Total Motion Release® for Restoring Normal Knee Function after ACL Reconstruction: A Case Study

Diane L. Stankevitz, DAT, ATC, CSCS, EMT* & Lindsey Larkins, DAT, CSCS, PRT-C†
* East Los Angeles College, Monterey Park, CA; † University of Idaho, Moscow, ID

ABSTRACT

The objective of this study was to illustrate the case of an intercollegiate soccer player who sustained a grade 3 anterior cruciate ligament (ACL) injury and underwent surgical repair at 4 months. The patient engaged in her regular daily activity prior to the surgical procedure. One week prior to surgery the patient produced 140° of active knee flexion and -1° of active knee extension, and scored 69.0 on the International Knee Documentation Committee Subjective Knee Evaluation (SKE). One day post-ACL reconstruction by semitendinosus autograft, the patient's knee range of motion (ROM) was 40° of flexion and 20° of extension and reported a score of 21.8 on the SKE. The patient began rehabilitation immediately following surgery with the goal to increase ROM of the involved limb. A Total Motion Release® (TMR ®) rehabilitation protocol was implemented for the first four weeks in lieu of a traditional ACL reconstruction rehabilitation protocol. Three sessions were completed each week over a four-week period, for a total of 12 sessions. Rehabilitation sessions consisted of 15 minutes of ice massage of the quadriceps with simultaneous quadriceps contraction/relaxation immediately followed by TMR ®. The patient ended each session with progressive exercise: 5 minutes of half rotations on the bike on day one, progressing to a 20 minute light jog on the treadmill by week four. Patient was re-assessed by the orthopedic surgeon at a one and six month post-operative follow-up appointments. Changes in flexion and extension ROM and SKE were assessed weekly prior to treatment to evaluate knee ROM. Four weeks following the TMR® protocol, knee range of motion was restored demonstrating the effectiveness of TMR®.

Key Phrases
Exercise, surgery, patient outcomes

Correspondence
Dr. Diane L, Stankevitz, 875 Perimeter Dr, Moscow, ID 83843
E-mail: stankedl@elac.edu

Full Citation
Stankevitz DL & Larkins L. Total motion release® for restoring normal knee function after acl reconstruction: a case study. *Clin Pract Athl Train*. 2020;3(6):46-54. https://doi.org/10.31622/2020/0003.3.7.

Submitted: March 26, 2020 **Accepted**: June 29, 2020

INTRODUCTION

Recovery from anterior cruciate ligament (ACL) reconstruction is a time-consuming undertaking both for patient and clinician.[1-14] In the past decade, researchers have studied and published rehabilitation protocols that vary in effectiveness and duration, with an average total timeline of 6-9 months to return to pre-injury activity.[1-8] In the first four weeks alone, patients can expect to spend anywhere from 30-150 minutes in a single rehabilitation session and complete several sessions per week.[2,8,12,14] Furthermore, neuromuscular electrical stimulation devices,[2,3,5,8,9,12,14] and continuous passive motion (CPM) machines are commonly used in addition to supervised rehabilitation sessions.[1,2,6-8,14] The CPM machine is sometimes used for several hours each day immediately following surgery with the goal to restore range of motion (ROM) quickly and avoid the formation of unnecessary scar tissue in the joint.[1-3,8,14]

Across the literature regarding ACL reconstruction rehabilitation protocols, patients achieved similar results by the fourth week after surgery. The patient should be capable of bilateral pain-free step-up progressions to 60°, stationary biking, swimming, and proprioception drills (e.g. balance boards).[1,4-9,11,13-15] To accomplish this, patients begin rehabilitation with a two-week post-operative phase that includes bracing and crutches, with the goal to reduce pain and swelling.[1-8] During weeks two through four, rehabilitation goals are to progress the patient to achieve weight-bearing with a normal gait, appropriate patellar mobility, and knee flexion ROM of 0° to 130°.[1-14] The most common rehabilitation exercises to achieve normal gait during the first four weeks begin with a straight leg raises and gait training.[1-6,8-12,14,15]

