RESEARCH ARTICLE

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Received / *Geliş tarihi* : September 12, 2024
Accepted / *Kabul Tarihi* : January 08, 2025

Cite this article as
Bu makalede yapılacak atıf
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Akd Med J 2025;11(2): 290-297

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The Relationship Between Hip Muscle Strength and Core Muscle Endurance with Walking Capacity In Patients with Multiple Sclerosis

Multipl Skleroz Hastalarında Kalça Kas Kuvveti ve Kor Kas Dayanıklılığı ile Yürüme Kapasitesi Arasındaki İlişki

ABSTRACT

Objective

The aim of the study was to determine the relationship between hip muscle strength and core muscle endurance with walking capacity in patients with multiple sclerosis.

Material and Methods

Fifty multiple sclerosis patients (15 female, 35 male) with a mean age of 40.34 ± 9.51 years were included in this study. Hip muscle strength was measured by hand-held dynamometer. Trunk flexion endurance test, sorenson test and lateral bridge test were performed to assess core muscle endurance. Walking capacity was assessed by Timed 25-Foot Walk, Timed-Up-and-Go, and 2-Minute-Walk tests. Regression and correlation analysis were used to determine factors affecting gait.

Results

Participants with high hip muscle strength and core muscle endurance had significantly better walking capacity test results ($p< 0.05$). Only, trunk flexion endurance test did not show any significant correlation with any walking test ($p>0.05$). Regression analysis revealed that hip extension force, sorenson test and right lateral bridge test accounted for 53% variability in Timed 25-Foot Walk test and 62% variability in Timed-Up-and-Go test, and right lateral bridge and hip abduction force explained 60% variability in 2-Minute-Walk test.

Conclusion

Core muscle endurance affects walking capacity of multiple sclerosis patients. Inclusion of exercises that will increase hip muscle strength and core muscle endurance in rehabilitation program is important.

Key Words

Multiple sclerosis, Hip muscle strength, Core muscle endurance, Walking capacity

DOI: 10.53394/akd.1536222

ÖZ

Amaç

Çalışmanın amacı, multipl skleroz hastalarında kalça kas kuvveti ve kor kas dayanıklılığı ile yürüme kapasitesi arasındaki ilişkiyi belirlemektir.

Gereç ve Yöntemler

Ortalama yaşları 40,34 ± 9,51 yıl olan 50 multipl skleroz hastası (15 kadın, 35 erkek) çalışmaya dahil edildi. Kalça kas kuvveti el dinamometresi ile ölçüldü. Çekirdek kas dayanıklılığı değerlendirilirken gövde fleksiyon dayanıklılık testi, sorenson testi ve lateral köprü testi uygulandı. Yürüme kapasitesi, Zamanlı 25 Metrelik Yürüyüş, Zamanlı Kalk-Yürü ve 2 Dakikalık Yürüme testi ile değerlendirildi. Yürüyüşü etkileyen faktörleri belirlemek için regresyon ve korelasyon analizi kullanıldı.

Bulgular

Kalça kas kuvveti ve kor kas dayanıklılığı yüksek olan katılımcıların yürüme kapasitesi testi sonuçları anlamlı derecede daha iyi oldu ($p< 0.05$). Sadece gövde fleksiyon dayanıklılık testi herhangi bir yürüme testiyle anlamlı korelasyon göstermedi ($p>0,05$). Regresyon analizi, kalça ekstansiyon kuvveti, sorenson testi ve sağ yan köprü testinin, Zamanlı 25 Ayak Yürüme testinde %53, Zamanlı Kalk ve Yürü testinde ve sağ yan köprü testinde %62 değişkenliği açıkladığını gösterdi ve kalça abdüksiyon kuvveti 2 Dakikalık Yürüyüş testinde %60 değişkenliği açıkladı.

Sonuç

Kor kas dayanıklılığı multipl skleroz hastalarının yürüme kapasitesini etkilemektedir. Kalça kas kuvveti ve kor kas dayanıklılığını artıracak egzersizlerin rehabilitasyon programına dahil edilmesi önemlidir.

