Editorial Commentary: Gait Symmetry After Anterior Cruciate Ligament Reconstruction Is Improved Using Functional Rehabilitation Braces That Resist Knee Motion

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Abstract: The effort of the rehabilitation journey to solve the several known functional and clinical problems after anterior cruciate ligament reconstruction should be directed toward implementing effective recovery strategies starting the day after surgery. Resistance training is a reliable approach to restore general knee function, but in the early postoperative stages, it may be difficult to apply proper loading strategies to obtain tangible improvements owing to surgery-related impairments. Accordingly, applying continuous light resistance during functional tasks such as gait may help to address this issue. As such, bracing models that provide resistance to knee motion have recently been developed and have been shown to help in restoring a proper walking pattern in terms of moment and range-of-motion symmetry. Therefore, the adoption of such bracing models may be regarded as a suitable option to consider to boost the achievement of rehabilitative milestones, therefore generally improving rehabilitation quality.

See related article on page 3043

Side-to-side asymmetries during gait,[1] strength imbalances,[2] persistent muscle atrophy,[3] and motor programming alterations[4] are common and known problems after anterior cruciate ligament reconstruction (ACLR). Finding strategies to effectively act on such parameters in the early stages after surgery is therefore paramount, and new rehabilitation techniques such as blood flow restriction training[5] and neuromuscular electrical stimulation superimposed on movement[6] seem to be promising. Concerning walking pattern alterations, different strategies have been implemented and resistance training is widely used although it is gait-nonspecific. The use of traditional braces in the first few weeks postoperatively have been shown to have little or no effect on gait-pattern restoration[7]; on the contrary, newer rehabilitative braces with applied resistance to knee motion have been shown to be effective in restoring gait alterations. In particular, our preliminary investigation in 2020 showed that the adoption of an innovative rehabilitative brace equipped with a spring system that resists knee flexion and facilitates knee extension helps in recovering range of motion (ROM) in terms of side-to-side symmetry and damping ability during gait early after ACLR compared with a traditional brace that locks the knee in full extension.[8]

In their study "Functional Resistance Training After Anterior Cruciate Ligament Reconstruction Improves Knee Angle and Moment Symmetry During Gait: A Randomized Controlled Clinical Trial," Johnson, Brown, Palmieri-Smith, and Krishnan[9] further examined this topic, randomizing 30 patients into 3 groups. The first group received functional resistance training (FRT) by use of a robotic rehabilitative brace that provided resistance to both knee flexion and extension motion coupled with real-time kinematic feedback. The second group received FRT through a custom resistance band device that applied resistance to knee extension along with kinematic feedback. The third group wore the same brace model as the first group except that no resistance was applied; however, kinematic feedback was maintained. All groups underwent 8 weeks of

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treadmill walking training 2 to 3 times per week. Before and after this 8-week period, patients underwent testing of the knee angle and moment symmetry. In brief, the results of the study can be summarized as follows: FRT used in both the brace and custom-device groups showed significant improvements compared with the third group, in which no resistance was applied. In particular, the brace group showed greater improvements in knee ROM compared with the custom-device and no-resistance groups whereas the custom-device group achieved greater results in moment symmetry compared with the brace and no-resistance groups.

It is a matter of fact that, considering the available evidence up to now, the use of a knee orthosis after ACLR—despite its large-scale adoption—is not crucial from the clinical and functional recovery perspectives. Nevertheless, it should be taken into account that the robust of evidence is mainly built on the analysis of "non-rehabilitative" braces either locked in full extension or with adjustable ROM,[10] therefore giving no rehabilitative stimulus to the knee and lower-limb complex. In light of this, one is likely to think that such types of orthoses may provide little or no benefit to the multidimensional recovery process after ACLR because none of the aforementioned parameters are being rehabilitated. On the contrary, first, our preliminary investigation in 2020[8] and, subsequently, the current randomized controlled trial by Johnson et al.[9] have analyzed the effectiveness of orthoses in stimulating the neuromuscular system when coupling applied resistance with functional tasks such as walking in this case, showing that the adoption of these brace models may be promising in supporting functional recovery after ACLR. Furthermore, considering the donor-site morbidity of hamstring and patellar tendon autografts (the 2 autografts mainly used for ACLR), the robotic brace model used in the study of Johnson et al., which provides resistance to both knee extension and flexion, may overcome the limitations of the brace used in our study, which applies resistance only to knee flexion, thus increasing the effectiveness and rehabilitative power of the orthosis model presented in their study.

To conclude, whether the adoption of a postoperative knee brace after ACLR is actually beneficial is yet to be established; however, newly developed rehabilitative brace models with applied resistance to knee motion seem to be promising in helping to restore the gait pattern, as well as knee function in general. In my experience, in all patients presenting with voluntary activation and load avoidance problems in the early stages, the adoption of a rehabilitative brace may be a suitable option to help in "getting out of trouble."

References

1. Lin PE, Sigward SM. Subtle alterations in whole body mechanics during gait following anterior cruciate ligament reconstruction. *Gait Posture* 2019;68:494-499.
2. Tourville TW, Voigt TB, Choquette RH, et al. Skeletal muscle cellular contractile dysfunction after anterior cruciate ligament reconstruction contributes to quadriceps weakness at 6-month follow-up. *J Orthop Res* 2022;40:727-737.
3. Ong MT-Y, Fu S-C, Mok S-W, Franco-Obregón A, Yam SL-S, Yung PS-H. Persistent quadriceps muscle atrophy after anterior cruciate ligament reconstruction is associated with alterations in exercise-induced myokine production. *Asia Pac J Sports Med Arthrosc Rehabil Technol* 2022;29:35-42.
4. Gokeler A, Dingenen B, Hewett TE. Rehabilitation and return to sport testing after anterior cruciate ligament reconstruction: Where are we in 2022? *Arthrosc Sports Med Rehabil* 2022;4:e77-e82.
5. Jack RA II, Lambert BS, Hedt CA, Delgado D, Goble H, McCulloch PC. Blood flow restriction therapy preserves lower extremity bone and muscle mass after ACL reconstruction [published online June 27, 2022]. *Sports Health*. doi:10.1177/19417381221101006.
6. Labanca L, Rocchi JE, Giannini S, et al. Early superimposed NMES training is effective to improve strength and function following ACL reconstruction with hamstring graft regardless of tendon regeneration. *J Sports Sci Med* 2022;21:91-103.
7. Culvenor AG, Girdwood MA, Juhl CB, et al. Rehabilitation after anterior cruciate ligament and meniscal injuries: A best-evidence synthesis of systematic reviews for the OPTIKNEE consensus [published online June 29, 2022]. *Br J Sports Med*. doi:10.1136/bjsports-2022-105495.
8. Rocchi JE, Labanca L, Luongo V, Rum L. Innovative rehabilitative bracing with applied resistance improves walking pattern recovery in the early stages of rehabilitation after ACL reconstruction: A preliminary investigation. *BMC Musculoskelet Dis* 2020;21:644.
9. Johnson AK, Brown SR, Palmieri-Smith RM, Krishnan C. Functional resistance training after anterior cruciate ligament reconstruction improves knee angle and moment symmetry during gait: A randomized controlled clinical trial. *Arthroscopy* 2022;38:3043-3055.
10. Knapik DM, Singh H, Gursoy S, Trasolini NA, Perry AK, Chahla J. Functional bracing following anterior cruciate ligament reconstruction: A critical analysis review. *JBJS Rev* 2021;9.