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Improving the Hamstrings-to-Quadriceps Strength Ratio in Sedentary Women: Comparison of Stabilization Training and Aerobic Training After a 6-Months Follow-up

Sedanter Kadınlarda Hamstring-Quadriseps Gelişimi: 6 Ay Takipli Stabilizasyon ve Aerobik Eğitimin Karşılaştırılması

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Abstract

Objective: The goals of this study were to investigate and compare the effects of aerobic and spinal stabilization training on the knee muscle hamstring-to-quadriceps (H/Q) ratio in adult women.
Methods: Seventy of 85 women who applied to the fitness center were randomly assigned to spinal stabilization or aerobic training groups (1, 2). Twenty-one women out of 35 sedentary women from the university who had not participated to any sport or exercise program were followed as controls. The training programs were conducted for 3 days/week for six months. All subjects were assessed before training, at the 3rd, and 6th month of training. Assessments were performed with the Isomed 2000 isokinetic system (D&R Ferstl GmbH, Hemau, Germany). The peak torque and total work of H/Q ratios were calculated. Repeated measures and the "as treated" protocol (spinal stabilization (n=28), aerobic training (n=23)) were used for the analysis.
Results: The hamstring-to-quadriceps ratio of peak torques on the dominant side increased between pre-training (0.732±0.12) and the 6th month of training (0.847±0.11) in the aerobic training group (F=6.08; p=0.03). The H/Q ratio of the total work increased on the dominant side in the stabilization training group between pre-training (0.773±0.15) and the 3rd month (0.855±0.12), (F=6.402; p=0.002) of training. It increased pre-training (0.707±0.17) and in the 6th month of training (0.777±0.13) in aerobic training group.
Conclusion: Both aerobic and stabilization trainings improved the total work of the H/Q ratio. Stabilization training could be recommended for prompt improvement of the H/Q ratio for sedentary women.
Key words: Knee joint, exercise, isokinetic testing

Öz

Amaç: Bu çalışmada yetişkin kadınlarda aerobik ve spinal stabilizasyon egzersiz eğitiminin dizde hamstring-quadriseps kas kuvvetleri oranına (H/Q) etkisinin belirlenmesi ve karşılaştırılması amaçlandı.
Yöntemler: Spor salonuna başvuran 85 kadından 70'i rastgele spinal stabilizasyon ve aerobik eğitim gruplarına atandı (1, 2). Herhangi bir spor ya da egzersiz programına katılmayan, üniversite bölümlerinde çalışan 35 sedanter kadından 21'i kontrol grubu olarak takip edildi. Programlar haftada 3 gün olmak üzere 6 ay boyunca uygulandı. Tüm bireyler eğitim öncesinde ve eğitimin 3. ve 6. aylarında değerlendirildi. Değerlendirmeler Isomed 2000 (D&R Ferstl GmbH, Hemau, Germany) izokinetik sistem ile yapıldı. Tepe torku ve toplam işin H/Q oranı hesaplandı. Tekrarlı ölçümler ve "tedaviyi tamamlayanlar" protokolü (spinal stabilizasyon (n=28), aerobik eğitim (n=23)) istatistiksel analizde kullanıldı.
Bulgular: Aerobik eğitim grubunun dominant taraf tepe torku H/Q oranı eğitim öncesi (0,732±0,12) ve eğitimin 6. ayında (0,847±0,11) arttı (F=6,08; p=0,03). Stabilizasyon eğitimi grubunun dominant taraf toplam iş H/Q oranı eğitim öncesi (0,773±0,15) ve eğitimin 3. ayında (0,855±0,12) arttı (F=6,402; p=0,002). Aerobik eğitim grubunda H/Q oranı eğitim öncesi (0,707±0,17) ve eğitimin 6. ayında (0,777±0,13) arttı.
Sonuç: Hem aerobik hem de stabilizasyon eğitimi toplam iş H/Q oranını geliştirdi. Sedanter kadınlarda H/Q oranının hızlı gelişimi için stabilizasyon eğitimi önerilebilir.
Anahtar Kelimeler: Diz eklemi, egzersiz, izokinetik test

