

Comparison of Balance Parameter and Muscle Strength after Anterior Cruciate Ligament Reconstruction in Professional Football Players

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ABSTRACT

Aims: Most ACL injuries occur during sports activities. It is aimed to compare the anthropometric measurements, muscle strength and balance abilities of the lower extremities of professional male football players who have undergone ACL surgery and completed their rehabilitation programs.

Methodology: In both groups, anthropometric measurements, lower extremity muscle strengths with manual hand dynamometer and lower extremity balance measurements were made with an easytech balance device.

Results: An increase in right hip flexion strength was determined in football players who had undergone ACL surgery ($p < 0.05$). There was an increase in ipsilateral hip abduction angles in the surgical group ($p < 0.05$). When the data of the right and left extremities of the participants in the experimental group were compared, it was determined that there was an increase in the flexion strength of the operated knee ($p < 0.05$). When the balance data of the football players were examined, it was concluded that the right leg and double leg balance data were impaired compared to the control group ($p < 0.05$).

Conclusion: Categorizing sports injuries by type and branch of sports; it is important to determine the physical characteristics of athletes gained after treatment. We think that this approach can contribute to the design of rehabilitation programs and reduce recurrent injuries.

Keywords: Sports injury, Anterior cruciate ligament, Balance

INTRODUCTION

Sport has become one of the important parts of social life all over the world. Today, sport is defined not only as an activity field, but also as a market and, as a natural consequence, an industry. Football constitutes the largest share in the sports industry¹. The financial and moral effects of injuries in professional football players on both the athlete and the sports industry are quite high. It is observed that the frequency of ACL (Anterior cruciate ligament) injuries is increasing day by day in both professional athletes and individuals doing sports². In this context; it is important to improve the speed of athletes returning to their professional lives and to prevent injuries again³.

ACL injuries that cause instability in the knee cause functional limitations in people. It is known that these injuries cause loss of proprioceptive sensation around the knee and muscle weakness⁴. Proprioception is a sensory system that includes joint position sense and movement. Recently, it has gained importance in preventing injuries and preventing their reoccurrence⁵. The increase in social tendency to sports activities is naturally the reason for the increase in sports injury cases. Almost 50% of ligament injuries during sports activities are ACL lesions and 90% of ACL injuries occur during sports activities¹. It is important that the follow-up and evaluation of patient data be continuous in order to increase the anatomical and functional adequacy of the athletes included in the rehabilitation program to the normal level after the treatment⁶.

The knee joint, which is the largest joint of the human body, is a synovial joint consisting of the femoral condyles, tibial plateaus, patella, menisci, ligaments and bursae extending between them, and the joint capsule connecting these formations. The knee joint is very vulnerable to injury, as it has a large range of motion in the sagittal plane and provides the stiffness of the joint mostly with ligaments⁷. The forces acting on the anterior cruciate ligament during daily activities are usually tensile forces. Knee joint is the most common injury in sports injuries. The ACL is an important structure in knee kinematics and its injuries can lead to significant loss of function⁸.

Balance is to ensure the continuity of the posture depending on the gravity and the direction of the movement. It minimizes the stress on the joints by arranging the skeletal elements in the correct posture in a way that protects the body's support structures from injury and deformation⁹. The sense of proprioception has an

important role in the formation of body balance. Proprioceptive sense is the position perception of the joint and extremity provided by the neural inputs formed through the receptors in the joint and surrounding tissues. It can also be defined as the ability to be aware of the extremities at the conscious and unconscious level¹⁰. Balance and proprioceptive sense are of great importance for the preservation and maintenance of joint stability³. Also; proprioception provides dynamic stabilization and protection of the joint and is also responsible for the coordinated walking of movements and this situation is very important in regaining body balance after knee injuries⁵. A healthy sense of balance has a positive effect on the distribution of body weight on the lower extremities. In addition to this, it contributes to the recovery of joint ability and the return of people who have had surgery to their normal lives¹¹. In this context; the main purpose of our study is to investigate to what extent the balance ability and related muscle strength, joint mobility and anthropometric measurements of football players are recovered after the surgery and rehabilitation period.

METHODOLOGY

The study group and the method: Measurements made in the study were carried out at the Faculty of Medicine, Department of Anatomy, Faculty of Sport Sciences and Private Physical Therapy Rehabilitation Center.

Twenty male professional football players who had undergone isolated right ACL surgery as the experimental group and 20 sedentary male individuals who did not have any knee disease as the control group were included in the study. It was determined that the dominant body half of all participants was the right side.

Anthropometric measurements (age, height, weight, BMI, lower extremity circumference-length measurements, normal joint range of motion measurements), lower extremity muscle strengths (hip flexion, hip extension, hip abduction, hip adduction, knee extension, knee flexion, ankle dorsiflexion, ankle plantar flexion) with manual hand dynamometer, and lower extremity balance measurements were made with Easytech balance device. Balance measurements were repeated three times for 30 seconds. Measurements were evaluated separately as right leg, left leg and double leg.

