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Effects of Balance Training on Unstable Grounds in Kinesiophobia After ACL Injury

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Authors' Contribution: A: Study design, B: Data collection, C: Data analysis, D: Manuscript preparation, E: Discussion and conclusion

ABSTRACT

Study aim(s): It has been observed that post-injury pain following an ACL injury leads to a decline in functional status and leads to kinesiophobia, which limits movements and activity. Our study aimed to examine the effects of an anterior cruciate ligament injury on kinesophobia in athletes recovering from an ACL injury.
Methods: A total of 191 athletes participated in the study. They were divided into two groups: an exercising (97 people) and a non-exercising (94 people) group. The Tampa Kinesophobia Scale (TSK) was used to determine the athletes' kinesophobia levels. For data analysis, a T-test, one-way ANOVA, and Tukey test for post-hoc analysis were used. The data were analyzed using the licensed SPSS 26 program.
Results: The study found a significant difference in kinesophobia levels between the exercising group (37.34±5.73) and the non-exercising group (39.29±5.51) following ACL injury ($p < 0.05$). However, no significant differences in kinesophobia were observed concerning gender, age, sports history (except within the exercise group, $p < 0.05$), ACL surgery, or the injured knee (except within the exercise group, $p < 0.05$) ($p > 0.05$).
Conclusion: The findings suggest that engaging in exercise after an ACL injury may help reduce kinesophobia levels. However, factors such as gender, age, sports history, ACL surgery, and the injured knee do not seem to significantly affect kinesophobia, except within the exercise group. This highlights the potential importance of exercise in recovery, regardless of demographic or injury-related variables.

Keywords: Anterior Cruciate Ligament, Exercise, Unstable Grounds, Kinesiophobia

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INTRODUCTION

Persistent pain, or chronic pain, can lead to changes in behavior due to both physical and psychological factors. The International Association for the Study of Pain defines chronic pain as '... pain persisting beyond the normal recovery period'. Additionally, it is reported that up to 80% of the population will experience musculoskeletal pain, making it a major cause of disability and activity limitation [1]. Lethem et al. introduced the fear-avoidance model, which explains how some individuals develop a significant psychological overlap of pain problems [2]. According to this model, avoiding pain and painful activities due to fear (cognitive and behavioral avoidance) can lead to both physical and psychological consequences. This model is widely supported and frequently applied [1]. Psychosocial factors play a crucial role in recovery following an injury. Common factors include anxiety, depression, pain-related fear, and pain beliefs. Pain-related fear and avoidance behaviors in the development of functional disability are a topic of interest in studies [3, 4]. The avoidance of physical movements and activities due to the fear of pain or re-injury is defined as "kinesiophobia". Kinesiophobia is a term coined by Miller, Kori, and Todd at the Ninth Annual Scientific Meeting of the American Pain Society in 1990 [5, 6].

Kinesiophobia refers to the fear an individual experiences regarding physical activity or movement, driven by the perception of pain and a sense of vulnerability to painful injury or re-injury [5]. In chronic cases with functional disorders, both pain intensity and cognitive response to pain emerge. These cognitive responses in painful situations form the basis of the fear-avoidance model [7,8]. Individuals with kinesiophobia believe that movement will cause additional pain or re-injury, making kinesiophobia a risk factor for the persistence of pain [9]. Kinesiophobia that arises after pain leads to movement limitations, resulting in a decrease in physical capacity, strength, and flexibility. The inability to treat the injury due to fear of movement avoidance can also lead to a reduced quality of life, an increased risk of depression, and disruption in sleep patterns [10-14].

Anterior Cruciate Ligament (ACL) rupture accounts for approximately 50% of all knee ligament injuries and is a common and physically debilitating knee injury for athletes, as it leads to functional deficits [15]. While advances in surgical techniques offer the potential for improved outcomes and a return to pre-injury performance levels, the rehabilitation process plays a crucial role in recovery as well [16,17]. In the post-surgery rehabilitation process, determining the appropriate time to safely return to physically strenuous and demanding activities is crucial. The aim is to create a controlled environment and prepare athletes for challenging activities by teaching them special movement patterns throughout the rehabilitation program [18,19,20]. Unstable surfaces have become increasingly important in the return-to-sport phase and have been proven in many studies to be a preventive method for lower extremity injuries. The instability of the surface during exercises encourages the individual to be more cautious, focused, and stable. This positively affects the body's balance mechanism in possible falls or sudden movements. As a result, the athlete with a fear of movement after surgery will feel stronger both physically and psychologically. Kinesiophobia that develops after an injury leads to fear of movement and activity in athletes. Therefore, the athlete may avoid exercises due to the fear of re-injury, which ultimately leads to a decrease in performance.