 ISSN Online 2577-8188

With such a strong emphasis on restoring joint ROM and muscular strength, it is important that clinicians have appropriate, effective, and time efficient tools to accomplish rehabilitation goals. In addition to local modalities (e.g., mobilizations, CMP), clinicians can incorporate techniques that utilize the central nervous system to improve ROM and increase strength at the involved joint and throughout the body. Total Motion Release® (TMR®) is a treatment approach that utilizes contralateral movements to influence neural coupling and the nervous system's interpretation of electrical signals to the injured body segment.[16] Referred to as cross education, this mechanotransduction is a means by which a movement force (e.g. stretching, resistance) applied to the muscle fiber can influence balance of the neuromusculoskeletal system, helping to re-align imbalances in strength and ROM. [17-19]

TMR® attempts to sustain a dynamic center of gravity as part of a unified system by treating imbalances in the body.[17,20] Patients with pain, deficiencies, or impairments in one area of the body can be influenced by movements performed elsewhere in the body. The technique incorporates the use of contralateral exercises to the unaffected side to promote therapeutic results in the affected side.[17] Although TMR® research is still in its infancy, some researchers have provided insight into the positive effects of TMR® on shoulder pain, range of motion, and muscle re-education, while reducing rehabilitation session duration.[20-23]

This case study includes the outcomes of a rehabilitation protocol in which a patient was treated with TMR® following ACL reconstruction surgery to restore normal knee range of motion.

PATIENT INFORMATION

The patient was a 20-year old female intercollegiate soccer player who suffered an injury of her left (non-dominant) knee during a game via a non-contact mechanism attempting to decelerate to avoid a collision with an opponent. The patient was referred to an orthopedic surgeon for magnetic resonance imaging (MRI) which identified an isolated Grade III ACL sprain. The patient underwent a semitendinosus autograft surgical reconstruction approximately four months later. The four month delay was contributed to a combination of the patient's schedule and insurance authorization. The patient did not implement a detailed pre-surgery rehabilitation protocol except for activities of daily living and general conditioning. The patient reported to the clinic one week prior to surgery to assess her function prior to surgery.

Outcomes utilized to assess knee function were range of motion (ROM) with goniometer [1,3,5-8,9,11-13] and the International Knee Documentation Committee Subjective Knee Evaluation (SKE).[2,24,25] Initial outcomes were assessed one week prior to surgery and were repeated one day post-surgery and weekly for four weeks. Outcomes were also assessed at the one month and the six month follow-up.

Active flexion and extension ROM of the knee were measured using a standard goniometer (scale marked in 1° increments; model 12-1002; MeyerDC™, Hudson, OH). The same clinician conducted flexion and extension measurements prior to the commencement of the rehabilitation session at the beginning of each week.[13,26] The ROM measurement was performed as follows:

- Flexion: The patient started in a supine position with full knee extension and the hip in neutral. The axis of the goniometer was placed on the lateral epicondyle of the femur. The proximal arm was placed at the midline of the femur aligned with the greater trochanter. The distal arm was placed at the midline of the fibula and aligned with the lateral malleolus and the fibular head. The patient then flexed the knee as far as possible while flexing the hip.[1]
- Extension: The patient started in a supine position with full knee extension and the hip in neutral. A bolster was placed under the ankle. The axis of the goniometer was placed on the lateral epicondyle of the femur. The proximal arm was placed at the midline of the femur

 ISSN Online 2577-8188

aligned with the greater trochanter. The distal arm was placed at the midline of the fibula and aligned with the lateral malleolus and the fibular head.[1]

