Re-Injury anxiety and return to sport after anterior cruciate ligament reconstructions: a cluster analysis and prospective study among 162 athletes

ABSTRACT : 349 words

Background: Recent studies have investigated the impact of psychological factors on the return to sport (RTS), but none have tested the existence of psychological profiles linked to re-injury anxiety and its links with return to sport with re-injury.

Purpose: To assess the impact of different psychological profiles on the RTS and re-injury.

Study Design: Prospective study; Level of evidence 2

Methods: The study screened patients, who were involved in all types of sports for ACL reconstruction (hamstring and patellar tendon autografts). All participants were included during the reathletisation phase (90-180 days after ACL reconstruction). Re-injury anxiety, fear of re-injury, kinesiophobia, perceived stress, anxiety, depression, knee confidence, self-esteem, optimism, coping, and pain were measured. Hierarchical cluster analyses (Ward method), and analysis of variance (ANOVA) were performed. In the second year after surgery, patients were recontacted by telephone to follow up. RTS and re-injury were compared from type of profiles.

Results: A total of 162 athletes were initially included, of whom 123 responded on RTS and re-injury. Cluster analysis showed a 4-cluster solution ($\chi^2(21) = 428.59$, $\lambda = .064$; $p < .001$). Profile 1 (27.8%) was characterized by "moderate re-injury anxiety, no depression"; profile 2 (22.8%) by "moderate re-injury anxiety and minor anxious-depressive reaction"; profile 3 (30.9%) by "no re-injury anxiety, no depression, high confidence"; and profile 4 (18.5%) by "high anxiety, high depression, low confidence". Profile 4 had the lowest self-esteem and optimism scores compared to profile 3 ($p < 0.001$). In addition, a higher percentage of males was found in profile 3 as opposed to profile 4 ($\chi^2(3) = 11.35$, $p < 0.01$). Profile 4 had the

highest rate of non-return to sport with 45.8% (Profile 1: 85.7%, p 0.001, Profile 2: 75.0%, p = 0.031, Profile 3: 77.8%, p = 0.011). Finally, profile 3 had a higher risk of re-injury (13.9%) than profile 4 (0%, p = 0.047), which was extremely conservative at returning to sport.

Conclusion: The different profiles will affect RTS, but also the risk of re-injury exclusively for profiles 3 and 4. Rehabilitation management will probably require all stakeholders to understand psychological profiles of athletes in order to develop an "on demand" rehabilitation plan.

Keywords: re-injury anxiety, psychologic profiles, knee, anterior cruciate ligament, return to sport, emotions, personality, re-injury

What is known about this subject:

It is known that athletes after an injury, often have mixed emotions between positive and negative. However, it is known that there are several different reactions to the injury depending on the athlete. Some will be more adapted to the injury, while others will be distressed by it.

What this study adds to existing knowledge

Few studies have investigated the psychological profile of reactions to injury. Even less on specific long-term injuries. It is not known how many injury reaction profiles could be expected for injured athletes, and their impact on return to sport or re-injury.

INTRODUCTION

Injuries are the most common and frequent negative event experienced by the athletes in their career[62]. Despite the fact that many studies have documented the psychological effects of injuries[5,58], recent studies proposed to focus on the negative emotions that take place before returning to sport, described in terms of re-injury anxiety[10,59]. While some athletes sometimes return to sport with no concern about their injury, some athletes have high levels of anxiety about sustaining another injury[34,45]. Re-injury anxiety is one of the most common emotions following an injury[20,40]. This psychological reaction has also been described in terms of fear of re-injury[25] and kinesiophobia[30].

After an ACL injury, psychological symptoms such as anxiety[28] and depression[4] are frequently observed and are linked to fear of re-injury[21]. Additionally, stress is among the most common psychological reactions after an injury[28].

Self-esteeem and optimism have been examined in literature as potential personality psychological outcomes[19] for ACL reconstruction, and they also been shown to be predictor of rehabilitation compliance, return to sport (RTS), and self-rated knee symptoms[19].

There are, however, a number of gaps and inconsistent results throughout these studies that tested the interaction and the relationship between these variables and re-injury anxiety. It has been reported that some of them consider age as a predictor of re-injury anxiety or[35] whereas others claim the opposite[31]. Despite their descriptive nature, these studies do not provide a detailed explanation of the differences between athletes who experience negative emotions and cognitions after suffering an injury and those who recover and return to sport without psychological complications. Finally, none of these studies investigated psychological profiles among injured athletes. Furthermore, none of the studies examined the relationship between these profiles and the outcomes of re-injury anxiety. Psychological profiles have

already been demonstrated to be of value in other populations of athletes who are injured or concussed[46].

Aim of this study is 1) to test the existence of psychological profiles of ACL injured athletes based on negative cognitions and emotions. In a second time, 2) to test the differences between the different profiles concerning sociodemographic characteristics (age, sex, level of practice, type of sport), type of surgery, pain, and psychological resources (optimism, self-efficacy, and coping). Finally, 3) to determine whether profiles can predict RTS and the risk of re-injury.

MATERIALS AND METHODS

Inclusion criteria were as follows: Athletes who underwent ACL autograft reconstruction and rehabilitation in a sport rehabilitation center (France) were screened for inclusion in this cohort study (Figure 1). Once the patients had been informed of the study and given their consent, their data was entered into a computerized database, which included surgical, medical, and sports-related information. In this study, patients aged 18 to 45 were eligible if they had undergone one of two types of surgery for a first reconstruction: 1) patellar tendon autografts (PT), involving transplantation of the patellar tendon (bone-patellar tendon-bone), and two tunnels (a femoral and a tibial tunnel); 2) hamstring autografts (HT) requiring two hamstring muscles (semitendinosus and gracilis), folded over, with a single bundle and two tunnels (a femoral and a tibial tunnel). Between the third and sixth months following surgery, athletes who had been injured in sports were included.

The following criteria were used for exclusion: Patients with osteotomy, bone fracture or chondroplasty, associated medial/lateral ligament surgery, and iso +/- controlateral rupture

were not included. Athletes who underwent psychological intervention or who suffered a career-ending injury were excluded from the study.

