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Jeffrey B. Driban
Tufts University

Heather K. Vincent
University of Florida

Thomas H. Trojian
Drexel University

Kristin R. Ambrose
University of North Carolina - Chapel Hill

Shelby Baez
Michigan State University

See next page for additional authors

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Preventing Osteoarthritis After an Anterior Cruciate Ligament Injury: An Osteoarthritis Action Alliance Consensus Statement

Jeffrey B. Driban, PhD, ATC, CSCS*; Heather K. Vincent, PhD†; Thomas H. Trojian, MD‡; Kirsten R. Ambrose, MS§; Shelby Baez, PhD, ATC‖; Nicholas Beresic, EdD, CSCS§; David J. Berkoff, MD¶; Leigh F. Callahan, PhD§; Bruce Cohen, PhD, CSCS#; Madison Franek, PT, DPT; Yvonne M. Golightly, PT, MS, PhD§; Matthew Harkey, PhD, ATC‖; Christopher M. Kuenze, PhD, ATC‖; Mary Catherine Minnig, MS††; Ali Mobasheri, BSc, MSc, DPhil (Oxon)‡‡§§‖‖¶¶; Adam Naylor, EdD##***; Connie B. Newman, MD†††; Darin A. Padua, PhD, ATC‡‡‡; Brian Pietrosimone, PhD, ATC¶‡‡‡§§§; Daniel Pinto, PT, PhD‖‖‖‖; Hayley Root, PhD, MPH, ATC¶¶¶; Matthew Salzler, MD###; Laura C. Schmitt, PT, MPT, PhD****; Lynn Snyder-Mackler, PT, ATC, ScD††††; Jeffrey B. Taylor, PT, DPT, PhD, CSCS‡‡‡‡; Louise M. Thoma, PT, DPT, PhD§§§§; Kevin R. Vincent, MD, PhD†; Elizabeth Wellsandt, PT, DPT, PhD‖‖‖‖‖‖‖; Monette Williams¶¶¶¶¶**

*Division of Rheumatology, Allergy, and Immunology, Tufts Medical Center, Boston, MA; †UF Health Sports Performance Center, Department of Physical Medicine and Rehabilitation, University of Florida, Gainesville; ‡College of Medicine, Drexel University, Philadelphia, PA; §Osteoarthritis Action Alliance, Thurston Arthritis Research Center, University of North Carolina, Chapel Hill; ‖Department of Kinesiology, Michigan State University, East Lansing; ¶Department of Orthopaedics, University of North Carolina, Chapel Hill; #Excusercise, LLC, Waltham, MA; **Wellness Center at Meadowmont, Department of Therapy Services, University of North Carolina, Chapel Hill; ††Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina, Chapel Hill; ‡‡Research Unit of Medical Imaging, Physics and Technology, Faculty of Medicine, University of Oulu, Finland; §§Department of Regenerative Medicine, State Research Institute Centre for Innovative Medicine, Vilnius, Lithuania; ‖‖‖‖Department of Joint Surgery, First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China; ¶¶World Health Organization Collaborating Centre for Public Health Aspects of Musculoskeletal Health and Aging, Liège, Belgium; ##Telos SPC, Boston, MA; ***Deloitte US, Boston, MA; †††Department of Medicine, Division of Endocrinology, Diabetes, and Metabolism, School of Medicine, New York University; ‡‡‡Department of Exercise and Sport Science, University of North Carolina, Chapel Hill; §§§MOTION Science Institute, Department of Exercise and Sport Science, University of North Carolina, Chapel Hill; ‖‖‖‖‖‖Department of Physical Therapy, Marquette University, Milwaukee, WI; ¶¶¶Department of Physical Therapy and Athletic Training, Northern Arizona University, Flagstaff; ###Division of Sports Medicine, Department of Orthopaedic Surgery, School of Medicine, Tufts Medical Center, Boston, MA; ****Division of Physical Therapy, School of Health and Rehabilitation Sciences, The Ohio State University, Columbus; ††††Department of Physical Therapy, University of Delaware, Newark; ‡‡‡‡Department of Physical Therapy, Congdon School of Health Sciences, High Point University, NC; §§§§Division of Physical Therapy, Department of Allied Health Sciences, University of North Carolina, Chapel Hill; ‖‖‖‖‖‖‖‖Division of Physical Therapy Education, University of Nebraska Medical Center, Omaha; ¶¶¶¶Triangle Multisport, Durham, NC