Chronic pain has been shown to lead to a decline in functional status, causing kinesiophobia, which in turn results in restriction in movement or activity. Studies are showing that kinesiophobia can be reduced through training [21, 22]. Therefore, it is important to determine the effect of an exercise program using unstable ground and materials on kinesiophobia to optimize return-to-sport outcomes

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and performance improvement. In addition, the lack of research on this specific study group in the existing literature makes this study unique, and it is expected to contribute by addressing this gap.

This study aimed to evaluate the effect of an exercise program conducted on unstable grounds on kinesiophobia following an ACL injury and to determine the relationships between various variables.

METHODS

Study model

This research was designed based on the survey model, which focuses on describing and analyzing the current state of the phenomenon under investigation. Data is collected from the target population through systematic observations, surveys, and questionnaires, providing a comprehensive understanding of the subject.

Study Group

The study group comprised 191 athletes with ACL injury, divided into two subgroups: 97 athletes in the exercising group and 94 athletes in the non-exercising group. In the exercising group, the mean height was 177.44±7.42, with a range from 158 cm to 195 cm. The mean weight was 75.57±11.33, ranging from 50 to 100 kg. The mean body mass index was 23.94±2.91, with a range from 17.84 to 34.60. The mean height of the non-exercising group was 175.84±8.85, ranging from 150 to 198 cm. The mean weight was 73.54±13.07, with a range from 50 kg to 116. The mean body mass index was 23.70±3.38. The minimum body mass index of the group was 17.90 and the maximum body mass index was 37.45.

This research protocol was approved by Recep Tayyip Erdoğan University Social and Human Sciences Ethics Committee (number: 2021/45, Date: 23/02/2021).

Data Collection

This study utilized the general survey model, a descriptive research method. The survey model focused on collecting information about a specified subject and intending to determine the characteristics of a particular community. Data collection in the survey model is conducted through telephone, e-mail, or direct questioning, reaching many individuals efficiently [23]. In this study, a questionnaire was created using the 'Personal Information Form' and 'Tampa Kinesiophobia Scale (TKS)' to assess the kinesiophobia levels of athletes with ACL injuries.

The questionnaire form was designed using 'Google Form' and delivered to participants via a shared link (URL). The necessary information about the questionnaire was provided electronically along with the link. The questionnaire created via Google Form remained open for data collection for ten days and was closed once the target number of participants was reached.

Tampa Kinesiophobia Scale (TKS)

The original scale was developed by Miller, Kopri, and Todd in 1991 but was not published. Vlaeyen et al. (1995) republished the scale with permission from the original researchers [24]. The TKS is a 17-question Likert scale that examines fear-avoidance and injury/reinjury related to physical activity. The scale uses a 4-point Likert scale (1 = strongly disagree, 4 = strongly agree). After reversing items 4, 8, 12, and 16, a total score is calculated, ranging from 17 to 68. Higher scores indicate greater level of kinesiophobia. The Turkish validity and cultural adaptation of the scale were provided by Tunca et al. [25].

Personal Information Form

The personal information form included questions to gather the personal information of the athletes, such as age, gender, injured knee, sport branch, number of ACL surgeries, and sport history.

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Data Analysis

The SPSS 26 licensed package program was used in the data analysis phase, while data organization and tabulation were performed using the licensed Microsoft Excel from Office 365. It was determined by Shapiro-Wilk test that the data were normally distributed. A t-test was used to compare quantitative continuous data between two independent groups, while a one-way ANOVA was used for comparisons between more than two independent groups [26]. The Tukey test was performed as a complementary post-hoc analysis to determine the differences following the ANOVA test. A significance level of $p<0.05$ was used for the analyses.

FINDINGS

This section presents the findings on the kinesiophobia levels of athletes with anterior cruciate ligament (ACL) injuries who participated in the study. Using the Tampa Kinesiophobia Scale (TKS), the analysis explores the severity of fear related to movement or reinjury and its impact on their recovery, physical activity, and rehabilitation. The results also highlight potential variations in kinesiophobia based on demographic factors, injury history, and rehabilitation practices, offering valuable insights into this psychological aspect of sports injuries.