In the first stage of the study, data were collected between three and six months after surgery. Participants completed measurements of re-injury anxiety (RIAI, Re-Injury Anxiety Inventory[57], adapted in French[12]), fear of re-injury (ACL RSI, Anterior Cruciate Ligament-Return to Sport after Injury[61], adapted in French[8]), kinesiophobia (TSK-17, Tampa Scale of Kinesiophobia[30], adapted in french[21]), perceived stress, anxiety (PSS-10, Perceived Stress Scale[13], adapted in french[37]), depression (HADS, Hospital Anxiety and Depression Scale[63], adapted in french[53]), knee confidence (IKDC subjective, International Knee Documentation Committee Subjective Knee Form[27], validated in french[26]), self-esteem (RSES, The Rosenberg Self-Esteem Scale[44], adapted in french[54]), optimism (LOT-R, The Life Orientation Test-Revised[47], adapted in french[51]), coping (WCC-R, The Ways of Coping Checklist-Revised[55], adapted in french[14]), and pain (EVA, Visual Analogue Pain Scale*)*. Various sports were analyzed based on their disciplines and were grouped accordingly based on whether they were individual or team sports. Sports levels were classified as regional, national, and international for patients who played competitively, whereas patients who did not play competitively were classified as other athletes, including sports teachers, coaches, and monitors.

Rehabilitation included post-operative recovery of articular extension at 0° and articular flexion at more than 120°, quadriceps contraction against gravity, and technique for walking without assistance from three to six weeks following surgery. Rehabilitation is conducted in accordance with a validated protocol[33]. In accordance with the surgeon's recommendation, a brace was worn for a period of three to six weeks. During this period, cardiovascular activities were introduced gradually, including riding a bicycle, using a step

machine, or rowing a machine, as well as swimming (crawl). As a result of the surgeon's decision, running was resumed around the third or fourth month. Return to the original activity was subject to the surgeon's approval.

Following the verification of eligibility criteria, patients were contacted by telephone within one month of the second year following surgery. Data regarding return to sport (competition), and recurrence were collected. A surgeon's assessment of the patient's progress determined the patient's return to competition. The study was approved by an ethics committee (*Comité de Protection des Personnes du SUD-OUEST ET OUTRE-MER 4, LIMOGES, CPP18-025a/2017-A03659-44*).

Statistical analyses

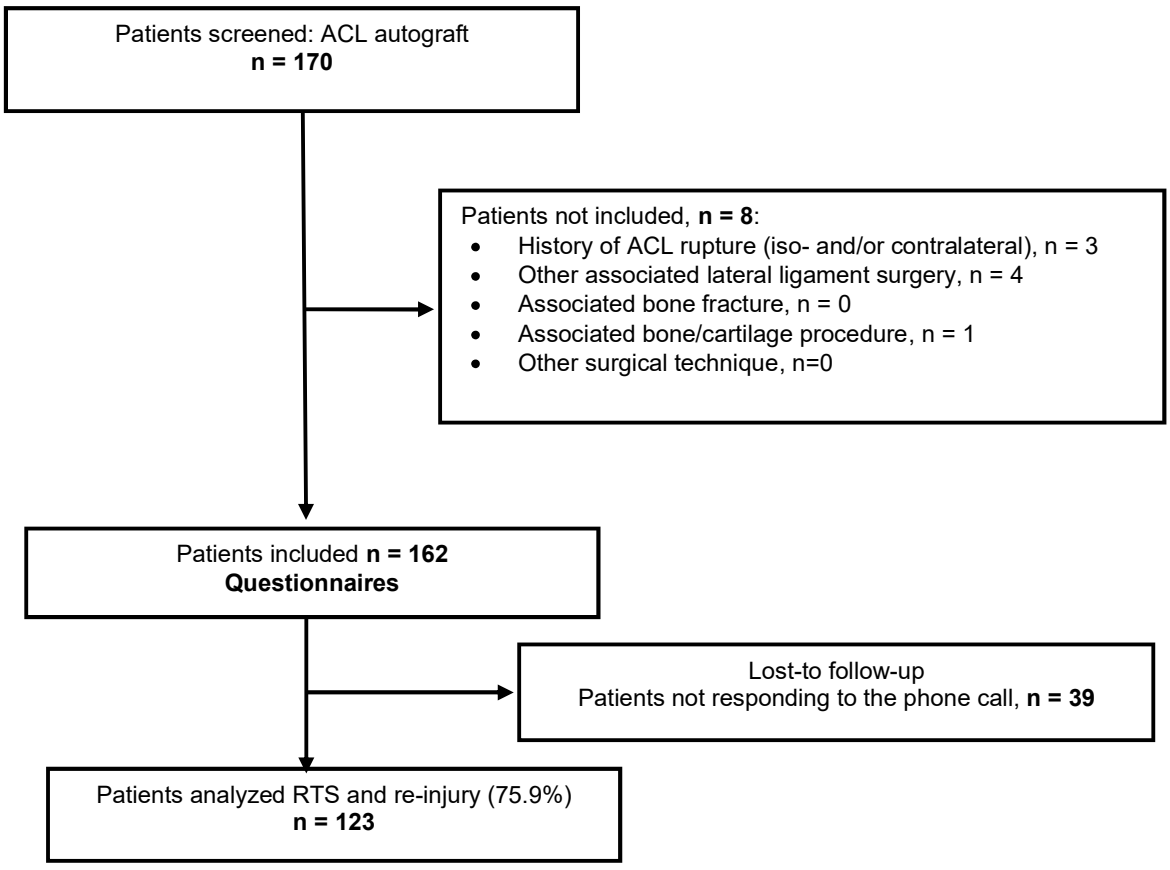
This study utilized a cluster analysis with a two-step procedure in order to identify psychological profiles. As a first step, the z-scores for all variables were subjected to ascending hierarchical cluster analyses (Ward's method) based on squared Euclidean distances. In order to identify a cluster solution[39]: three criteria were used: theoretical predictions, the parsimony of the solution, and its explanatory power. The optimal number of profiles was determined according to their theoretical and statistical adequacy[49]. The second step consisted of an iterative k-means clustering procedure integrating barycentric of the solution previously chosen. Moreover, differences across gender, age, level of sport, ACLR graft type, and associated lesion in the four emotional profiles were investigated by Chi-square tests. The differences between the profiles obtained regarding personality (self-esteem, optimism), coping (problem-focused, emotion-focused, and seeking social support), and pain were tested using analyses of variance (ANOVA) with Tukey posthoc tests, as well as Chisquare tests for re-injury and return to sport. All analyses were performed with SPSS software (version 23.0) and all p values were considered at $p \leq .05$. Demographic data were

summarized using frequencies in % and number of athletes. Means and standard deviations were used for quantitative variables.

RESULTS

Between May 2018 and November 2018, 162 athletes (95.2% response rate) undergoing ACL autograft reconstruction were screened (Figure1).

Figure 1: Flowchart summarizing the study design



In the second year following the ACL reconstruction, 75.9% of patients (n = 123) responded to the phone call regarding return to sport and re-injury.

