RESEARCH ARTICLE

Return To Dance Following Arthroscopic Knee Surgeries: What Are The Differences Between Return To Sport and Return To Dance.

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NA participated in the design of the study, performed the statistical analysis and drafted the manuscript. NA, TD, VA, ANK, AH, BA conceived of the study and participated in the acquisition of data. NA, TD and VA participated in the whole design and coordination of the study, NA performed the statistical analysis and helped to draft the manuscript. All authors read and approved the final manuscript.
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Abstract
Background: Due to risks of reinjury and osteoarthritis, the timing of return to sports after surgery is important. Although there are numerous studies on the return to sports (RTS) criteria in athletes who have undergone knee surgery, there are no studies on the return to dance (RTD) criteria after knee surgery in dancers. In this retrospective clinical study, we investigated the rates of osteoarthritis and reinjury after arthroscopic knee surgery and the criteria for RTD.
Materials and Methods: In a professional dance group consisting of 84 members (mean age: 29.8 ± 9.2 range: 18 to 49 years), during an 11 year period (between January 2009 and January 2020), 14 dancers (mean age 29.1±5.7 (20-38) years) sustained knee injuries (3 meniscus tears, 4 Anterior Cruciate Ligament (ACL) tears, 1 Posterior Cruciate Ligament (PCL), 1 patellar dislocation, 1 infrapatellar bursitis, 2 Hoffa's fat pad syndromes, 2 symptomatic medial plicas) that required arthroscopic surgery. The RTD times after surgery, follow up lenghts, clinical and functional tests used for deciding on RTD were recorded.
Result: The postoperative follow up period was 56.7 ±23 (26-108) months. The rate of reinjury was 7.14% after knee surgery. All dancers who underwent knee surgery were evaluated for osteoarthritis according to the Kellgren Lawrence classification, and the ostearthridites were classified as G:0 in 7 patients, G:1 in 3 patients, and G:2 in 4 patients on final knee radiographs.
Conclusion : In dancers who have undergone arthroscopic surgery, the return to dance criteria should assess painless repeated turnout after meniscus repair, and also safe landing and postural contol after ACL reconstruction or PCL reconstruction.

Key words: Return to dance criteria; clinical decision making; ACL reconstruction; PCL reconstruction; meniscus repair.

Background:

Reinjury and development of osteoarthritis are among the serious problems that delay return to sports and lower the performance of athletes with injuries. In professional athletes, the rates of reinjury after ACL reconstruction or isolated meniscus repair were reported as 2.8%[1] and 16.2%[2] respectively. The risk of reinjury is greater after insufficient treatment or early return to sports (RTS)[3,4]. Early RTS after surgery may be associated with poor functional performance and proprioception, or inadequate quadriceps power. These may consequently lead to overloading in the joint cartilages which triggers a degenerative process resulting in osteoarthritis[4].

Due to the risks of reinjury and osteoarthritis, the timing of return back to level 1 (jumping, pivoting and hard cutting) sports after surgery is important[3,4]. There are numerous studies on the return to sports criteria after operations for ACL and meniscus tears.[5-7] In the review by Burgi, 85% of the studies used time as an RTS criterion after ACL reconstruction. Measures of participation and contextual factors were uncommonly reported as RTS criteria after ACL reconstruction. Strength (41% of studies), physical performance-based criteria (20% of studies) and patient-report criteria (12% of studies) were infrequently used as RTS criteria. Although the time for RTS is reported as 4 months in noncontact sports and 6 months for contact sports, the average suggested time is 6-12 months after the injury[8]. RTS criteria after meniscus repair include full, painless knee ROM that is symmetric with the uninjured limb, no reactive effusions with sport-specific activities, return of normalized running mechanics, appropriate neuromuscular coordination demonstrated by the ability to perform regular and single leg jumps, agility ladder drills, lateral hops, and change in direction/cutting drills, greater than 90% of strength regained for knee extension, flexion, and single-leg press, and being psychologically ready for return as demonstrated by lack of apprehension with sport-specific activities[2].