After an anterior cruciate ligament (ACL) injury, people need secondary prevention strategies to identify osteoarthritis at its earliest stages so that interventions can be implemented to halt or slow the progression toward its long-term burden. The Osteoarthritis Action Alliance formed an interdisciplinary Secondary Prevention Task Group to develop a consensus on recommendations to provide clinicians with secondary prevention strategies that are intended to reduce the risk of osteoarthritis after a person has an ACL injury. The group achieved consensus on 15 out of 16 recommendations that address patient education, exercise and rehabilitation, psychological skills training, graded-exposure therapy, cognitive-behavioral counseling (lacked consensus), outcomes to monitor, secondary injury prevention, system-level social support, leveraging technology, and coordinated care models. We hope this statement raises awareness among clinicians and researchers on the importance of taking steps to mitigate the risk of osteoarthritis after an ACL injury.

Knee injuries are common and account for more than 625 000 emergency department visits each year in the United States.[1] The incidence increased >20% between 2002 and 2014.[2,3] Many knee injuries occurred in young, physically active people; more than 1 in 3 anterior cruciate ligament (ACL) reconstructions (ACLRs) were performed in high school or college athletes in the United States.[4–6] Reconstruction of the ACL often led to positive outcomes, such as a return to physical activity (eg, sport, occupational, recreational). Unfortunately, for at least 1 in 3 young patients, the knee injury was a catalyst to living with knee osteoarthritis for most of their lives. Many younger adults with knee osteoarthritis experienced reductions in quality of life, physical activity levels, and physical function—all of which may have led to long-term psychosocial and psychological concerns (eg, depression), economic challenges (eg, high medical costs), and comorbidities (eg, cardiovascular disease).[7–10]

Chronic knee symptoms indicative of early-onset knee osteoarthritis were present in a number of patients within a few years after an ACL injury.[11–15] Various early (preradiographic) osteoarthritis criteria were met by 28% to 54% of adolescents or young adults based on their self-reported knee symptoms 6 months after an ACLR.[11] Furthermore, 1 to 3 years after ACLR, 36% of people perceived their knee symptoms as unacceptable, including 10% to 13% who believed their treatment failed,[12,13] and 28% who were dissatisfied with their knee.[14] Between 2 and 6 years after ACLR, 40% of people reported symptoms that may have led to medical care, and 12% described a clinically relevant increase in knee pain during these 4 years.[15] Up to 37% of patients underwent a subsequent knee surgery within 5 years after an ACLR,[15,16] which elevated the risk of negative outcomes (eg, greater knee symptoms).[16] Finally, after an ACL injury, regardless of reconstruction, 1 in 3 people had radiographic knee osteoarthritis (ie, presence of a definite osteophyte) within 10 years,[17–19] creating "young people with old knees." In the United States, the economic burden of individuals with a history of ACLR was greater than $7.6 billion per year.[7]

Prevention of the long-term burden of knee osteoarthritis among people after an ACL injury is urgently needed. In addition to optimizing short-term outcomes (eg, return to activity), a focus on secondary prevention of osteoarthritis can help preserve quality of life and wellness for the remainder of the patients' lives. The goal of secondary prevention is to identify an injury, illness, or disease at its earliest stages so that interventions can be implemented to halt or slow its progression toward long-term problems. The current literature on secondary prevention for people with an ACL injury lacks high-quality evidence. In the absence of consistent, evidence-based conclusions from the literature, consensus guidelines can be established by leveraging expert opinion and clinician experience.[20] Consensus statements fill a unique role in emerging fields with insufficient evidence to inform clinical practice guidelines.[21]

Our goal was to provide clinicians with secondary prevention recommendations that were intended to (1) reduce the risk of osteoarthritis after a person has an ACL injury and (2) provide insight into areas that needed additional research. These recommendations, which were based on the available evidence and expertise from an interdisciplinary panel, encompassed a broad approach to mitigate the risk of osteoarthritis from the time of injury until the diagnosis of osteoarthritis, when osteoarthritis treatment guidelines should be consulted.[22–24] We acknowledged the dearth of high-quality evidence (eg, randomized trials) to inform these recommendations. Therefore, we included all dissenting opinions from members of our task force to facilitate future discussion. Furthermore, we envisioned that this document will need to be revised in 5 to 10 years to reassess the recommendations based on emerging evidence.