The SKE is a patient-completed questionnaire designed to detect improvement or impairment of symptoms, function, and sports activities due to a variety of knee conditions (e.g. ACL injuries).[2,24,25] The SKE form is divided into three domains: 1) symptoms (i.e., pain, stiffness, swelling, locking/catching, and giving way); 2) sports and daily activities; and 3) current knee function and knee function prior to knee injury. These domains are comprised of 18 items (1 for current knee function, 1 for sport participation, 7 for symptoms, and 9 for daily activities). Responses vary for each item. Item 6 requires a yes or no response. Items 1, 4, 5, 7, 8, and 9 use 5-point Likert scales. Items 2, 3, and 10 use 11-point numerical rating scales by which the responses to each item are scored using 0 to indicate the lowest level of function or highest level of symptoms, and the highest number to indicate no symptoms and full function. Items 2 and 3 are related to pain and the responses are scored in reverse where "Constant" is assigned a score of 0, and "Never" is assigned a score of 10. The response to item 10a is not included in the overall score as it relates to pre-injury function. The results are summed (excluding item 10a) and the score transformed to a scale ranging from 0 to 100 (**Figure 1**). Higher scores represent higher levels of function and lower levels of symptoms, with a score of 100 interpreted as no limitations and no symptoms.[24]

$$\text{SKE Score} = \left[\frac{\text{Sum of Items}}{\text{Maximum Possible Score}}\right] \times 100$$

Figure 1. SKE Score Calculation

INTERVENTION

Total Motion Release® can be implemented using a set of standardized movements, or by testing and treating with any movement of choice. The standardized procedures of TMR® consist of repetitively recording a patient-rated numeric scale of dysfunction between zero (e.g., no pain, tightness, or impaired function) and 100 (e.g., extensive pain, tightness, or impaired function) during active movement through the TMR® screening which includes six primary exercises known as the Fab 6.[17] The Fab 6 movements, developed by the TMR® originator Tom Dalonzo-Baker, include arm raise, arm press, trunk twist, leg raise, sit to stand, and bent knee toe reach (**Figure 2**). [17] The patient performs each exercise bilaterally and assigns a score to each movement for each side. The motion with the greatest bilateral discrepancy as perceived by the patient is treated first. Treatment consists of sets of repetitions and/or end-range holds of the Fab 6 movements performed to the good side. Scores are re-evaluated after every two to three sets, until a patient-reported score of 5 or below is achieved. The Fab 6 is then repeated and rescored, and the next most discrepant movement is treated until balance is achieved across all movements.[21,23,27,28] Modifications of the Fab 6 or additional movements can be incorporated to accommodate a patient's limitations or needs.

Figure 2: Fab 6 evaluation movements.[30]

During the first week, which included the inflammatory phase of healing, the patient was instructed to use crutches to assist with weight bearing as tolerated. The patient was permitted to ice for pain but did not engage in any other forms of treatment or pain medication for the first week. Intervention commenced one week after surgery and the patient began attending rehabilitation sessions three times per week, and did so for the next four weeks. The patient began each session with a 15-minute ice massage of the quadriceps to produce a hypoalgesic effect,[29] while simultaneously isometrically contracting then relaxing the quadriceps of the affected limb with the knee in full extension (**Figure 3**).

Figure 3. Ice massage over the quadriceps of the affected leg while simultaneously contracting and relaxing for 15 minutes.

Immediately following the ice massage, TMR® was used with straight leg raises (**Figure 4**). Progression was indicated when the patient's score decreased to 25 or less. As the patient progressed, knee hyperextensions (**Figure 5**) and the Fab 6 "Sit to Stand" movement were incorporated (**Figure 6**). The patient completed the movements on the injured side reporting a score between 0 (i.e., no symptoms and full function) and 100 (i.e., very symptomatic and no function). Because the patient reported the injured limb to have lower function, she performed the TMR treatment exercises on the uninjured side. The treatments consisted of either 3 sets of 10 repetitions and/or 5 holds for 30 seconds and were determined based on the ease to the patient. After each series, the patient completed the exercise on the injured side and reported a new score. During session one, the patient ended by performing self-paced half revolutions for 5 minutes on a stationary bike enabling the knee to flex and extend to 90° (**Table 1**). The patient progressed appropriately and by the eighth session was capable of 20 minutes of full rotations on the stationary bike. She progressed from the bike to the treadmill and at the end of the four week time frame, the patient was jogging at a 5 mph pace at a 0° incline for 10 minutes on the treadmill (**Table 1**). In addition to her treatment sessions, the patient was instructed to perform the entire treatment series of TMR® each day at home.