Similar to athletes, most of the injuries requiring surgery in dancers occur around the knee area[9,10]. However, there are no published studies on the criteria for return to dance (RTD) after knee surgery in dancers. In this retrospective clinical study, we investigated the criteria for RTD, and rates of osteoarthritis and reinjury following arthroscopic knee surgery in dancers.

Material and Method: In a professional dance group consisting of 84 members (mean age: 29.8 ± 9.2 range: 18 to 49 years), during an 11 year period (between January 2009 and January 2020), 14 dancers (mean age 29.1±5.7 (20-38) years) sustained knee injuries (3 meniscus tears, 4 Anterior Cruciate Ligament (ACL) tears, 1 Posterior Cruciate Ligament (PCL), 1 patellar dislocation, 1 infrapatellar bursitis, 2 Hoffa's fat pad syndromes, 2 symptomatic medial plicas) that required arthroscopic surgery. Injuries that did not require surgery were excluded and reported separately. The dance group trains for 5 days a week for 6 hours a day and performs live for 4 days a week in a 90-minute show with two intermissions. All of the data were recorded at Istanbul Bilim University archieves. Minor injuries were excluded from this study to be published as a separate paper. Injuries mostly happened during stage performances and were evaluated by the medical teamin charge at the time. All of the injuries informed to our system and dancers with serious injuries were transferred to our clinic directly. All subjects gave written informed consent. All dancers received postoperative physical therapy and rehabilitation. The surgical procedures, times for return to sports, test used for deciding on the return to dance Kellegran Lawrens classifications[11], and follow up lengths were evaluated.

Results: Following surgeries, the dancers could restart to perform live on the stage in

19,5 ±12 (range:5 to52) weeks on average. Injuries and postoperative times to return to dance was 56,7± 23 (26-108) months to follow-up with the same clinic and same surgeon for the patients. Of the 14 dancers who underwent surgery, only 1 was injured again 4 years later. The rate of reinjury is 7.14% after knee surgery. All of the dancers who underwent arthroscopic knee surgery were evaluated for osteoarthritis according to the Kellgren Lawrence classification. The osteoarthritis was classified as G:0 in 7 patients, G:1 in 3 patients, and G:2 in 4 patients on final knee radiographs. All of the operated patients continued with their careers in dancing. The surgical procedures, times for return to sports, Kellegran Lawrens classifications, and follow up lengths are shown in Table 1. The criteria for returning to dance according to injury types are seen in Table 2 and 3.

Table 1: Surgical procedures, times to return to dance, Kellegran Lawrens scales, and follow up lengths.

Table 1: Knee surgery	Postoperative practice beginning Mean ±SD (min-max) 15.4±9.1 weeks (4-36)	Postoperative stage show Mean ±SD (min-max) 19.5±12.4 weeks (5-52)	Kellegran Lawrens classification G: Grade	Follow-up time Mean ±SD (min-max) 45±22.3 months (23.5-108)
ACL reconstruction (n:4, all M, including one PLC repair)	26.5±6.4 weeks (22-36)	35±11.3 weeks (28-52)	G:0,G:1,G:2,G:2	59.2±35.9 months (26-108)
PCL reconstruction (n:1,M)	20 weeks	21 weeks	G:0	55,5 months
Meniscus repair (n:3, all M)	6.7±4.6 weeks (4-12)	8±4.3 weeks (5-13)	G:0,G:0,G:1	39.6±10.5 months (30-51)
Medial Patellofemoral ligament repair (n:1 F)	12 weeks	16 weeks	G:1	27 months
Symptomatic medial plica resection (n:2, all M)	8±1.4 weeks (7-9)	12±5.6 weeks (8-16)	G:0,G:2	39.5±17.6 months (27-52)
Hoffa fat pad syndrome (n:2, 1M, 1F)	17±1.4 weeks (16-18)	18±1.4 weeks (17-19)	G:0,G:1	45±15.5 months (34-56)
Infrapatellar bursitis (n:1, M)	8 weeks	12 weeks	G:0	23.5 months

