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Original Article

Effects of the bilateral isokinetic strengthening training on functional parameters, gait, and the quality of life in patients with stroke

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Abstract: Objective: To evaluate the effects of the bilateral isokinetic strengthening training applied to knee and ankle muscles on balance, functional parameters, gait, and the quality of in stroke patients. Methods: Fifty patients (33 M, 17 F) with subacute-chronic stroke and 30 healthy subjects were included. Stroke patients were allocated into isokinetic and control groups. Conventional rehabilitation program was applied to all cases; additionally maximal concentric isokinetic strengthening training was applied to the knee-ankle muscles bilaterally to the isokinetic group 5 days a week for 3 weeks. Biodex System 3 Pro Multijoint System isokinetic dynamometer was used for isokinetic evaluation. The groups were assessed by Functional Independence Measure, Stroke Specific Quality of Life Scale, Timed 10-Meter Walk Test, Six-Minute Walk Test, Stair-Climbing Test, Timed up&go Test, Berg Balance Scale, and Rivermead Mobility Index. Results: Compared with baseline, the isokinetic PT values of the knee and ankle on both sides significantly increased in all cases. PT change values were significantly higher in the isokinetic group than the control group ($P<0.025$). Furthermore, the quality of life, gait, balance and mobility index values improved significantly in both groups, besides the increase levels were found significantly higher in the isokinetic group ($P<0.025$, $P<0.05$). Conclusion: Bilateral isokinetic strengthening training in addition to conventional rehabilitation program after stroke seems to be effective on strengthening muscles on both sides, improving functional parameters, gait, balance and life quality.

Keywords: Hemiplegia, isokinetic exercise, quality of life, rehabilitation, stroke

Introduction

Stroke is a common cause of weakness, gait disorder, and disability. It has been shown that muscle strength has been in association with gait performance [1]. On the other hand, isokinetic system is a convenient application used for testing and improving the loss of kinetic chain causing functional loss, mobility, and eventually the quality of life in individuals with stroke [2, 3].

Concerning the effects of isokinetic program after stroke in the previous literature; whether or not the isokinetic exercise program applied to lower extremities are combined with other strengthening and conventional rehabilitation methods, it has useful effects on gait and functional parameters [4-9]. In addition, following a short time of stroke, even one week, motor muscle strength in non-paretic lower limb extremities found to be lower than the age/sex-matched control groups. Moreover, non-paretic lower limb strength has been found to be associated with the functional performance [4-7, 9]. From this point of view, strengthening the non-paretic side in patients with stroke is getting more noteworthy for improving gait and functional parameters. However, to our best knowledge, bilateral isokinetic strengthening (applied to both paretic and non-paretic sides) application has not been studied in stroke patients before. Therefore, the objective of our study was to evaluate the effects of the isokinetic strengthening training applied to bilateral knee and ankle muscles on balance, functional parameters, gait and the quality of life in stroke patients.

Materials-methods

Study design

This study was carried out prospectively. Stroke patients were randomized into the isokinetic and control groups. Conventional rehabilitation program was applied to all cases; further maximal concentric isokinetic strengthening training was applied to the knee and ankle muscles bilaterally to the isokinetic group 5 days a week for 3 weeks. Ethical approval was obtained from the hospital Local Ethics Committee. Informed consent was obtained from the patients.

Participants

A total of 50 cases (33 M, 17 F) with subacute-chronic stroke who were applied to an inpatient rehabilitation program, and 30 healthy subjects were included. Subjects who met any of the following criteria were excluded; not cooperative, with a previous history of stroke, concomitant disorders preventing rehabilitation program such as severe cardiovascular and pulmonary diseases, uncontrolled hypertension, stroke due to tumor or trauma, major sensorimotor aphasia, orthopedic disorders can affect isokinetic assessments, musculoskeletal pain of lower limbs, and vestibular disorders.

Data collection

Demographic and clinical features of the patients (age, gender, body mass index, stroke etiology, stroke duration, paretic and dominant sides of the subjects) were enrolled.

Assessment tests (baseline and post-intervention)

All subjects were assessed by Functional Independence Measure (FIM) [10], Stroke Specific Quality of Life Scale (SS-QOL) [11], Timed 10-Meter Walk Test [12], Six-Minute Walk Test (6MWT) [12], Stair-Climbing Test (SCT) [13], Timed up&go (TUG) Test [14], Berg Balance Scale (BBS) [15], Rivermead Mobility Index (RMI) [16] prior to the treatment and post-intervention by the same clinician. Brunnstrom's stages were used to assess the motor recovery [17]. Modified Ashworth Scale (MAS) was used to measure muscle tonus. Mental status was evaluated using Mini Mental Test (MMT). Besides, all patients' knee flexion-extension and ankle plantar flexion and dorsiflexion muscle performances were evaluated before the treatment and after the treatment. The healthy subjects were applied to only isokinetic test protocol to compare with the non-paretic side of the stroke patients.