Furthermore, 162 athletes were analyzed for the 2 types of surgery: 74.1% (n = 120) for the hamstring group (HT), and 25.9% (n = 42) for the patellar tendon autograft group (PT). Additionally, 17.9% (n= 29) athletes had a lesion of the lateral meniscus, and 17.9% (n=29) had a lesion of the medial meniscus, and 64.2% (n=104) athletes did not have any associated meniscus lesions (Table 1). Mean age was 24.3(SD = 5.3) years. A total of 51 women (31.5%) are included in this study. Rugby (27.2%) was the most commonly practiced sport, followed by soccer, handball, and basketball.

Table 1. Characteristics of patients (N = 162)

Variable		All
Age at surgery	n	162
	Mean (standard deviation)	24.3 (5.3)
Sex	n	162
	M	111 (68.5%)
	W	51 (31.5%)
Sport	n	162
	Basketball	12 (7.4%)
	Soccer	39 (24.1%)
	Handball	21 (12.9%)
	Rugby	44 (27.2%)
	Ski	9 (5.5%)
	Fight sports	8 (4.9%)
	Racket sports	3 (1.9%)
	Other	26 (16.1%)
Type of sport	n	162
	Individual	45 (27.8%)
	Team Sports	117 (72.2%)

Level	n	162
	International	38 (11.1%)
	National	81 (50.0%)
	Regional	47 (29.0%)
	Others	16 (9.9%)
Surgery	HT	120 (74.1%)
	PT	42 (25.9%)
Meniscus associated lesion	Lateral Meniscus	29 (17.9%)
	Medial Meniscus	29 (17.9%)
	No meniscus associated lesion	104 (64.2%)

Determining psychological profiles

A hierarchical cluster analysis (Ward's method) using a two-step procedure allowed us to identify four clusters of emotional profiles. In Figure 2, the mean levels of each of the seven dimensions of emotional profiles are shown separately for each cluster. This solution explained 69.2% of the variance in re-injury anxiety, 55.7% for perceived stress, 32.7% for kinesiophobia, 56.8% for fear of re-injury, 43.7% for general anxiety, 30.4% for depression, and 36.9% for confidence in knee. A discriminant function analysis supported this final cluster solution ($\chi^2(21) = 428.59$, $\lambda = .064$; $p < .001$; 96.9% of cross-validated grouped cases correctly classified).

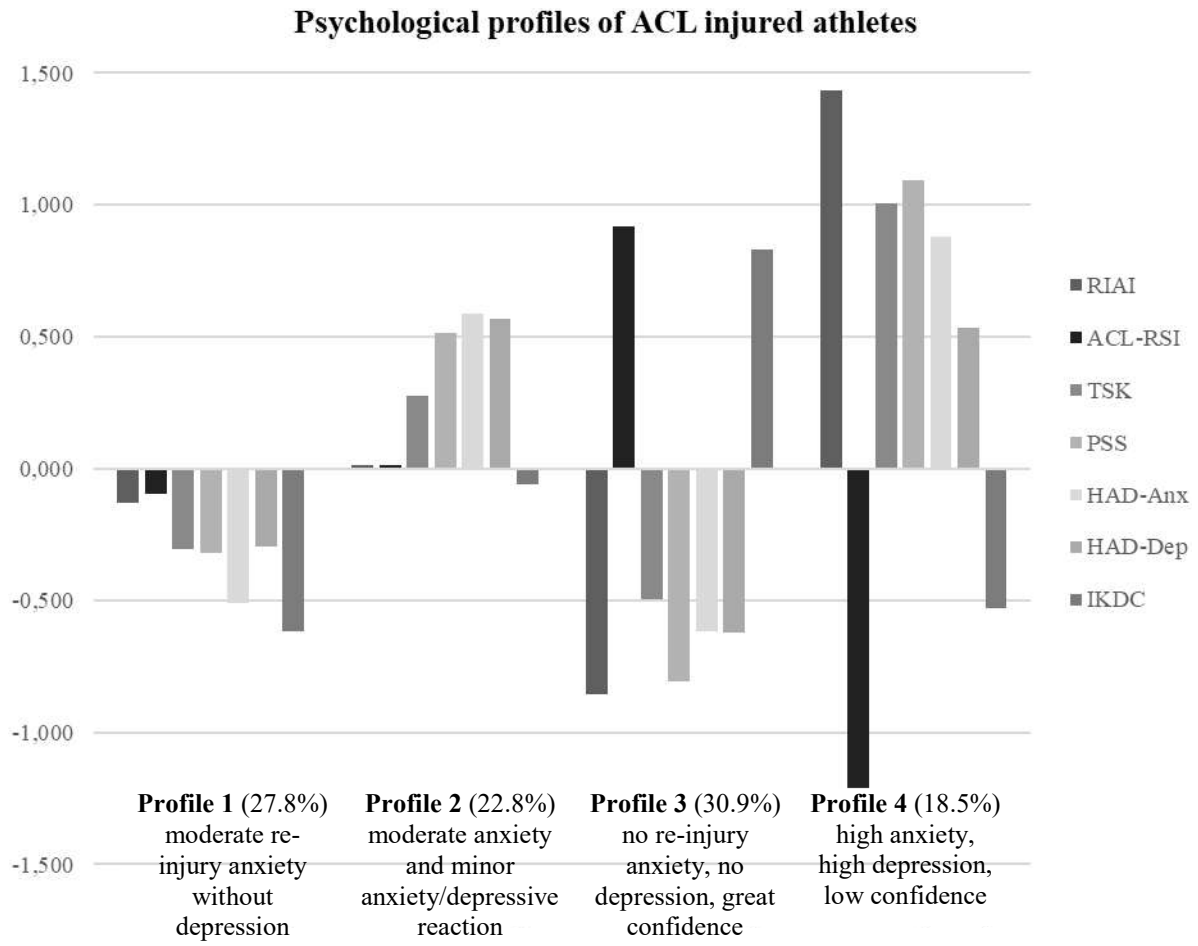


Fig 2. Final solution of clusters analysis on psychological profiles of ACL injured athletes. Z-scores for re-injury anxiety (RIAI), fear of re-injury (ACL-RSI), kinesiophobia (TSK), perceived stress scale (PSS), anxiety (HAD-Anx), depression (HAD-Dep), and confidence in knee (IKDC).

According to ANOVAS and Tukey post hoc tests (Table 2), the **first profile** (27.8%) is characterized by intermediate scores for re-injury anxiety (RIAI Mean = 11) and fear of re-injury (ACL RSI = 80.2) and low scores for kinesiophobia (TSK = 34.5), stress (PSS = 11.1), anxiety (HAD A = 3.5), depression (HAD D = 1.8) and knee confidence (IKDC = 56.6) and was interpreted in terms of "moderate re-injury anxiety without depression". In this case, the patient was suffering from a classic anxiety reaction to the injury, without any negative consequences for his mood.

