

# Analysis of the influence of core muscle training on the results of selected locomotion tests in patients with relapsing-remitting multiple sclerosis

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## Abstract

**Background:** Multiple sclerosis (MS) is the most common demyelinating disease of the nervous system. The most common symptoms include sensory disturbances, weakened muscle strength, impaired motor coordination, chronic fatigue, speech deficits, and memory impairment.

**Aims:** To evaluate the impact of "core" muscle training on the locomotor function of patients with relapsing-remitting multiple sclerosis (RRMS).

**Material and methods:** The study group consisted of 20 patients with a clinical diagnosis of MS. Inclusion criteria were: the ability to walk 30 meters unassisted and the ability to remain standing for at least one minute. Each patient underwent a gait assessment prior to therapy using the 6MW (six-minute walk test) to determine parameters such as the ability to perform the test, traveled distance, and gait speed. Subsequently, a training program consisting of a series of three, one-hour individual meetings per week over a four-

week period was conducted. Immediately after the completion of the training program, a final assessment was performed using the 6MW test.

**Results:** A statistically significant difference ( $p < 0.05$ ) in traveled distance was observed in the general population ( $N=20$ ) and among women ( $N=13$ ) and men ( $N=7$ ).

**Conclusion:** The effectiveness of guided training in improving gait ability among MS patients was observed based on a statistical analysis of six-minute walk test results.

## Key words

training, core muscles, locomotion, multiple sclerosis, gait

## Introduction

Multiple sclerosis (MS) is an inflammatory demyelinating disease of the central nervous system (CNS) [1]. It is the most common demyelinating disease of the nervous system [2]. MS is an incurable and chronic disease, but it does not directly endanger the patient's life [3]. In the progression of MS disease, multifocal inflammatory lesions spread in space and time, degeneration of axons and oligodendrocytes, demyelination of nerve cells, and proliferation of astrocytes, which leads to atrophy of axons [4,5].

The etiology of MS is not fully known. Genetic conditions are one of the causes of demyelinating changes due to abnormal immune responses [6,7]. Environmental factors (latitude, pollution, diet, sunlight exposure) may also influence the development of the disease [8,9].

Chronicity of the disease process leads to neurological deficits due to CNS atrophy. MS mainly affects young adults between 18 and 40 years [10,11], with women being more frequently affected. MS takes its toll on patients by impairing their motor, social and economic abilities [12]. MS leads, in the first place, to loss of productivity independence in performing daily life activities (moving around, performing hygienic activities, eating, controlling physiological needs), and ultimately results in the patient requiring comprehensive and costly medical care [13]. Common symptoms include sensory disturbances, impaired muscle strength, impaired motor coordination, chronic fatigue, speech deficits, and memory impairment [14].

## Aims

The main objective of this study was to evaluate the effect of individually tailored training of "core" muscles on the results of selected gait assessment tests among patients with relapsing-remitting MS (RRMS).

## Material and methods

The research was conducted at the Department of Rehabilitation of Medical University in Białystok in Poland, after obtaining the consent of the Bioethics Committee (No. R-I-002/392/2019).

The inclusion criteria for participation were: the ability to remain standing for at least one minute and the ability to walk a distance of 30 meters without the assistance of another person. The research sample consisted of 26 patients between 21 and 66 years, with a mean age of 49.9 years. There were 18 women, who accounted for 69% of the group, and eight men, which was 31% of the group. All subjects were diagnosed with RRMS. The effect of therapy was assessed in the whole group and individually for men and women. Data collection took place between 03.03.2019 and 06.03.2020. There were two men and one woman who walked with the help of an orthopedic aid such as a cane or crutch.

The proposed therapy was based on the premise that in the course of MS, patients experience weakening of the muscles that stabilize the trunk, which prevents them from moving effectively. The proposed exercises primarily focus on learning how to consciously stabilize the trunk through the ability to tighten the transverse abdominal muscle and indirectly the multifidus muscle and other paraspinal muscles. The aim was to create automatism in flexing these muscles when performing locomotor activities but also to increase the strength of these muscles. It should be mentioned that the applied exercises were not specific only to the above-mentioned muscles. The situation of having these muscles perform in isolation would contradict with the idea that they are supposed to serve as trunk stabilizers during walking and other daily activities. Subsequently, in accordance with the patient's progress, exercise progression was employed, including greater training volume, increased intensity, and enhanced level of exercise. When increasing the training load, the characteristics of the disease were taken into account, and it was recommended to avoid excessive overheating as it may provoke episodes and progression of the disease. More individualized exercises, consist-

ent with the basic premise, were incorporated over time as the patients progressed. The training sessions were conducted individually or in pairs, which allowed the therapists to observe the individuals very closely while ensuring that they performed the assigned exercises in the most engaging manner possible. Training sessions were held for each patient at a rate of three hours per week for four weeks, with no breaks in-between weeks. Each session lasted one hour, including the time for changing clothes; thus, the effective exercise time was approximately 45-50 minutes. The following are examples of exercises employed in therapy.