Postoperative Therapy Program: A 6-month rehabilitation

program was applied to the football players in the experimental group who had undergone right knee (ACL) surgery. The patients were included in the study 6 months after the surgical operation. Before the study; care was taken to ensure that the patients did not have any pain or similar complications.

In the previously described ¹² rehabilitation program after ACL surgery; strengthening exercises, stretching exercises, isometric and isotonic exercises, resistance exercises, balance and coordination exercises, proprioception exercises, running program, cycling and plyometric exercises were applied.

Statistical analysis: In the statistical evaluation of our results, Kolmogorov-Smirnov analysis was performed for the normal distribution test. Independent T-Test was applied for those with normal distribution. Mann Whitney U statistic method was used for values that did not fit the normal distribution. Statistical analysis SPSS 22.0 (IBM, Package program) was used.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author, [MDY], upon reasonable request.

RESULTS

The average age of the athletes participating in the study was determined as 25.4 ± 5.3 for the experimental group and 26.0 ± 4.2 for the control group. The average height, weight and BMI (Body Mass Index) of the groups are given in Table-1.

Table 1: Average age, height, weight and body mass index (BMI) of the groups.

	Experimental Group (Post-operative)	Control Group (Sedentary)	P value
Age	25,40 ± 5,32	26,0 ± 4,21	0,659
Height	1,77 ± 0,59	1,76 ± 0,54	0,738
Weight	74,0 ± 6,96	73,7 ± 7,07	0,968
BMI	23,47 ± 1,20	23,54 ± 1,48	0,820

There was no significant difference between the two groups in terms of age, height, weight and BMI characteristics of the participants. The anthropometric measurements of the groups that did not differ in terms of basic physical characteristics are given in Table-2.

Table 2: Average of anthropometric measurements according to groups and statistical significance values (SIAS: Spina iliaca anterior superior; Med. mall: Medial malleolus).

	Experimental Group (Post-operative)	Control Group (Sedentary)	P value
Circumference measurements (right knee)	38,80 ± 3,172	38,45 ± 1,701	0,495
Circumference measurements (left knee)	38,65 ± 3,117	38,50 ± 1,539	0,738
Circumference measurement (10cm above right knee)	48,20 ± 2,966	46,95 ± 3,014	0,265
Circumference measurement (10cm above left knee)	47,75 ± 3,143	46,75 ± 2,511	0,341
Circumference measurement (10cm above right knee)	57,05 ± 3,692	56,70 ± 3,585	0,925
Circumference measurement (10cm above left knee)	56,75 ± 3,768	56,35 ± 3,265	0,841
Circumference measurement (10 cm below the right knee)	37,30 ± 3,011	36,95 ± 1,791	0,301
Circumference measurement (10 cm below the left knee)	37,35 ± 3,100	37,05 ± 1,849	0,383
Length measurement (right SIAS – med. mall.)	91,65 ± 4,648	91,55 ± 4,383	0,799
Length measurement (left SIAS – med. mall.)	91,55 ± 4,707	91,55 ± 4,383	0,862
Length measurement (right SIAS – patella)	48,20 ± 2,821	48,05 ± 2,282	0,495
Length measurement (left SIAS – patella)	48,15 ± 2,770	48,00 ± 2,317	0,529
Length measurement (right patella– med. mall.)	42,45 ± 2,982	40,85 ± 3,870	0,253
Length measurement (left patella– med. mall.)	42,60 ± 2,998	40,80 ± 3,607	0,162
Length measurement (umbilicus – right SIAS)	15,95 ± 1,605	15,30 ± 1,418	0,134
Length measurement (umbilicus – left SIAS)	15,95 ± 1,605	15,35 ± 1,461	0,165

Considering the anthropometric measurements taken from the important anatomical reference points of the lower extremity, there is no statistically significant difference between the groups. When the surgical group and the sedentary group were compared in terms of mean strength measurement, a significant difference was found in the increase in the right hip flexion strength of the surgical group (P<0.05) (Table-3). Also when the strength measurements were compared between the surgical extremity and the normal extremity of the experimental group, a significant difference was found in the increase in knee flexion in the surgical extremity (P < 0.05).

When the goniometric measurements made to determine the range of motion of the lower extremity were evaluated, a significant difference was found in the increase in left hip abduction of the experimental group who had undergone ACL surgery (P < 0.05) (Table-4).