SUMMARY AND RECOMMENDATIONS

The task group developed 16 preliminary recommendations (Table) to address the areas of patient resources and education, comprehensive rehabilitation programs for safe return to sport, psychological skills training, regular physical activity participation, standardized physical testing, patient support programs, and ethically sound use of technology to support recovery. Except for the cognitive-behavioral counseling recommendation (77% support), all recommendations achieved a consensus, with >80% of voters supporting each recommendation. We ordered the recommendations in part based on the timing of when the recommendations could be implemented for each patient. However, the last 4 recommendations with a consensus are overarching recommendations (eg, social support, use of technology, and coordinated care programs) that could help implement the preceding recommendations.

These consensus-based recommendations provide clinicians with secondary prevention strategies intended to reduce the risk of osteoarthritis in patients after an ACL injury. The recommendations describe a comprehensive approach to addressing a patient's physical and mental well-being after an ACL injury. We hope these recommendations foster more discussion on how we can help ensure

Table. Consensus on Recommendations for Secondary Prevention of Osteoarthritis After an Anterior Cruciate Ligament (ACL) Injury

Recommendation[a]	Support in Final Round, %
Recommendations with consensus (total = 15)	
Provide accessible resources that health care providers can distribute to a patient.	95
Provide educational opportunities to health care professionals regarding how to best educate patients about osteoarthritis prevention.	100
A toolkit should be developed to enable the caregiver to identify a patient's willingness for rehabilitation and the patient's preferred mode of obtaining self-management resources.	91
After an ACL injury or reconstruction, individuals should undergo a supervised, comprehensive, and progressive rehabilitation program to address impairments and neuromuscular deficits, specifically those related to quality of movement, knee range of motion, quadriceps muscle strength/performance, and functional performance, before return to activity.	100
Before full reintegration into a sport, individuals should gradually resume sport-specific training to restore metabolic conditioning, build tolerance to chronic training loads, and adopt desired movement strategies.	100
After an ACL injury, individuals should be encouraged to meet the *Physical Activity Guidelines for Americans*, 2nd edition.[25]	100
Psychological skills training should be considered as part of the short-term and long-term care plans after ACL injury and reconstruction to prevent reinjury, improve overall health and wellness, and encourage engagement in and adherence to physical activity.	86
Graded exposure therapy can be added to therapy programs after ACL injury and reconstruction to overcome fear and prevent reinjury.	91
Patients should be monitored regularly after an ACL injury using a comprehensive approach, including patient-reported outcomes, performance-based outcomes, and measures of disease progression.	100
A multifaceted return-to-sport test battery should be used to inform a shared decision among all stakeholders (eg, patient, parents, health care team, and coach) when determining readiness to return to play.	95
A multifaceted preventive training program should be implemented that includes strategies to improve agility, balance, flexibility, strength, and movement quality in order to reduce the risk of secondary injury.	95
Organizations should optimize socially supportive environments for athletes, service members, employees, providers, families, and caregivers. This can be achieved by recognizing and providing support for psychosocial stressors during the rehabilitation process, including injury-related stigma, uncertainty regarding return to activity, and threats to personal identity.	100
Technology should be used to enable individuals with a knee injury to monitor their physical and psychological well-being over time, access evidence-based educational materials developed specifically for their needs, and engage in health promotion.	100
Practitioners ought to consider both the ethics and effectiveness of how and which technology is adopted for monitoring health outcomes and osteoarthritis prevention after joint injury.	82
An interdisciplinary, coordinated, patient-centered care strategy is recommended to comprehensively address the needs of patients with a history of knee injury.	100
Proposed recommendations lacking consensus[a]	
Cognitive-behavioral counseling should be considered to promote patient engagement with therapies and exercise, prevent reinjury, and improve overall health and wellness after ACL injury or reconstruction.	77