The **second profile** (22.8%) is characterized by intermediate levels of re-injury anxiety (RIAI = 12.4) and fear of re-injury (ACL RSI = 80.2), and "medium/high" levels of

stress (PSS = 17.1), anxiety (HAD A = 7), and depression (HAD D = 3.8). This profile was interpreted in terms of “moderate anxiety and minor anxiety/depressive reaction”. In this profile, the patient experiences a classic anxiety reaction as a result of the injury, which has consequences for his stress levels and his mood.

The **third profile** (30.9%) is characterized by the absence of negative emotions (low re-injury anxiety (RIAI = 4.3) and kinesiophobia (TSK = 33.3), absence of fear of re-injury (ACL RSI = 104), low stress (PSS = 7.6), anxiety (HAD A = 3.2), and depression (HAD D = 1.1). and by high knee confidence (IKDC = 73). This profile was interpreted in terms of “no re-injury anxiety, no depression, great confidence". In this case, the patient is almost "overconfident and is often eager to return to sports as soon as possible".

Finally, the **last profile** (18.5%) is characterized by high re-injury anxiety (RIAI = 25.7), kinesiophobia (TSK = 42.7), severe fear of re-injury (ACL RSI = 54.7), high stress (PSS = 21.2), anxiety (HAD A = 8), and depression (HAD D = 3.7), and low knee confidence (IKDC = 57.6). This profile was interpreted in terms of “high anxiety, high depression, low confidence". The profile indicates that this patient is very cautious and very low in confidence, which has an adverse impact on his mood.

Table 2. Comparison between emotional profiles and psychological characteristics of injured athletes

	Profile 1 (moderate re-injury anxiety without depression) **(27.8%)**	**Profile 2** (moderate anxiety and minor anxiety/depressive reaction) **(22.8%)**	**Profile 3** (no re-injury anxiety, no depression, great confidence) **(30.9%)**	**Profile 4** (high anxiety, high depression, low confidence) **(18.5%)**	***p* value**
Re-Injury Anxiety (RIAI)	11.0 ± 4.7^{b}	12.4 ± 5.8^{b}	4.3 ± 3.5^{c}	25.7 ± 6.1^{a}	<.001*
Fear of re-injury (ACL-RSI)	80.2 ± 13.3^{b}	82.8 ± 12.7^{b}	104 ± 12.4^{a}	54.7 ± 21.6^{c}	<.001*
Kinesiophobia (TSK)	34.5 ± 4.6^{c}	38.2 ± 4.6^{b}	33.3 ± 5.3^{c}	42.7 ± 5.7^{a}	<.001*
Stress (PSS)	11.1 ± 4.4^{c}	17.1 ± 4.2^{b}	7.6 ± 4.7^{d}	21.2 ± 5.2^{a}	<.001*
Anxiety (HADS)	3.5 ± 1.9^{b}	7.0 ± 2.8^{a}	3.2 ± 1.9^{b}	8.0 ± 3.0^{a}	<.001*
Depression (HADS)	1.8 ± 1.5^{b}	3.8 ± 2.0^{a}	1.1 ± 1.3^{b}	3.7 ± 2.8^{a}	<.001*
Confidence in Knee (IKDC)	56.6 ± 11.5^{c}	62.9 ± 9.5^{b}	73.0 ± 5.7^{a}	57.6 ± 9.5^{c}	<.001*

Data are presented as mean ± SD $^{a, b, c, d}$: each letter indicate the same mean between profiles or different scores.
*Reading note : for re-injury anxiety, the highest scores were reported by profile 4 (exponent a), followed by profile 2 and profile 3 (exponent b), and the lowest scores were reported by profiles 3 (exponent c). * for significant differences*

Relationship of psychological profiles with morphostatic characteristics, type of surgery, pain and psychological ressources

To test for differences between the four profiles based on demographic, sporting, surgical, and psychological characteristics (Table 3), Chi-square tests and ANOVAs were conducted with Tukey post-hoc tests.

242 **Table 3.** Comparison between psychological profiles and characteristics of injured athletes

	Profile 1 (27.8%)	**Profile 2 (22.8%)**	**Profile 3 (30.9%)**	**Profile 4 (18.5%)**	***p* value**
Demographic characteristics					
Gender					<.001*
Male	31 (68.9%)	24 (64.9%)	42 (84.0%)	14 (46.7%)	
Female	14 (31.1%)	13 (35.1%)	8 (16.0%)	16 (53.3%)	
Age	24.7 ± 4.1[a]	24.1 ± 5.9[a]	23.4 ± 4.9[a]	25.4 ± 6.4[a]	0.71
Sport characteristics					
Level of sport					0.26
Regional	15 (33.3%)	8 (21.6%)	11 (22.0%)	13 (43.3%)	
National	19 (42.2%)	21 (56.8%)	31 (61.0%)	10 (33.3%)	
International	5 (11.1%)	3 (8.1%)	5 (10.0%)	5 (16.7%)	
Other	6 (13.3%)	5 (13.5%)	3 (6.0%)	2 (6.7%)	
Sport type					0.58
Individual sport	16 (35.6%)	9 (24.3%)	12 (24.0%)	8 (26.7%)	
Team sport	29 (64.4%)	28 (75.7%)	38 (76.0%)	22 (73.3%)	
Surgical characteristics					
ACL graft type					0.47
HT	33 (73.8%)	31 (83.8%)	35 (68.0%)	21 (70.0%)	
PT	12 (26.2%)	6 (16.2%)	15 (32.0%)	9 (30.0%)	
Meniscus associated lesion					0.53
Lateral Meniscus	9 (27.3%)	8 (19.0%)	8 (14.5%)	4 (12.5%)	
Medial Meniscus	7 (21.2%)	9 (21.4%)	8 (14.5%)	5 (15.6%)	
No mesniscus associated lesion	17 (51.5%)	25 (59.5%)	39 (70.9%)	23 (64.2%)	
Pain	2.4 ± 2.4[a]	2.5 ± 2.0[a]	1.8 ± 2.3[a]	3.0 ± 2.3[a]	0.07
Psychological resources					
Self-esteem (RSES)	34.8 ± 2.8[a]	31.0 ± 4.3[b]	35.9 ± 3.6[a]	30.9 ± 5.3[b]	<.001*
Optimism (LOT-R)	27.5 ± 4.4[b]	24.2 ± 3.8[c]	30.4 ± 4.5[a]	24.4 ± 6.7[c]	<.001*
Coping (WCC-R)					
Problem-focused	31.8 ± 4.5[b]	30.7 ± 4.4[b]	34.2 ± 5.0[a]	30.5 ± 4.0[b]	<.001*
Emotion-focused	19.5 ± 4.5[c]	22.5 ± 5.7[b]	18.6 ± 5.6[c]	26.0 ± 5.2[a]	<.001*
Social support-seeking	24.1 ± 4.5[a]	23.1 ± 5.2[a]	22.7 ± 5.7[a]	24.0 ± 4.0[a]	0.84