Table 3: Strength measurement averages and statistical values of the lower extremity

	Experimental Group (Post-operative)	Control Group (Sedentary)	P value
Right hip flexion	34,22 ± 5,53	29,88 ± 8,06	0,042
Left hip flexion	33,98 ± 5,42	30,77 ± 6,84	0,127
Right hip extension	32,07 ± 9,23	31,64 ± 10,80	0,947
Left hip extension	31,97 ± 8,76	30,95 ± 10,26	0,820
Right hip abduction	35,59 ± 8,64	35,40 ± 12,39	0,904
Left hip abduction	37,13 ± 9,27	35,49 ± 12,81	0,989
Right hip adduction	31,76 ± 7,10	28,54 ± 11,13	0,461
Left hip adduction	30,26 ± 7,34	28,61 ± 11,03	0,925
Right knee flexion	20,34 ± 6,53	19,36 ± 3,70	0,946
Left knee flexion	20,13 ± 6,13	20,84 ± 4,07	0,363
Right knee extension	32,21 ± 6,30	32,99 ± 6,09	0,718
Left knee extension	33,25 ± 6,59	33,44 ± 5,85	0,852
Right ankle dorsie flexion	24,11 ± 3,99	23,55 ± 5,35	0,678
Left ankle dorsie flexion	23,56 ± 4,81	23,82 ± 6,33	0,820
Right ankle plantar flexion	26,33 ± 7,24	28,15 ± 3,93	0,314
Left ankle plantar flexion	25,94 ± 6,43	27,36 ± 4,12	0,461

Table 4: Goniometric measurement averages and statistical significance values of lower extremity range of motion.

	Experimental Group (Post-operative)	Control Group (Sedentary)	P Value
Right hip flexion	121,85 ± 2,66	121,75 ± 2,17	0,968
Left hip flexion	121,35 ± 1,81	121,55 ± 1,70	0,565
Right hip extension	31,25 ± 2,55	31,35 ± 1,72	0,512
Left hip extension	31,80 ± 2,3	31,05 ± 1,43	0,265
Right hip abduction	45,05 ± 2,48	44,05 ± 2,01	0,277
Left hip abduction	45,35 ± 2,03	43,55 ± 1,98	0,018
Right hip adduction	31,00 ± 1,55	31,05 ± 1,45	0,529
Left hip adduction	31,20 ± 1,64	29,05 ± 6,90	0,242
Right knee flexion	135,10 ± 2,55	137,30 ± 5,30	0,231
Left knee flexion	134,65 ± 2,70	136,45 ± 3,92	0,221
Right knee extension	0,35 ± 1,11	0,00 ± 0,000	0,602
Left knee extension	0,25 ± 1,11	0,00 ± 0,000	0,799
Right ankle dorsie flexion	21,75 ± 5,50	20,60 ± 1,27	0,461
Left ankle dorsie flexion	21,75 ± 6,73	20,50 ± 0,08	0,779
Right ankle plantar flexion	48,75 ± 6,26	49,55 ± 2,08	0,738
Left ankle plantar flexion	48,45 ± 6,32	49,75 ± 1,80	0,904

A significant difference was found between the football players who had undergone ACL surgery and the sedentary group in terms of the mean balance measurement in the right leg balance measurements of the surgical group (P < 0.05). In terms of balance measurement average, a significant difference was found in the decrease in double leg balance measurements of the surgical group (P < 0.05), (Table-5).

Table 5: Balance measurement averages and statistical significance values of the lower extremity

	Experimental Group (Post-operative)	Control Group (Sedentary)	P value
Right leg	4,22 ± 1,36	5,41 ± 1,99	0,046
Left leg	4,28 ± 1,95	4,63 ± 1,55	0,201
Double leg	5,25 ± 2,28	6,51 ± 2,44	0,023

DISCUSSION

The anterior cruciate ligament (ACL) is one of the most important

structures that plays a role in the kinematics and stability of the knee by connecting the femur and tibia¹³. ACL damage leads to impaired biomechanical function and kinematics of the knee. After the anterior cruciate ligament lesion, translational and rotational stability is impaired⁷. While this situation paves the way for serious disabilities, it also causes a significant loss of quality of life. Especially professional athletes have to go through a very difficult process after injury. Patients first experience a painful surgical process and then go through an intense and disciplined rehabilitation process that spans a long time¹. All these processes aim at restoring the anatomical structures of the patients. At the end of this process, it is aimed to regain all of the muscle strength, joint mobility, anthropometric competencies and balance parameters⁴.

The post-injury goal is to return the person to his/her daily life activities. With this, the rehabilitation process is not just for muscle strength, joint mobility and ligament flexibility¹⁴. Balance ability, which is a very important parameter, can be ignored when looking at whether people return to their former muscle strength after treatment¹⁰. It is known that the proprioceptive sense is extremely important in the extent to which the muscles contract and in the realization of appropriate movement kinematics. Especially balance is of great importance in people who are involved in sports, who have been injured due to excessive use or a trauma⁶. The extent to which the balance and proprioceptive senses of patients who have undergone surgical treatment are restored can directly affect the rehabilitation process¹⁵. In this context, we think that in our study, not only muscle strength and range of motion, but also balance functions should be investigated.