INTRODUCTION

International evidence on health promotion indicates the importance of regular physical activity for preventing and reducing the incidence of musculoskeletal disease, especially in women (1-3). Avoiding a sedentary life style and participating in regular exercises are vigorously suggested (1-3). In recent years, preventative rehabilitation has been of great significance. The main purpose of health professionals has turned out to be preventing injuries and promoting regular and optimal physical activities. Adult women have been participating in different kinds of exercises for musculoskeletal injury prevention. Aerobic training and spinal stabilization training (commonly known as core, or Pilates-based training) are two types of popular, long term attainable exercise regiments.

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Aerobic training has been used for many years in sports and rehabilitation programs. Cardio-protective effects, metabolic benefits, and improvements on muscle strength had been areas of interest (4-6). However, Pilates-based spinal stabilization training has been more and more popular lately, especially among women, and has become a beneficial adjunctive treatment to improve flexibility, enhance control-mobility of the trunk and pelvic segments, and to enhance functional capacity even in patients with heart failure (7-9). In addition to stability effects to the core segments of these sorts of exercises, the peripheral influence to the extremity functions have been a research of matter. The focus of these exercises has shifted to how well the core could transfer forces to the extremities for functional improvement and injury prevention (10-12).

The lower extremities have the highest potential for injury and musculoskeletal complaint; and many adult women have long been suffering from knee problems such as osteoarthritis, patellofemoral pain syndrome, and degenerative meniscus problems (13, 14). The prevention of these disorders and injuries with exercise has been highly important (15).

Optimal knee joint function is related to the optimal quadriceps and hamstring muscles functioning rather than the strength of the muscles (16-18). The hamstring-to-quadriceps (H/Q) strength ratio was introduced as a concept for the examination of knee functioning performance (19). The agonist-antagonist strength relationship for knee extension and flexion is described and calculated by dividing the maximal knee flexor (hamstring) moment by the maximal knee extensor (quadriceps) moment measured at an identical angular velocity and contraction mode (19, 20). It has been suggested that females with relatively lower H/Q ratios may be at a higher risk for injury (19, 20). To prevent knee injuries, an H/Q ratio of 0.6 at a minimum (the hamstrings being 60% as strong as the quadriceps) is accepted (19, 21). Evidence suggests that highly developed quadriceps muscles, to a great extent, contribute to the force capacity of hamstring muscles and imbalance of the muscles (19, 22).

Some studies have examined the ways of improving H/Q ratios (23, 24). It was suggested that plyometric exercises improved the ratio in physically active woman and whole body vibration training was effective on moderately active females (21, 23, 24). However, it is not exactly known whether aerobic exercises or spinal stability training has any impact on knee muscle strength and the H/Q ratio, and which exercise is more effective for the knee muscles in adult women. Moreover, since the exercise programs were designed for up to 6 or 12 weeks, long term following are missing.

Therefore, the aims of this study were to assess and compare the different exercise approaches on knee joint functioning with the H/Q ratio in the long term (with the flow-up at the 3rd and 6th months of training). The following hypotheses were investigated: 1. Both stabilization and aerobic trainings would be effective for improving the H/Q ratio for women in comparison to the control group. 2. The trainings had no superiority to each other. 3. The trainings would be effective starting at the 3rd month and improvement would continue to increase into the 6th month with continuation of the programs.