Table 1. Demographic Characteristics of Athletes

Variable	Group	Exercising Group	Non-Exercising Group
		n (%)	n (%)
Gender	Male	71 (73.20)	61 (64.89)
	Female	26 (26.80)	33 (35.11)
Age	Under 30 years	62 (63.92)	61 (64.89)
	Over 30 years	35 (36.08)	33 (35.11)
Sport	Basketball	14 (14.43)	13 (13.83)
	Football	51 (52.58)	51 (54.26)
	Handball	4 (4.12)	10 (10.64)
	Volleyball	5 (5.15)	3 (3.19)
	Other	23 (23.71)	17 (18.09)
Sport Background	1-3 Years	8 (8.25)	13 (13.83)
	4-6 Years	9 (9.28)	15 (15.96)
	7-9 Years	80 (82.47)	66 (70.21)
ACL Surgery	1 Operation	64 (65.98)	73 (77.66)
	2 Operation	26 (26.80)	18 (19.15)
	3 Operation	7 (7.22)	3 (3.19)
Injured Knee	Right	45 (46.39)	42 (44.68)
	Left	32 (32.99)	38 (40.43)
	Right and Left	20 (20.62)	14 (14.89)

Upon analysis of Table 1, the total number of athletes was 191, with the majority in both groups being male. It was observed that the majority of the athletes were 30 years of age or younger.

Most of the group consisted of football players and a significant number had a sports history between 7-9 years. Additionally, most of the athletes had undergone one operation and had right knee injuries (Table 1).

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Table 2. Kinesiophobia Levels According to Groups

Variable	n	X±SD	df	t	p
Exercising Group	97	37.34±5.73	189	-2.391	0.01*
Non-Exercising Group	94	39.29±5.51			

**Independent sample T-Test, **n: number of people, X: mean, SD: standard deviation.*

The kinesiophobia levels of the exercising and the non-exercising group were tested using a t-test. The results showed a significant difference between the groups ($p<0.05$). The mean kinesiophobia level of the non-exercising group was significantly lower compared to the exercising group (Table 2).

Table 3. Kinesiophobia Levels of the Groups According to Gender

Group	Gender	n	X±SD	df	t	p
Exercising Group	Male	71	37.85±4.80	95	1.441	0.153
	Female	26	35.96±7.68			
Non-Exercising Group	Male	61	38.85±5.09	92	-1.040	0.301
	Female	33	40.09±6.22			

**Independent sample T-Test, **n: number of people, X: mean, SD: standard deviation.*

The kinesiophobia levels of the exercising group and the non-exercising group in terms of gender were compared using a t-test. According to the tests, no significant difference was found in terms of gender in both the exercising group ($p>0.05$) and the non-exercising group ($p>0.05$). In the exercising group, the mean kinesiophobia levels of women were lower than those of men. Conversely, in the non-exercising group, the mean kinesiophobia levels of men were lower than those of women (Table 3).

Table 4. Kinesiophobia Levels of the Groups According to Age

Group	Age	n	X±SD	df	t	p
Exercising Group	Under 30 years	62	37.24±6.14	95	-0.224	0.824
	Over 30 years	35	37.51±5.01			
Non-Exercising Group	Under 30 years	61	40.00±5.96	92	1.723	0.088
	Over 30 years	33	37.97±4.34			

**Independent sample T-Test, **n: number of people, X: mean, SD: standard deviation.*

The kinesiophobia levels of the exercising and the non-exercising groups in terms of age were tested using a t-test. The results showed no significant difference in terms of age in either the exercising group ($p>0.05$) or the non-exercising group ($p>0.05$). In the exercising group, the mean kinesiophobia levels of athletes aged 30 years and younger were lower than those of athletes aged over 30. Conversely, in the non-exercising group, the mean kinesiophobia levels of those aged over 30 were lower than the mean kinesiophobia levels compared to those aged 30 years and younger (Table 4).