Anahtar Kelimeler

Multipl skleroz, Kalça kas kuvveti, Kor kas dayanıklılığı, Yürüme kapasitesi

INTRODUCTION

Multiple Sclerosis (MS) is an autoimmune, demyelinating central nervous system disease with inflammatory attacks associated with inflammation and neurodegeneration (1). Axonal damage resulting from central nervous system demyelination causes progressive disability and disease (2, 3-5). Although symptoms of the disease are highly variable, in general, it includes sensory, cognitive and motor disorders (6, 7). Corticospinal tract demyelination and loss of axons typically cause muscle weakness, lower extremity spasticity, coordination problems and commonly fatigue (1, 6, 8-10). Decreased lower extremity function and inability to walk create a major limitation which affects quality of life negatively (11).

Muscle weakness leads to a decrease in the function of the upper extremity as well as mobility and causes postural changes (8). This leads to abnormal stress on various structures during ambulation and therefore patients develop compensatory techniques to continue walking (8). Very high percentage of people with MS report that their main complaints are walking problems, 76% of them need a walking aid and 52% need a bilateral walking aid in the 45-year period after the diagnosis of MS (3, 8, 12). While many patients report impaired walking capacity, walking speed progressively decreases as the disease progresses (3, 4, 7-9, 11-13).

Gait is defined as a complicated event requiring the coordination of many systems in the body (7). Therefore, walking problems seen in MS are seen as a complex and difficult to explain problem caused by a combination of factors (3). In the literature, studies mostly focus on muscle weakness and gait, distal part of lower extremity such as upper leg and ankle, but limited studies have been conducted on hip muscles, a proximal muscle group that creates stability for walking (6, 9, 14).

Today, postural stability of the trunk is called ‘core stability’ (5, 15-17). Core muscles that provide core stability provide stabilization of the spine, pelvis and kinetic ring during functional movements (15, 16). Core muscles show various levels of activation during walking (13). Increased activations of abdominal muscles were determined in phases such as middle posture or heel stroke according to electromyography results during gait in individuals without disability (18). In a study, where individuals with MS were compared with healthy individuals, MS patients demonstrated decreased muscle strength and endurance (5). Limited studies in the literature investigated core muscle strength and endurance and their relationship with walking capacity. In this study, we aimed to determine the relationship between hip muscle strength and core muscle endurance with walking capacity in patients with MS. We hypothesized that patients with better hip muscle strength and core muscle endurance have better walking capacity.

MATERIAL and METHODS

This cross-sectional study took place at Nicosia State Hospital Neurology Unit between January 2018 and May 2018. A total of 69 ambulatory MS patients who were followed by this unit during 2017-2018 were reached and a total of 62 cases accepted to participate and 50 cases were included in the study according to inclusion/exclusion criteria. Inclusion criteria were; diagnosis of MS according to McDonald's criteria, being at age 18 or more, having no MS attack or any surgical operation in the last one month, and level of disability according to Expanded Disability Status Scale (EDSS) to be between 0-6.0. Exclusion criteria were; the presence of any perception problems that may affect the results of the research, presence of orthopedic problems in the hip, knee and ankle joints that may affect walking, presence of a spasticity score of 2 or higher in the muscles around the hip according to the Modified Ashworth Scale, having botulinum toxin injection in the last 6 months and pregnancy. All participants were required to sign an informed consent form which was approved by the Ethics Committee of the European University of Lefke in accordance with the Helsinki Declaration before being included in the study. (Ethics Committee Approval Number: ÜEK/03/02/04/1617/06) This study was prepared based on the master's thesis titled “The Relationship Between Hip Muscle Strength and Core Muscle Endurance with Walking Capacity and Falls In Patients with Multiple Sclerosis” which was done under the consultancy of B. B. K., PT, PhD, Assoc Prof. and presented and completed on August 8, 2017.

Hip Muscle Strength

The maximum isometric contraction force of both hips was measured with a Hand-held dynamometer (Lafeyette Hand-held Dynamometer, New York, USA) (19). To ensure that the patient performed the test position correctly, a trial measurement was performed with submaximal power before the main test. Then 5 sec. isometric, maximum voluntary contraction performed. The measurement was repeated twice and averaged. Ninety seconds rest intervals were allowed between the maximum contractions.