[a] Consensus was defined as >80% of voters supporting a recommendation.

the long-term wellness of people after joint injury, not just after ACL injury, and spark discussion about what patients need to know to be "informed consumers" in a health care system. This consensus statement can also guide research because each recommendation requires high-quality evidence to justify and refine the advice derived from expert opinion and clinician experience. We also hope this document and the accompanying evidence review raise awareness among clinicians and researchers and encourage them to take steps to mitigate the risk of osteoarthritis after an ACL injury.

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REFERENCES

1. Gage BE, McIlvain NM, Collins CL, Fields SK, Comstock RD. Epidemiology of 6.6 million knee injuries presenting to United States emergency departments from 1999 through 2008. *Acad Emerg Med*. 2012;19(4):378–385. doi:10.1111/j.1553-2712.2012.01315.x
2. Gray AM, Buford WL. Incidence of patients with knee strain and sprain occurring at sports or recreation venues and presenting to United States emergency departments. *J Athl Train*. 2015;50(11):1190–1198. doi:10.4085/1062-6050-50.11.06
3. Herzog MM, Marshall SW, Lund JL, Pate V, Mack CD, Spang JT. Incidence of anterior cruciate ligament reconstruction among adolescent females in the United States, 2002 through 2014. *JAMA Pediatr*. 2017;171(8):808–810. doi:10.1001/jamapediatrics.2017.0740
4. Mall NA, Chalmers PN, Moric M, et al. Incidence and trends of anterior cruciate ligament reconstruction in the United States. *Am J Sports Med*. 2014;42(10):2363–2370. doi:10.1177/0363546514542796
5. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. *J Athl Train*. 2007;42(2):311–319.
6. Joseph AM, Collins CL, Henke NM, Yard EE, Fields SK, Comstock RD. A multisport epidemiologic comparison of anterior cruciate ligament injuries in high school athletics. *J Athl Train*. 2013;48(6):810–817. doi:10.4085/1062-6050-48.6.03
7. Mather RC III, Koenig L, Kocher MS, et al. Societal and economic impact of anterior cruciate ligament tears. *J Bone Joint Surg Am*. 2013;95(19):1751–1759. doi:10.2106/JBJS.L.01705
8. Driban JB, Harkey MS, Liu S-H, Salzler M, McAlindon TE. Osteoarthritis and aging: young adults with osteoarthritis. *Curr Epidemiol Rep*. 2020;7:9–15. doi:10.1007/s40471-020-00224-7
9. Snoeker B, Turkiewicz A, Magnusson K, et al. Risk of knee osteoarthritis after different types of knee injuries in young adults: a population-based cohort study. *Br J Sports Med*. 2020;54(12):725–730. doi:10.1136/bjsports-2019-100959
10. Meehan WP, Weisskopf MG, Krishnan S, et al. Relation of anterior cruciate ligament tears to potential chronic cardiovascular diseases. *Am J Cardiol*. 2018;122(11):1879–1884. doi:10.1016/j.amjcard.2018.08.030
11. Harkey MS, Baez S, Lewis J, et al. Prevalence of early knee osteoarthritis illness among various patient-reported classification criteria after anterior cruciate ligament reconstruction. *Arthritis Care Res (Hoboken)*. 2022;74(3):377–385. doi:10.1002/acr.24809
12. Ingelsrud LH, Granan L-P, Terwee CB, Engebretsen L, Roos EM. Proportion of patients reporting acceptable symptoms or treatment failure and their associated KOOS values at 6 to 24 months after anterior cruciate ligament reconstruction: a study from the Norwegian Knee Ligament Registry. *Am J Sports Med*. 2015;43(8):1902–1907. doi:10.1177/0363546515584041
13. Roos EM, Boyle E, Frobell RB, Lohmander LS, Ingelsrud LH. It is good to feel better, but better to feel good: whether a patient finds treatment 'successful' or not depends on the questions researchers ask. *Br J Sports Med*. 2019;53(23):1474–1478. doi:10.1136/bjsports-2018-100260
