The Effects of Radiotherapy on Lower Extremity Muscle Strength in Patients With Pelvic Bone Metastases

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Abstract

This study examined the possible effects of radiotherapy on lower extremity muscle strength in patients with pelvic bone metastases. Ten male patients aged 40-60 years with pelvic bone metastases applied to participate in this study voluntarily. The muscle strength of these patients was measured with an isokinetic dynamometer device twice, before and after radiotherapy. The present study was carried out on ten patients with pelvic bone metastases. The analysis of the data obtained from the research was made in the SPSS 26.0 (SPSS, Inc., Chicago, IL, USA) program. No statistically significant difference was observed in the comparison of the knee flexion and knee extension peak torque values before and after radiotherapy, regardless of the right and left legs [knee flexion peak torque: $F(1,14)= 2.986$, $p=.106$, partial eta squared: .176; knee extension peak torque: $F(1,14)= 3.426$, $p=.085$, partial eta squared: .197]. According to the Bonferroni test, although there was no significant difference, it was determined that the participants' right and left leg peak torque values increased after radiotherapy application. It was determined that radiotherapy application positively affected muscle strength in patients with bone metastases. Especially in these populations, repeating such studies by increasing the sample size may contribute to planning training programs targeting strength development.

Keywords: Pelvis • Bone metastasis • Patient • Muscle strength • Isokinetic test

Introduction

Isokinetic dynamometers are devices in which the movement speed is constant and the resistance to the muscle is applied equally at every angle of the movement. These devices evaluate muscle strength, muscle power and endurance objectively and also perform training and rehabilitation of muscles [1]. The isokinetic dynamometer helps to provide specific movement and speed in the muscle or muscle group to be trained. Moreover, it has been used in the rehabilitation and follow-up of muscle injuries because it provides measurable scientific values, especially about muscle performance, and provides a safe increase in strength during studies [2]. Advanced cancers often metastasize to bone [1]. These metastases are frequently vertebra, femur, pelvis, ribs, sternum, humerus and skull bones, and palliative radiotherapy is one of the first-choice methods in bone metastases [3]. Depending on the cancer treatment in cancer patients, muscle strength may decrease; side effects such as loss of pelvic floor muscle function, urinary incontinence, and fecal incontinence may occur depending on radiotherapy [4]. Isokinetic devices are used successfully in muscle strength measurement [5]. Evaluation of muscle strength is the primary function of these systems, and measurements in these devices provide information about the dynamic performance of a muscle, such as torque, work and endurance [1]. The speed of the isokinetic devices can be adjusted according to the patient’s condition [1, 2].

No studies were found in the literature examining the effects of radiotherapy on lower extremity muscle strength in patients with bone metastases. This study aims to investigate the possible effects of radiotherapy on lower extremity muscle strength in patients with pelvic bone metastases and to contribute to the treatment protocols that are aimed to be developed in the future.

Material and Methods

Ten male patients aged 40-60 years with pelvic bone metastases applied to participate in the study voluntarily. The muscle strength of these patients was measured with an isokinetic dynamometer device twice, before and after radiotherapy. The present study was carried out in 10 patients with pelvic bone metastases. Dose calculation was performed to completely cover the PTV with the 100% prescribed isodose line of 30 Gy in 10 fractions while minimizing the dose to OARs. When performing salvage radiation therapy (RT) for pelvic bone metastases, it is necessary to prescribe a dose sufficient to control the tumor while considering the tolerable dose to normal organs (organs at risk, OARs).

Before the study started, similar studies in the literature were used to calculate the sample size of this study (6-8). Similar studies' mean and standard deviation values were placed in the G*Power 3.1.9.4 analysis program. [Bidirectional, $\alpha= 0.05$, Power $(1-\beta)= 0.95$, Effect size=1.43]. According to the calculation result, this study’s minimum number of samples was 9.

In our study, all kinds of explanations and information about the study were made, and an Informed Consent Form was signed by the volunteer patient group before the study.

Inclusion criteria for the study

1. 40-60 years old
2. Patient group with stable pelvic region metastases

Exclusion Criteria

1. Below 40 years old and above 60 years old
2. Patient group with unstable severe pelvic region metastases
3. In the patient group; the presence of diabetes mellitus, hypertension, cardiovascular disorder, neurodegenerative disease, head trauma, alcohol and drug addiction, epilepsy
4. Patients with contraindications for isokinetic tests (acute muscle spasm, limitation of joint range of motion, joint effusion, severe osteoporosis around the joint immediately after surgical procedures).

