



# Effect of Eight Weeks of Reformer Pilates on Shoulder Proprioception Dynamic Stability and Functionality

## Sekiz Haftalık Reformer Pilatesin Omuz Proprioepsiyonu Dinamik Stabilitesi ve Fonksiyonu Üzerine Etkisi

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### ABSTRACT

**Objective:** This study aimed to compare shoulder proprioception, dynamic stability, and upper extremity function between Reformer Pilates practitioners and asymptomatic individuals.

**Methods:** The study included twenty individuals who practiced Reformer Pilates for eight weeks (25.45±2.56) as the case group, and twenty asymptomatic individuals (25.70±1.80) of similar age and gender, who did not participate in any exercise program, as the control group. Shoulder proprioception was assessed using the Clinometer mobile app [4.3.1 (1412091) on IOS] using an active joint position sense. The function, dynamic balance, and stability of the upper extremity and trunk were evaluated with the Y balance test - upper quarter. The dynamic stability of the shoulder was evaluated with the Closed Kinetic Chain Upper Extremity Stability test.

**Results:** Shoulder joint position sense ( $p<0.001$ ,  $d=1.64$  to  $3.07$ ), upper extremity functionality ( $p<0.001$ ,  $d=1.49$  to  $2.35$ ), and dynamic stability ( $p<0.001$ ,  $d=2.82$ ) were found significantly better in the Reformer Pilates group.

**Conclusion:** Reformer Pilates practitioners have better shoulder joint position sense, upper limb functionality, and dynamic stability.

**Keywords:** Pilates training, shoulder joint, proprioception, joint instability, sedentary behavior

### ÖZ

**Amaç:** Bu çalışmanın amacı, Reformer Pilates uygulayıcıları ile asemptomatik bireyler arasında omuz proprioepsiyonu, dinamik stabilite ve üst ekstremité fonksiyonunu karşılaştırmaktır.

**Yöntemler:** Sekiz hafta boyunca Reformer Pilates yapan 20 birey (25,45±2,56) olgu grubu olarak ve benzer yaş ve cinsiyetteki herhangi bir egzersiz programına katılmayan 20 asemptomatik birey (25,70±1,80) kontrol grubu olarak dahil edildi. Omuz proprioepsiyonu Clinometer mobil uygulaması [iOS'ta 4.3.1 (1412091)] kullanılarak aktif eklem pozisyon hissi ile değerlendirilmiştir. Üst ekstremité ve gövdenin fonksiyonu, dinamik dengesi ve stabilitesi üst çeyrek Y dengesi testi ile değerlendirildi. Omuzun dinamik stabilitesi Kapalı Kinetik Zincir Üst Ekstremité Stabilite testi ile değerlendirildi.

**Bulgular:** Reformer Pilates grubunda omuz eklemi pozisyon hissi ( $p<0,001$ ,  $d=1,64-3,07$ ), üst ekstremité fonksiyonu ( $p<0,001$ ,  $d=1,49-2,35$ ) ve dinamik stabilitesi ( $p<0,001$ ,  $d=2,82$ ) anlamlı derecede daha iyi bulundu.

**Sonuç:** Reformer Pilates uygulayıcıları daha iyi omuz eklemi pozisyon hissine, üst ekstremité fonksiyonuna ve dinamik stabilitesine sahiptir.

**Anahtar Sözcükler:** Pilates eğitimi, omuz eklemi, proprioepsiyon, eklem instabilitesi, sedanter yaşam

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## Introduction

The shoulder is one of the most commonly used joints for everyday tasks such as eating, drinking, grooming, and using technology. The shoulder is prone to overuse injuries, including subacromial impingement syndrome, rotator cuff tendinitis, biceps tendinitis, and frozen shoulder (1). Shoulder disorders are the third most common disease of the musculoskeletal system (2) and the second most common musculoskeletal issue encountered in physical therapy (3). To improve musculoskeletal health and prevent these diseases regular physical activity is recommended (4). Regular physical activity is a key factor for aging well and preventing chronic diseases (5) such as diabetes (6), hypertension, and dementia (7). In recent years, physical activities that involve large muscle group movements such as yoga, tai chi, and Pilates have become more popular (8).