METHODS

Subjects

The participants included sedentary adult women between 25 and 55 years of age who had not attended to any regular physical activity or activities performed for less than 20 minutes or fewer than three times per week. Eighty-five women that applied to the fitness center of Kecioren Municipality and had not participated in an exercise program over last one year were treated as the study group. Twenty-one women out of 35 sedentary women volunteers from the university who had not participated in any sport or exercise program were followed as controls at the 3rd and 6th months (n=21, 41±6 years of age). The participants received a health certificate from a general practitioner to see if they could join an exercise program. They were also assessed with the use of a standardized questionnaire for eligibility. The exclusion criteria were as follows: (i) lower extremity and low back pain for more than 3 months; (ii) having a systemic pathology including inflammatory joint disease; (iii) having active intervention in the last 6 months; (iv) body mass index above the 35 kg/m^2; (v) taking anti-inflammatory medication over the past two weeks; and (vi) experiencing musculoskeletal disorders that limit daily activities. Fifteen of the participants were dismissed. Seventy of them were randomly assigned to one of two groups: spinal stabilization training group and aerobic training group. Block randomization was carried out by a computer-generated random number list. Each group included 35 women at the beginning. Fifty-one of all the participants completed the study: Spinal stabilization training group (n=28, 37±8 years of age), aerobic training group (n=23, 39±6 years of age). A flowchart is provided in Figure 1.

The programs were designed for six months for the training groups. The evaluations were applied at pre-training, at the 3rd, and 6th months of training. The 3rd month was considered as the milestone for monitoring musculoskeletal alterations. Moreover, the 3rd month evaluations and gains were used as a motivator for long-term training programs. The control group was asked not to participate in any exercise or physical activity program during the six months of study.

A prospective randomized, blind, controlled trial was used. All participants read the university approved consent form and gave written consent. The Ethical Committee Approval of the University was received for the study (Ethical Committee Number: 426).

Assessments

An Isomed 2000 (D&R Ferstl GmbH, Hemau, Germany) was used to apply knee flexion and extension isokinetic strength tests. Concentric and eccentric measures on both sides were performed from 90-deg knee flexion to 0-deg extension. A strap (VELCRO USA, Inc.; Manchester, New Hampshire, USA) was used to fasten the torso onto the testing table and stabilize the body and thigh. During testing, the subjects were in the sitting position and restrained by straps across their shoulder girdle, chest, and abdomen (25). The concentric maximal torque production (measured in Nm/Kg) was determined for both the knee flexors and extensor muscles at 180 °/s. Before the testing, all subjects were informed about the particular requirements of the testing, and they were given three to five submaximal consecutive contraction trials to become accustomed to the procedure and to warm up their muscles. Each test took one minute for ten repetitions at 180 °/s. All assessments were conducted by the same examiner (ID), who was blinded to the group interventions. Assessments were performed at the Hacettepe University, Department of Physio-