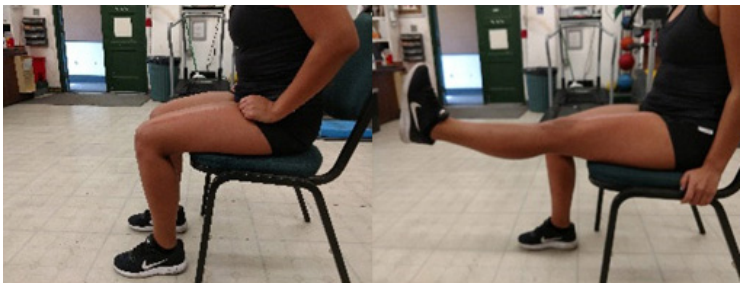

Figure 4. The starting (left) and ending (right) positions for the straight leg raise

Figure 5. The starting (left) and ending (right) positions for the leg extension.

Figure 6. The starting (left) and ending (right) positions for the sit to stand.

OUTCOMES

At the end of 12 TMR® sessions, the straight leg raise had improved from an initial patient-reported score of 70 to a final score of 0. The knee hyperextensions and sit to stand had improve to a score of 5 from an initial score of 60 and 80, respectively (**Table 2**). The patient achieved 99.0% of pre-surgery extension and 96.4% of pre-surgery flexion. The patient had achieved 98.3% of their initial SKE score. At the one-month after the TMR® rehabilitation protocol, the patient's knee flexion was at 100% (140°) and extension increased 1° (-2°) from pre-surgical scores. The SKE scores improved 36%

Table 1. Comparison of TMR® to a Traditional Rehabilitation Protocol for 12 sessions over four weeks after surgery.

Traditional		TMR®	
Sessions	Exercises	Sessions	Exercises
1-3	Arm Ergometer for Cardiovascular Fitness†	1-12	15 minutes ice massage with quadriceps contractions
1-3	Wall slides‡	1-4	Straight Leg Raises for a maximum of 6 series*
1-3	Patellar mobilization 30 to 50 times per day	2-12	Knee Extensions for a maximum of 6 series**
1-3	Gait Training†	5-12	Sit to Stand for a maximum of 6 series*
1-3	Bike for ROM†	1-2	5 minutes half revolutions on the stationary bike
1-3	Quadriceps long-arc (90°-45°)‡	3-11	20 minutes full revolutions on the stationary bike
1-3	Straight Leg Raises‡	12	10 minutes treadmill at 5mph at 0° incline
1-3	Step-ups in pain-free range‡		
1-3	Proprioceptive/balance training‡		
4-6	Portal/incision mobilization as needed‡		
4-6	StairMaster†		
4-6	Wall squats†		
4-6	Wall sits†		
4-6	Prone hangs‡		
4-6	Patellar mobilization in flexion‡		
4-6	Stationary Biking†		
7-12	Tibiofemoral mobilizations‡		
7-12	Continue balance and proprioceptive activities‡		
7-12	Increase intensity of stationary bike†		
7-12	May add treadmill walking and/or elliptical†		
7-12	Advance intensity of pool program as tolerated		

* Series: 3 sets of 10 repetitions on the unaffected side followed by one set of 10 repetitions on the affected side.
** Series: 5 repetitions holding each for 30 seconds on the unaffected side followed by one repetition at a 30 second hold on the affected side.
† 10 to 30 minutes
‡ 3 sets of 10 repetitions (3 times per day)
Adams, Biggs, Rosenberg, Saka, Shaw, Shelbourne, van Grinsven

from the initial intake prior to surgery. At the six month follow-up, knee flexion and knee extension were also measured at 140° and -2° respectively (**Table 3**). During week three, the patient reported an incident in which she was struck in the knee resulting in a minor regression.

