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Association of the Psychological Response to the ACL-SPORTS Training Program and Self-reported Function at 2 Years After Anterior Cruciate Ligament Reconstruction

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Association of the Psychological Response to the ACL-SPORTS Training Program and Self-reported Function at 2 Years After Anterior Cruciate Ligament Reconstruction

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Abstract

Background:

Psychological readiness to return to sport has emerged as an important factor associated with outcomes after anterior cruciate ligament reconstruction (ACLR). Psychological factors are potentially modifiable during the course of rehabilitation, and improving them may lead to better outcomes.

Purpose:

To determine whether athletes with a positive psychological response after participation in a neuromuscular training and second injury prevention program had better self-reported function and activity outcomes compared with athletes who did not have a meaningful change.

Study Design:

Cohort study; Level of evidence, 3.

Methods:

After ACLR and the completion of formal rehabilitation, 66 level I/II athletes completed the following self-reported measures at enrollment (pretraining): the Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) scale, the International Knee Documentation Committee (IKDC) subjective knee form, and the 5 subscales of the Knee injury and Osteoarthritis Outcome Score (KOOS). Participants completed these measures after 10 sessions of agility, plyometric, and progressive strength training and at 1 and 2 years after ACLR. Participants who displayed an increase in the ACL-RSI score from pretraining to posttraining that exceeded the minimal clinically important difference (≥10 points) were defined as having a positive psychological response (responders) to training, and those who did not were defined as nonresponders. A mixed-model analysis of variance was used to determine if group differences in IKDC and KOOS scores existed over the 4 time points (pretraining, posttraining, and the 1- and 2-year follow-ups).

Results:

The responders reported better self-reported function compared with the nonresponders, regardless of time, on the IKDC form (P = .001), KOOS–Sport and Recreation (P = .014), KOOS-Pain (P = .007), and KOOS-Symptoms (P = .002) but not on the KOOS–Quality of Life (P = .078). Overall, 77% of responders and 67% of nonresponders returned to their previous level of sport by 1 year after ACLR (P = .358), and 82% of responders and 78% of nonresponders returned to their previous level of sport by 2 years after ACLR (P = .668).

Conclusion:

Ultimately, 59% of the athletes in this study displayed a meaningful improvement in their psychological outlook over the course of the training program. Responders demonstrated persistently better self-reported function at posttraining and at 1 and 2 years after ACLR, but there were no between-group differences in return-to-sport rates.

Keywords

ACL reconstruction, psychological factors, self-reported function

Upwards of 200,000 anterior cruciate ligament (ACL) ruptures occur each year in the United States.[23] ACL reconstruction (ACLR) is the gold-standard treatment for athletes involved in cutting, jumping, and pivoting sports, with the goal of returning them to their previous level of sport. However, recent data suggest that less than two-thirds of athletes who undergo ACLR return to their previous level of sport, despite good knee function.[5,8] Psychological factors, such as the fear of reinjuries, confidence, self-efficacy, and psychological readiness to return to sport, have emerged as potential barriers for athletes attempting to return to sport.[3,6,7,15,17,20,21] Webster et al[28] developed the Anterior Cruciate Ligament–Return to Sport after Injury (ACL-RSI) scale, which measures psychological readiness to return to sport. Psychological readiness to return to sport encompasses 3 psychological responses (emotions, confidence, and risk appraisal) specifically related to returning to sport. Cross-sectional studies have found that athletes who were able to return to sport have higher ACL-RSI scores.[3,18] Prospective studies also suggest that higher ACL-RSI scores, indicating a more positive psychological outlook, are predictive of returning to sport and returning to competition.[6,19]

Transitioning back to sport can be especially fearful for athletes after ACLR.[2] This is also the time when athletes are weaned from consistent rehabilitation and focus is placed on an independent program. The Anterior Cruciate Ligament–Specialized Post-Operative Return to Sport (ACL-SPORTS) secondary injury prevention program was designed to bridge the gap between the time when formal physical therapy traditionally ends and the time when an athlete returns to sport.[29] Although this program was not specifically designed to address psychological factors, such as the fear of reinjuries and confidence, it does apply the concepts of graded activity and graded exposure that have been investigated with other patient populations. For example, graded exposure is effective in reducing disability, pain, and catastrophizing in patients with chronic low back pain.[22] The ACL-SPORTS secondary injury prevention program therefore has the potential to improve psychological readiness to return to sport.