Data are presented as mean ± SD or no. (%). Chi-square test for qualitatives variables. ANOVA and Tukey post-hoc for quantitatives variables. [a, b, c, d]: each letter indicate the same mean between profiles or different scores. *Reading note : for emotion focused coping, the highest scores were reported by profile 4 (exponent a), followed by profile 2 (exponent b), and the lowest scores were reported by profiles 1 and 3 (exponent c). * for significant differences*

Results from ANOVA showed significant differences between profiles on self-esteem [$F_{(3,153)} = 16.7$; $p < .001$; $\omega^2 = .231$], optimism [$F_{(3,154)} = 15.0$; $p < .001$; $\omega^2 = .209$], problem-focused [$F_{(3,155)} = 6.19$; $p < .001$; $\omega^2 = .089$], and emotions-focused [$F_{(3,155)} = 14.8$; $p < .001$; $\omega^2 = .207$]. Results showed higher percentage of men in profile 3 (84%) and lower percentage (46.7%) in profile 4 ($\chi^2(3) = 11.35$, $p < .01$). No other difference was found for demographic, sport, surgical characteristics and pain. Tukey post hoc tests for the scores for psychological resources highlighted that profiles 1 and 3 reported higher scores for self-esteem than those for profiles 2 and 4 ($p < .001$). Profile 3 reported the highest scores of optimism, and the lowest for profiles 2 and 4 ($p < .001$). Profile 3 also reported higher scores of problem focused coping that every other profile ($p < .001$), whereas profile 4 reported the highest scores for emotion focused coping and profiles 1 and 3 the lowest ($p < .001$). No significant difference was found for social support seeking.

Association of psychological profiles with the return to sport and re-injury.

Finally, chi-squared test were conducted in order to test the differences between the profiles for the outcomes (Table 4), and highest rates was highlighted for no return to sport observed in profile 4 with 45.8% (Profile 1: 85.7%, p 0.001, Profile 2: 75.0%, p = 0.031, Profile 3: 77.8%, p = 0.011). The highest return to sport rate was 77.8% for profile 3 and 85.7% for profile 1. However, it is interesting to note significant difference in re-injury p = 0.047 between athletes in profile 3 (13.9% of re-injury) and those in profile 4 (0% of re-

injury). The more frequently that profile's 3 athletes return to sport at the beginning of second year after ACLR, the more re-injuries they could have. We also note that the percentages of re-injuries in groups 1 and 2 are intermediate and comparable (5.7% and 7.7% of re-injuries).

Table 4. Comparison between psychological profiles and characteristics of injured athletes

	Profile 1 (27.8%)	**Profile 2 (22.8%)**	**Profile 3 (30.9%)**	**Profile 4 (18.5%)**
Outcomes				
Re-injury				
No	33 (94.3%)	24 (92.3%)	31 (86.1%)	26 (100.0%)
Yes	2 (5.7%)	2 (7.7%)	5 (13.9%)	0 (0.0%)
				p = 0.047*
Return to Sport				
No	5 (14.3%)	7 (25.0%)	8 (22.2%)	13 (54.2%)
Yes	30 (85.7%)	21 (75.0%)	28 (77.8%)	11 (45.8%)
			p = 0.011*	
		p = 0.031*		
	p = 0.001*			

Data are presented as mean ± SD or no. (%). Chi-square test for qualitatives variables. ANOVA and Tukey post-hoc for quantitatives variables. ** for significant differences.*

DISCUSSION

The most important finding of the study was that psychological profiles are associated with return to sport and recurrence. It has been reported that there are psychological profiles that display some emotional difficulties following an ACL reconstruction. One of them is characterized by high levels of negative psychological characteristics, resulting in a fear of returning to sports.

These findings confirm the existence of four different psychological profiles among injured athletes recovering from ACL surgery. Based on these four psychological reactions, it

was determined that athletes of profile 4 had a high level of anxiety/fear about re-injury. Other authors have found similar results authors[31]. Furthermore, some athletes never expressed anxiety/fear of re-injury. This result was also found by authors[31].

It has been suggested by some authors that there are well adapted athletes and poorly adapted athletes when faced with an injury. Indeed, we were able to determine the size of these two groups based on the profile percentage. The results of our study were in accordance with the findings of some studies[31,41] concerning the proportion of athletes who expressed fear of re-injury (between 24-30%).

A further finding is that the comparison between "well adapted" injured athletes and "maladapted"[31], should be considered as simplistic, since two "intermediate" profiles were identified. Whereas studies based on the general population reported equal proportions of participants who reported intermediate levels of anxio/depressive symptoms[1,18]. However, no previous study confirmed these results for re-injury anxiety among injured athletes.

One of these intermediate profiles has been described as characterized by moderate anxiety and minor anxiety/depressive symptoms. This cluster suggests that these athletes should not be regrouped with those who will experience high levels of re-injury anxiety. On the other hand, studies based on kinesiophobia cut-off scores of TSK>37, as used in previous literature to describe high levels of fear of re-injury[56] correspond to 59% of athletes[3] and 43.1% of athletes[50]. Furthermore, another intermediate profile was identified as having intermediate scores but low confidence in the knee (profile 1). This result confirms the findings of Papadopoulos et al.[42] who concluded that further study of the relationship between re-injury anxiety and knee confidence should be undertaken. Our results allow us to precise that knee confidence should not only be considered as a predictor of re-injury anxiety, but as a

310 specific cognition characterizing one of the psychological profiles observed among injured
311 athletes.

312 The results also provide insight into why some studies reported a difference between
313 male and female athletes[6], whereas other showed no significant differences[50]. As a result of
314 our findings, we may suggest that the differences between men and women may be explained
315 by differences in their psychological profiles and support the general statement that women
316 are more anxious than men at the time of return to sport[7,38].

317 There is no difference between the levels of competition. These results are consistent
318 with those reported with gymnasts[9] but they are contrary to those of De Pero et al.[17] , who
319 highlighted a connection between fear of re-injury and high levels of competition.
320 Nevertheless, caution should be exercised when considering the absence of differences
321 between the different types of sport in this study, as the comparison does not extend beyond
322 comparing individual sports with team sports. It would be particularly relevant to conduct
323 further studies based on samples from specific sports, especially when considering high-risk
324 activities[43]. Low fear of re-injury was associated with high risk activities according to a
325 study[23]. The results of this study highlight one of our limitations. As we limited sports
326 participation to individual and team sports, we were not able to draw any conclusions from
327 this result.