Isokinetic training and assessments

Biodex System 3 Pro Multijoint System isokinetic dynamometer (Biodex Medical Imc, Shirley/NY, USA) was used for isokinetic strengthening and assessments. Isokinetic system comprised mainly two parts as the computer system collecting and storing data, controlling movement and as the dynamometer with its apparatus. All steps of the isokinetic testing were explained to the participants to achieve maximum orientation.

As for the knee evaluation; the patients were seated back and the seat back was set to 85 degrees from the horizontal plane. Hip-waist belt and crossing-trunk belts were used to provide trunk stabilization. Thigh was also fixed by a velcro crossing from its proximal part. Transverse line passing through the femoral condyles was accepted as the axis for the knee joint. The dynamometer was adjusted according to this axis. Dynamometer effort arm was determined according to the length of the leg. The pad surrounding the leg was fixed to the leg as its distal part was just above the lateral malleolus.

With respect to the ankle evaluation; patients were seated and seat back was set as the knee evaluation. Afterwards the trunk stabilization, knee was fixed in 20-30 degrees flexion on to the leg ramp (with its T-bar) from its distal part. Dynamometer orientation was fixed at 90° and tilted at 0°. Tilt of the foot platform was set to 0° as well. Dynamometer angle was set when the foot was in neutral position and ankle angle was in alignment with lateral malleolus or just above it.

Prior to the tests, active range of motion was evaluated and isokinetic tests were performed in these ranges for both knee and ankle assessments. Apparatus were also adjusted for all subjects individually. 3 submaximal trial repetitions were performed at both angular velocities for warm exercise. Subjects were stated to

Table 1. Clinical and demographic features of the patients. n, (%)

Variables	Isokinetic Group (n=25)	Control Group (n=25)	*p*-value
Age (years)	51.3±12.0	55.4±10.5	0.210
Gender			
Male	17	16	0.765
Female	8	9	
BMI (kg/m^2)	26.6±3.1	26.9±2.6	0.668
Time After Stroke (months)	3 (2-8)	3 (2-9)	0.888
Stroke Type			
Ischemic	21 (84)	23 (92)	0,667
Hemorrhagic	4 (16)	2 (8)	
Paretic Side			
Right	17 (68)	15 (60)	0.556
Left	8 (32)	10 (40)	
Dominant Side			
Right	23 (92)	24 (96)	1.000
Left	2 (8)	1 (4)	
Brunnstrom Stages of LL			
Grade 4	7 (28)	9 (36)	0.745
Grade 5	13 (52)	11 (11)	
Grade 6	5 (20)	5 (20)	
MMT	27 (24-30)	26 (24-29)	0.058

BMI: Body mass index, LL: Lower limb; MMT: Mini mental test.

move their legs and ankles against the resistance as much as they could do to achieve maximal contractions. In addition, power graphics were shown on the monitor to the patients in order to standardize the visual feedback effects. The isokinetic protocols were set as the following:

Knee test protocol: 5 maximal reciprocal contractions at 60°/sec angular velocity; 15 seconds rest period; 10 maximal reciprocal contractions at 180°/sec angular velocity.

Ankle test protocol: 5 maximal reciprocal contractions at 60°/sec angular velocity; 15 seconds rest period; 10 repetitions at 120°/sec angular velocity; Maximal concentric isokinetic strengthening training was applied to the bilateral knee-ankle muscles to the isokinetic group five days a week for three weeks as for the following protocols.

Knee exercise protocol: 5 repetitions at 60°/sec, 90°/sec, 120°/sec, 150°/sec angular velocities; 10 seconds rest period; 10 repetitions at 180°/sec.

Ankle exercise protocol: 5 repetitions at 60°/sec, 90°/sec, 120°/sec angular velocities; 10 seconds rest period; 10 repetitions at 150°/sec angular velocity.