No published studies, to our knowledge, have investigated how psychological factors change over the course of a secondary injury prevention program. Furthermore, it is unknown how a change in psychological outlook during the time when an athlete is transitioning back to sport is related to functional and activity-related outcomes. Therefore, the purpose of this study was to (1) determine if athletes who demonstrate an improvement in psychological readiness to return to sport have better self-reported function after the intervention program and at 1 and 2 years after ACLR than those who do not and (2) determine if athletes who demonstrate an improvement in psychological readiness to return to sport have better activity-related outcomes at 1 and 2 years after ACLR than those who do not. We hypothesized that athletes with an improvement in psychological readiness to return to sport would demonstrate better outcomes immediately after the program and at 1 and 2 years after ACLR compared with athletes who did not demonstrate a meaningful positive response.

Methods

Participants

A total of 66 level I/II athletes (those who participated in cutting, pivoting, and jumping sports for at least 50 hours per year)[14] aged between 13 and 55 years who had undergone primary ACLR were included in this secondary analysis of a prospective clinical trial. All athletes were part of a randomized controlled trial (ClinicalTrials.gov: NCT01773317) investigating the effect of a secondary injury prevention program with or

without the addition of specialized neuromuscular training.[29] This study was approved by the institutional review board of the University of Delaware and is registered on IRBNet (225014-15). All participants completed informed consent forms. Athletes with a pretraining ACL-RSI score ≥91 were excluded from this secondary analysis because of the mathematical impossibility of achieving a meaningful increase of at least 10 points (ie, ceiling effect).

After ACLR, all participants underwent rehabilitation and had to meet the following criteria before enrollment: quadriceps strength index of at least 80% (measured isometrically with an isokinetic dynamometer), full knee range of motion compared with the uninjured side, minimal effusion present (trace or less),[27] ability to hop on one leg without pain, and had started a running progression program. Participants were excluded from enrollment in this trial if they had a previous ACL or other significant lower extremity injury, a concomitant grade III ligament injury, or an osteochondral defect ≥1 cm^2. For more information regarding the enrollment process of this trial, see Capin et al[10] and Arundale et al.[9]

Training Program

Full details of the protocol have been published.[29] All participants in the trial underwent 10 sessions of progressive strengthening, plyometric training, and agility training. Proper form (encouraging greater knee flexion and reducing lower extremity valgus) was encouraged throughout the sessions during the plyometric and agility exercises. Plyometric and agility exercises were gradually progressed in quantity and complexity over the course of the 10 sessions. For example, single-leg plyometric exercises were performed over ground during the first 3 sessions. Sessions 4 to 10 incorporated a hurdle that increased in height over the sessions. For agility, linear movements were introduced first and then progressed to multidirectional movements with the athletes completing movements related specifically to their individual sport and utilizing a ball/equipment specific to their sport.

Self-reported Measures

All participants completed the ACL-RSI scale at enrollment (pretraining) and after the training program (posttraining).[28] This scale includes 12 questions and measures an athlete's psychological readiness to return to sport, which encompasses emotions (including the fear of reinjuries), confidence, and risk appraisal. The ACL-RSI scale is scored from 0 to 100, with higher scores indicating a more positive psychological outlook in terms of returning to sport (ie, less fear of reinjuries, more confidence). Participants in the present study were dichotomized into 2 groups based on their ACL-RSI score. Those who displayed an increase in the ACL-RSI score from pretraining to posttraining of ≥10 points were defined as having a positive psychological response (responders) to training, and those who did not were defined as nonresponders. An increase of ≥10 points was chosen to define the groups based on face validity and known group validity because there are no established minimal clinically important difference (MCID) values for the ACL-RSI scale. Face validity was based on an expert consensus from our research group, which has extensive clinical and research experience in the ACL injury population. We determined that an increase of ≥10 points reflected a meaningful improvement based on a mean 1-point increase on each of the 12 questions of the ACL-RSI scale and on the study of Langford et al[19] of ACL-RSI scores at 3 and 6 months after ACLR that found that the group of athletes that returned to competition at 1 year scored 9 points higher on the ACL-RSI scale at 3 months and 11 points higher at 6 months.