DISCUSSION

The purpose of this study was to explore the effects of a rehabilitation protocol that included TMR® on knee range of motion after ACL reconstruction. Researchers have indicated an ACL reconstruction patient should achieve greater than 110° of flexion and full knee extension by the

Table 2. Patient's TMR® Pre and Post Session Scores

		Straight Leg Raises		Knee Hyperextension		Sit to Stand	
Week	Session	Pre	Post	Pre	Post	Pre	Post
	1	70	55	NA	NA	NA	NA
1	2	55	15	60	55	NA	NA
	3	15	10	70	55	NA	NA
	4	10	0	40	25	NA	NA
2	5	NA	NA	25	20	80	50
	6	NA	NA	10	5	50	40
	7*	NA	NA	50	45	35	30
3	8	NA	NA	45	40	45	30
	9	NA	NA	30	20	15	10
	10	NA	NA	10	5	15	10
4	11	NA	NA	10	5	10	5
	12	NA	NA	5	5	5	5

* Patient experienced a minor hindrance when a person ran into her knee.

Table 3. Patient's Knee Range of Motion and Subjective Progress

Timeframe	Flexion	Extension	SKE Score
1 week pre-op	140°	-1°	69.0
1 day post-op	40°	20°	21.8
1 week post-op	50°	22°	24.1
2 week post-op	110°	13°	34.5
3 week post-op	130°	10°	44.8
4 week post-op	135°	0°	67.8
1 month follow up	140°	-2°	94.3
6 month follow up	140°	-2°	96.6

fourth week of rehabilitation following ACL reconstruction surgery. [2,4-7,9,13] In this case study, the patient achieved greater than 110° of flexion and full knee extension by the end of the four weeks of TMR®. One month following TMR® the patient added an additional 5° of flexion and -2° of extension which was maintained at the six-month follow-up (**Table 3**).

A direct comparison of the time to completion for traditional rehabilitation elements and the protocol including TMR® is provided in **Table 1**. Rehabilitation exercises were included if they have been established in the literature and are widely used in patient practice for rehabilitation to increase ROM following ACL reconstruction.[1,4-7,9,15] The TMR® protocol for the patient in this study was an effective method as compared to traditional rehabilitation, but was less time-consuming and required less exercises.[1,4-7,9,15] Traditional rehabilitation averaged over 90 minutes per session three to five times per week for four weeks,[1,4-7,9,15] and can include home exercises performed 3 times per day. In contrast, TMR® averaged less than 45 minutes per clinical session three times per week for four weeks, as well as daily at home, and generated the same patient outcomes as a traditional protocol.

Cryotherapy was incorporated for yielding therapeutic effects associated with the decrease of motor nerve conduction. The amount of the multiple action potential denotes the amount of nerve fibers that responds to an appropriate stimulus.[29] Therefore, the diminution of this parameter after the cold application could infer an escalation in the activation threshold of some nerve fibers, as well as the blocking of the fibers more sensitive to cooling.[29]

Although the results were successful, some limitations exist. Goniometric measurements were not blinded and could have decreased outcome validity.[27] To determine the greatest effects of the protocol used in this case study, additional research is necessary using a larger number of participants randomized into TMR® and traditional rehabilitation groups. Future researchers should blind the individuals measuring outcomes to the group assignments.

CLINICAL BOTTOM LINE

Total Motion Release®[17,20-23,28] was an effective treatment to restore knee ROM following ACL reconstruction surgery that took less time per treatment session than traditional ROM techniques.[1,4-7,9,15] Ice massage while simultaneously contracting and relaxing the quadriceps may have contributed to stimulating the muscle fibers.[30] The stationary bike also assisted with the patient's ROM.[1,4-7,9,15] TMR® can be a practical, less time-consuming alternative for clinicians attempting to improve a patient's ROM after ACL reconstruction.