ACL: Anterior Cruciate Ligament, PCL: Posterior Cruciate Ligament, PLC: Posterolateral Corner

We recorded the criteria used for deciding on the return to dance after physical therapy in dancers who underwent surgery. The criteria for return to dance in dancers who were included in the study and underwent ligament reconstruction (ACL, PCL) or primary ligament repair (posterolateral corner (PLC), patellofemoral ligament (PFL)) are shown in Table 2. The return to dance criteria for the dancers who underwent meniscus repair, or resection of Hoffas fat pad, symptomatic medial plica, or infrapatellar bursitis are shown in Table 3. The risk of the development of postoperative osteoarthritis in all dancers were assessed on radiographs, based on the Kellgren Lawrence classification system.

Table 2: Return to dance criteria after arthroscopic ACL and PCL reconstruction
1-No clinical complaints in the patient 2-Completeness of joint range of motion 3-No effusion in the knee 3-Negative Lachman, negative pivot shift test. 4- Successful completion of the stability test and no complaints during the test 5-Quadriceps and hamstring muscle strength should be at least 85-90% compared to the non-operated side 6- Absence of postural instability while standing on the operated side 7- Ability to perform landing without dynamic valgus fall, in repeated 3 single leg jumping. 8- Absence of ipsilateral femur adduction and internal rotation on the operated side, in repeated 3 single leg squat test.

Table 3: While presence of 9 criteria are sufficient for return to dance after arthroscopic meniscus repair, the fullfillment of the first 6 criteria were sufficient for RTD after arthroscopic Hoffa's fat pad resection, arthroscopic symptomatic medial plica resection, and bursitis excision.
1-Absence of any complaints related to the knee during daily activities 2-No knee joint effusion 3-Full range of motion in the joint 4-Quadriceps muscle athrophy < 2 cm 5-Single-leg press > %70 of normal (compared to the non-operated side) 6-Single-leg squat >60° 7- Ability to perform max 3 repeated full squats without pain. 8-Ability to perform max 3 repeated turnout without pain. 9-Ability to perform squat in max 3 repeated painless full squat.

Discussion

Reinjury risk after RTD: The rate of reinjury after meniscus repair is 16.5%. The timing of RTS is crucial due to reinjury risk[2,12]. There were 3 dancers in our study who underwent isolated meniscus repair, and their RTD periods were 8±4.3 weeks (min 5-max13). Among the dancers with meniscus repairs, only one had a reinjury. This patient returned to dance 13 weeks after meniscus repair, and after dancing actively for 4 years he had revision surgery due to a reinjury. A comprehensive review reported a mean period of 4-6 months in return to sports after isolated

meniscus repair[2,12]. In our opinion, dancers should not return to dance before 6 months following a meniscus repair. In contrast to athletes, dancers may expose their menisci to rerupture by repetitive fast full squat and stand up, turnout figures. These are risky moves in the formation of a meniscus tear[9,10]. Therefore, we added the prerequisites of performing maximum 3 repetitive painless turnouts, maximum 3 repetitive full squats, and squats in maximum 3 repetitive full turnouts to the criteria of returning to dance. We did not add a certain time period to RTD after meniscus repair. Scissoria wrote that a forceful flexion causes pain in the posterior horn rupture; similarly, a forceful extension causes pain in the anterior horn rupture. Meniscal tears occur from percussive squats or from "screwing the knee" to increase turnout in ballet trainees[9,10]. In Anatolian folk dances, the dancers frequently perform repeated turnout, fast squat standup, and turning around on single foot stance, which are risk factors for meniscus injuries[9,10]. We therefore believe that completion of 6 months should be added to the RTD after surgery criteria.