In addition to the ACL-RSI scale, all participants completed the International Knee Documentation Committee (IKDC) subjective knee form[14] and the 5 subscales of the Knee injury and Osteoarthritis Outcome Score (KOOS)[25] at pretraining, posttraining, and 1 and 2 years after ACLR. The IKDC form is a validated instrument that is used for patients with various knee conditions and includes questions about symptoms, sports, and daily activities as well as current knee function.[16] The KOOS was designed to evaluate short-term and long-term outcomes in patients after a knee injury and knee osteoarthritis. It includes 5 subscales: (1) Pain, (2) Symptoms,

(3) Activities of Daily Living (KOOS-ADL), (4) Sport and Recreation (KOOS-Sport), and (5) Quality of Life (KOOS-QOL).[26] The KOOS-ADL was not included in this analysis because of a high ceiling effect in this population. Finally, participants were asked at 1 year and 2 years after ACLR if they returned to their previous level of sport activity.

Statistical Analysis

All statistical analyses were performed using SPSS Version 24.0 (IBM). A mixed-model analysis of variance was performed for the IKDC form and each subscale of the KOOS to determine the interaction of group (responder vs nonresponder) by time (pretraining, posttraining, 1 year, 2 years) as well as the main effects of group and time. Independent *t* tests and chi-square tests were used to determine differences between groups in timing and demographics. The percentages of athletes who returned to their previous level of sport were reported by group. A *P* value ≤.05 was determined a priori to denote statistically significant differences between groups.

Results

There were 39 athletes (59%) who demonstrated an increase in the ACL-RSI score ≥10 points and formed the responder group (pretraining score: 56.7 ± 19.9; posttraining score: 79.0 ± 17.7), while 27 athletes had a change of <10 points and formed the nonresponder group (pretraining score: 59.9 ± 13.2; posttraining score: 58.4 ± 13.4). There were no significant group differences in sex (*P* = .453), age (*P* = .478), body mass index (*P* = .060), weeks from surgery to pretraining (*P* = .469), weeks from surgery to posttraining (*P* = .594), preinjury sport level (*P* = .130), or preinjury competitive level (*P* = .504) (Table 1).

Table 1 Demographics and Characteristics of Participants[a]

	Responder (n = 39)	Nonresponder (n = 27)	P Value
Sex, female/male, n	21/18	12/15	.453
Age, y	20.7 ± 7.6	23.0 ± 8.8	.478
Body mass index	25.9 ± 7.8	21.6 ± 3.0	.060
Time from surgery to pertaining, wk	24.6 ± 8.1	22.0 ± 7.4	.469
Time from surgery to posttraining, wk	31.9 ± 8.2	29.3 ± 7.8	.594
ACL-RIS score			
Pretraining	56.7 ± 19.9	59.9 ± 13.2	.497
Posttraining	79.0 ± 17.7	58.4 ± 13.4	<.001
Underwent pertubation training,[29] n (%)	21 (54)	15 (56)	.891
Competitive level of support, n			
Intramural/recreational	9	10	
Club	16	8	
School	13	9	
Professional	1	0	
Level I/II, n (%)	33 (85)	26 (96)	.130

[a]Values are shown as mean ± SD unless otherwise indicated. ACL-RSI, Anterior Cruciate Ligament-Return to Sport after Injury.

There was a significant main effect of group for IKDC, KOOS-Sport, KOOS-Pain, and KOOS-Symptoms scores (*P*≤ .014) but not for the KOOS-QOL score (*P* = .078). The responder group demonstrated better self-reported function regardless of time. There was a significant group by time interaction for IKDC and KOOS-QOL scores (Table 2). Both groups' IKDC scores improved significantly from pretraining to posttraining (*P* < .001) and from posttraining to 1 year (*P*≤ .002). The responders displayed significantly higher IKDC scores than the nonresponders at posttraining (*P* = .001) and at 2 years (*P* = .001) but not at pretraining. For the KOOS-QOL score, only the responders improved significantly from pretraining to posttraining (*P* < .001), from posttraining