Statistical analysis

SPSS 16.00 (SPSS Inc., Chicago, IL, USA) program for Windows was used for statistical analysis in this study. Shapiro-Wilk test was used for determining whether the continuous variables were normally distributed. Descriptive statistics are shown as mean ± standard deviation or median (min, max). The comparison of the means and medians of the groups were determined by using Student's t test and Mann Whitney U test (for continuous variables). Pearson chi-square or Fisher's exact tests were used for categorical variables. Wilcoxon Signed Rank test was used whether there was a significant difference before and after the treatment in the groups. Spearmen's correlation test was used whether there was a significant difference between the continuous variables. A *p*-value of <0.05 was considered as statistically significant. However, Type I error was controlled by Bonferroni Correction for the possible multiple comparisons.

Results

There were 25 patients (8 F, 17 M) with a mean age of 51.3±12.0 years in the isokinetic group and 25 patients (9 F, 16 M) with a mean age of 55.4±10.5 years in the control group. Moreover, there were 30 healthy subjects (age, gender, BMI were similar) with a mean age of 49.9±8.8 years. Demographic and clinical features of the patients are given in **Table 1**. The groups were similar with respect to the Brunnstrom stages of upper/lower extremities and hand, functional status, quality of life, balance, mobility, and gait tests (all P>0.05).

Comparison of the peak torque (PT) values of the healthy subjects and non-paretic side of the hemiplegic subjects before the treatment are given in **Table 2**.

Table 2. Comparison of the peak torque measurements of the healthy subjects and non-paretic side of the hemiplegic subjects before the treatment Mean, (Min-Max)

Isokinetic Parameter	Healthy Group	Right Hemiplegia	Left Hemiplegia	*p*-value
Knee 60°/sec AV				
Flexion	50.2 (24.6-79)	22.7 (5.4-54)	24.7 (6.9-53)	**<0.001**
Extension	110.4 (53-174)	58.2 (20-102)	64.4 (18.4-109)	**<0.001**
Knee 180°/sec AV				
Flexion	31.1 (12,4-61,8)	14.9 (8.3-26.3)	14.7 (8.4-27.8)	**<0.001**
Extension	68.1 (38-115)	34.1 (19.8-65)	30.5 (19.2-52)	**<0.001**
Ankle 60°/sec AV				
Flexion	41.3 (17.8-96.5)	18.8 (2.3-77.9)	16.6 (3.1-44)	**<0.001**
Extension	34.7 (21.6-53.4)	15.7 (5.2-25)	16.2 (8.3-27)	**<0.001**
Ankle 120°/sec AV				
Flexion	29.3 (9.8-72.9)	11.4 (2.4-44)	10.9 (3.6-29.5)	**<0.001**
Extension	26.8 (17.9-41)	11.9 (6.1-19.1)	11.6 (5-17.2)	**<0.001**

*Bold *p* values indicate statistically significance. AV: Angular velocity.

Table 3. Paretic Side Knee and Ankle Peak Torque Values Before and After the Treatment and Progression Levels. Mean, (Min-Max)

Isokinetic Parameter	Peak Torque Before Treatment	Peak Torque After Treatment	*p*-value[a]	Change Level	*p*-value[b]
Knee Flexion 60°/sec AV					
Isokinetic Group	10 (4.4-41)	28.9 (7.1-49.2)	**<0.001**	74 (8.9-407.4)	**<0.001**
Control Group	9.7 (5.8-34.7)	12 (6.3-42.7)	**<0.001**	20 (0.4-153)	
Knee Extension 60°/sec AV					
Isokinetic Group	38.7 (14.2-104)	57.4 (17.2-105)	**<0.001**	50 (0.5-284.9)	**<0.001**
Control Group	33.3 (16.7-109)	44 (20-120.6)	**<0.001**	23 (0-115)	
Knee Flexion 180°/sec AV					
Isokinetic Group	11.3 (5.6-25)	16.3 (7.4-40)	**<0.001**	43.5 (0.5-200)	**0.018**
Control Group	13.6 (7.8-33.5)	17 (8.9-44.2)	**<0.001**	20 (10-50)	
Knee Extension 180°/sec AV					
Isokinetic Group	24.5 (14.2-36)	34.5 (21.1-65,7)	**<0.001**	43.1 (0.3-168)	0.071
Control Group	25 (15.3-47.6)	30 (24-55.3)	**<0.001**	20.4 (10-60)	
Ankle Flexion 60°/sec AV					
Isokinetic Group	6.7 (2,1-19)	11.5 (3.4-47.4)	**<0.001**	97 (0-368.7)	**<0.001**
Control Group	4.7 (2.1-23.6)	6.3 (2.6-29.5)	**<0.001**	22 (10-156)	
Ankle Extension 60°/sec AV					
Isokinetic Group	11.7 (4.6-21.9)	15.2 (7-31)	**<0.001**	38.8 (0-103.4)	0.109
Control Group	9.7 (4.2-28)	12 (5.2-35.9)	**<0.001**	20 (11-50)	
Ankle Flexion 120°/sec AV					
Isokinetic Group	4.4 (2.4-14.5)	7.9 (3.3-30.5)	**<0.001**	86 (1.4-343)	**<0.001**
Control Group	4.3 (2.4-13.6)	5.2 (3.4-17)	**<0.001**	22 (12-150)	
Ankle Extension 120°/sec AV					
Isokinetic Group	9.3 (6.3-16.2)	13.9 (7.1-21.9)	**<0.001**	24.1 (5.5-98)	**0.006**
Control Group	10 (5-30)	11.5 (6-27)	**<0.001**	15.4 (0-60)	