328 Regarding pain, no difference was found between the profiles. However, the results
329 highlighted a non-significant trend correlated to the profiles: profile 4 has the most pain while
330 profile 3 has the least. However, persistent knee pain could negatively affect the return to
331 sports[36].

As for psychological resources, self-esteem, optimism, problem-focused coping, and emotion-focused coping differed among profiles. Self-esteem was found to be related to sport experiences level in a study[2]. Self-esteem was higher among athletes with a higher level of experience[2]. Furthermore, self-esteem and coping strategies were related to a sport injury and were different among athletes[60]. Our results were consistent with all of these findings. However, a study comparing coping strategies used by injured athletes revealed that coping strategies differed based on the type of injury involved[29]. Coping strategies could be specific to injury type and profile. The results of our study showed a difference in profiles between athletes with ACL injuries. An individual may use coping strategies skills in order to cope with an injury based on the stage of their rehabilitation[22]. When focusing on optimism, a study showed no difference between athletes on win orientation, competitiveness[16]. It was found, however, in a study of swimming athletes, that there was a difference between pessimistic and optimistic styles regarding performance[48]. The results of our study are in agreement with those of Seligman, but they differ from those of Gallagher and Gardner. In fact, optimism may serve as a protective factor when an athlete injures himself, as it helps him remain positive and concentrate on the process of healing.

The psychological profiles of athletes have been shown to influence their return to sports. Possibly, we can modify profiles and influence the return to sport with mental preparation.

Additionally, pain is higher in group 4, which is the most cautious group. The clinical evolution (pain, IKDC) may also have an impact on the psychological aspect of the patient.

Stakeholders should focus on the HAD instrument in order to detect whether athletes are likely to develop anxiety or depression and, if so, implement psychological follow-up appropriate for athletes in profiles 2 and 4. Similarly, profile 4 would also require

mental preparation interventions to decrease perceived stress, fear and anxiety through mental imagery and/or relaxation techniques[15]. This would give them the confidence to resume sports activities and make them less worried about returning to sport. In our opinion, athletes with profile 3 profiles should be delayed in their return to sport to decrease their risk of injury due to premature return to sport, despite the fact that all psychological factors appear to be in favor of such a return. Moreover, practitioners should promote confidence in body parts through motivational self-talk[24] for profile 1, and their focus should be directed towards the performance they hope to achieve upon return to their sport. Regardless of the type of intervention used, randomised and controlled trials should be conducted in order to assess its efficacy among the different profiles of injured athletes.

As a clinical application, a better understanding of athlete profiles would allow a more comprehensive understanding of the athlete and enhance the use of various scores within the rehabilitation process. We may consider proposing psychological monitoring when scores on the HAD scale are high in terms of anxiety and depression (profile 2). In cases where the subjective scores of the ACL RSI/IKDC are high, it may be appropriate to conduct an optimism and self-esteem assessment to determine if the athlete is overconfident. As a consequence, the athlete will be able to moderate their activities if necessary (profile 3). When the athlete's subjective ACL RSI/IKDC score is low, it should be important to examine an organic cause (e.g., joint, tendon, or muscle pain) to address this issue which may hinder their progress. In the absence of organic causes, it would be appropriate to perform RIAI / Tampa / coping assessments, which will identify kinesiophobia or anxiety about reinjury (profile 4), which may require psychological support in the process of resuming sports (e.g., emotional management, goal setting).

Limitations of the study

While there are several classification methods available, cluster analysis and latent class analysis are the two most commonly used. In both analyses, the objective is to identify different groups and classify their members on the basis of their similarities. Cluster analysis is based on a geometric approach, defining clusters based on Euclidean distances (i.e., geometric proximity in a space) whereas latent class analysis is based on a probabilistic approach. Latent class method is currently popular and may be considered here as an alternative to the geometric distance approach, since it takes a probabilistic approach instead of one based on geometric distance. In addition, return to sport was determined by the date of return to competition. The authors of this study have proposed several classifications to distinguish the return to sport, namely return to running, return to training, return to competition, and return to the same level of competition[32]. In studies interested in classification, this could enhance the quality of information collected about return to sport. This study has a limitation of 25% lost to follow-up, which is common to studies of this type. There have been similar percentages (34-43%) of losses to follow-up reported in comparable studies[11,52], illustrating its prevalence in longitudinal studies of patients. Furthermore, the study has three important limitations, 1) the high percentage of men, 2) the high percentage of team sports, and 3) the high percentage of competitive sports make this study difficult to generalize to all injured athletes. Furthermore, we did not quantify post-op activity and level of frequency of participationn which might explain part or all the difference in reinjury rates between profile 3 and 4. Studies should focus on individual sports to provide better insight into psychological profiles associated with injuries among these athletes. Furthermore, psychological profiles applied to the sports domain, and in particular injury, are quite uncommon in the literature. Research on specific types of injuries, or on the impact of an injury on athletes' emotions, would allow stakeholders to gain a better understanding of

405 psychological reactions to injury. In spite of this, one of the strengths of this study was the use
406 of a prospective follow-up by telephone with a very low rate of participants who did not
407 receive follow-up.
408
409 **CONCLUSION**
410 In addition to affecting the return to sport, the various profiles will also be associated
411 with the risk of re-injury for profile 3 and 4. When it comes to rehabilitation management, it is
412 likely that it will be necessary to moderate patients with profile 3, which corresponds
413 primarily to men, and to provide psychological support for those with profile 4. Also,
414 counseling could be provided to those with depressive symptoms (profiles 2 and 4) in order to
415 develop a tailored rehabilitation program "on demand" based on the profiles of those affected.
416 This will enable all stakeholders to operate according to the profiles of the athletes.

REFERENCES

1. Airaksinen E, Larsson M, Lundberg I, Forsell Y. Cognitive functions in depressive disorders: evidence from a population-based study. *Psychological Medicine*. 2004;34(1):83-91. PMID: 14971629

2. Aktop A, Erman KA. Relationship between achievement motivation, trait anxiety and self-esteem. *Biology of sport*. 2006;23(2):127-141.

3. Anderson MN, Womble MN, Mohler SA, et al. Preliminary Study of Fear of Re-Injury following Sport-Related Concussion in High School Athletes. *Developmental Neuropsychology*. 2019;44(6):443-451. PMID: 31537099

4. Appaneal RN, Levine BR, Perna FM, Roh JL. Measuring Postinjury Depression among Male and Female Competitive Athletes. *Journal of Sport and Exercise Psychology*. 2009;31(1):60-76. PMID: 19325188

5. Ardern CL, Taylor NF, Feller JA, Webster KE. A systematic review of the psychological factors associated with returning to sport following injury. *British Journal of Sports Medicine*. 2013;47(17):1120-1126. PMID: 23064083

6. 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. *Journal of Science and Medicine in Sport*. 2012;15(6):488-495. PMID: 22695136

7. Armstrong KA, Khawaja NG. Gender Differences In Anxiety: An Investigation Of The Symptoms, Cognitions, And Sensitivity Towards Anxiety In A Nonclinical Population. *Behavioural and Cognitive Psychotherapy*. 2002;30(2):227-231.