The six-minute walk test was conducted over a measured distance of 30 meters. The results were recorded in meters. For safety reasons, the subjects were equipped with a pulse oximeter, and fatigue was measured on the Borg scale before and after the test. Pulse oximeter readings were checked every 2 minutes. Twenty out of 26 subjects were selected to participate in the study. Table 2 and Table 3 present the results among men and women before and after therapy. The percentage change in the performance was also included. Data were analyzed using STATISTICA (Dell Inc., Tulsa, USA). The paired samples Wilcoxon test was used.



**Figure 1.** The "plank" exercise with a progression of lifting one lower limb.

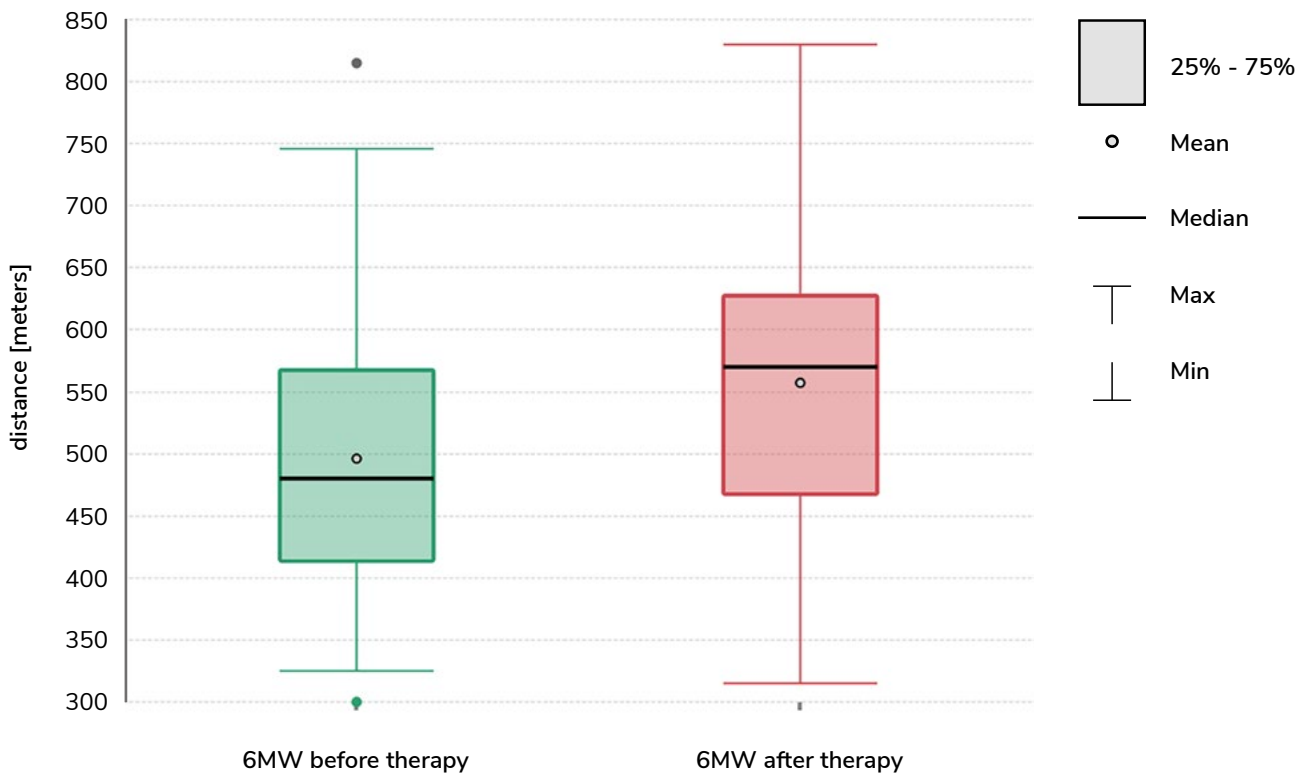


**Figure 2.** Extension of the lower limb in a supported kneeling position with progression in the form of a sensorimotor disc.