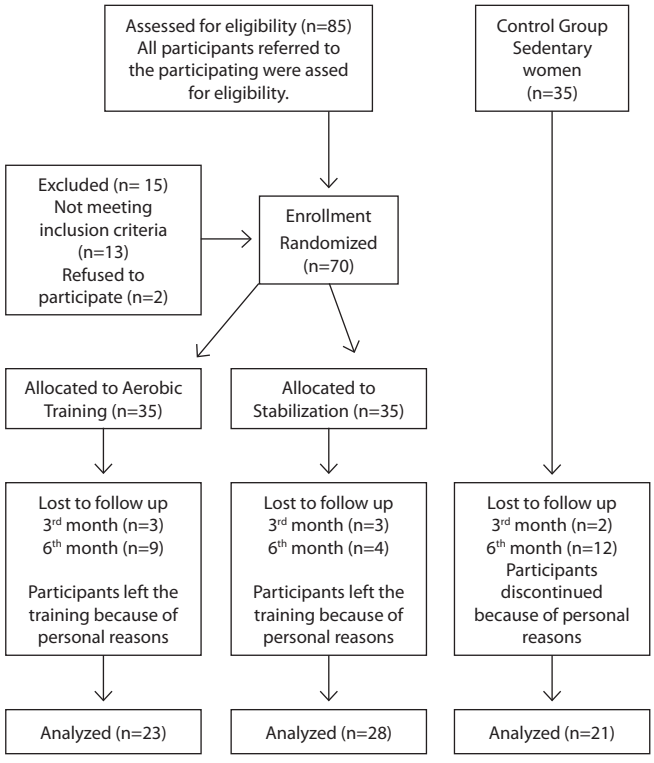

Figure 1. The flow chart of the participants

therapy and Rehabilitation, Sports Physiotherapy Unit. The examiner employed a standardized protocol to ensure the consistency of subject positioning, instructions, and testing procedures. Standardized verbal instructions and encouragements were given to the subjects during the testing procedure. To obtain a consistent result, the best three maximal contractions in each test were automatically selected by the dynamometer software program. The peak torque, total work, and H/Q ratio were recorded.

Interventions

Spinal Stabilization training sessions were composed of 10 minutes of warm-up exercises, 30 minutes of stabilization exercises, and 10 minutes of cool-down and stretching exercises in a group setting. The whole program was carried out 3 days/week for 6 months. The training concentrated on creating neutral spine and activation of lumbar multifidus and transversus abdominus muscles with abdominal bracing techniques at the beginning. The exercises included workouts of the bracing in neurodevelopment stages (supine, prone, side lying, quadripedal, bipedal). They held the contraction for 10 seconds at each position for 3 sets of 10 repetitions. Also, upper and lower extremity range of motion exercises were conducted while maintaining a stabile spine at the specific positions. Then, mat exercises for abdominal, back, hip, and leg muscles were added with true breathing techniques. Mat exercises included following specific named exercise: hundred preparation, hundred, ½ roll up, single leg circle, rolling like a ball, single leg stretch, crisscross, spine stretch forward, spine stretch side, saw, swan, single leg kicks, swimming, side leg lifts, side leg circles, side leg bananas bridge (9, 12, 26). The progression was structured in three phases throughout the six months starting from simple to complex movements. All repetitions for the exercises were raised progressively from 6 to 20.

Table 1. Physical characteristics of the subjects

	Aerobic Training (n=23) X±SD (Min–Max)	**Stabilization Training (n=28) X±SD (Min–Max)**	**Control (n=21) X±SD (Min–Max)**	**p**
Age (year)	39±6 (28–51)	37±8 (25–52)	41±6 (30–55)	0.194
BMI (kg/m^2)	29.05±3.25 (20–34.1)	26.97±3.89 (19.5–33.1)	26.58±4.19 (19.6–34.6)	0.068

BMI: body mass index; N: number of participants;
X±SD: mean±standard deviation; p: statistical significance level;
Kg: kilogram; m^2: meter squared; Min: minimum value;
Max: maximum value

Aerobic training program was applied at 60% or 70% of heart pulse for the exercise intensity standardization, for 50 minutes for 3 days/week. The exercise program was composed of 10 minutes of warm-up exercises, 25 minutes of aerobic exercises, 10 minutes of exercises for the abdomen, hip, and leg muscles, and 5 minutes of cool-down and stretching exercises (27).

Statistical Analysis

The sample size was calculated with the G*Power package software program (G*Power, Version 3.0.10, Franz Faul, Universität Kiel, Germany) that a sample consisting of at least 70 subjects was needed to obtain 80% power with f=0.40 effect size, and α=0.05 type I error. Statistical Package for the Social Science Programme (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY, USA) was used for the outcomes. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov–Simirnov/Saphiro–Wilk) to determine whether or not they were normally distributed. Repeated measures for statistical analyses within groups and the Bonferroni method as post-hoc analyses for the comparison of three groups were used. The subset of per protocol analysis is an "as treated" analysis, in which only participants who were adherent to the intervention were included. These analyses seem reasonable for this study because participants can only be affected by an intervention that they actually receive. The level of significance for all statistical analyses was set at an α value of <0.05.

RESULTS

Fifty-one participants from the training programs (spinal stabilization training group (n=28), aerobic training group (n=23)) and 21 controls completed the 3rd and 6th months of assessment. The physical characteristics of the subjects are represented in Table 1. There were no significant differences among groups (Table 1), (p>0.05). The quadriceps and hamstring muscles peak torque and total work values are shown in Table 2, 3.