*Bold *p* values show significance, AV: Angular Velocity. a: A *p*-value of <0.0125 according to Bonferroni Corrections was considered as statistically significant for the comparison of the assessments before and after the treatment in the groups. b: A *p*-value of <0.025 was considered as statistically significant for the comparison of the change levels after the treatment between the groups.

Table 4. Non-paretic side knee and ankle peak torque values before and after the treatment and progression levels. Mean, (Min-Max)

Isokinetic Parameter	Peak Torque Before Treatment	Peak Torque After Treatment	*p*-value[a]	Change Level	*p*-value[b]
Knee Flexion 60°/sec AV					
Isokinetic Group	19.6 (5.9-54)	41 (16.9-54.5)	**<0.001**	76.8 (1-430)	**0.006**
Control Group	23.8 (5.4-53)	28 (7.5-70)	**<0.001**	25 (10-222)	
Knee Extension 60°/sec AV					
Isokinetic Group	52.5 (25.5-98)	77.9 (50.7-143)	**<0.001**	35.5 (2.4-278)	**<0.001**
Control Group	46.6 (18.4-109)	52.8 (24-128)	**<0.001**	14.8 (0.5-170)	
Knee Flexion 180°/sec AV					
Isokinetic Group	13.9 (9.2-24.4)	23.2 (11.9-38.2)	**<0.001**	62.2 (0.6-218)	**0.010**
Control Group	16.3 (8.3-27.8)	19 (9.6-33.7)	**<0.001**	23 (12-100)	
Knee Extension 180°/sec AV					
Isokinetic Group	28 (20-65.3)	50 (27.6-79)	**<0.001**	43.8 (0.3-186)	**0.004**
Control Group	28.7 (19.2-57.1)	36 (23.6-72)	**<0.001**	20 (7.7-70,2)	
Ankle Flexion 60°/sec AV					
Isokinetic Group	15.3 (3.1-77.9)	22.1 (9.9-78)	**<0.001**	51.3 (0-798.8)	**0.008**
Control Group	15.7 (2.3-44.6)	18.2 (3.3-50.2)	**<0.001**	27 (10-100)	
Ankle Extension 60°/sec AV					
Isokinetic Group	15.6 (5.2-24)	20.5 (9.8-37)	**<0.001**	20.8 (4-108.1)	0.930
Control Group	15.7 (7.7-27)	18.8 (9-34)	**<0.001**	19 (8.8-51)	
Ankle Flexion 120°/sec AV					
Isokinetic Group	8.1 (2.4-44)	14.7 (3.3-52.3)	**<0.001**	39 (0.4-196)	0.031
Control Group	8.4 (3.2 -29.5)	10.4 (4.1-35)	**<0.001**	23 (13-48.4)	
Ankle Extension 120°/sec AV					
Isokinetic Group	12.2 (6.1-18.6)	15.1 (7.1-26)	**<0.001**	23.3 (0-103)	**0.013**
Control Group	11.9 (5-19.1)	13.2 (6.2-26)	**<0.001**	10 (0-92)	

*Bold *p* values show significance, AV: Angular Velocity. a: A *p*-value of <0.0125 according to Bonferroni Corrections was considered as statistically significant for the comparison of the assessments before and after the treatment in the groups. b: A *p*-value of <0.025 was considered as statistically significant for the comparison of the change levels after the treatment between the groups.

Paretic side knee and ankle PT values before and after the treatment and progression levels are shown in **Table 3**. Non-paretic side knee and ankle PT values before and after the treatment and progression levels are shown in **Table 4**. Compared with baseline; all PT values improved both on the paretic and non-paretic sides (all p<0.01). PT change values were significantly higher in the isokinetic group than the control group except for the values of the knee extension at 180°/sec AV, ankle extension at 60°/sec AV on paretic side; ankle extension at 60°/sec AV and flexion at 120°/sec AV on non-paretic side (all P<0.025).