REFERENCES

1. Biggs A, Jenkins WL, Urch SE, Shelbourne KD. Rehabilitation for patients following ACL reconstruction: a knee symmetry model. *N Am J Sports Phys Ther*. 2009; 4(1):2-12.
2. Kruse LM, Gray B, Wright RW. Rehabilitation after anterior cruciate ligament reconstruction. *J Bone Joint Surg Am*. 2012; 94A(19), 1737-1748. https://doi.org/10.2106/JBJS.K.01246.
3. Lobb R, Tumilty S, Claydon LS. A review of systematic reviews on anterior cruciate ligament reconstruction rehabilitation. *Phys Ther Sport*. 2012; 13(4), 270-278. https://doi.org/10.1016/j.ptsp.2012.05.001.
4. Rosenberg Cooley Metcalf Orthopedic Clinic at Park City. Anterior cruciate ligament (ACL) reconstruction post-operative protocol. https://rcmclinic.com/patient-information/knee-information/knee-post-op-care-rehab/acl-reconstruction-post-op/. Published 2007. Accessed April 14, 2017.
5. Saka T. Principles of postoperative anterior cruciate ligament rehabilitation. World *J Orthop*. 2014; 5(4), 450-459. https://doi.org/10.5312/wjo.v5.i4.450.
6. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1990; 18(3), 292-299. https://doi.org/10.1177/036354659001800313.
7. van Grinsven S, van Cingel RE, Holla CJ, & van Loon CJ. Evidence-based rehabilitation following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2010; 18(8), 1128-1144. https://doi.org/10.1007/s00167-009-1027-2.
8. Wright RW, Preston E, Fleming BC, Amendola A, Andrish JT, Bergfeld JA, Dunn WR, Kaeding, Kuhn JE, Marx RG, McCarty, Parker RC, Spindler KP, Wolcott M, Wolf BR, Williams GN. ACL reconstruction rehabilitation: a systematic review part I. *J Knee Surg*. 2008; 21(3), 217-224. https://doi.org/10.1055/s-0030-1247822.
9. Adams D, Logerstedt D, Hunter-Giordano A, Axe MJ, Snyder-Mackler L. Current concepts for anterior cruciate ligament reconstruction: a criterion–based Rehabilitation progression. *J Orthop Sports Phys Ther*. 2012; 42(7), 601-614. https://www.jospt.org/doi/10.2519/jospt.2012.3871.
10. Ardern CL, Webster KE, Taylor NF, Feller JA. Return to the preinjury level of competitive sport after anterior cruciate ligament reconstruction surgery: two-thirds of patients have not returned by 12 months after surgery. *Am J Sports Med*. 2011; 39(3), 538-543.