Pilates is a mind-body exercise that is used in rehabilitation and is becoming more and more popular as a method of rehabilitation. Pilates exercises increase the strength of the deep core stabilization muscles and the control of the mind over the movements of the body and limbs (9). It improves flexibility, muscle strength, endurance, cardio-respiratory function, range of motion, attention, and enjoyment of life (10). In addition, it reduces the risk of injury and chronic disease (11). Pilates includes varied exercises that are performed with rhythm and controlled breathing while maintaining core stabilization. Core stabilization is part of the synchronized upper limb movements that make up the kinetic chain. In the kinetic chain, all parts of the upper extremity are considered as a single kinetically connected functional unit. This coactivation between the proximal and distal muscles of the upper extremity allows the successful performance of daily activities (12).

Activities of daily living require a synergistic coordination of the upper extremity and the core region. The core region's muscles are activated before the upper extremities' muscles, even in a movement that requires only the use of the upper extremity (13). Core stabilization provides force, velocity, and momentum transfer to the shoulder. The shoulder is a transferring point that effectively transfers the energy generated in the core to the upper extremity. There is an important relationship between strength and endurance of core and shoulder function (14). The core stabilization exercises are beneficial for healthy aging and injury prevention (15). Pilates is one of the exercises that have a beneficial effect on core stabilization and balance (16). Pilates is a therapeutic technique for disabilities (17) and a preventive program for healthy individuals (18). There are studies that demonstrate the beneficial therapeutic effects of Pilates on muscle strength, core stabilization, risk of falls, balance, gait, and cardiorespiratory fitness (19). However, there are only a few studies that have examined the effects of Pilates on specific joints or functions, such as the shoulder (20). The aim of this study was to compare shoulder proprioception, dynamic stability and function between Reformer Pilates practitioners and non-Pilates practitioners in asymptomatic participants. We hypothesized that those who practiced 8 weeks Reformer Pilates would have

better shoulder's proprioception, dynamic balance, and function than those who did not.

## Methods

### Design

This study was designed case-control. It was carried out at the North Sport Institution between June and December 2021 and conducted in accordance with the Declaration of Helsinki. Before starting the study, the approval was obtained from the Üsküdar University Non-Interventional Research Ethics Committee (approval number: 61351342/ŞUBAT 2021-12, date: 25.02.2021). The participants were informed about the study, and their written consent was obtained.

### Participants

This study was designed to compare shoulder proprioception, dynamic stability and upper extremity function between Reformer Pilates practitioners and individuals who did not participate in any exercise or physical activity program. The study was conducted in İstanbul, a metropolitan area in Türkiye. We enrolled individuals between the ages of 20 and 55 who regularly participated in 8-week Reformer Pilates exercises. A total of 25 individuals were evaluated for eligibility and 2 individuals were excluded because they had a shoulder injury and 3 individuals were excluded because they had been practicing Pilates for many years. We continued with 20 individuals (13 female, 7 male) in the case group.

We enrolled 20 individuals (12 female, 8 male) who did not participate any excises or regular physical activity program in the same city as a control group by inviting them through brochures and social media. We used the following exclusion criteria for both the case and control groups: Participants with a history of shoulder trauma, with limited shoulder range of motion, and who consulted a physician in the previous 6 months for musculoskeletal, neurologic, or rheumatologic conditions (such as pain, edema or increased temperature) were excluded. We also excluded individuals with a history of previous surgery or fracture, a complaint related to the shoulder region, and those who were regular participations in any type of exercise or sport program.

### Intervention

Reformer Pilates exercises were performed one-on-one under the supervision of a physiotherapist at the center three times a week for 8 weeks. The physical therapist was certified in Reformer Pilates by the Türkiye Gymnastics Federation. The sessions lasted 60 min, including 10 min of warm-up and 40 min of reformer exercises, followed by 10 min of cool-down. Warm-up exercises included breathing, mini squat, roll down, twist stretch, shoulder circles, hip roll, seated hip stretch. Reformer Pilates provided a variety of exercises such as the footwork (leg series), tendon stretch, running, and supine arm work, including parallel pull, lateral pull (arm series), drawing down, shoulder bridge, feet in straps, arm work, hundred, short box arm work, pulling the strap long box, side split, cat series, side split, and mermaid. Cool-

down exercises included breathing, cat stretch, chest stretch, seated hip stretch, swinging, toy soldier, cobra.