Comparison of the quality of life and functional parameters after the treatment are given in **Table 5**. When compared to baseline, the quality of life, gait, balance, and mobility index values were found significantly higher in both groups after the rehabilitation program, besides the increase levels were found significantly higher in the isokinetic group than the control group (P<0.025, P<0.05). The isokinetic PT values of the knee and ankle were significantly lower in the hemiplegic cases than the healthy cases on both paretic and non-paretic sides (P<0.05). On the other hand, there was no significant difference between the groups regarding isokinetic PT values at all angular velocities before the treatment (all P>0.05).

Discussion

In this study, we objected to show the effects of bilateral isokinetic strengthening training in addition to conventional rehabilitation program after stroke. The most significant result is that

Table 5. The quality of life, gait, balance, and mobility tests values before and after the treatment and change levels in test scores after the treatment. Mean, (Min-Max)

Variables	Before Treatment	After Treatment	*p*-value[a]	Change Level	*p*-value[b]
FIM (Motor)					
Isokinetic Group	73 (43-88)	86 (63-90)	**<0.001**	9 (1-20)	**0.025**
Control Group	72 (62-86)	81 (68-90)	**<0.001**	6 (2-19)	
SS-QOL					
Isokinetic Group	146 (93-198)	200 (123-231)	**<0.001**	48 (26-83)	**<0.001**
Control Group	143 (107-195)	177 (138-229)	**<0.001**	31 (19-55)	
10 m Walk Test					
Isokinetic Group	16 (10-50)	11 (7-30)	**<0.001**	-4 (-26 – -2)	**<0.001**
Control Group	16 (11-30)	13 (9-24)	**<0.001**	-3 (-8 – -1)	
6-Minute Walk Test					
Isokinetic Group	210 (60-320)	250 (100-370)	**<0.001**	50 (20-130)	**<0.001**
Control Group	200 (110-360)	225 (125-390)	**<0.001**	20 (10-40)	
SCT					
Isokinetic Group	13 (8-45)	9 (6-32)	**<0.001**	-4 (-20 – -2)	**<0.001**
Control Group	18 (7-40)	16 (7-32)	**<0.001**	-2 (-8-0)	
TUG					
Isokinetic Group	16 (12-51)	12 (8-30)	**<0.001**	-4 (-26-4)	**<0.001**
Control Group	17 (8-37)	15 (7-31)	**<0.001**	-2 (-6-0)	
BBS					
Isokinetic Group	47 (28-53)	53 (46-56)	**<0.001**	7 (3-21)	**<0.001**
Control Group	47 (36-52)	53 (43-55)	**<0.001**	4 (1-8)	
RMI					
Isokinetic Group	11 (5-13)	14 (11-15)	**<0.001**	3 (1-6)	**<0.001**
Control Group	11 (8-13)	12 (9-14)	**<0.001**	1 (0-3)	

a: A *p*-value of <0.025 according to Bonferroni Corrections was considered as statistically significant for the comparison of the assessments before and after the treatment in the groups. b: A *p*-value of <0.05 was considered as statistically significant for the comparison of the change levels after the treatment between the groups. FIM=Functional Independence Measure, SS-QOL=Stroke Specific Quality of Life Scale, SCT=Stair-Climbing Test, TUG: Timed up&go Test, BBS=Berg Balance Scale, RMI=Rivermead Mobility Index. *Bold *p* values indicate significance. *Bold *p* values show significance.

improvement in the parameters was more prominent in the isokinetic group. In addition, in contrast to previous studies not only improvement in isokinetic parameters but also in the quality of life and functional parameters were seen.

There is a relation between the gait performance and the quality of life after stroke [18]. Therefore, isokinetic exercises have been used as a strengthening program to improve functional performance in hemiplegic patients several times in the previous studies [2-6]. It has been shown that isokinetic exercise training of the hemiparetic limbs improves gait speed [4, 5]. However, these studies lack of a control group. In a double-blinded controlled trial including 20 subjects [6] whereby paretic side isokinetic training provided more strength recovery than the control group; however it did not reveal favorable effects on gait performance [6].