14. Ardern CL, Österberg A, Sonesson S, Gauffin H, Webster KE, Kvist J. Satisfaction with knee function after primary anterior cruciate ligament reconstruction is associated with self-efficacy, quality of life, and returning to the preinjury physical activity. *Arthroscopy*. 2016;32(8):1631–1638.e3. doi:10.1016/j.arthro.2016.01.035
15. Wasserstein D, Huston LJ, Nwosu S, et al; MOON Group. KOOS pain as a marker for significant knee pain two and six years after primary ACL reconstruction: a Multicenter Orthopaedic Outcomes Network (MOON) prospective longitudinal cohort study. *Osteoarthritis Cartilage*. 2015;23(10):1674–1684. doi:10.1016/j.joca.2015.05.025
16. Filbay SR, Roos EM, Frobell RB, Roemer F, Ranstam J, Lohmander LS. Delaying ACL reconstruction and treating with exercise therapy alone may alter prognostic factors for 5-year outcome: an exploratory analysis of the KANON trial. *Br J Sports Med*. 2017;51(22):1622–1629. doi:10.1136/bjsports-2016-097124
17. Frobell RB, Roos HP, Roos EM, Roemer FW, Ranstam J, Lohmander LS. Treatment for acute anterior cruciate ligament tear: five year outcome of randomised trial. *BMJ*. 2013;346:f232. doi:10.1136/bmj.f232
18. Harris KP, Driban JB, Sitler MR, Cattano NM, Balasubramanian E, Hootman JM. Tibiofemoral osteoarthritis after surgical or nonsurgical treatment of anterior cruciate ligament rupture: a systematic review. *J Athl Train*. 2017;52(6):507–517. doi:10.4085/1062-6050-49.3.89
19. Luc B, Gribble PA, Pietrosimone BG. Osteoarthritis prevalence following anterior cruciate ligament reconstruction: a systematic review and numbers-needed-to-treat analysis. *J Athl Train*. 2014;49(6):806–819. doi:10.4085/1062-6050-49.3.35
20. Görtz S, Tabbaa SM, Jones DG, et al; MOCA Committee. Metrics of OsteoChondral Allografts (MOCA) group consensus statements on the use of viable osteochondral allograft. *Orthop J Sports Med*. 2021;9(3):2325967120983604. doi:10.1177/2325967120983604
21. Joshi GP, Benzon HT, Gan TJ, Vetter TR. Consistent definitions of clinical practice guidelines, consensus statements, position statements, and practice alerts. *Anesth Analg*. 2019;129(6):1767–1770. doi:10.1213/ane.0000000000004236
22. Bannuru RR, Osani MC, Vaysbrot EE, et al. OARSI guidelines for the non-surgical management of knee, hip, and polyarticular osteoarthritis. *Osteoarthritis Cartilage*. 2019;27(11):1578–1589. doi:10.1016/j.joca.2019.06.011
23. Kolasinski SL, Neogi T, Hochberg MC, et al. 2019 American College of Rheumatology/Arthritis Foundation guideline for the management of osteoarthritis of the hand, hip, and knee. *Arthritis Rheumatol*. 2020;72(2):220–233. doi:10.1002/art.41142

24. Nelson AE, Allen KD, Golightly YM, Goode AP, Jordan JM. A systematic review of recommendations and guidelines for the management of osteoarthritis: the chronic osteoarthritis management initiative of the US Bone and Joint Initiative. *Semin Arthritis Rheum*. 2014;43(6):701–712. doi:10.1016/j.semarthrit.2013.11.012

25. US Department of Health and Human Services. *Physical Activity Guidelines for Americans*, 2nd edition. US Department of Health and Human Services; 2018. Accessed December 20, 2022. https://health.gov/sites/default/files/2019-09/Physical_Activity_Guidelines_2nd_edition.pdf

Address correspondence to Jeffrey B. Driban, PhD, ATC, CSCS, Division of Rheumatology, Allergy, and Immunology, Tufts Medical Center, 800 Washington Street, Box 406, Boston, MA 02111. Address email to jeffrey.driban@tufts.edu.