8. Bohu Y, Klouche S, Lefevre N, Webster K, Herman S. Translation, cross-cultural adaptation and validation of the French version of the Anterior Cruciate Ligament-Return to Sport after Injury (ACL-RSI) scale. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(4):1192-1196. PMID: 24676789

9. Cartoni AC, Minganti C, Zelli A. Gender, Age, and Professional-Level Differences in the Psychological Correlates of Fear of Injury in Italian Gymnasts. *Journal of Sport Behavior*. 2005;28(1):3-17.

10. Cassidy CM. *Development of a measure of sport injury anxiety: The Sport Injury Appraisal Scale*. Doctoral Thesis. The University of Tennessee; 2006.

11. Castoldi M, Magnussen RA, Gunst S, et al. A Randomized Controlled Trial of Bone-Patellar Tendon-Bone Anterior Cruciate Ligament Reconstruction With and Without Lateral Extra-articular Tenodesis: 19-Year Clinical and Radiological Follow-up. *Am J Sports Med*. 2020;48(7):1665-1672. PMID: 32368935

12. Caumeil B, Edouard P, Décamps G. Adaptation et validation francophone du Re-Injury Anxiety Inventory : Le Questionnaire d'Anxiété de Re-Blessure (RIAI-F). *Journal de Traumatologie du Sport*. 2022;39(4):229-238.

13. Cohen S, Karmack T, Mermelstein R. A Global Measure of Perceived Stress. *Journal of health and social behavior*. Published online 1983:385-396. PMID: 6668417

14. Cousson-Gélie F, Bruchon-Schweitzer M, Quintard B, Nuissier J, Rascle N. Analyse multidimensionnelle d'une échelle de coping: validation française de la W.C.C. (Ways of Coping checklist). *Psychologie Française*. Published online 1996.

15. Cupal DD, Brewer BW. Effects of relaxation and guided imagery on knee strength, reinjury anxiety, and pain following anterior cruciate ligament reconstruction. *Rehabilitation Psychology*. 2001;46(1):28-43.

16. Czech DR, Burke KL, Joyner AB, Hardy CJ. An exploratory investigation of optimism, pessimism and sport orientation among NCAA Division I college athletes. *International Sports Journal*. 2002;6(2):136-145.

17. De Pero R, Minganti C, Pesce C, Capranica L, Piacentini MF. The relationships between pre-competition anxiety, self-efficacy, and fear of injury in elite teamgym athletes. *Kinesiology*. 2013;45.(1.):63-72.

18. El-Rufaie OEF, Absood GH. Minor Psychiatric Morbidity in Primary Health Care: Prevalence, Nature and Severity. *Int J Soc Psychiatry*. 1993;39(3):159-166. PMID: 8225812

19. Everhart JS, Best TM, Flanigan DC. Psychological predictors of anterior cruciate ligament reconstruction outcomes: a systematic review. *Knee Surg Sports Traumatol Arthrosc*. 2015;23(3):752-762. PMID: 24126701

20. Flanigan DC, Everhart JS, Pedroza A, Smith T, Kaeding CC. Fear of Reinjury (Kinesiophobia) and Persistent Knee Symptoms Are Common Factors for Lack of Return to Sport After Anterior Cruciate Ligament Reconstruction. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*. 2013;29(8):1322-1329. PMID: 23906272

21. French DJ, France CR, Vigneau F, French JA, Evans RT. Fear of movement/(re)injury in chronic pain: A psychometric assessment of the original English version of the Tampa scale for kinesiophobia (TSK). *Pain*. 2007;127(1):42-51. PMID: 16962238

22. Gallagher BV, Gardner FL. An Examination of the Relationship between Early Maladaptive Schemas, Coping, and Emotional Response to Athletic Injury. *Journal of Clinical Sport Psychology*. 2007;1(1):47-67.

23. Gignac MA, Cao X, Ramanathan S, et al. Perceived personal importance of exercise and fears of re-injury: a longitudinal study of psychological factors related to activity after anterior cruciate ligament reconstruction. *BMC Sports Sci Med Rehabil*. 2015;7(1):4. PMID: 25973208

24. Hatzigeorgiadis A, Zourbanos N, Mpoumpaki S, Theodorakis Y. Mechanisms underlying the self-talk–performance relationship: The effects of motivational self-talk on self-confidence and anxiety. *Psychology of Sport and Exercise*. 2009;10(1):186-192.

25. Heil J. *Psychology of Sport Injury.* Human Kinetics Publishers; 1993:xiv, 338.

26. Higgins LD, Taylor MK, Park D, et al. Reliability and validity of the International Knee Documentation Committee (IKDC) Subjective Knee Form. *Joint Bone Spine*. 2007;74(6):594-599. PMID: 17888709

27. 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. PMID: 11573919

28. Ivarsson A, Johnson U. Psychological Factors as Predictors of Injuries Among Senior Soccer Players. A Prospective Study. *J Sports Sci Med*. 2010;9(2):347-352. PMID: 24149706

29. Kontos AP, Elbin RJ, Newcomer Appaneal R, Covassin T, Collins MW. A Comparison of Coping Responses Among High School and College Athletes With Concussion, Orthopedic Injuries, and Healthy Controls. *Research in Sports Medicine*. 2013;21(4):367-379. PMID: 24067122

30. Kori SH, Miller RP, Todd DD. Kinisophobia : A new view of chronic pain behavior. *Pain management*. 1990;3(1):35-43.

31. 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. PMID: 15703963

32. Laboute E, James-Belin E, Ucay O, Caubere A, Verhaeghe E. Prospective study of functional outcomes and return to sports after anterior cruciate ligament reconstruction in the knee. *International Orthopaedics (SICOT)*. Published online September 13, 2023. PMID: 37700201

33. Laboute E, Verhaeghe E, Ucay O, Minden A. Evaluation kinaesthetic proprioceptive deficit after knee anterior cruciate ligament (ACL) reconstruction in athletes. *J Exp Orthop*. 2019;6(1):6. PMID: 30729340

34. Langford JL, Webster KE, Feller JA. A prospective longitudinal study to assess psychological changes following anterior cruciate ligament reconstruction surgery. *British Journal of Sports Medicine*. 2009;43(5):377-378. PMID: 19019910