to 1 year ($P < .001$), and from 1 year to 2 years ($P = .010$). Nonresponders improved significantly only from posttraining to 1 year ($P < .001$). The responders displayed significantly higher KOOS-QOL scores at 2 years ($P = .015$). At 1 year after ACLR, there was no significant group difference in the percentage of athletes who returned to their previous level of sport (responders: 30/39 [77%]; nonresponders: 18/27 [67%]; $P = .358$). At 2 years, there was no significant difference in those who returned to their previous level of sport (responders: 32/39 [82%]; nonresponders: 21/27 [78%]; $P = .668$).

Table 2 Self-reported Functional Outcome Scores[a]

					P Value		
	Pretraining	Posttraining	1 y	2 y	Time	Group	Group × Time
IKDC					<.001	.001	.031[b]
Responder	79.8 ± 8.6	89.0 ± 7.5	94.2 ± 7.9	97.1 ± 7.4			
Nonresponder	76.8 ± 8.1	81.9 ± 9.0	91.0 ± 9.4	87.6 ± 14.9			
KOOS-Sport					<.001	.014	.117
Responder	78.1 ± 15.4	91.7 ± 10.7	95.0 ± 8.4	94.4 ± 13.1			
Nonresponder	77.6 ± 13.8	82.2 ± 13.1	91.0 ± 9.8	85.7 ± 22.2			
KOOS-QOL					<.001	.078	.020[b]
Responder	54.8 ± 15.7	70.0 ± 21.7	82.7 ± 15.3	88.8 ± 15.8			
Nonresponder	57.9 ± 13.2	62.7 ± 13.4	75.7 ± 15.1	78.2 ± 18.2			
KOOS-Symptoms					<.001	.002	.373
Responder	86.4 ± 9.7	88.5 ± 10.9	91.9 ± 8.7	93.3 ± 8.3			
Nonresponder	81.2 ± 10.3	81.5 ± 11.4	87.8 ± 11.3	84.7 ± 13.5			
KOOS-Pain					<.001	.007	.248
Responder	91.6 ± 6.4	94.7 ± 5.4	97.0 ± 3.9	98.3 ± 4.8			
Nonresponder	89.5 ± 8.2	92.2 ± 7.6	94.6 ± 5.1	93.0 ± 8.3			

[a]Values are shown as mean **±** SD. IKDC, International Knee Documentation Committee; KOOS, Knee Injry and Osteoarthritis Outcome Score; QOL, Quality of Life.
[b]Significant group by time interaction (P < .05)

Discussion

The purpose of this study was to determine if athletes who demonstrated a positive psychological response after participation in the program had better self-reported function and activity-related outcomes than those who did not. Our secondary purpose was to determine if athletes who demonstrated an improvement in psychological readiness to return to sport had better activity-related outcomes at 1 and 2 years after ACLR than those who did not. Our first hypothesis was supported. The responder group demonstrated better self-reported function (IKDC and KOOS-QOL scores) immediately after participating in the training program that persisted to 1 and 2 years after ACLR compared with the nonresponder group. Our second hypothesis was not supported; however, the responder group had 10% more athletes return to their previous level of sport by 1 or 2 years after ACLR. It is possible that this study was underpowered to detect a difference in returning to previous levels of sport. Findings from this study offer important considerations for future research. Examining the effectiveness of supervised neuromuscular training versus no intervention, and/or an intervention focused purely on targeting psychological factors, will help clarify the psychological benefits of this program.

A key finding of this study is that the responder group demonstrated persistently better self-reported function up to 2 years after ACLR compared with the nonresponder group. The responder group's mean IKDC, KOOS-QOL, and KOOS-Sport scores were approximately 10 points higher than those of the nonresponder group at 2 years. These data suggest that those who improve their psychological outlook throughout the course of rehabilitation