Data Collection

The isokinetic muscle strength of all volunteer patients was measured in the "Sport Sciences Application and Research Center Exercise Physiology Laboratory.” For standardization of measurements, all measurements were made by the same expert.

Isokinetic Test Procedure

Participants were applied warm-up exercises with 10 minutes of low-intensity walking at the exercise intensity (heart rate reserve or pulse range that corresponds to 50-60% of the target heart rate) recommended by the American Cancer Society (ACS) and American Sports Medicine (ACSM) (9). Also, to prevent injuries that may occur before and after the test, static stretching exercises were implemented on the lower extremity muscles of the participants for 5 minutes. The isokinetic knee strengths of the participants were tested with a computer-controlled isokinetic dynamometer, "Isomed2000" (D&R Ferstl GmbH, Hemau, Germany). Before the test started, the participants' personal information and anthropometric measurements were recorded in the database of the device. Angular velocities for knee flexion-extension force were determined as 60 °/sec. Since concentric measurements are easier to understand than eccentric measurements, measurements were performed concentrically/concentrically (10). For the 'ISOMED 2000' device, the recommended range of motion in the knee flexion-extension movement pattern is +10/+90°. The knee extension movement is performed against gravity and the participant has to carry the weight of the arm of the instrument during the movement. Since the flexion movement is performed in the opposite direction of gravity, applying the movement is easier. Therefore, the flexion torque is artificially higher than the extension torque (11). Gravity correction was made after the participants' legs were brought to full extension before starting the measurement, considering the effect of gravity. The chair’s back angle is 90^0, and a pillow is placed on the lumbar region for support. The dynamometer length and all seat values have been adjusted to be optimal for the participants. The shoulder, trunk, pelvis and non-measured legs are fixed with apparatus (Picture 1).

Figure 1. Isokinetic Measurement Position of the Patient

The axis of rotation of the knees (lateral femoral epicondyle) was aligned with the mechanical axis of the dynamometer for knee flexion-extension by using the laser alignment apparatus in the dynamometer. Verbal motivation was provided during the movement and the ball was held at the highest point where the participant's leg would be lifted to realize the extension movement fully. The dynamometer arm was placed 3 cm proximal to the medial malleolus. The test was started when the participant was ready. During the test, the participant was verbally encouraged. Before starting the test, the researcher performed an exercise to understand the movement with the help of the hand. Measurements were started from the non-dominant leg. Since the tests are force measurements, 3 minutes of resting time was given between measurements. Researchers emphasize that the tests should consist of at least 5 repetitions and that less than 10 repetitions should be performed in muscle strength assessments. However, repetitions can be increased at high angular velocities (12). The test protocol values we used during the measurement are shown in Table 1. A graphical summary of all stages is shown in figure 2.

Table 1. Isokinetic dynamometer test protocol

60/60°/sec.: (CON/CON)	
Trial with submaximal force	3
Rest interval	30 seconds
Retest with maximal force	5 repetitions
Rest between the transition to next angular velocity	3 minutes

Table 2. Comparison of right and left leg knee flexion peak torque (PT) mean values for 600.s-1 angular velocity before and after radiotherapy application

					Test Time		Side* Time	
					F	P	F	P
Parameter	N	Side	Test Time	M+S.D				
P.T(Nm)	10	Right Leg	Pre-test	50.92±24.51				
	10		Post-test	63.11±24.18				
		Left Leg	Pre-test	52.33±21.88	2.986	.106	.007	.933
			Post-test	63.37± 16.13				

P.T: Peak Torque (Nm); Side: Right Left leg; Test Time: Before and after radiotherapy

Low angular velocities are used for strength tests and high angular velocities for endurance tests. The number of repetitions should be low in strength measurements, and the number of repetitions should be higher in endurance tests. (12). The lower extremity strength test was performed at low speed, with only the non-compulsive low-speed strength test planned to be applied to the patients. During the study, the researchers who conducted the study were with our patients so that they could make isokinetic muscle strength measurements without any problems.