According to our results, the isokinetic PT values of the knee and ankle significantly increased in all cases on both sides as well as PT change values were significantly higher in the isokinetic group than the control group. When we compared the PT changes in our study with the previous similar studies, improvement levels were higher in our study than the others [4, 19]. Severity of the baseline muscle strength of the paretic muscles might have affected the improvement levels [6]. Kim et al. [6] have applied 3 times a week for 6 weeks. Although we have applied shorter than this study, we have applied 5 times a week. Additionally, we have applied in addition to conventional rehabilitation. In contrast to previous studies, gait performance showed improvement in our study. Moreover, the FIM motor scores significantly increased in all cases after the intervention as well, and increase values were significantly higher in the isokinetic group than the control group. Our results show that bilateral isokinetic program seems to be effective on mobility, transfer, and partially on self-care activities in FIM. While SS-QOL values increased in all cases as well, SS-QOL progression values were significant in favor of the isokinetic group. Kim et al. (6) found that isokinetic strengthening application to paretic lower limb muscles did not change the quality of life (SF-36 scoring). On contrary, in our study bilateral isokinetic training improved the quality of life. We could attribute this improvement to the larger sample size, early rehabilitation program within the 3 months after stroke, bilateral isokinetic application, and the high baseline scores of SS-QOL.

Psychological effects of exercise were researched and relationship between the physical activity and psychological well being were shown [20]. In our study, the participants told that they could walk faster than before and stated that they felt themselves more confident. Power graphics showing the strength on the monitor could provide visual feedback and have the patients felt well-being during the isokinetic training in our study.

There were marked improvement in mobility index and walking tests in all subjects in our study. We advocate that isokinetic training in addition to tailored to the task achieved better results in our study. Kim et al. [6] found increase in walking speed in the control and study groups. On the other hand, they did not found difference between the groups. According to Sharp et al. [4]; isokinetic training improved walking speed significantly; however it did not change SCT and TUG scores significantly. In our study; functional parameters might have improved due to bilateral isokinetic training application to knee and ankle in addition to conventional rehabilitation program including task specific practices, being more participants than the other studies, and early rehabilitation program (within the 3 months) in our study. Improvements in the control group might have occurred due to the effects of the practices tailored to the task including gait training, balance-coordination and training of the stair climbing. Strengthening exercises and task specific programs were shown to be effective on functional parameters in acute and chronic stroke patients [6]. Petterson et al. [21] and Pang et al. [22] determined the knee extensor muscles as an important parameter on walking endurance. Flansbjer et al. [18] declared that strength of the knee extensor and flexor muscles are the most important determiner for walking endurance (6-minute walk test). Improvement in 6-minute walk test was more in the isokinetic group in our study. Knee flexor and extensor PT values also increased more in the isokinetic group on the paretic side. Our results support that motor improvement affects walking endurance. Hemiplegic gait ability is associated with the strength of hip flexors and plantar flexors [23]. Lack of the isokinetic strengthening and evaluation of his muscles is a limitation of our study.

Shamay et al. [14] found TUG score 22.6±8.6 sec in patients with chronic stroke. This score was longer than the score of elderly adults who were functionally independent (24). In addition, TUG test scores are associated with the weakness and spasticity [24]. After intervention, there was significant improvement in TUG test scores in favor of the isokinetic group in our study. It might be related to the more improvement in PT scores in the isokinetic group than the control group. Sharp et al. [4] did not found a significant difference regarding SCT and TUG test scores after the isokinetic exercise program applied to paretic knee muscles. Flansbjer et al. [18] declared the contribution of both paretic and non-paretic lower limb muscles in SCT. In our study, marked improvements in SCT scores might have seen due to the isokinetic training of paretic ankle muscles and non-paretic knee and ankle muscles in addition to paretic knee muscles.

Muscle strength and balance are determinant of the gait speed in the acute phase of the stroke [25]. In the previous data; gait speed, aerobic capacity, daily ambulatory activity and cognitive status have been found to be correlated with the BBS in chronic stroke patients [26, 27]. Current data shows that stroke rehabilitations improve balance. In our study there was more improvement in BBS in the isokinetic group than the control group.

As for the limitations, although our sample size is not small when compared with the previous studies, it could be larger. Although current study comprised a control group; we could compare the bilateral isokinetic application with the only paretic side isokinetic application.

Conclusion

In light of our results, we can conclude that bilateral isokinetic strengthening training in addition to conventional rehabilitation program after stroke is effective on strengthening muscles on both two sides, improving functional parameters, gait, balance, and the quality of life. Further studies comparing the effects of unilateral and bilateral isokinetic strengthening after stroke are awaited.

Disclosure of conflict of interest

None.

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