https://doi.org/10.1177/0363546510384798.
11. Myer GD, Paterno MX, Ford KR, Quatman CE, Hewett TE. Rehabilitation after anterior cruciate ligament reconstruction: criteria-based progression through the return-to-sport phase. *J Orthop Sports Phys Ther*. 2006; 36(6), 385-402. https://doi.org/10.2519/jospt.2006.2222.
12. Risberg MA, Lewek M, Snyder-Mackler L. A systematic review of evidence for anterior cruciate ligament rehabilitation: how much and what type. *Phys Ther Sport*. 2004; 5(3), 125-145. https://doi.org/10.1016/j.ptsp.2004.02.003.
13. Shaw T, Chipchase LS, Williams MT. (2004). A users guide to outcome measurement following ACL reconstruction. *Physical Therapy in Sport*. 2004; 5, 57–67. https://doi.org/10.1016/j.ptsp.2003.11.007.
14. Wright RW, Preston E, Fleming BC, Amendola A, Andrish JT, Bergfeld JA, Dunn WR, Kaeding, Kuhn JE, Marx RG, McCarty, Parker RC, Spindler KP, Wolcott M, Wolf BR, Williams GN. ACL reconstruction rehabilitation: a systematic review part II. *J Knee Surg*. 2008; 21(3), 225-234. https://doi.org/10.1055/s-0030-1247823.
15. Shaw T. Accelerated rehabilitation following anterior cruciate ligament reconstruction. *Phys Ther Sport*. 2002; 3(1), 19-26. https://doi.org/10.1054/ptsp.2001.0089.
16. Carroll TJ, Herbert RD, Munn J, Lee M, Gandevia SC. Contralateral effects of unilateral strength training: evidence and possible mechanisms. *J Appl Physiol*. 2006; 101(5), 1514–1522. https://doi.org/10.1152/japplphysiol.00531.2006.
17. Dalonzo-Baker, Tom. Total Motion Release. https://totalmotionrelease.com/tmrhome. N.d. Accessed July 30, 2015.
18. Chen CS, Ingber DE. Tensegrity and mechanoregulation: from skeleton to cytoskeleton. *Osteoarthr Cartil*. 1999; (1), 81–94. https://doi.org/10.1053/joca.1998.0164.
19. Wainner RS, Whitman JM, Cleland JA, Flynn TW. Regional Interdependence: A musculoskeletal examination model whose time has come. J Orthop Sports Phys Ther. 2007; 37(11): 658–660. https://doi.org/10.2519/jospt.2007.0110.
20. Gamma SC, Baker RT, Iorio S, Nasypany A, Seegmiller JG. A total motion release warm-up improves dominant arm shoulder internal and external rotation in baseball players. *Int J Sports Phys Ther*. 2014; 9(4), 509–517.
21. Drake R, Rhinehart A, Smith-Goodwin E, Tecklenburg L. Can total motion release increase shoulder range of motion in collegiate swimmers? *JSMAHS*. 2016; 2(1), 1-3. https://doi.org/10.25035/jsmahs.02.01.19.
22. Gamma SC, Baker RT, May J, Seegmiller JG. Nasypany A, Iorio S. Comparing the immediate effects of a total motion release warm-up and dynamic warm-up protocol on the dominant shoulder in baseball athletes. *J Strength Cond Res*. 2018; 00(00), 1–7. https://doi.org/10.1519/JSC.0000000000002229.
23. Fermin S, Larkins L, Beene S, Wetzel D. The effect of contralateral exercise on patient pain and range of motion. *J Sport Rehabil*. 2018; 27(2), 185–188. https://doi.org/10.1123/jsr.2016-0181.
24. Collins NJ, Misra D, Felson DT, Crossley KM, RoosEM. Measures of knee function: International Knee Documentation Committee (SKE) Subjective Knee Evaluation Form, Knee Injury and Osteoarthritis Outcome Score (KOOS), Knee Injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). *Arthritis Care Res (Hoboken)*. 2011; 63(11), S208-S228. https://doi.org/10.1002/acr.20632.
25. Rodriguez-Merchan EC. Knee instruments and rating scales designed to measure outcomes. J Orthop Traumatol, 2012; 13(1), 1-6. https://doi.org/10.1007/s10195-011-0177-4.
26. Brosseau L, Balmer S, Tousignant M, O'Sullivan JP, Goudreault C, Goudreault M, Gringras S. Intra- and intertester reliability and criterion validity of the parallelogram and universal goniometers for measuring maximum active knee flexion and extension of patients with

knee restrictions. *Arch Phys Med Rehabil*. 2001; 82(3), 396-402. https://doi.org/10.1053/apmr.2001.19250.

27. Total Motion Release. Research & Evidence 2015. https://tmrseminars.com/research-evidence. Accessed November 19, 2015.
28. Rohman E, Steubs JT, Tompkins M. Changes in involved and uninvolved limb function during rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2015; 46(6), 1391-1398. https://doi.org/10.1177/0363546515576127.
29. Herrera E, Sandoval MC, Carmago DM, Ferris DP. Motor and sensory nerve conduction are affected differently by ice pack, ice massage, and cold water immersion. *Phys Ther*. https://doi.org/10.2522/ptj.20090131.
30. Total Motion Physical Therapy, Inc. Pics of FAB 6. Copyright© 2013 https://www.tmrseminars.com/pics-of-fab-6/.