35. 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. PMID: 25480833

36. Lentz TA, Zeppieri G, Tillman SM, et al. Return to Preinjury Sports Participation Following Anterior Cruciate Ligament Reconstruction: Contributions of Demographic, Knee Impairment, and Self-report Measures. *Journal of Orthopaedic & Sports Physical Therapy*. 2012;42(11):893-901. PMID: 22951437

37. Lesage FX, Berjot S, Deschamps F. Psychometric properties of the French versions of the Perceived Stress Scale. *IJOMEH*. 2012;25(2):178-184. PMID: 22528542

38. Lewinsohn PM, Gotlib IH, Lewinsohn M, Seeley JR, Allen NB. Gender differences in anxiety disorders and anxiety symptoms in adolescents. *Journal of Abnormal Psychology*. 1998;107(1):109-117. PMID: 9505043

39. Luyckx K, Schwartz SJ, Berzonsky MD, et al. Capturing ruminative exploration: Extending the four-dimensional model of identity formation in late adolescence. *Journal of Research in Personality*. 2008;42(1):58-82.

40. McCullough KA, Phelps KD, Spindler KP, et al. Return to High School– and College-Level Football After Anterior Cruciate Ligament Reconstruction: A Multicenter Orthopaedic Outcomes Network (MOON) Cohort Study. *Am J Sports Med*. 2012;40(11):2523-2529. PMID: 22922520

41. Mikkelsen C, Werner S, Eriksson E. Closed kinetic chain alone compared to combined open and closed kinetic chain exercises for quadriceps strengthening after anterior cruciate ligament reconstruction with respect to return to sports: A prospective matched follow-up study. *Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA*. 2000;8:337-342. PMID: 11147151

42. Papadopoulos SD, Tishukov M, Stamou K, Totlis T, Natsis K. Fear of re-injury following ACL reconstruction: an overview. *JRPMS*. 2018;02(04):124-130.

43. Rechel JA, Yard EE, Comstock RD. An Epidemiologic Comparison of High School Sports Injuries Sustained in Practice and Competition. *Journal of Athletic Training*. 2008;43(2):197-204. PMID: 18345346

44. Rosenberg M. Rosenberg self-esteem scale (RSE). Acceptance and commitment therapy. *Measures package*. 1965;61(52):18.

45. Rosso F, Bonasia DE, Cottino U, Cambursano S, Dettoni F, Rossi R. Factors Affecting Subjective and Objective Outcomes and Return to Play in Anterior Cruciate Ligament Reconstruction: A Retrospective Cohort Study. *Joints*. 2018;06(1):23-32. PMID: 29675503

46. Sandel N, Reynolds E, Cohen PE, Gillie BL, Kontos AP. Anxiety and mood clinical profile following sport-related concussion: From risk factors to treatment. *Sport, Exercise, and Performance Psychology*. 2017;6(3):304-323. PMID: 29130023

47. Scheier MF, Carver CS, Bridges MW. Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A reevaluation of the Life Orientation Test. *Journal of Personality and Social Psychology*. 1994;67:1063-1078. PMID: 7815302

48. Seligman MEP, Nolen-Hoeksema S, Thornton N, Thornton KM. Explanatory Style as a Mechanism of Disappointing Athletic Performance. *Psychol Sci*. 1990;1(2):143-146.

49. Spurk D, Hirschi A, Wang M, Valero D, Kauffeld S. Latent profile analysis: A review and "how to" guide of its application within vocational behavior research. *Journal of Vocational Behavior*. 2020;120:103445.

50. Theunissen WWES, van der Steen MC, Liu WY, Janssen RPA. Timing of anterior cruciate ligament reconstruction and preoperative pain are important predictors for postoperative kinesiophobia. *Knee Surg Sports Traumatol Arthrosc*. 2020;28(8):2502-2510. PMID: 31879792

51. Trottier C, Mageau G, Trudel P, Halliwell WR. Validation de la version canadienne-française du Life Orientation Test-Revised. [Validation of the Canadian-French version of Life Orientation Test-Revised.]. *Canadian Journal of Behavioural Science / Revue canadienne des sciences du comportement*. 2008;40:238-243.

52. Ulstein S, Årøen A, Engebretsen L, Forssblad M, Lygre SHL, Røtterud JH. A Controlled Comparison of Microfracture, Debridement, and No Treatment of Concomitant Full-Thickness Cartilage Lesions in Anterior Cruciate Ligament-Reconstructed Knees: A Nationwide Prospective Cohort Study From Norway and Sweden of 368 Patients With 5-Year Follow-up. *Orthop J Sports Med*. 2018;6(8):2325967118787767. PMID : 30083564

53. Untas A, Aguirrezabal M, Chauveau P, Leguen E, Combe C, Rascle N. Anxiété et dépression en hémodialyse : validation de l'Hospital Anxiety and Depression Scale (HADS). *Néphrologie & Thérapeutique*. 2009;5(3):193-200. PMID : 19346177

54. Vallieres EF, Vallerand RJ. Traduction et Validation Canadienne-Française de L'échelle de L'estime de Soi de Rosenberg. *International Journal of Psychology*. 1990;25(2):305-316.

55. Vitaliano PP, Russo J, Carr JE, Maiuro RD, Becker J. The Ways of Coping Checklist: Revision and Psychometric Properties. *Multivariate Behavioral Research*. 1985;20(1):3-26. PMID: 26776273

56. Vlaeyen JWS, Linton SJ. Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain*. 2000;85(3):317-332.

57. Walker N, Thatcher J, Lavallee D. A preliminary development of the Re-Injury Anxiety Inventory (RIAI). *Physical Therapy in Sport*. 2010;11(1):23-29. PMID: 20129120

58. Walker N, Thatcher J, Lavallee D. Review: Psychological responses to injury in competitive sport: a critical review. *Journal of the Royal Society for the Promotion of Health*. 2007;127(4):174-180. PMID: 17711063

59. Walker NC. *The Meaning of Sports Injury and Re-Injury Anxiety Assessment and Intervention*. Ph.D. Aberystwyth University; 2006.

60. Wasley D, Lox C. Self-Esteem and Coping Responses of Athletes with Acute versus Chronic Injuries. *Perceptual and Motor Skills*. 1998;(3 suppl):1402-1402. PMID: 9700819

61. 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. *Physical Therapy in Sport*. 2008;9(1):9-15. PMID: 19083699

62. Yang J, Tibbetts AS, Covassin T, Cheng G, Nayar S, Heiden E. Epidemiology of Overuse and Acute Injuries Among Competitive Collegiate Athletes. *Journal of Athletic Training*. 2012;47(2):198-204. PMID: 22488286

63. Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavica*. 1983;67(6):361-370. PMID: 6880820