may have better self-reported function compared with those who do not improve their psychological outlook. It is important to note that this analysis does not allow us to determine the direction of the relationship between psychological outlook and self-reported function. Perhaps our responder group's improvement in self-reported function from pretraining to posttraining led to an improved psychological outlook. There were group-by-time interactions for the IKDC score. The IKDC form encompasses questions regarding symptoms, function, and sport activities. Both the responder and nonresponder groups improved on the IKDC form from pretraining to posttraining and from posttraining to 1 year. However, the responder group demonstrated significantly higher IKDC scores at posttraining compared with the nonresponder group. With an IKDC score of 89.0 at posttraining, the responder group almost achieved 90 points, which is our clinical cutoff for returning to sport. The nonresponder group's mean IKDC score was well below 90 points (81.9) at posttraining and did not achieve >90 points until 1 year after ACLR. Thus, it took the nonresponder group longer to achieve adequate self-reported knee function (ie, ≥90 points). Although there was not a significant group-by-time interaction for the KOOS-Sport, we observed the same pattern of improvement between the groups. The responder group's mean score surpassed 90 points (91.7), while the nonresponder group's mean score was well below 90 points (82.2) at posttraining. At 1 year, the nonresponder group caught up to the responder group, achieving a mean KOOS-Sport score >90 points (91.0). The pattern of change in IKDC and KOOS-Sport scores has both beneficial and potentially deleterious implications for the responder group. From a positive perspective, a score ≥90 points on self-reported functional measures is often used as one criterion needed to allow an athlete to return to sport.[1,13] The responders approached 90 points on the IKDC form (89.0) and exceeded 90 points (91.7) on the KOOS-Sport at the posttraining time point. From a negative perspective, athletes with higher self-reported function and a more positive psychological outlook for return to sport may return to sport too soon and perhaps increase their risk of second ACL injury.

The relationship between self-reported function and different psychological constructs has been well established.[3,4,24] However, the direction of this relationship is still not clear. In the current study, both groups demonstrated improvements in self-reported function (IKDC and KOOS-Sport scores) from pretraining to posttraining, with the responder group demonstrating higher self-reported function at posttraining. It is plausible that a greater improvement in self-reported function led to a greater improvement in psychological outlook. It is also plausible that the IKDC and KOOS-Sport scores are influenced by psychological outlook. Future research should elucidate the relationship between psychological outlook and self-reported function.

Group differences were not present in the number of athletes who returned to their previous level of sport at 1 or 2 years after ACLR. This indicates that many of the nonresponders returned to their previous level of sport, despite reporting deficits in function, sport-specific activities, and knee-related quality of life, at 2 years after ACLR. Although not statistically significant, however, 10% fewer athletes in the nonresponder group returned to their preinjury sport level compared with the responder group. Additionally, a meta-analysis of 69 studies found that only 65% of athletes returned to their preinjury sport level.[5] A higher percentage of athletes in the current study's responder group returned to their preinjury sport level (77%), while the nonresponder group's percentage (67%) was consistent with the meta-analysis.

On average, the athletes in our cohort displayed similar ACL-RSI scores to other studies examining athletes at similar times after ACLR. Langford et al[19] examined psychological readiness to return to sport at 6 months after ACLR. Athletes who returned to competitive sport by 12 months had a mean ACL-RSI score of 63, while athletes who did not return to competition had a mean score of 52. Ardern et al[6] examined ACL-RSI scores at 4 months after ACLR, finding that athletes who returned to sport by 1 year had a mean score of 57, while athletes who did not return to sport had a mean score of 40. Using a receiver operating characteristic curve analysis, the authors found that a cutoff score of 56 at 4 months after ACLR was best at discriminating the athletes who are able to return to sport versus those who are not able. In the present study, the responders displayed very similar scores

(mean, 56.7) to the nonresponders (mean, 59.9) at pretraining, and both groups' scores were around the cutoff score determined by Ardern et al.[6] Our entire cohort therefore displayed psychological readiness scores that could potentially benefit from improvement. In fact, there were 19 athletes in the current study with ACL-RSI scores ≥70 at pretraining. One may think that these athletes, with already high ACL-RSI scores, may not have room for improvement. However, 11 athletes with pretraining ACL-RSI scores ≥70 displayed at least a 10-point increase from pretraining to posttraining (responder group), while 8 athletes with scores ≥70 did not display a 10-point increase (nonresponder group). This finding suggests that even athletes with scores ≥70 on the ACL-RSI scale can still continue to improve their psychological outlook.