The first Pilates session covered the basics: breath control and positioning of the pelvic floor, chest, shoulders, head, and neck. Reformer exercises were performed on springs, ropes, and a sliding platform with variable resistance. We adjusted the difficulty of the exercises by increasing the resistance of the springs and adding different positions. All participants started at level 1 and gradually progressed to level 3. They were asked to inform the physiotherapist if they felt any discomfort. The average number of weekly sessions attended by the Reformer Pilates group over an 8-week period was  $2.82 \pm 1.03$ .

### Outcome Measures

Demographic data such as gender, age, weight, height, the dominant hand, and health status of all participants were obtained by face-to-face interviews. Shoulder joint proprioception sensation was measured using a mobile phone application called "Clinometer". The dynamic balance, functionality, and stability of the upper extremity and trunk were evaluated with the Upper Extremity Y Balance test (YBT-UQ), and the dynamic stability of the shoulder was evaluated with the Closed Kinetic Chain Upper Extremity Stability test (CKCUEST).

### Shoulder Joint Position Sense

Shoulder joint position sense was measured using a smartphone application Clinometer [4.3.1 (1412091) on IOS]. The application was a low-cost method that could be easily accessed by everyone, and was used together with an inclinometer and goniometer, with proven validity and reliability in Turkish population by Keleş et al. (21). The inter-user reliability value of the Clinometer application was found to be 0.98 (22).

The active angle repetition method was used for the proprioception evaluation. The evaluation was made as  $45^\circ$  for internal rotation and  $45^\circ$ - $75^\circ$  for external rotation (23). The participant was lying on her back in the  $90^\circ$  flexion and abduction position. The smartphone was fixed between the participant's shoulder and elbow. The test was explained in detail before the participant started the measurement. The participants were first taught the value of each angle with their eyes open. Then, the participants' eyes were covered with black tape and asked to perform the movement with their eyes closed. During the measurement, when the participant's arm reached the target angle. The participant was asked to wait 10 seconds and feel the movement. Later, the arm was brought back to the starting angle. Measurements were started after the target angle was felt three times. The participant was instructed to stand at the previously felt target angle and say "OK". A five-second rest interval was given between measurements. Measurements were repeated six times. The absolute value of the difference between the angle read in the clinometer and the measured target angle value was recorded (21). The test was performed bilaterally. Absolute values of deviations from the target angle were taken.

### The Upper Extremity Y Balance Test (YBT-UQ)

The YBT-UQ was used to evaluate the functionality, dynamic balance, and stability of the trunk and upper extremities. The YBT-UQ was shown to be reliable in the Turkish population to measure shoulder dynamic balance (24). Initially, the participant was asked to take a push-up position with her arms shoulder-width apart. The participant was allowed to experiment before starting the test. During the test phase, the participant was asked to reach the maximum possible points in 3 different directions: nondominant hand medial ( $0^\circ$ ), inferior lateral ( $45^\circ$ ), and superior lateral ( $45^\circ$ ), and the distances were recorded. The same test was repeated for the dominant hand. Within the scope of this test, the upper extremity lengths of the participants were also measured. The measurement was made in the anatomical position, with the arms of the person in the  $90^\circ$  abduction position and recording the distance in cm between the spinous process of the 7<sup>th</sup> cervical spine and the tip of the middle finger. The total score obtained using the participant lying in 3 different directions was divided by the length of the upper extremity multiplied by 3. The result obtained was multiplied by 100 and recorded as the test result. The formula [mean maximum reach (cm)/limb length (cm)] X 100 was used. The test was applied to both sides. The calculation was made by taking the average of the dominant and non-dominant values (25).

### The Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST)

Dynamic stability of the shoulder was evaluated with CKCUEST. The CKCUES test is a reliable tool for assessing upper extremity function in asymptomatic individuals (26). Participants took a push-up position and placed their hands on strips that were 1.5 inches (3.81 centimeters) wide, and 36 inches (91.44 centimeters) apart. With one hand fixed on the ground, the other hand was lifted, and the band under the fixed hand was touched back to the starting point. The test was done bilaterally. The number of repetitions was recorded for 15 sec. and 3 attempts were made. Between trials, the participant was given a rest of 45 sec. Three trials were averaged (26).