Core Muscle Endurance

Static endurance of the core muscles was measured using the Mc Gill Protocol, which was proven to be valid and reliable; Trunk Flexor Endurance, Sorenson test and Left/Right Lateral Bridge Tests were performed (5, 18, 20, 21). During the measurements, the patient's performance was recorded in seconds using a stopwatch.

Walking Capacity

Three tests were used to assess walking capacity. During walking tests, subjects were allowed to use a walking aid if they needed.

Timed 25-Foot Walk Test (T25FW)

The Timed 25-Foot Walk Test basically evaluates walking performance and speed. A distance of 25 steps was clearly marked and the patient was asked to complete this distance as soon as possible and safely. The same task was repeated immediately and the patient returned to the same distance. The results obtained were averaged. The time taken to walk was measured with a stopwatch and recorded in seconds (6, 9, 11, 22).

Time Up-and-Go (TUG)

The Time Up-and-Go (TUG) is a validated and reliable test that evaluates gait performance (25). The patient was asked to stand up from his chair, walk for three meters, then turn back, walk back to chair and sit again. The time spent was measured in stopwatch and recorded in seconds (6, 22, 23).

2-Minute Walk Test

The 2-Minute Walk Test is a valid and reliable test (27, 28). The distance was marked at 30 meters and the distance the patient walks within 2 minutes is measured with a tape measure in cm. Time tracking was performed with a stopwatch. The patient was informed that if he/she got tired during walking, he/she could rest and continue walking, and the time was not stopped during rest (6, 11, 24, 25).

Statistical Analysis

Statistical analyses were performed by Statistical Package for the Social Sciences (Version 21). Demographic and clinical characteristics were determined by descriptive statistics. The relationships between continuous variables were investigated by Pearson Correlation analysis. In the regression analysis, the variables to be entered into the model were determined by backward selection. G*Power software 3.1.9.2 was used to set the sample size. Previous study done by Broekmans T. et al. (2013) guided us to decide the effect size and for a 0.5 effect size with 0.95 power, a total of 50 participants needed (6). The significance value was determined as $p < 0.05$.

RESULTS

Of the 50 participants in the study, the mean age was 40.34 ± 9.51 years, mean height was 166.32 ± 9.61 cm, mean body weight was 69.52 ± 15.34 kg and mean score of Expanded Disability Status Scale was 2.018. The median disease duration was 96 months. 70% of the participants were female (35 persons) and 30% (15 persons) were male. In terms of working status, it was found that 68% (34 people) were working, 22% (11 people) were not working, and 10% (5 people) were retired. Fifty-two percent (26 people) of the subjects in the study stated that the left side was affected by the disease and 48% (24 people) stated that the right side was affected. Ninety percent (45 people) of the subjects in the study do not need any walking aids, and 10% use single walking aids. While 82% (41 people) of MS patients do not receive physical therapy and rehabilitation programs, 18% (9 people) do home exercise programs. It was seen that 32% (16 people) of the patients had a history of falling in the last month. However, 68% (34 people) of participants did not have a history of falling in the last month. Demographics and clinical characteristics of participants are given in Table I.

Table I. Demographic and Clinical Characteristics of Participants (n = 50)

Variables	Number (n)	Percentage (%)
Gender		
Female	15	15,00
Male	35	70,00
Working Status		
Working	34	68,00
Not working	11	22,00
Retired	5	10,00
Affected Lower Limb		
Right	24	48,00
Left	26	52,00
Walking Aid		
Not user	45	90,00
User (single walking aid)	5	10,00
Rehabilitation Attendance		
Not attending	41	82,00
Supervised Home Programme	9	18,00
History of Falling (last month)		
Yes	11	22,00
No	39	78,00

Results of the Relationship Between Hip Muscle Strength and Walking Capacity

A significant, weak, and inverse relationship was found between T25FW and hip flexion, extension, adduction, abduction, external rotation, and internal rotation strength (p <0.05). As the average muscle strength of the hips increases, the time required to complete the 25-foot walk decreases (Table II). Similarly, a significant, weak correlation was found between hip flexion, extension, adduction, abduction, external rotation and internal rotation forces with TUG (p <0.05). As the average muscle strength of the hips increases, the TUG score decreases (Table II).