The rate of reinjury (re-rupture) in ACL reconstruction after returning to sports is between 5-15%[13]. One of the most significant causes of reinjury is early RTS after surgery[14]. The average recommended RTS period after ACL reconstruction is between 4 and 9 months. Previous studies have shown that 65-88% of the patients returned to sports within one year[14]. According to Rembaud et al., 275 athletes who underwent ACL reconstruction returned to training 6-9 months later, and to competiton 9-12 months later[14]. Erickson et al. reported that following ACL rupture, 77% of soccer players returned to sports after a mean period of 10 months[15]. Return to sports after ACL injury was 80% in NBA players[15]. In our study we did not see any reinjuries during a follow up period of 59.2±35.9 (26-108) months.

Time to RTD: In our study, the patients returned to dance 35±11.3 (28-52) weeks after ACL reconstruction. The patient with PCL reconstruction returned 21 weeks later. There were no reinjuries in these patients. In a comprehensive review of ACL injuries it was reported that in noncontact sports, return to sports 4 months after surgery could be accepted as an RTS criteria[8]. On the other hand, others reported that the risk of reinjury increased by 51% in those who returned to sports after 6 months compared to 9 months[14]. Harner et al. stated that the amount of time before return was 6.5 months for jumping sports, 5 months for light sports, 5.8 months for moderate sports, and 8.1 months for strenuous sports[16]. Classical ballet and modern dancers perform strenuous and intense jumps as much as other team (basketball, football, and volleyball) athletes[17]. During their daily training and practice, dancers perform more than 200 jumps and landings. Due to aesthetic performance requirements, most of these are single leg landings[18]. The Lezginka ballet jumps which are part of Anatolian folk dances, are faster and more fierce compared to ballet jumps, therefore constitute risks for ACL and PCL injuries[9,10]. In our study, 4 patients with ACL reconstruction (follow up 59.2±35.9 months) and 1 patient with PCL reconstruction (follow up 55.5 months) were Lezginka dancers, and none of them sustained a reinjury. Therefore, we believe that RTD can be allowed 9 months after ACL reconstruction and PCL reconstruction.

Osteoarthritis risk after RTD: Even in the absence of previous injuries, athletes are already at risk for moderately severe hip and knee ostoarthritis (OA). In the long term after an injury, the risk of OA increases due to joint degeneration. During the occurrence of ACL injury, the femoral condyles hit the plateau and cartilage injury also occurs. The subsequent knee instability leads to cartilage wear and formation of OA. ACL reconstruction decreases the incidence of OA, but does not totally eliminate it[15,19]. However not all patients develop OA after ACL reconstruction; radiographic OA is evident in approximately

one in two patients, and one in three will have symptomatic radiographic OA within 10–15 years of injury[20]. In our study, mean age of the 4 patients who underwent ACL reconstruction was 38.2±7.9 (29-48), with mean follow up of 59.2±35.9 (26-108) months. The OA degrees according to Kellegran Lawrens classification were G:0 in one dancer, G:1 in one, and G:2 in two.

Menisectomy, applied widely in the past, has been replaced by meniscus repair due to severe early OA outcomes. The menisci carry vital significance for knee joint cartilage and need to be repaired when they are torn[21]. All dancers with meniscus tears underwent repair, and no menisectomies were performed. According to Kellegran Lawrens classification, the OA degrees in dancers who had meniscus repairs were G:0 in 2 dancers, and G:1 in one. The G:1 dancer is now 41 years old, and underwent repair twice. We did not see any severe osteoarthritis in dancers who had meniscus repairs.