### Statistical Analysis

Statistical Package for Social Science (SPSS) 26.0 was used to analyze the data obtained in our study. We considered  $p < 0.05$  statistically significant. We used the G\* power analysis program to calculate the sample size. Using shoulder proprioception as the primary outcome, we calculated that for a 5% alpha error and 80% 1-D error, there should be at least 18 patients in both groups for an effect size of 0.85 (10). We calculated the effect size so that a difference of  $3.2^\circ \pm 1.3^\circ$  in the case group and  $5.3^\circ \pm 3.2^\circ$  in the control group would be significant (27). The conformity of the data to the normal distribution was evaluated using the Kolmogorov-Smirnov/Shapiro-Wilk tests. Categorical demographic variables between groups were analyzed with the chi-square test. Shoulder proprioception, balance, and functionality scores of the groups were compared with the independent t-test as they showed a normal distribution. When the comparison was

found to be significant, an effect size analysis was performed. Cohen-d value was used in the effect size analysis because the number of cases in the two groups was equal. In calculating the effect size, the small effect was considered as  $0.2 \geq$ , the medium effect was  $0.5 \geq$ , and the large effect was  $0.8 \geq$ . The relationship between shoulder proprioception, function and dynamic stability was calculated by Pearson correlation coefficient. Correlation coefficient score between 0 and 0.19 was considered as very low correlation, between 0.2 and 0.39 as low correlation, between 0.4 and 0.59 as moderate correlation, between 0.6 and 0.79 as high correlation, between 0.8 and 1.0 as very high correlation.

### Results

The demographic characteristics of the case and control groups were not significantly different (Table 1).

The Reformer Pilates group had significantly better shoulder proprioception scored with a large effect size in  $45^\circ$  internal rotation and  $45^\circ$ - $75^\circ$  external rotation with both dominant and nondominant sides ( $p < 0.001$  and d score ranging 1.61 to 3.07) (Table 2).

The Reformer Pilates group had significantly better shoulder functionality and balance with a large effect size on both the dominant and nondominant sides ( $p < 0.001$  and d score ranging 1.49 to 2.35) (Table 2).

The Reformer Pilates group had a significantly higher upper extremity stability score with a large effect size on both the dominant and non-dominant sides ( $p < 0.001$  and  $d = 2.82$ ) (Table 2).

**Table 1.** Sociodemographic data of the participants

Variables	PG (n=20) Mean (SD)	CG (n=20) Mean (SD)	P
<b>Gender</b>			
Female	13	12	0.744 $\times^2$
Male	7	8	
<b>Dominant side</b>			
Right	18	18	0.698 $\times^2$
Left	2	2	
Age (year)	25.45 (2.56)	25.70 (1.80)	0.91 <sup>t</sup>
BMI (kg/m <sup>2</sup> )	20.66 (1.87)	22.29 (1.98)	0.43 <sup>t</sup>
Average Participation in Session (per/week)	3.12 (1.56)	NA	

Data expressed as mean (SD: Standard deviation), BMI: Body mass index, CG: Control group, PG: Pilates group,  $\chi^2$ : Chi-square test, t: t-test

**Table 2.** Comparison of shoulder proprioception functionality and stability of Pilates and sedentary participants

Proprioception (°)	PG (n=20)	CG (n=20)	Test statistics	
	Mean (SD)	Mean (SD)	p	Cohen-d
45° IR dominant	2.23 (1.09)	4.03 (0.60)	<0.001 <sup>t</sup>	-2.04
45° IR non-dominant	2.88 (1.10)	4.29 (0.56)	<0.001 <sup>t</sup>	-2.65
45° ER dominant	1.52 (0.79)	3.18 (0.40)	<0.001 <sup>t</sup>	-3.07
45° ER non-dominant	2.13 (0.76)	3.40 (0.38)	<0.001 <sup>t</sup>	-1.61
75° ER dominant	1.82 (0.67)	3.55 (0.43)	<0.001 <sup>t</sup>	-2.11
75° ER non-dominant	2.54 (0.66)	3.68 (0.44)	<0.001 <sup>t</sup>	-2.03
<b>UE functionality</b>				
M dominant	104.67 (1.84)	101.41 (1.41)	<0.001 <sup>t</sup>	1.98
M non-dominant	102.98 (1.65)	96.05 (4.48)	<0.001 <sup>t</sup>	1.85
SL dominant	70.19 (5.46)	61.03 (4.35)	<0.001 <sup>t</sup>	1.49
SL non-dominant	68.90 (6.10)	56.93 (3.87)	<0.001 <sup>t</sup>	2.05
IL dominant	75.81 (4.65)	68.80 (4.75)	<0.001 <sup>t</sup>	2.35
IL non-dominant	73.10 (3.94)	64.48 (5.26)	<0.001 <sup>t</sup>	1.85
<b>CKQUEST</b>				
Number of touches	17.89 (1.29)	14.28 (1.27)	<0.001 <sup>t</sup>	2.82