Table 3. Comparison of right and left leg knee extension peak torque (PT) mean values for 600.s-1 angular velocity before and after radiotherapy application

					Test Time		Side* Time	
					F	P	F	P
Parameter	N	Side	Test Time	M+S.D				
P.T(Nm)	10	Right Leg	Pre-test	72.27±43.77				
	10		Post-test	65.96±40.07				
		Left Leg	Pre-test	86.61±43.57	3.426	.085	.085	.775
			Post-test	85.66±29.59				

P.T: Peak Torque (Nm); Side: Right Left leg; Test Time: Before and after radiotherapy

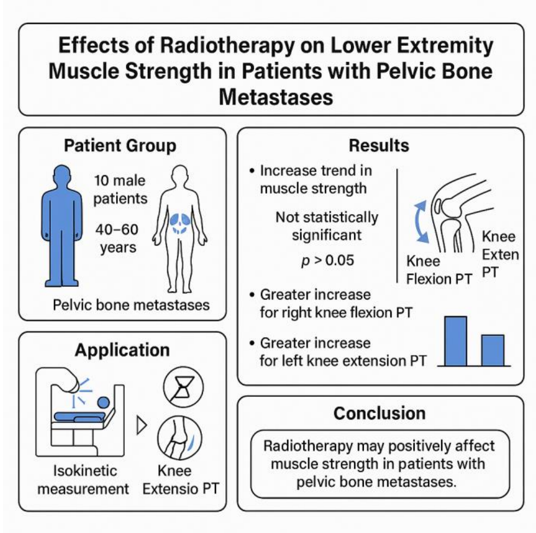


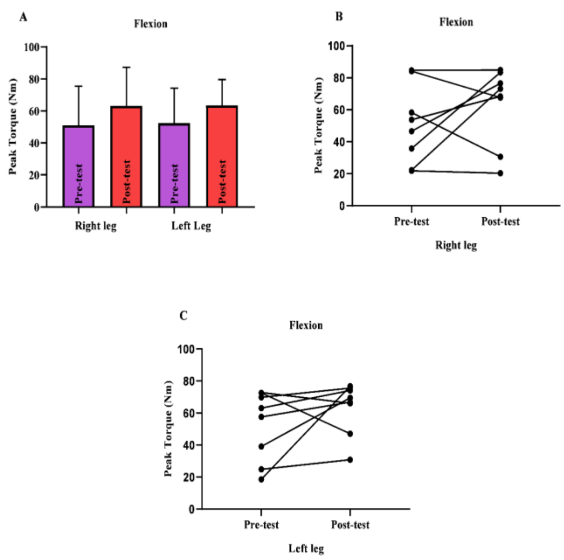
Figure 2. Graphical Abstract of Study

Statistical analysis

The analysis of the data obtained from the research was done in the SPSS 26.0 (SPSS, Inc., Chicago, IL, USA) program. Knee extension or flexion peak torque values for the right and left legs of the whole group before and after radiotherapy application was shown in bar charts as mean ± standard deviation, and individual variations were shown in scatter plot graphs. Shapiro-Wilk test results, skewness and kurtosis values were evaluated by examining whether the data showed normal distribution. According to these results, the data had a normal distribution. Two-way repeated measures ANOVA was used to compare the mean values of right and left leg knee flexion peak torque before and after radiotherapy application (Side: right_left leg*Test Time: before_after radiotherapy). In cases with a significant difference, pairwise comparisons were analyzed with the Bonferroni test. The significance level was accepted as $p<0.05$.

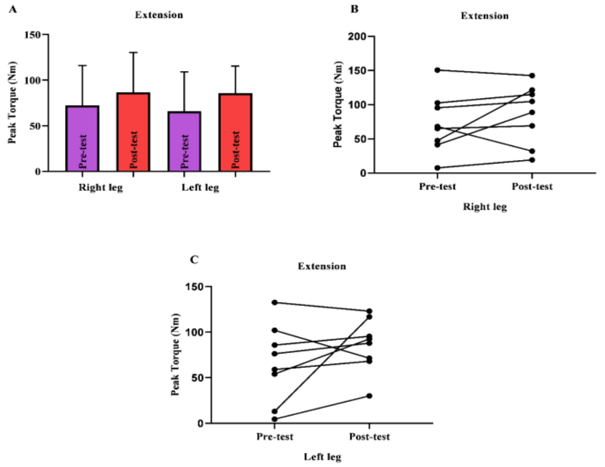
Results

As shown in Table 2, no statistically significant difference was observed in the comparison of the mean values of knee flexion peak torque before and after radiotherapy, regardless of right and left legs [$F(1,14)= 2.986$, $p=.106$, partial eta squared: .176]. According to the Bonferroni test, although there was no significant difference, it was determined that both the right and left leg peak torque values of the participants increased after radiotherapy application. In addition, it was found that the Side*Test Time interaction did not have a statistically significant effect on the mean value of knee flexion peak torque [$F(1,14)= .007$, $p=.933$, partial eta squared: .001]. Although there was no significant effect, a greater increase was found in the right leg knee flexion peak torque values of the participants compared to the left leg after radiotherapy application **(Graphic 1A, B, C).**



Graph 1. All Group, Right-Left Leg Torque Comparison After Radiotherapy Application

