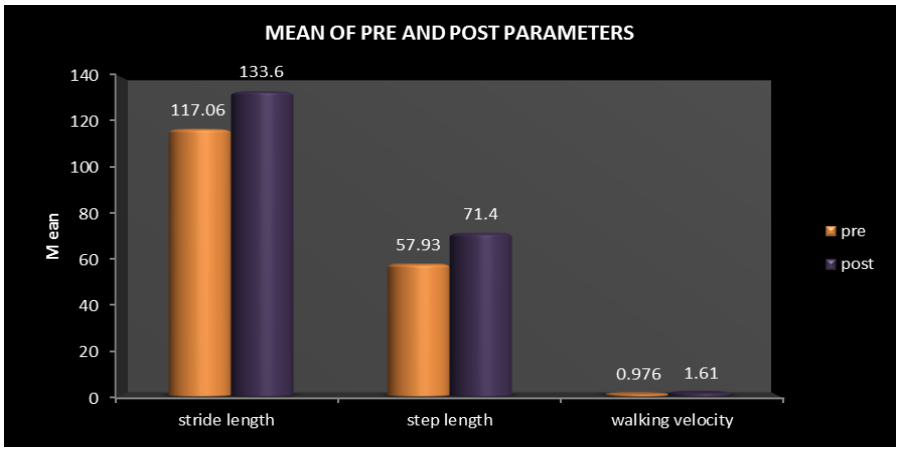


Fig 3: Represents pre and post parameters like stride length, step length and walking velocity.

Result no 3: The above graph shows the comparison of mean value of pre and post stride length, t value was 13.155, df=14 and p <0.0001 using student paired' test within the group which shows extremely significant difference. Comparison of mean value of pre and post step length, t value was 15.06, df=14and p<0.0001using student paired 't' test within the group which shows extremely significant difference. Comparison of mean value of pre and post walking velocity, t value was 7.380, df =1and p<0.0001 using student paired 't' test within the group which shows extremely significant difference.

Table 4: Data representation of post interventional stride length of group A and B

Stride length	Mean+-SD	p value	T value
Group A	118.6+11.55	0.0123,considered significant	2.675
Group B	33.6+-18.27		

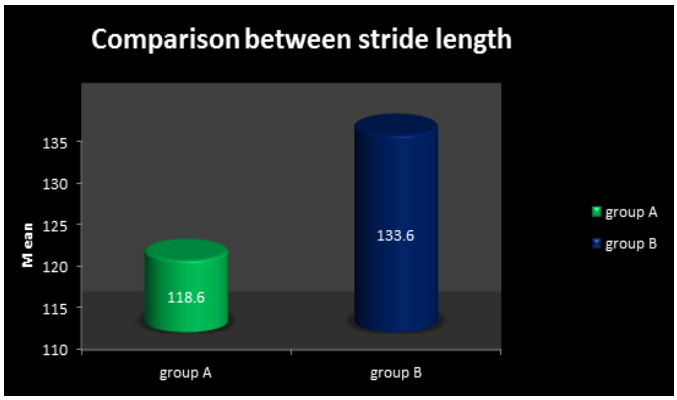


Fig 4: Represents post Nordic walking stride length of group A and B.

Result no 4: The above Graph shows the comparison of stride length of group A (Levelled) and group B (Inclined slope) using unpaired "t" test, where the t value is 2.675 with 28 degrees of freedom and p value is 0.0123, which is considered significant.

Table 5: Data representation of post interventional step length of group A and B

Step length	Mean+-SD	p value	T value
Group A	60.33+-70.17	0.0037,considered extremely significant	3.164
Group B	71.4+-71.48		

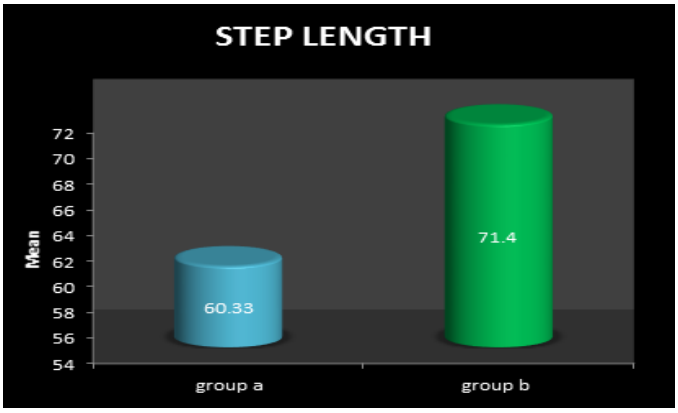


Fig 5: Represents post Nordic walking comparison of step length between group A and B.