Data expressed as mean (SD: Standard deviation), CKCUES: Closed Kinetic Chain Upper Extremity Stability, CG: Control group, ER: External rotation, IL: Inferolateral, IR: Internal rotation, M: Medial, SL: Superolateral, PG: Pilates group, t: t-test, UQYBT: Upper Quarter Y Balance test, UE: Upper extremity

There was no significant correlation between proprioception and shoulder function and dynamic stability in the case group except left external rotation at 75° and dynamic stability, whereas a positive, moderate to very high correlation ( $p < 0.001$ ,  $r$  score ranging -463 to -826) was found in the control group in all parameters (Table 3).

### Discussion

The study compared shoulder proprioception, shoulder dynamic stability and upper limb functioning between individuals with and without regular Reformer Pilates. In our study, the participants, who did regular reformer plates for 8 weeks, had better shoulder proprioception, dynamic stability, and upper extremity function compared to control group.

There is some evidence in the literature that open and closed kinetic chain exercises have a positive effect on shoulder abduction and external rotation proprioception (28-30). In our study, Reformer Pilates participants had significantly better shoulder proprioception with a large effect size. To the best of our knowledge, our study is the first to investigate shoulder proprioception in asymptomatic individuals performing Pilates. Salles et al. (27) investigated the effect of strengthening exercises on shoulder proprioception in asymptomatic individuals and found that strengthening exercises performed at constant intensity were most effective for shoulder repositioning proprioception. In their research, the intervention group demonstrated about 2° shoulder rotation repositioning deviation after post-exercise, in comparison to the control group which exhibited approximately 5° deviation (27). The comparable results of the case and control groups in two studies support the idea that regular Reformer Pilates supports the repositioning proprioception. Proprioception is defined as the body's ability to transmit a sense of position, interpret processed information, and respond to stimuli, consciously or unconsciously (31). Proprioception provides

the sensory information necessary for effective neuromuscular control. The sense of proprioception helps to increase movement control and coordination (32). We found that individuals who performed Reformer Pilates exercises had more controlled and coordinated shoulder movements. Reformer Pilates exercises may be recommended to support shoulder proprioception in asymptomatic individuals.

Our study shows that Reformer Pilates practitioners has a significantly better the dynamic stability of the shoulder. Reformer Pilates includes strength and endurance exercises for the core and shoulder stabilizer muscles. Core stability supports the upper extremities' motor control (33). A study of female handball players found that they significantly increased their ball-throwing speed with core stabilization training (34). Another study of baseball players showed that athletes who received six weeks of core training improved their throwing performance and upper extremity closed kinetic chain balance (35). Reformer Pilates may strengthen the kinetic chain between the upper extremity and core. Thus, it may have provided more torque and momentum transfer to the upper extremity and increased the dynamic stability of the shoulder. It should be noted that practice for 8 weeks of Reformer Pilates is sufficient to achieve better dynamic shoulder stability.

Core stabilization exercises, including closed kinetic chain activities, contribute to upper extremity function. The progressive and dynamic trunk stabilization exercises are effective in improving upper extremity function in athletes (36). However, there are few studies in the literature focusing on exercise performance to assess upper extremity-specific functions in asymptomatic healthy participants. We found that upper extremity function was better in individuals doing 8 weeks of Reformer Pilates than in those doing no exercise. Zengin Alpozgen et al. (37) showed that 8 weeks of Pilates training significantly improved shoulder function in individuals with breast cancer. Pilates participants

**Table 3.** Relationship between shoulder proprioception and shoulder functionality and stability in case and control group