## Results

There was a significant change in the distance covered by the subjects regardless of whether we examined the entire group or a specific portion of it. For each group, we obtained a similar average distance improvement (12%, 13%, 12%) and all these differences were statistically significant. The improvement can be explained by the muscle strength enhancement and the overall effectiveness of the adopted training methods in improving speed and gait performance among MS patients.

In the six-minute walk test, an increase in the average distance covered by the entire study group (N=20) was observed from 495.15 meters before therapy to 557.2 meters after therapy representing a 12% improvement. In the paired Wilcoxon test, the difference was found to be statistically significant, with a score of  $p=0.00$  at an assumed significance level of  $p<0.05$ .



**Figure 3.** The differences in distance traveled by MS patients before and after applied therapy in the general population.

In the group of male subjects (N=7), the average distance was 463.14 meters before therapy, while after receiving treatment, it increased to 523.71 meters representing a 13% of improvement. The

paired Wilcoxon test indicated that the difference was statistically significant with a score of  $p=0.05$  at the assumed significance level of  $p<0.05$ .

**Table 1.** The differences in distance covered by MS patients before and after applied therapy in a population of men.

<b>N = 7</b>	<b>6MW before (meters)</b>	<b>6MW after (meters)</b>	<b>% of improvement</b>
Mean	463.14	523.71	+13%
Median	480	570	+19%
Minimum	150	315	+110%
Maximum	746	811	+9%
Significance	0.05*		

\* Statistically significant ( $p < 0.05$ )

In the group of female subjects (N=13), the average distance was 513.92 meters before therapy, while after receiving treatment, it increased to 575.23 meters representing a 12% of improvement.

**Table 2.** The differences in distance covered by MS patients before and after applied therapy in a population of women.

<b>N = 13</b>	<b>6MW before (meters)</b>	<b>6MW after (meters)</b>	<b>% of improvement</b>
Mean	513.92	575.23	+12%
Median	480	570	+19%
Minimum	325	400	+23%
Maximum	815	830	+2%
Significance	0.00*		

\* Statistically significant ( $p < 0.05$ )

In the paired Wilcoxon test, the difference was found to be statistically significant, with a level of  $p = 0.00$  at an assumed significance level of  $p < 0.05$ .

**Table 3.** Wilcoxon test result for 6MW pairs - statistically significant change in gait distance measured in meters before and after therapy.

<b>N = 20</b>	<b>Before vs. After</b>
Significance	0.00*
<b>Men N = 7</b>	<b>Before vs. After</b>
Significance	0.05*
<b>Women N=13</b>	<b>Before vs. After</b>
Significance	0.00*

\* Statistically significant ( $p < 0.05$ )

## Discussion

Research conducted by Goldman et al. [15] showed excellent reproducibility of the 6MW test between trials and between different researchers. The test in our study was performed by 20 out of 26 patients, and failure to undertake the test was caused by contraindications such as high heart rate, low blood oxygen saturation, malaise, or fatigue on the Borg scale  $>5$ .

However, Kopciuch [16] suggests a choice between the six-minute walk test and an alternative version conducted within two minutes. A factor that should be considered when selecting a test is the patient's degree of disability and the severity of the disease progression. There is a significant change in the distance traveled by the subjects regardless of whether we study the entire group or a specific portion of it. For each group, we get a similar average distance improvement (12%, 13%, 12%), and in each group, the difference is statistically significant.

A meta-analysis of 22 articles ( $n=600$ ) conducted by Snook on the effect of exercise on gait among MS patients showed an association of exercise with a slight improvement in gait mobility [17], which agrees with the results derived from the

6MW test. Pearson et al. [18], in their 2015 meta-analysis, showed an effect of exercise on improving the mean score in the 6MW by 36.46 m compared to the improvement of the mean score in the 6MW test in our studies by 61.05m. The six-minute walk test appears to be a valid choice when working with such a selected group of MS patients. It is commonly used in research investigating patients with moderate locomotor impairment due to MS.

### Study limitations

Although the study achieved its goal, it had its limitations due to the long duration of treatment for each patient. The study was limited by the small study group and brief observation of treatment effects. It is recommended that future studies include a control group and a longer follow-up period.

### Conclusions

The effectiveness of the "core" muscle training in improving gait performance was established among MS patients based on a statistical analysis of six-minute walk test results.

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