Table II. Relationship Between Average Hip Muscle Strength and Walking Capacity

Variables		T25FW	TUG	2-Minute Walk
Flexion Strength	r	**-0,38**	**-0,36**	**0,68**
	p	0,007*	0,01*	0,0001*
Extension Strength	r	**-0,45**	**-0,44**	**0,66**
	p	0,001*	0,01*	0,0001*
Abduction Strength	r	**-0,51**	**-0,49**	**0,75**
	p	0,0001*	0,0001*	0,0001*
Adduction Strength	r	**-0,43**	**-0,41**	**0,64**
	p	0,002*	0,003*	0,0001*
Int. Rot. Strength	r	**-0,45**	**-0,42**	**0,64**
	p	0,001*	0,001*	0,0001*
Ext. Rot. Strength	r	**-0,38**	**-0,30**	**0,64**
	p	0,006*	0,01*	0,0001*

***p<0,05** **Int. Rot.** Internal Rotation, **Ext. Rot.** External Rotation

2-Minute Walk test showed a significant and moderate relationship between hip flexion, extension, adduction, abduction, external, rotation and internal rotation strength (p <0.05). As the mean muscle strength of the hip increases, the distance covered by the 2-Minute Walk increases (Table II).

Results of Relationship Between Core Muscle Endurance and Walking Capacity

There was an inverse, significant and weak correlation between the T25FW and sorenson, lateral bridge test results-left and right (p <0.05). There was no significant relationship between T25FW and trunk flexion endurance test (p> 0.05) (Table III).

Table III. Relationship Between Core Muscle Endurance and Walking Capacity

Tests		T25FW	TUG	2-Min Walk Test
Sorenson	r	**-0,31**	**-0,29**	**0,50**
	p	0,03*	0,04*	0,0001*
Trunk Flexion	r	-0,23	-0,20	0,38
	p	0,10	0,15	0,07
Right Lateral Bridge	r	**-0,32**	**-0,32**	**0,58**
	p	0,02*	0,02*	0,0001*
Left Lateral Bridge	r	**-0,32**	**-0,31**	**0,60**
	p	0,02*	0,03*	0,0001*

***p<0,05**

There was an inverse, significant and weak correlation between TUG and sorenson, right and left lateral bridge test results (p <0.05). There was no significant relationship between TUG and trunk flexion endurance test (p> 0.05) (Table III).

There was a similar, significant and weak correlation between the 2-Minute Walk test and sorenson results (p <0.05). There was a significant, strong and significant relationship between the 2-Minute Walk test and lateral bridge right and left tests (p <0.05). No significant relationship was detected between the 2-Minute Walk test and trunk flexion endurance test (p> 0.05) (Table III).

Factors Determining Walking Capacity

The results of the multiple regression analysis to determine the factors affecting walking capacity were determined by backward selection. Accordingly, the model established for all 3 walking capacity tests were significant. The model can explain 53% of the total variance in T25FW. Extension muscle strength, lateral bridge right and sorenson static endurance were found to be inversely correlated with walking capacity measured by T25FW (p <0.05). The model can explain 62% of the total variance in TUG. Hip extension muscle strength, lateral right bridge and sorenson core endurance test showed an inverse and significant relationship with walking capacity measured by TUG (p <0.05). The model can also explain 60% of the total variance in the 2-Minute Walk Test. Hip abduction force and right lateral bridge static endurance test showed a significant relationship with walking capacity measured by 2-Minute Walk test (p <0.05) (Table IV).