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Table 5. Kinesiophobia Levels of the Groups According to the Year of Practicing Sports

Group	Sport Background	n	X±SD	df	F	p	Diff.
Exercising Group	1-3 Years	8	42.38±8.91	2-96	3.574	0.03*	1>3
	4-6 Years	9	37.33±5.45				
	7-9 Years	80	36.84±5.20				
Non-Exercising Group	1-3 Years	13	42.38±6.01	2-93	2.891	0.061	
	4-6 Years	15	39.93±7.23				
	7-9 Years	66	38.53±4.79				

**One-Way ANOVA Test, Tukey, **n: number of people, X: mean, SD: standard deviation, 1: 1-3 years, 3: 7-9 years.*

The kinesiophobia levels of the exercising and the non-exercising groups were compared based on years of sporting history using ANOVA. According to the tests, a significant difference was found in the exercising group ($p<0.05$), while no significant difference was found in the non-exercising group ($p>0.05$). In the exercising group, athletes with 7-9 years of sports history had significantly lower mean kinesiophobia levels compared to those with 1-3 years of sports history. In the non-existing group, although no significant difference was found, the mean kinesiophobia levels of those with 1-3 years of sports history were higher (Table 5).

Table 6. Kinesiophobia Levels of the Groups According to ACL Surgery

Group	ACL Surgery	n	X±SD	df	F	p
Exercising Group	1 Operation	64	37.64±5.51	2-96	0.851	0.430
	2 Operation	26	36.19±5.25			
	3 Operation	7	38.86±9.08			
Non-Exercising Group	1 Operation	73	38.90±5.14	2-93	0.897	0.411
	2 Operation	18	40.39±5.72			
	3 Operation	3	42.00±12.53			

**One-Way ANOVA Test, **n: number of people, X: mean, SD: standard deviation.*

The kinesiophobia levels of the exercising and the non-exercising groups were compared based on the number of ACL surgeries using ANOVA. According to the tests, no significant difference was found in both the exercising group ($p>0.05$) and the non-exercising group ($p>0.05$). In the exercising group, the mean kinesiophobia of individuals who had undergone 3 operations was higher. Similarly, in the non-exercising group, those who had undergone 3 operations also exhibited higher mean (Table 6).

Table 7. Kinesiophobia Levels of the Groups According to the Injured Knee

Group	Injured Knee	n	X±SD	df	F	p	Diff.
Exercising Group	Right	45	37.76±5.46	2-96	4.822	0.01*	1>3, 2>3
	Left	32	38.81±6.09				
	Right and Left	20	34.05±4.59				
Non-Exercising Group	Right	42	38.71±5.09	2-93	0.473	0.625	-
	Left	38	39.58±5.34				
	Right and Left	14	40.21±7.23				

**One-Way ANOVA Test, Tukey, **n: number of people, X: mean, SD: standard deviation, 1: right, 2: left, 3: right and left.*

The kinesiophobia levels of the exercising and the non-exercising groups in terms of injured knee were tested using ANOVA. The results showed a significant difference in the exercising group ($p<0.05$), while no significant difference was found in the non-exercising group ($p>0.05$). In the exercising group, the mean kinesiophobia levels of individuals with injuries in both knees were significantly lower than those of

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individuals with injuries to the right or left knee. Although no significant difference was found in the non-exercising group, the mean kinesiophobia levels were higher for individuals with injuries to both knees (Table 7).

DISCUSSION

This study aimed to determine the effect of an exercise program on unstable surfaces on kinesiophobia after an ACL injury and to determine the relationships between the variables.

Ardern et al. reported that physical, psychological, and demographic factors affect the return to sport following ACL treatment [27]. Among these, kinesiophobia stands out as one of the most significant challenges for individuals recovering from ACL injuries [28]. As shown in Table 2, a significant difference was found between the kinesiophobia levels of the exercising and the non-exercising groups with ACL injuries. It was observed that kinesiophobia was higher in the non-exercising group. Similarly, Demirkapi et al. (2015) found that the kinesiophobia levels in patients who had undergone ACL surgery were high. Tengman et al. (2014) reported a persistently high fear of movement in their 20-year follow-up after ACL surgery [30]. When the literature was examined, no studies were found in which the effect of exercise programs on kinesiophobia after an ACL injury was examined. According to the findings of this study, it can be concluded that participation in an exercise program after an ACL injury helps reduce the fear of movement and re-injury. Conversely, it can be thought that athletes who are not involved in exercise programs are more likely to experience kinesiophobia because they cannot overcome this fear. Harput et al. (2018) reported that the fear and anxiety scores were elevated following ACL surgery, which was related to insufficiency of lower extremity functional levels [31]. They also found that the mean kinesiophobia score of patients was 35 [31]. In the present study, the mean kinesiophobia score was 37 for the exercising group and 39 for the non-exercising group. Both values are below the score of 41, which is considered of high risk [32].