Criteria for RTD: Burgi et al. classified RTS criteria under six categories: time, muscle power, hop test, clinical assessment, performance based criteria and patient reports. In determining the RTS criteria, 85% of the studies used time, 41% used isokinetic and isometric tests of quadriceps and hamstring muscles, 26% used clinical assessments, 20% used performance based criteria, 15% used plyometric, speed, stability tests, and 12% used subjective reports such as passive range of motion and pain[8]. In that review, of the 159 studies that included RTS criteria 85% reported on the time for returning to sports, which was 4 months for noncontact sports, 6 months for contact sports, with an average period of 6-12 months[8]. The review also emphasized that 73% of the studies, which used at least one hop test as RTS criteria, required a minimum of 85% LSI (limb symmetry index)[8]. Clinical assessments include ligament stability tests, active range of motion, stroke test and leg circumference measurement. Performance based criteria include proprioception, Y-balance, coordination tests, functional stability, lactate aerobic-anaerobic threshold tests[8].

A systemic review that analyzed 264 studies on RTS after ACL reconstruction showed that 40% of the studies included return to sports criteria, 32% focused on the postoperative period required for return to sports, 15% focused on detailed time and subjective criteria, and 13% focused on objective criteria[3]. In another review that analyzed 222 articles on RTS criteria after ACL reconstruction, 83 articles were included, and 5 main RTS criteria emerged as a result: psychologic factors, performance/functional tests, power tests, time, modifiable and non modifiable risk factors[5]. In that review, for the objective criteria, 9% of the studies used reaching 80-90% of the quadriceps and hamstring muscle power on the contralateral side, 6% used effusion and joint range of motion, 4% used single leg hop test, 1 used stability, and 1 used questioning forms[5].

Although there are numerous studies reporting on the RTS criteria after ACL reconstruction, currently none of the studies has a predictive validity[22]. Proximal neuromuscular control is crucial in ACL reinjury prevalance. The determinants of ACL reinjury are neuromuscular control asymmetries, the initiation of rotation moment in landing, knee movement and hip rotation in the frontal plane, muscle powers of the hip rotator and extensor muscles, aymmetry of knee movements in the sagittal plane and deficiency in the postural stability, and loading asymmetries after reconstruction during the first 2 years[23]. The difference in the quadriceps muscle power between the operated and contralateral side decreases down to 10-15% around postoperative 18-24 months. Lower extremity asymmetries during jumping and landing activities are seen two years after ACL reconstruction[23].

The level of neuromuscular control around the hip and knee, and postural stability are biomechanical factors that play important

roles in reinjury. Biomechanical specific factors which cause reinjury, as described by Paterno et al., include dynamic valgus with the vertical drop test, valgus malalignment, greater asymmetry in internal knee extensor moment at initial contact, increased hip rotation moment, and a deficit in single leg postural stability of the involved limb[13].

Core stability is the ability of the lumbopelvic hip complex to prevent buckling and to return to equilibrium after perturbation. Although static elements (bone and soft tissue) contribute to some degree, core stability is predominantly maintained by the dynamic function of muscular elements. There is a clear relationship between trunk muscle activity and lower extremity movement. Core stability also may contribute to the etiology of ACL injury[24]. During landing after a jump, the adduction and internal rotation of the hip causes the knee to go into valgus and external rotation relative to the femur. This may lead to impingement of the ACL in the femoral notch and stretching of the ligament, which may result in its tear[25]. Sommer reported markedly greater femoral adduction and internal rotation motion with the onset of fatigue. He proposed that the cause for this movement tendency was the inability of the athletes to generate sufficient torque in the gluteal muscles, hamstrings, and abdominal muscles to resist external moments at the hip and knee[25]. The formation of a dynamic valgus in vertical drop test demonstrates excessive movement of the femur into adduction and internal rotation, both of which are positive signs of decreased core muscle capacity[24]. The single-leg squat test is a very simple test of core stability. During this test, patients are asked to stand on one leg and squat to a predetermined depth. A contralateral pelvic drop and femoral adduction or internal rotation are considered evidence of decreased hip muscle capacity. Compensatory strategies to decrease the demand on the gluteus medius are common. For example, patients may use more proximal muscles to elevate the pelvis or shift the weight over the supporting leg to decrease the lever arm for the center of mass. The examiner may have the patient repeat this test movement several times to obtain a more complete assessment of lower extremity alignment in the setting of hip and thigh muscle fatigue[24]. Therefore we added the single-leg squat test, which is a simple test to assess core stability, to our RTD criteria.