To our knowledge, this is the first study to examine if changes in psychological outlook after completing a secondary injury prevention program are associated with improved self-reported function after ACLR and with continued better function. However, the relationship between psychological factors and functional outcomes has been investigated cross-sectionally.[11,12] A recent clinical review indicated that self-reported function and the fear of reinjuries are associated during the late stages of rehabilitation.[15] Inconsistent findings have been found during the earlier stages of rehabilitation when physical impairments may contribute more to functional deficits.[21] Future research should continue to evaluate how specific interventions affect psychological outlook, given the association between psychological factors and outcomes after ACLR.

There are limitations to this study. First, there are currently no established minimal detectable change (MDC) or MCID values established for the ACL-RSI scale. Only one study examined test-retest reliability and calculated MDC values.[18] That study adopted a 0-to-10 scale as opposed to the original 0-to-100 scale and is therefore inappropriate to use. We thus dichotomized our groups based on known groups' validity and face validity. Future research should attempt to calculate true MDC and MCID values for the ACL-RSI scale. Second, based on the study's design and lack of a control group, we are not able to ascertain whether having an improvement in psychological readiness led to better self-reported function or if an improvement in function led to psychological readiness scores. Future research should examine interventions directly related to improving psychological readiness to return to sport.

Conclusion

A total of 59% of the athletes in this study demonstrated a positive psychological response, by our definition, to a neuromuscular training and secondary ACL injury prevention program. These athletes, categorized as responders, demonstrated better self-reported function immediately after the program and at 1 and 2 years after ACLR compared with the nonresponders. Significant group differences in returning to previous sport levels were not found. Our findings suggest that those who improve their psychological outlook over the course of rehabilitation may report increased function compared with those who do not, indicating that interventions targeting psychological factors may be warranted to improve rehabilitation outcomes.

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References

1. Adams, D, Logerstedt, DS, 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.

2. Ardern, CL. Anterior cruciate ligament reconstruction: not exactly a one-way ticket back to the preinjury level. A review of contextual factors affecting return to sport after surgery. Sports Health. 2015;7(3):224-230.
3. Ardern, CL, Osterberg, A, Tagesson, S, Gauffin, H, Webster, KE, Kvist, J. The impact of psychological readiness to return to sport and recreational activities after anterior cruciate ligament reconstruction. Br J Sports Med. 2014;48(22):1613-1619.
4. Ardern, CL, Taylor, NF, Feller, JA, Webster, KE. Fear of re-injury in people who have returned to sport following anterior cruciate ligament reconstruction surgery. J Sci Med Sport. 2012;15(6):488-495.
5. Ardern, CL, Taylor, NF, Feller, JA, Webster, KE. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis including aspects of physical functioning and contextual factors. Br J Sports Med. 2014;48(21):1543-1552.
6. Ardern, CL, Taylor, NF, Feller, JA, Whitehead, TS, Webster, KE. Psychological responses matter in returning to preinjury level of sport after anterior cruciate ligament reconstruction surgery. Am J Sports Med. 2013;41(7):1549-1558.
7. Ardern, CL, Taylor, NF, Feller, JA, Whitehead, TS, Webster, KE. Sports participation 2 years after anterior cruciate ligament reconstruction in athletes who had not returned to sport at 1 year: a prospective follow-up of physical function and psychological factors in 122 athletes. Am J Sports Med. 2015;43(4):848-856.
8. Ardern, CL, Webster, KE, Taylor, NF, Feller, JA. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. Br J Sports Med. 2011;45(7):596-606.
9. Arundale, AJH, Cummer, K, Capin, JJ, Zarzycki, R, Snyder-Mackler, L. Report of the clinical and functional primary outcomes in men of the ACL-SPORTS trial: similar outcomes in men receiving secondary prevention with and without perturbation training 1 and 2 years after ACL reconstruction. Clin Orthop Relat Res. 2017;475(10):2523-2534.
10. Capin, JJ, Zarzycki, R, Ito, N, et al. Gait mechanics in women of the ACL-SPORTS randomized control trial: interlimb symmetry improves over time regardless of treatment group. J Orthop Res. 2019;37(8): 1743-1753.
11. Chmielewski, TL, Jones, D, Day, T, Tillman, SM, Lentz, TA, George, SZ. The association of pain and fear of movement/reinjury with function during anterior cruciate ligament reconstruction rehabilitation. J Orthop Sports Phys Ther. 2008;38(12):746-753.
12. Chmielewski, TL, Zeppieri, G, Lentz, TA, et al. Longitudinal changes in psychosocial factors and their association with knee pain and function after anterior cruciate ligament reconstruction. Phys Ther. 2011;91(9):1355-1366.
13. Grindem, H, Snyder-Mackler, L, Moksnes, H, Engebretsen, L, Risberg, MA. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study. Br J Sports Med. 2016;50(13):804-808.
14. Hefti, E, Müller, W, Jakob, RP, Stäubli, HU. Evaluation of knee ligament injuries with the IKDC form. Knee Surg Sports Traumatol Arthrosc. 1993;1(3-4):226-234.
15. Hsu, C-J, Meierbachtol, A, George, SZ, Chmielewski, TL. Fear of reinjury in athletes: implications for rehabilitation. Sports Health. 2017;9(2):162-167.
16. Irrgang, JJ, Anderson, AF, Boland, AL, et al. Development and validation of the International Knee Documentation Committee subjective knee form. Am J Sports Med. 2001;29(5):600-613.
17. Kvist, J, Ek, A, Sporrstedt, K, Good, L. Fear of re-injury: a hindrance for returning to sports after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2005;13(5):393-397.