In the aerobic training group, the H/Q ratio of the peak torques on the dominant side increased between pre-training and the 6th month of training (F=6.08; p=0.03), while the non-dominant side showed no differences between groups and pre to post training values (F=3.015; p=0.52), (Table 4). The H/Q ratio of the total work on the dominant side increased between pre-training and the 6th month of training in the aerobic training group (Table 5).

Table 2. Isokinetic peak torque values of the groups

			Aerobic n=23 X±SD	Stabilization n=28 X±SD	Control n=21 X±SD
Pre test	Quadriceps	Dominant	0.96±0.23	0.97±0.19	1.02±0.21
		Non-dominant	0.98±0.20	0.98±0.18	1.06±0.19
	Hamstring	Dominant	0.71±0.21	0.77±0.17	0.79±0.23
		Non-dominant	0.75±0.19	0.74±0.17	0.81±0.18
3rd month	Quadriceps	Dominant	1.03±0.20	1.07±0.21	1.06±0.20
		Non-dominant	1.04±0.20	1.09±0.19	1.06±0.20
	Hamstring	Dominant	0.83±0.21	0.88±0.16	0.85±0.21
		Non-dominant	0.83±0.22	0.84±0.18	0.82±0.23
6th month	Quadriceps	Dominant	0.99±0.17	1.09±0.21	1.05±0.17
		Non-dominant	0.96±0.19	1.06±0.17	1.01±0.19
	Hamstring	Dominant	0.84±0.20	0.88±0.14	0.79±0.21
		Non-dominant	0.78±0.19	0.84±0.15	0.78±0.23

n: number of participants; X±SD: mean±standard deviation

Table 3. Isokinetic total work values of the groups

			Aerobic n=23 X±SD	Stabilization n=28 X±SD	Control n=21 X±SD
Pre test	Quadriceps	Dominant	401.5±114.3	412.7±128.1	428.1±111.9
		Non-dominant	429.8±100.6	424.3±129.3	463.1±80.3
	Hamstring	Dominant	285.3±110.5	316.1±105.4	328.5±105.9
		Non-dominant	309.8±95.8	314.7±98.8	343.4±74.8
3rd month	Quadriceps	Dominant	504.3±99.9	485.9±126.5	463.3±83.3
		Non-dominant	490.65±98.7	480.8±124.8	467.6±96.8
	Hamstring	Dominant	381.3±106.4	410.1±103.8	365.1±87.1
		Non-dominant	385.8±106.9	388.1±102.7	352±99.2
6th month	Quadriceps	Dominant	485.3±90.4	504.6±131.4	460.1±73.3
		Non-dominant	452.4±98.7	449±118.3	421.1±79.9
	Hamstring	Dominant	376.5±90.9	399.4±89.5	338.6±83.9
		Non-dominant	356.9±93.6	410.9±141	333.7±99.6

n: number of participants; X±SD: mean±standard deviation

In the stabilization training group, no differences were observed during the intervals for H/Q ratio of the peak torques (Table 4). The H/Q ratio of the total work increased on the dominant side in the stabilization training group between pre-training and the 3rd month of training (F=6.402; p=0.002). The non-dominant side in the stabilization groups among pre-training, 3rd month of training, and 6th month of training were significantly different (F=10.20; p<0.001), (Table 5).

There were no significant differences in the control group H/Q ratio for peak torque and total work values during the intervals. Moreover, there were no significant differences within the groups (Table 4, 5).

DISCUSSION

This study hypothesized that both exercises improved the H/Q ratio of the total work of the dominant leg in female adults. However, spinal stabilization training was effective starting at the third month of the training, while aerobic training had an effect starting in the 6th month. The H/Q ratio of the peak torque increased only in the aerobic training group at the 6th month of training.