It is seen that the importance of kinesiological examinations in rehabilitation management after ACL surgery is frequently emphasized in current publications⁷. In a study conducted on patients who had undergone ACL surgery, it was reported that patients who underwent left ACL reconstruction had a decrease in ipsilateral left hip internal rotation movements. With this; It has also been noted that a reduction of approximately 30 degrees is required for ACL injury due to hip internal rotation limitation. It is stated that the decrease in hip flexion and internal rotation of the hip will increase the pressure on the knee and increase the risk of ACL injury¹⁶. Webster et al.⁸ investigated abnormal movement patterns in patients who had undergone ACL reconstruction surgery.

In the analyzes performed 10 months after the surgical procedure, they showed that the flexion angle of the operated knee was reduced. They stated that the ipsilateral hip flexion moment of the subjects increased in order to compensate for this kinematic anomaly. In our study, we found a significant difference in the increase in the ipsilateral right hip flexion strength of the surgical athlete group compared to the control group ($P < 0.05$). There was no significant difference in the degree of motion of both hip joints ($P > 0.05$). When the goniometric measurements of lower extremity movements are evaluated; It was determined that there was a significant increase in contralateral hip abduction movement in the surgical group ($P < 0.05$).

There are many studies comparing both extremities in terms of muscle strength and joint openings in patients after cruciate ligament surgery^{1,4}. It is seen that the main purpose of similar studies is to compare the contributions of the surgical technique and the rehabilitation programs applied afterward to the patients⁵. However, it is stated that the effect of determining the changes in the muscle strength and balance abilities of the athletes on the knee kinematics may contribute to the return of the athletes to their professional lives⁶. Araújo et al.¹⁷ evaluated the muscle strength of the m. vastus lateralis and m. biceps femoris after ACL surgery. When they compared the situation before and after surgery; while there was no significant difference in muscle strength of m.vastus lateralis, a difference was found in the muscle strength of m.biceps femoris in the direction of increase in the surgical extremity. When we compared the muscle strength between the operated and normal extremities, we also found a significant increase in the

flexion strength of the operated knee in the experimental group ($P < 0.05$).

In Anderson et al.⁴ comprehensive meta-analysis on ACL, the rehabilitation program which was also applied in our study was suggested and the contribution of the addition of post-operative balance exercises to the recovery process of the patients was emphasized. Also, it has been reported that the combination of balance and static stretching exercises has a reducing effect on re-injury in patients who have undergone ACL surgery due to its contribution to the sense of proprioception¹⁸. In our study, in accordance with the literature, it was determined that there was a statistically significant impairment in the right leg and double leg balance measurement values of the participants who had undergone surgery ($P < 0.05$).

Proprioceptive sense is of great importance for the preservation and maintenance of joint stability. It can also be defined as the ability to be aware of the extremities at the conscious and unconscious level³. The proprioceptive sense is perceived through receptors located in the joint and surrounding tissues. This sense is the position perception of the joint and extremity provided by neural inputs¹⁹. Post-surgical changes in the muscles involved in balance and joint movement directly affect the daily lives of individuals¹⁷. In this context, we believe that measurement, follow-up and evaluation of the sense of balance can contribute to the treatment processes of athletes, in addition to rehabilitation programs for joint regeneration and muscle strengthening.

CONCLUSION

After injuries, the body undergoes some anatomical and physiological changes in order to create its optimal balance. These asymmetrical changes in the extremities can also indirectly affect the body balance. These chain changes created by the extra load on muscle strength and extremities can affect people's return to their normal lives¹⁷. Determining and monitoring the kinesiological characteristics of professional athletes according to branches can contribute to the correct evaluation of rehabilitation processes.

In our study; An increase in the right hip flexion strength was determined in football players who had undergone ACL surgery and whose rehabilitation processes were completed. With this; There was an increase in ipsilateral hip abduction angles. In addition, when the data of the right and left extremities of the participants in the experimental group were compared, it was determined that there was an increase in the flexion strength of the operated knee. Looking at the balance data of the football players, it was concluded that the right leg and double leg balance data were impaired compared to the control group.

In addition to aiming at restoring physical characteristics in athlete injuries, it is also of great importance to prevent the recurrence of injuries^{20-24,25,26,27,28}. In this context, we think that the rehabilitation processes of the patients can be handled as a whole with the type of disability and sports branches and managed more comprehensively. We think that it would be appropriate to add exercises that can improve balance parameters to rehabilitation programs applied to improve muscle strength, joint mobility and other functional mechanisms after surgery.

Conflicts of Interest: The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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