In Table 3, no statistically significant difference was found in the comparison of the mean values of knee extension peak torque before and after radiotherapy, without distinguishing between the right and left legs [F(1,14)= 3.426, p=.085, partial eta squared: .197]. Although there was no statistically significant difference, it was observed that the knee extension peak torque value improved for both legs after radiotherapy application. In addition, it was found that the Side*Test Time interaction did not have a statistically significant effect on the knee extension peak torque mean value [F(1,14)= .085, p=.775, partial eta squared: .006]. Although no significant effect was found, further improvements were observed in knee extension peak torque for the left leg compared with the right leg after radiotherapy application **(Graphs 2A, B, C).**



Graph 2. Right-Left Leg Torque Comparison After Radiotherapy Application

Discussion

Isokinetic devices are used successfully in muscle strength measurement (5). Evaluation of muscle strength is the main function of these systems, and measurements in these devices provide information about the dynamic performance of a muscle, such as torque, work and endurance (1). The speed of the isokinetic devices can be adjusted according to the patient's condition (1,2).
Metastasis to the bone is a common finding in the course of cancer, and skeletal metastases, which form the basis of the movement system, cause significant problems due to complications such as pain, limitation of movement, pathological fracture, cord compression, and hypercalcemia. The main symptom in metastases is pain, which is mild at first and more often at night, but gradually it can reach disturbing and life-limiting dimensions (13-15). Although studies have shown that there is a decrease in muscle strength due to toxicities in the musculoskeletal system of cancer patients, and the decrease in muscle strength becomes more evident as the dosage of treatments and the number of cures increase (16-20), studies investigating the relationship between muscle strength and quality of life are insufficient in the literatüre (21-24). In 2007, an 18-week combined exercise (aerobic, resistant) program was applied to cancer patients whose treatments were completed in the Netherlands. It was shown that these patients improved their muscle strength and cardiovascular capacity and in functional performance, symptoms and general health score parameters of quality of life (25). The findings from this study support our research. In our study, although there was no significant difference, it was determined that the participants' right and left leg knee flexion peak torque values increased after radiotherapy application. Compared to the left leg, a more significant increase was found in the knee flexion peak torque values of the right leg.
When the effect of metastatic localization areas on the treatment response is examined, While an earlier response was obtained after irradiation of the vertebra and extremities, palling of the pain was more difficult in the irradiations of the pelvis region (25). No statistically significant difference was found in comparing the mean values of knee extension peak torque before and after radiotherapy without distinguishing between the right and left legs. Although there was no statistically significant difference, it was observed that the knee extension peak torque value improved for both legs after radiotherapy application. In addition, it was found that the Side*Test Time interaction did not have a statistically significant effect on the knee extension peak torque mean values. Although no significant effect was found, further improvements were observed in knee extension peak torque for the left leg compared with the right leg after radiotherapy application. The delayed response to pain in pelvic region irradiation (26) supports our study. We could not statistically prove the full effect of radiotherapy because isokinetic measurements were not made immediately after radiotherapy.

Conclusion & Recommendations

In our study, we analyzed the effects of radiotherapy on muscle strength, especially in patients with pelvic bone metastases, using isokinetic dynamometers. As a result, radiotherapy showed a curative effect on muscle strength. We believe this study will be very useful in taking necessary precautions regarding muscle strength while establishing a treatment protocol in patients with bone metastases who have received or will receive radiotherapy. It has been observed that the applied dose of radiotherapy increases muscle strength. To achieve better results, it may be recommended to increase the dose value by considering both the effectiveness of the tumor and the level of protection of critical organs. In our study, it was very difficult to find patients because it was carried out in a specific patient group and was voluntary. Since radiotherapy produces a delayed response in patients with pelvic metastasis regarding metastatic location, it can be supported by a study in which muscle strength is measured after a certain period, not immediately after radiotherapy. In the future, a study can be planned in which the low-intensity exercise program recommended by the ACS and ACSM is applied so that the number of patients is kept higher and/or radiotherapy is received.

Limitations of the Study

In our study, we analyzed the effects of radiotherapy on muscle strength, especially in patients with pelvic bone metastases, using isokinetic dynamometers. As a result, radiotherapy showed a curative effect on muscle strength. In our study, it was tough to find patients because it was carried out in a specific patient group and it was voluntary.

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Ethical Approval

The necessary ethics committee approval was obtained in accordance with the Declaration of Helsinki by the Faculty of Medicine Clinical Research Ethics Committee with the decision numbered B.30.2.AT**.0.01.00/224.

Data Sharing Statement

None

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