In the literature, it was emphasized that adult females could be at risk of knee injury when the H/Q ratio declined below 0.6 (19, 21). Devan et al. (17) suggested that the H/Q ratio below normal range was associated with an increased prevalence of overuse knee injuries among female athletes. They used the total work H/Q ratio at 60 °/s and 300 °/s in young female athletes. They were found to be 62.2%±7.8% on the right side and 63.5%±8.9% on the left side at 60 °/s (60%–69% normal); and 73.6±14% on the right side and 74.7%±16.1% on the left side at 300 °/s (80%–95% normal). We found that the total work H/Q ratio at 180°/s in adult sedentary women after 6th months in the aerobic, stabilization, and control groups on the dominant side to be 77.7%±13%, 81%±14%, 74%±16% and on the non-dominant side to be 79.4%±15%, 93.5%±28%, 79.5%±21%, respectively. In our case series, the H/Q ratios were greater than those of young female athletes. Furthermore, the H/Q ratios of the females were greater than 0.6 at the very beginning. It seems that they were outside of the risk cutoff, but when we take the age into account, this ratio turns out to be in conflict. In this study, the women's mean ages were about 40, and they could be close to their menopause stage. Thus, they were under risk for developing knee pain because of their age and sedentary life style. According to Jinks et al. (28), 47% of females between 50 and 64 years-old and 51% of females 75 years old and over suffer from knee pain. Therefore, the H/Q ratio could be important at this stage to prevent knee injuries.

The H/Q ratio of the total work of the dominant leg increased on the 3rd month in the stabilization training group, and on the 6th month in the aerobic training group. The 3rd month was considered as the milestone for monitoring musculoskeletal improvements. The differences were significant only for the stabilization training group. The H/Q ratio of the peak torque increased in only the aerobic exercise group at the 6th month. Hamstring and quadriceps strengths increased, but hamstring strength improvement was higher than quadriceps in both training groups. These differences could be explained by the characteristics of the exercises. Spinal stabilization exercises focused

Table 4. Peak torque H/Q ratios of the subjects

Variables	Groups	Test	X±SD	Group (experiment) F	Measurement (pre test-final test) F	Group Measurement Effects F	Sig.
Peak Torque H/Q Dominant side	Aerobic n=23	Pre test	0.732±0.12	0.373	6.08**	4.70**	Pre test-6th month (Aerobic Training)
		3rd month	0.798±0.12				
		6th month	0.847±0.11				
	Stabilization n=28	Pre test	0.800±0.12				
		3rd month	0.829±0.09				
		6th month	0.817±0.12				
	Control n=21	Pre test	0.767±0.16				
		3rd month	0.791±0.13				
		6th month	0.750±0.15				
Peak Torque H/Q Non dominant side	Aerobic n=23	Pre test	0.770±0.12	0.274	3.01	0.422	
		3rd month	0.795±0.12				
		6th month	0.814±0.12				
	Stabilization n=28	Pre test	0.759±0.11				
		3rd month	0.773±0.10				
		6th month	0.805±0.10				
	Control n=21	Pre test	0.767±0.12				
		3rd month	0.764±0.12				
		6th month	0.776±0.17				

H/Q: Hamstring-to-quadriceps ratio; n: number of participants; X±SD: mean±standard deviation; p: statistical significance level; F: F test value; Sig: significant value

on correct body position, proper technique, and overall posture, so they are used to reform antigravity muscles; whereas aerobic exercises focused on isolated big muscles. Furthermore, the stability exercises included more eccentric actions that might be helpful for developing greater forces faster. Moreover, the core might be enabled to transfer forces to the lower extremities. However, the maximum torque production was only reached by aerobic exercises.