Tichonova et al. (2016) reported that patients continue to have fear of movement even 3-4 years after ACL reconstruction [33]. It was found that 53% of patients who had undergone ACL surgery returned to their pre-injury activity levels and exhibited less fear of re-injury. In contrast, patients who did not regain their pre-injury activity levels scored higher on the CQS [28]. Additionally, Kvist et al. found that people with lower activity levels had higher levels of kinesiophobia [28]. Similarly, in the present study, it was determined that the activity levels of ACL patients decreased as their fear of movement increased [34,35]. Haugen (2022), in his study on individuals who had undergone ACL surgery, stated that mean kinesiophobia levels were higher in the group with lower activity levels. These studies align with the present study.

As shown in Table 3, no significant difference was observed in the kinesiophobia levels between the exercising and the non-exercising groups in terms of gender. However, it was observed that males in the exercising group experienced more kinesiophobia, whereas females in the non-exercising group experienced more kinesiophobia. Fleide et al. (2021) reported that the rate of return to sport was higher in younger individuals compared to older individuals [36]. Similarly, Wiese-Bjornstal (2021) reported that gender is an important factor, with women experiencing more fear of movement than men, and having lower rates of return to sport [37]. This study is similar to our study, particularly regarding the non-exercising group. It can be thought that the reason why kinesiophobia is higher in women is that women tend to have a lower pain threshold than men.

As shown in Table 3, no significant difference was found in the kinesiophobia levels between both the

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exercising and non-exercising groups in terms of age. However, there was no significant difference, it was also observed that those aged 30 years and older in the exercising group experienced more kinesiophobia, while those aged 30 years and younger in the non-exercising group experienced more kinesiophobia levels. Age is among the factors that predispose individuals to injury. Helme et al. (2021) reported that ACL injuries are frequently observed between the ages of 25 and 35 [38]. Age is a factor affecting injury, and it can be thought that as athletes age, their fear of pain and re-injury may increase, contributing to higher levels of kinesiophobia.

As shown in Table 4, a significant difference was found in the kinesiophobia levels of the exercising group based on years of doing sports, while no significant difference was found in the non-exercising group. In the exercising group, those with 1-3 years of sports history experienced significantly higher kinesiophobia than those with 7-9 years of sports history. Although no significant difference was detected in the non-exercising group, it was seen that those with 1-3 years of sports history experience more kinesiophobia. This may be attributed to the fact that less experienced athletes are more vulnerable to the fear of injury.

As shown in Table 5, no significant difference was found in kinesiophobia levels between the exercising and the non-exercising groups regarding the number of ACL surgeries. However, there was no significant difference, although it was observed that those who had 3 operations in both groups experienced higher levels of kinesiophobia. It is thought that the reason for this is that the athletes who experience recurring ACL injuries are more likely to fear that injury, will happen again.

As shown in Table 6, a significant difference was observed within the kinesiophobia levels of the exercising group in terms of the knee affected by the injury. In contrast, no significant difference was found in the kinesiophobia levels of the non-exercising group. Specifically, in the exercising group, it was observed that those who experienced injuries in either the right or left knee experienced significantly more kinesiophobia levels compared to those with injuries in both knees. Although no significant difference was detected in the non-exercising group, it was observed that those who experienced injuries in both knees experienced more kinesiophobia. It is thought that the reason for the high kinesiophobia of those who experienced a single knee injury may be due to experiencing the injury in a more painful and more affected period. In contrast, those who experienced both knee injuries had the same problem in both legs, which may suggest the fear that this problem may occur again.

When we examined the literature, it was observed that various exercise programs [11, 39] applied after different knee injuries region reduced symptoms, improved physical performance, and reduced fear of movement. The results obtained in the present study were similar to the literature.

This study was limited to two groups: those who engaged in exercise and those who did not after ACL injury, which may restrict the generalizability of the findings. Future research should explore diverse rehabilitation approaches and their psychological impacts.

CONCLUSION

In the kinesiophobia values of the exercising and the non-exercising groups, the exercising group showed lower levels of kinesiophobia. Therefore, it was concluded that exercise therapy on unstable grounds was beneficial in reducing fear of movement and fear of re-injury in athletes following ACL surgery. Based on this result, it can be said that exercise is necessary for helping athletes reduce kinesiophobia and return to their pre-injury activity levels after ACL injury. In light of the results obtained in our study, it is recommended that this gap should be filled by implementing different exercise programs for

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those with knee injuries and different options should be offered to individuals.

No potential conflict of interest was reported by the authors.

CONFLICT OF INTERESTS

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