Result no 5: The above Graph shows the comparison of step length of group A (Levelled) and group B (Inclined slope) using unpaired 't' test, where the t value is 3.164 with 28 degrees of freedom and p value is 0.0037, which is considered very significant.

Table 6: Data representation of post interventional walking velocity of group A and group B

Walking velocity	Mean+-SD	p value	T value
Group A	1.152+-0.25	0.0016,considered very significant	3.488
Group B	1.669+-0.51		

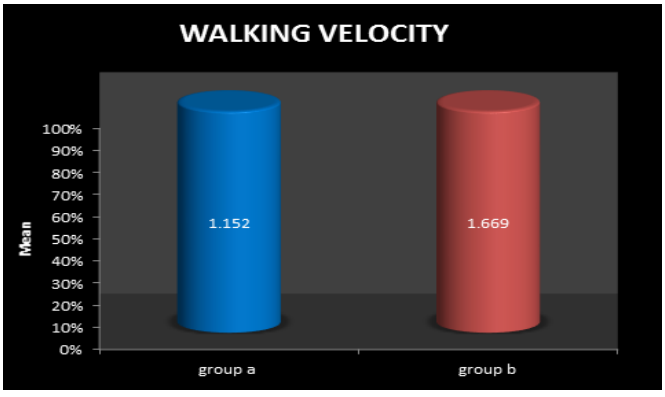


Fig 6: Represents post Nordic walking velocity of group A and B.

Result no 6: The above Graph shows the comparison of walking velocity of group A (Levelled) and group B (Inclined slope) using unpaired 't' test, where t value is 3.488 with 28 degrees of freedom and p value is 0.0016, which is considered very significant.

Discussion

The study evaluated the effect of Nordic poles walking on the Leveled ground and on the inclined slope in healthy individuals. The effect was measured after 4 weeks of post Nordic walking. The result of this study showed that there were extremely significant changes in the gait parameters such as stride length, step length and walking velocity of both the groups. However, when both the groups were compared, Group B (Inclined slope) showed extremely significant changes than Group A (Leveled ground).

The research done by Je-myung Shim concluded that on comparison of effects of walking with Nordic pole and without Nordic Pole on Upper Extremity and Lower Extremity Muscle Activation showed an increase in the average value of muscle activity of the latissimus Dorsi, but the difference was not statistically significant, although there was significant increase in its maximum value. The average and maximum values for muscle activity of the lower extremity did not illustrate large differences in either group, and the values did not show any statistically significant differences (2). So, according to the study performed to know the effect of Nordic poles on Leveled ground and Inclined slope in healthy individuals showed that after walking with Nordic poles the muscles got adapted to the offloading mechanism because when the Nordic poles are used there is increase in muscle activity of upper extremity and offloads the lower extremity which helps in increasing stride length, step length and walking velocity.

SeungKyu Park's study on effects of Nordic walking and walking on spatiotemporal gait parameters and ground reaction force found similar results when measured and compared the walking group with the Nordic walking group which showed an increase in cadence, stride length and step length, and a decrease in stride time, step time, and vertical ground reaction force [3].

Daisuke Homma has astudy on effects of Nordic walking on pelvis motion and muscle activities around the hip joints of adults with hip osteoarthritis, found results that the pelvic rotation angle was significantly larger in European style Nordic walking than in Japanese style Nordic walking. In the stance phase, hip abductor muscle activity was significantly decreased in Japanese style Nordic walking compared to both ordinary walking and European style Nordic walking. In the swing phase, rectus abdominis muscle activity was significantly increased in both Japanese style Nordic walking and European style Nordic walking compared to ordinary walking and lumbar erector spinae activity was significantly lower in Japanese style Nordic walking than in ordinary walking. Japanese style Nordic walking style may reduce the compensatory pelvic rotation in patients with hip Osteoarthritis. Japanese style Nordic walking might be better for joint protection and prevention of secondary disorders of the hip in Osteoarthritis patients(8). As a result in this study the European style Nordic walking was utilized and it is the type in the walker thrusts each pole in diagonal angle, creating driving force for a more active walking style which helps in increasing the walking velocity, stride length and step length.

There are very few studies that have shown the use of Nordic poles on balance which was effective. Hence, according to the result of the study it would be beneficial to use the Nordic poles for the people with impaired gait parameters or in

diseases like Parkinsonism, stroke, cerebellar disorders, vertigo and the patients with fear of fall.

Conclusion

The study concluded that the effect of Nordic walking on the inclined slope was more effective as compared to Leveled ground as the load on lower extremity is declined on walking on inclined slope.

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