



preservation of muscle mass, continued physical activity, access to health care, comorbidities, and weight changes are other aspects to consider. Each of these aspects of the life of a former NFL player affects not only the joint health but also the overall well-being.

Understanding characteristics of the sport and health behaviors that synergize to create clinically relevant pathology present an opportunity for prevention that is vital for the health of former football players and for the health of future generations of football players. Prevention of joint injuries and their chronic sequelae during sports participation is of paramount importance. Preventative measures, such as mandatory knee braces for offensive linemen and teaching rugby style tackling, have been two such approaches to prevention of musculoskeletal injuries in the sport. Management of recognized joint injuries may help enhance tissue healing and address risk factors for progression to advanced arthritis. For example, the chondrotoxic and tenotoxic effects of corticosteroids and anesthetics suggest that alternative strategies to modify inflammation may be more appropriate. Lifestyle factors, including diet, sleep, excess weight gain, and other behaviors, may influence both injury management and prevention. There is a clear association with metabolic syndrome and osteoarthritis. In addition, reduced mental health is associated with increased OA pain and pain flares. Targeted interventions may improve quality of life, particularly as it relates to joint health in current and former NFL players. For example, recognizing weight gain may be required for certain playing positions to optimize performance during active playing years and may create opportunities for prevention by targeting this after active playing years. This could include weight loss programs targeted at reducing BMI after completing professional careers that may reduce demand on joints and soft tissue. Similar post-career models have been proposed and are being studied on deconditioning former elite male athletes to improve their cardiovascular function and reduce left ventricular hypertrophy (13). Such interventions may have influence on global health, including nonsurgical management of arthritis. While weight loss and strengthening exercises are part of the standard of care for those with symptomatic osteoarthritis (14), these preventative interventions may be even more important for former NFL players who are recently retired.

As we prepare to explore and report more on these topics, we note a responsibility in the medical community to provide tailored and meaningful treatment for those who have the disease state of arthritis. Education to our peers on the most up-to-date treatment options in nonsurgical treatment of arthritis is important, and our goals are to provide direction and guidance for future preventative measures. As we have outlined above, we have a duty to redirect the conversation on joint health in former NFL players away from a one-dimensional view of trauma and collisions to a more nuanced understanding of the whole life of an athlete. As we move toward this “whole player, whole life” model, we create numerous opportunities and checkpoints for prevention and treatment of joint pain that will lead to a decreased burden of joint replacement and an increased quality of life. Thus, we urge all physicians and

health professionals working with this special population to be cognizant and thoughtful of each individual player's specific history, target treatments to manage both arthritis and global health, and provide the best quality of care possible.

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## References

1. Meehan WP, Weisskopf MG, Krishnan S, *et al*. Relation of anterior cruciate ligament tears to potential chronic cardiovascular diseases. *Am. J. Cardiol.* 2018; 122:1879–84.
2. Plessow F, Pascual-Leone A, McCracken CM, *et al*. Self-reported cognitive function and mental health diagnoses among former professional American-style football players. *J. Neurotrauma.* 2020; 37:1021–8.
3. Grashow RG, Roberts AL, Zafonte R, *et al*. Defining exposures in professional football: Professional American-style football players as an occupational cohort. *Orthop. J. Sports Med.* 2019; 7:2325967119829212.
4. Morris TP, McCracken C, Baggish A, *et al*. Multisystem afflictions in former National Football League players. *Am. J. Ind. Med.* 2019; 62:655–62.
5. Roberts AL, Taylor HA Jr., Whittington AJ, *et al*. Race in association with physical and mental health among former professional American-style football players: findings from the Football Players Health Study. *Ann. Epidemiol.* 2020; 51:48–52.e2.
6. Tenforde AS, Cortez B, Baker J, *et al*. Prevalence of total hip and knee arthroplasty in former National Football League players: comparison with the general US population and other populations of professional athletes. *BMJ Open Sport Exerc. Med.* 2020; 6:e000833.
7. Changulani M, Kalairajah Y, Peel T, Field RE. The relationship between obesity and the age at which hip and knee replacement is undertaken. *J. Bone Joint Surg. (Br.)*. 2008; 90:360–3.
8. Apold H, Meyer HE, Nordsletten L, *et al*. Risk factors for knee replacement due to primary osteoarthritis, a population based, prospective cohort study of 315,495 individuals. *BMC Musculoskelet. Disord.* 2014; 15:217.
9. Benazzo F, Rossi SM, Ghiara M, *et al*. Total knee replacement in acute and chronic traumatic events. *Injury.* 2014; 45(Suppl. 6):S98–104.
10. McAlindon TE, LaValley MP, Harvey WF, *et al*. Effect of intra-articular triamcinolone vs saline on knee cartilage volume and pain in patients with knee osteoarthritis: a randomized clinical trial. *JAMA.* 2017; 317:1967–75.
11. Brophy RH, Gray BL, Nunley RM, *et al*. Total knee arthroplasty after previous knee surgery: expected interval and the effect on patient age. *J. Bone Joint Surg. Am.* 2014; 96:801–5.
12. Hampton SN, Nakonezny PA, Richard HM, Wells JE. Pain catastrophizing, anxiety, and depression in hip pathology. *Bone Joint J.* 2019; 101-B:800–7.
13. Pelliccia A, Maron BJ, De Luca R, *et al*. Remodeling of left ventricular hypertrophy in elite athletes after long-term deconditioning. *Circulation.* 2002; 105: 944–9.
14. Conaghan PG, Dickson J, Grant RL, Guideline Development Group. Care and management of osteoarthritis in adults: summary of NICE guidance. *BMJ.* 2008; 336:502–3.