18. Kvist, J, Osterberg, A, Gauffin, H, Tagesson, S, Webster, K, Ardern, C. Translation and measurement properties of the Swedish version of ACL-Return to Sports after Injury questionnaire. Scand J Med Sci Sports. 2013;23(5):568-575.
19. Langford, JL, Webster, KE, Feller, JA. A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. Br J Sports Med. 2009;43(5):377-378.
20. Lentz, TA, Aeppieri, G, Tillman, SM, et al. Return to preinjury sports participation following anterior cruciate ligament reconstruction: contributions of demographic, knee impairment, and self-report measures. J Orthop Sports Phys Ther. 2012;42(11):893-901.
21. Lentz, TA, Zeppieri, G, George, SZ, et al. Comparison of physical impairment, functional, and psychosocial measures based on fear of reinjury/lack of confidence and return-to-sport status after ACL reconstruction. Am J Sports Med. 2015;43(2):345-353.
22. López-de-Uralde-Villanueva, I, Muñoz-García, D, Gil-Martínez, A, et al. A systematic review and meta-analysis on the effectiveness of graded activity and graded exposure for chronic nonspecific low back pain. Pain Med. 2016;17(1):172-188.
23. 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.
24. Paterno, MV, Flynn, K, Thomas, S, Schmitt, LC. Self-reported fear predicts functional performance and second ACL injury after ACL reconstruction and return to sport: a pilot study. Sports Health. 2018;10(3): 228-233.
25. Roos, EM, Lohmander, LS. The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. Health Qual Life Outcomes. 2003;1:64.
26. Salavati, M, Akhbari, B, Mohammadi, F, Mazaheri, M, Khorrami, M. Knee injury and Osteoarthritis Outcome Score (KOOS): reliability and validity in competitive athletes after anterior cruciate ligament reconstruction. Osteoarthritis Cartilage. 2011;19(4):406-410.
27. Sturgill, LP, Snyder-Mackler, L, Manal, TJ, Axe, MJ. Interrater reliability of a clinical scale to assess knee joint effusion. J Orthop Sport Phys Ther. 2009;39(12):845-849.
28. Webster, KE, Feller, JA, Lambros, C. Development and preliminary validation of a scale to measure the psychological impact of returning to sport following anterior cruciate ligament reconstruction surgery. Phys Ther Sport. 2008;9(1):9-15.
29. White, K, Di Stasi, SL, Smith, AH, Snyder-Mackler, L. Anterior Cruciate Ligament- Specialized Post-Operative Return-to-Sports (ACL-SPORTS) training: a randomized control trial. BMC Musculoskelet Disord. 2013;14(1):108.