Tsang et al. (23) recommended plyometric exercises to improve the H/Q ratio and to prevent injuries for recreationally active women. Similar to our study, they associated the success of this sort of training with the emphasis on proper technique, overall posture, correct take-off and landing positions, and eccentric muscle actions. Karatrantou et al. (24) investigated the effects of whole body vibration training on the "functional" H/Q ratio in moderately active females. As an effect mechanism, they focused on stretch tolerance and alterations in excitation of golgi tendon organs, inhibition of the antagonist muscles, the activation of the "tonic vibration reflex," and alterations in proprioceptors' discharge. Those may all lead to an alteration of intramuscular coordination. Similarly, the exercise programs might be reorganized the neuromuscular structures and adaptation mechanism, especially in spinal stabilization training group. Ebben investigated the effects of different hamstring resistance training exercises on the hamstring and quadriceps activation and ratios (29). Women, compared with men, were less able to activate the hamstrings and/or abler to activate the quadriceps. It was recommended that women may require disproportionately greater training for the hamstrings. Similarly, El-Ashker et al. (30) highlighted the importance of enhancing eccentric hamstring strength, especially in females who were at a higher risk of injury and the need to examine the H/Q ratio for continued observation. Core stability training may help women to activate hamstring muscles more properly for optimal knee joint function. This could be helpful to improving knee stability and to reduce the risk of knee injuries.

There are some limitations to the present study. The exercise designs were not specific to the knee joint. The two common general exercise trainings with long-term programs were compared and peripheral effects for the H/Q were observed. For the specific effects, more specific exercises might be used. The evaluation at the 3rd month used as a motivator and a milestone. However, long-term exercise programs caused high drop-out rates. Therefore, the "as treated" analysis, in which only participants who were adherent to the intervention, were included rather than "intention-to-treat" analysis. The analysis seemed

Table 5. Total work H/Q ratios of the subjects

Variables	Groups	Test	X	Group (experiment) F	Measurement (pre test-final test) F	Group Measurement Effects F	Sig.
Total Work H/Q Dominant side	Aerobic n=23	Pre test	0.707±0.17	1.76	6.40**	2.50*	Pre test-6th month (Aerobic Training) Pre test-3rd month (Stabilization Training)
		3rd month	0.750±0.12				
		6th month	0.777±0.13				
	Stabilization n=28	Pre test	0.773±0.15				
		3rd month	0.855±0.12				
		6th month	0.810±0.14				
	Control n=21	Pre test	0.762±0.17				
		3rd month	0.792±0.15				
		6th month	0.740±0.16				
Total Work H/Q Non dominant side	Aerobic n=23	Pre test	0.732±0.17	1.74	10.20**	2.32	Pre test-3rd month Pre test-6th month (Stabilization Training)
		3rd month	0.784±0.13				
		6th month	0.794±0.15				
	Stabilization n=28	Pre test	0.748±0.11				
		3rd month	0.814±0.15				
		6th month	0.935±0.28				
	Control n=21	Pre test	0.743±0.11				
		3rd month	0.760±0.17				
		6th month	0.795±0.21				

**p<0.01, *p<0.05
H/Q: Hamstring-to-quadriceps ratio; n: number of participants; X±SD: mean±standard deviation; p: statistical significance level; F: F test value; Sig: significant value

reasonable for this study because participants can only be affected by an intervention if they actually receive it. The isokinetic evaluation was chosen only at 180 °/s because of the safety and facility of the study group. However, different angular velocities may show some different results. This should be taken into account for further studies. Another limitation was that the study group was healthy and sedentary woman. We cannot generalize the outcomes for athletic populations for injury prevention or for osteoarthritic women. Further investigation is needed to clarify the effect of the H/Q ratio on different populations.

CONCLUSION

Both aerobic and spinal stabilization trainings improved the total work of the H/Q ratio. However, stabilization training was effective starting at the 3rd month of training, while aerobic training had an effect at the 6th month of training. The H/Q ratio of the peak torque increased only in the aerobic group at the 6th month of training. Spinal stabilization training could be recommended for the prompt improvement of the H/Q ratio for sedentary women.

Ethics Committee Approval: : Ethics committee approval was received for this study from the ethics committee of Gazi University (17.12.2007, Ethical Committee Number:426).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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