Table IV. Timed 25-Foot Walk, Time Up-and-Go and 2-Minute Walk Test Regression Equation

Timed 25-Foot Walk	**Constant**	**Extension**	**Sorenson**	**Right Lateral Bridge**
Std. Coefficients	2,37	-0,38	-0,31	-0,25
t	19,55	-3,43	-2,44	-2,08
p	**0,0001***	**0,001***	**0,02***	**0,04***
F= 19,55 (p= 0,0001)		**R^2=0,53**		
Timed-Up-and-Go	**Constant**	**Extention**	**Sorenson**	**Right Lateral Bridge**
Std. Coefficients	2,82	-0,44	-0,25	-0,33
t	23,69	-4,39	-2,16	-3,01
p	**0,0001***	**0,0001***	**0,04***	**0,004***
F= 27,90 (p= 0,0001)		**R^2=0,62**		
2-Min -Walk Test	**Constant**	**Abduction**	**Right Lateral Bridge**	
Std. Coefficients	3,96	0,61	0,27	
t	18,79	5,79	2,52	
p	**0,0001***	**0,0001***	**0,02***	
F= 37,50 (p= 0,0001)		**R^2=0,60**		

***p<0,05**

DISCUSSION

'Walking' is a complex event that requires coordination of many systems in the body and walking problems in MS patients are seen as complex and difficult to explain due to the combination of a number of factors. Muscle strength losses are among the leading factors that cause walking problems in this population. As muscle weakness causes decreased walking capacity, it is important to determine how much different muscle groups affect this function. Our study population included 50 ambulatory MS patients and the relationship between hip muscle strength and core muscle endurance with walking capacity was demonstrated.

Muscle strength measurements taken from the right and left hips were classified as weak and strong muscles and their relationship with walking was demonstrated. The findings of the study done by Broekmans et al. (2013), are similar in nature with our study, and we can conclude that the weak hip muscle and the strong hip muscle affect walking at the same rate (6). For this reason, weak and strong muscle strength averages were taken and the analysis was continued.

The relationship between mean hip muscle strength of all MS patients and walking tests was demonstrated. According to the obtained results, it can be stated that as walking is an activity that requires postural control, as the muscle strength of the hip increases proximal stabilization, fatigue during walking decreases and endurance increases. Previous studies have demonstrated the importance of hip muscle strength in postural control (26, 27).

Zackowski et al. (2014) evaluated the amount of time-dependent change in motor and sensory measurements in individuals with MS and its relationship with walking speed and found that weak hip flexion was most affected by walking speed (28). In a study done by Fritz et al. the relationship between posturography and gait measurements in individuals with MS, bilateral flexion and extension forces of the hip was measured and confirmed the previous study, yielding results showing poor hip flexion with low walking speed (12). Fritz et al. reveals the effect of hip extension force on walking speed (14). In both studies, the abduction, adduction and rotation forces of the hip were not examined. In our study, as in the previous studies, hip flexion, extension, as well as hip abduction, adduction, internal and external rotation muscle strength, which have not been evaluated before, have been found to be significantly related to walking capacity. Hip abduction strength, which has not been evaluated before, is significantly related to the 2-Minute Walk test, which assesses walking capacity and requires physical endurance. Kim et al. (2016) evaluated the role of gluteus medius on pelvic and knee stabilization in one-foot posture phase and mentioned the importance of gluteus medius muscle in pelvic stability by preventing pelvic fall (26). The results obtained in our study suggest that pelvic oscillations during walking may increase if abduction strength decreases and this may cause muscular fatigue.

In the literature, although the relationship between muscle strength and gait has been frequently examined with various muscle parameters, limited studies evaluated the relationship between walking and core muscle endurance, which is the basis for trunk stabilization. Postural control and spinal stabilization against gravity, which are among the core functions of the core muscles, is provided by coactivation of the axial flexor and extensor muscles (29). Yoosefinejad et al. (2015), measured core muscle strength and endurance, static endurance tests, trunk flexion endurance, sorenson test and lateral bridge endurance tests, body muscle strength by handheld dynamometer, and all these parameters have shown that the results are weaker in patients with MS than healthy individuals (5). The core muscles are individually activated and work in synergy rather than creating a force to form a complex control and movement pattern (27). This study aimed to determine the relationship between walking and endurance, and not to measure strength. A recent study by Ozkul et al revealed that decreases in both lower extremity strength and core muscle endurance are associated with lower functional performance in patients with MS, however, they only assessed lower extremity with sit to stand test which is a general strength test for lower extremities (30).