	CKCUEST		UQYBT (Right)		UQYBT (Left)	
	PG	CG	PG	CG	PG	CG
	P (r)	P (r)	P (r)	P (r)	P (r)	P (r)
<b>45° IR dominant</b>	0.182 (-0.311)	0.002** (-0.638)	0.152 (-0.332)	<0.001** (-0.821)	0.439 (-0.183)	<0.001** (-0.792)
<b>45° IR non-dominant</b>	0.298 (-0.245)	0.003** (-0.536)	0.736 (-0.080)	<0.001** (-0.789)	0.172 (-0.318)	<0.001** (-0.826)
<b>45° ER dominant</b>	0.554 (-0.141)	0.040* (-0.463)	0.214 (-0.290)	0.001** (-0.669)	0.951 (-0.015)	0.002** (-0.652)
<b>45° ER non-dominant</b>	0.869 (-0.039)	0.007** (-0.583)	0.683 (-0.097)	0.001** (-0.593)	0.293 (-0.247)	0.002** (-0.660)
<b>75° ER dominant</b>	0.546 (-0.143)	0.014* (-0.542)	0.015 (-0.537)	<0.001** (-0.732)	0.250 (-0.270)	0.001** (-0.694)
<b>75° ER non-dominant</b>	0.979 (-0.006)	0.001** (-0.702)	0.684 (-0.097)	0.001** (-0.703)	0.019* (-0.520)	<0.001** (-0.764)

CKCUES: Closed Kinetic Chain Upper Extremity Stability, CG: Control group, ER: External rotation, IR: Internal rotation, UQYBT: Upper Quarter Y Balance test, PG: Pilates group, r: Pearson correlation coefficient, \*:  $p < 0.05$ , \*\*:  $p < 0.01$

had better upper limb function, which might be due to the closed kinetic chain trunk stabilisation exercises in Pilates (17). There is literature data showing that Pilates exercises improve function and independence in daily life in clinical conditions such as chronic back pain (38), geriatric population (11), multiple sclerosis (39). In line with existing literature, our study demonstrates that asymptomatic Pilates practitioners exhibit better shoulder function.

Proprioception is critical for smooth and well-coordinated movement and is linked to both balance and functions (40). In our study, there was a moderate to high significant positive correlation between shoulder proprioception and function and dynamic stability in the control group, while no significant correlation was found in the case group. Suner-Keklik et al. (41) investigated the effects of online Pilates exercises on trunk proprioception and endurance. They found significant improvements in both parameters with similar effect sizes. However, in our study, the Pilates group demonstrated better shoulder proprioception with a higher effect size when compared to stability and function skills. It could be said that individuals in the Pilates group showed more individual variation in proprioception, stabilization, and functional skills compared to the control group.

### Study Limitations

To the best of our knowledge, this is the first study to compare the effectiveness of Reformer Pilates on shoulder proprioception, dynamic stabilization, and function in asymptomatic individuals. The main limitation of this study was that although individuals practicing Reformer Pilates were prospectively enrolled in the study, their baseline testing was not performed prior to the intervention. Therefore, only one measurement was available. In future studies, it is recommended that the design be prospective and that pretest-posttest evaluations be conducted. Another limitation concerns habit control of the participants. When participants start Reformer Pilates, they can adopt other behavioral changes that will improve their health. Although participants were told to maintain their current diet and not participate in any other exercise programs, there was no way to rigidly control this.

### Conclusion

Our study shows that regular Reformer Pilates practitioners have significantly better shoulder proprioception, dynamic stability, and upper extremity function with large effect sizes. The current study suggests that Reformer Pilates exercises can be recommended as an exercise program for asymptomatic individuals to obtain better shoulder proprioception, stabilization and function.

### Ethics

**Ethics Committee Approval:** Permission for the research was obtained from the Üsküdar University Non-Interventional Research Ethics Committee (approval number: 61351342/ŞUBAT 2021-12, date: 25.02.2021).

**Informed Consent:** The participants were informed about the study, and their written consent was obtained.

### Authorship Contributions

Surgical and Medical Practices: M.K., Concept: T.A., M.Ç., Design: T.A., M.Ç., Data Collection or Processing: M.K., Analysis or Interpretation: T.A., M.Ç., M.K., Literature Search: T.A., M.Ç., M.K., Writing: T.A., M.Ç., M.K.

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