Return to sports after surgical treatment of PCL injuries has not been sufficiently analyzed. In a study on isolated PCL reconstruction, Ryan C et al. reported a 78.6% rate for return to sports, which was 8 months after surgery, and there were no reinjuries during the 6.3 year follow up period[26]. In our study, the dancer with the isolated PCL injury returned to dance 21 weeks after PCL reconstruction, and did not have a reinjury during the 55.5 month follow up. The degree of OA was G:0 according to Kellegran Lawrens classification.

The role of medial patellofemoral ligament (MPFL) repair in the management of patellar instability is debated. Compared to repair, the reconstruction of the MPFL is reported to yield better midterm outcomes and lower recurrence rates[27]. On the other hand, repair is more strightforward and has a lower risk of stiffness (reduced mobility), also reconstruction may be associated with graft malpositioning or risk of patellar fracture due to overtensioning[28]. In a systematic review of 18 studies, 33.6% of those who underwent surgery could not return to sports, and 33.6% returned 6 months after surgery. In the same review, using time-based criteria, 51.4% suggested 6 months as the ideal time for return to full activity, while %17 percent recommended 3 months of rehabilitation before returning to full activity[29]. In our study we performed primary repair of the MPFL tear, and did not encounter any reinjuries during a 27 month follow up period. The dancer with MPFL repair could return to dance 16 weeks after surgery, and the degree of OA according to Kellegran Lawrens classification is G:1.

Patients with OA in the knee have a significantly higher (66.9%) rate of symptomatic medial plica. Cartilage degeneration on the surface of the medial condyle may coexist with medial plica. The severity of the degeneration has been shown to be positively correlated with the severity of the medial plica and patient's age[30]. In our study, the time to return to dance in the 2 dancers who underwent symptomatic plica resection were 12±5.6 (8-16) weeks. During the follow up of these two dancers which was 39.5±17.6 (27-52) months, the degrees of osteoarthritis were G:0 and G:2 according to Kellegran Lawrens classification. Two dancers with Hoffas fat pad resection returned to dance after a mean period of 18±1.4 (17-19) weeks, and their osteoarthritis degrees were G:0 and G:1 according to Kellegran Lawrens classification during the follow up period of 45±15.5 months (34-56). The dancer who underwent infrapatellar bursitis resection returned to dance 12 weeks later, and during the 23.5 month follow up period the degree of osteoarthritis is G:0 according to Kellegran Lawrens classification.

One of the limitations of our study is the limited number of dancers. We believe that our study is noteworthy because there is no other study which investigated the return to dance after knee surgery in dancers.

Although injuries requiring surgery are similar between dancers and athletes, return to dance may have some nuances due to the presence of some differences between these two groups[9]. Although the criteria for returning to dance are similar to the criteria for returning to sports after arthroscopic surgery, we believe some differences must be established because some moves are specific to dancing. Because the turnout figure constitutes a risk factor for meniscus tears, painless turnout must be tested among the criteria for returning to dance. Inappropriate landing after jump is one of the most significant factors in the formation of anterior and posterior cruciate ligament tears. Therefore landing and postural control must be tested after cruciate ligament tears.

Conclusion

In dancers who have undergone arthroscopic surgery, the return to dance criteria should assess painless repeated turnout after meniscus repair, and also safe landing and postural contol after ACL reconstruction or PCL reconstruction. We believe that our study can serve as a guide for further studies. More comprehensive studies are necessary on this topic.

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