The relationship between core muscle static endurance tests - sorenson, right and left lateral bridge tests and walking capacity tests were also demonstrated. Ketelhut et al. (2015) evaluated core muscle activity during walking in individuals with MS and it was shown that the trunk lateral flexor group muscle activity on the strong side was higher (13). In this study, it was emphasized that individuals with MS exhibited compensatory mechanisms to maintain their balance and postures and that these strategies could lead to increased muscle energy requirement and muscular fatigue (13). Findings obtained from our study are consistent with the findings of Ketelhut et al. (2015) that decreased endurance in the lateral trunk muscles and the trunk extensor muscles against gravity may cause muscular fatigue and affect walking speed and endurance (13).

In the determination of the factors determining the walking speed, it was seen that the changes in T25FW and TUG test results could be explained by hip extension strength, sorenson and lateral right bridge values at the rate of 53% and 62%, respectively. Fritz et al. (2015) in the study of the effects of dynamic balance on walking performance in individuals with MS, it was found that 70% of the walking speed was determined by hip extension force, eyes open, feet closed balance and anteroposterior direction oscillation (14). In our study, hip extension strength was determined as a factor affecting the walking speed in support of the above-mentioned study. However, in the literature, sorenson and lateral right bridge test, which evaluated the extension endurance of the trunk, have not been previously examined in relation to gait in individuals with MS. The results suggest that muscular fatigue may occur prematurely and decrease walking speed in patients with MS in case of weakening of hip extensor strength and back extensor muscle endurance, which are antigravity muscles. However, as previously mentioned, the increase in activity of the lateral core muscles during walking, especially on the strong side, was also found to be effective in walking speed.

Also, in our study, it was observed that the change in the 2-Minute Walk test was explained by 60% of the lateral right bridge and hip abduction force. The findings show the effect of hip abduction force on gait endurance and the relationship of the lateral right bridge with both gait velocity and endurance. Ketelhut et al. (2015) found that the effectiveness of trunk lateral muscles during walking was high in individuals with MS, and Kim et al. (2016) demonstrated the importance of gluteus medius in pelvic stabilization (13, 26). Our study has some limitations.
Our study has some limitations. We could look at the relationship between parameters but we could not prove that increased strength would increase walking capacity. So we suggest prospective studies for patients with MS where the effect of structured strengthening exercise program for hip and core muscles on walking performance can be shown.

CONCLUSION

It is a known fact that decreased walking capacity is a major limitation and decrease quality of life in individuals with MS. As a result of the findings obtained in this study, it is concluded that hip muscle strength and core muscle endurance affect walking capacity. During physiotherapy and rehabilitation of patients with MS, inclusion of exercises to improve hip muscle strength and core muscle endurance in the early stages of the disease would enhance walking capacity of patients. Keeping walking capacity strong, especially in progressive type MS patients, will reduce or prevent future walking problems. In this context, the most powerful aspect of our study is that our results emphasize the importance of studying hip and core muscle strength in the MS patient group. It will be a strong support for the quality of life of MS patients if physiotherapy and rehabilitation professionals working in this field include these results in their clinical work environments.

Ethics Committee Approval

This research complies with all the relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration, and has been approved by the Ethics Committee of the European University of Lefke (approval number: ÜEK/03/02/04/1617/06).

Informed Consent

All the participants' rights were protected and written informed consents were obtained before the procedures according to the Helsinki Declaration.

Author Contributions

Concept – N.G.K., B.B.K.; Design - N.G.K., B.B.K.; Supervision - N.G.K., B.B.K.; Resources - N.G.K.; Materials - N.G.K., B.B.K; Data Collection and/or Processing - N.G.K. .; Analysis and/ or Interpretation - N.G.K., B.B.K.; Literature Search - N.G.K., B.B.K.; Writing Manuscript - N.G.K., B.B.K.; Critical Review - B.B.K.

Conflict of Interest

The authors have no conflict of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

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