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

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

4  
**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.

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

6 **Study Design:** Prospective study; Level of evidence 2

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

15 **Results:** A total of 162 athletes were initially included, of whom 123 responded on RTS and  
16 re-injury. Cluster analysis showed a 4-cluster solution ( $\chi^2(21) = 428.59, \lambda = .064; p <.001$ ).  
17 Profile 1 (27.8%) was characterized by "moderate re-injury anxiety, no depression"; profile 2  
18 (22.8%) by "moderate re-injury anxiety and minor anxious-depressive reaction"; profile 3  
19 (30.9%) by "no re-injury anxiety, no depression, high confidence"; and profile 4 (18.5%) by  
20 "high anxiety, high depression, low confidence". Profile 4 had the lowest self-esteem and  
21 optimism scores compared to profile 3 ( $p <0.001$ ). In addition, a higher percentage of males  
22 was found in profile 3 as opposed to profile 4 ( $\chi^2(3) = 11.35, p <0.01$ ). Profile 4 had the

23 highest rate of non-return to sport with 45.8% (Profile 1: 85.7%, p 0.001, Profile 2: 75.0%, p  
24 = 0.031, Profile 3: 77.8%, p = 0.011). Finally, profile 3 had a higher risk of re-injury (13.9%)  
25 than profile 4 (0%, p = 0.047), which was extremely conservative at returning to sport.

26

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

31

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

34

### 35 **What is known about this subject:**

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

40

### 41 **What this study adds to existing knowledge**

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

45

## 46 INTRODUCTION

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

55 After an ACL injury, psychological symptoms such as anxiety<sup>28</sup> and depression<sup>4</sup> are  
56 frequently observed and are linked to fear of re-injury<sup>21</sup>. Additionally, stress is among the  
57 most common psychological reactions after an injury<sup>28</sup>.

58 Self-esteem and optimism have been examined in literature as potential personality  
59 psychological outcomes<sup>19</sup> for ACL reconstruction, and they also been shown to be predictor  
60 of rehabilitation compliance, return to sport (RTS), and self-rated knee symptoms<sup>19</sup>.

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

70 already been demonstrated to be of value in other populations of athletes who are injured or  
71 concussed<sup>46</sup>.

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

78

## 79 **MATERIALS AND METHODS**

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

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

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

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

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

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

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

126

## 127 **Statistical analyses**

128

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

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

145

## 146 RESULTS

147

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

150 **Figure 1:** Flowchart summarizing the study design

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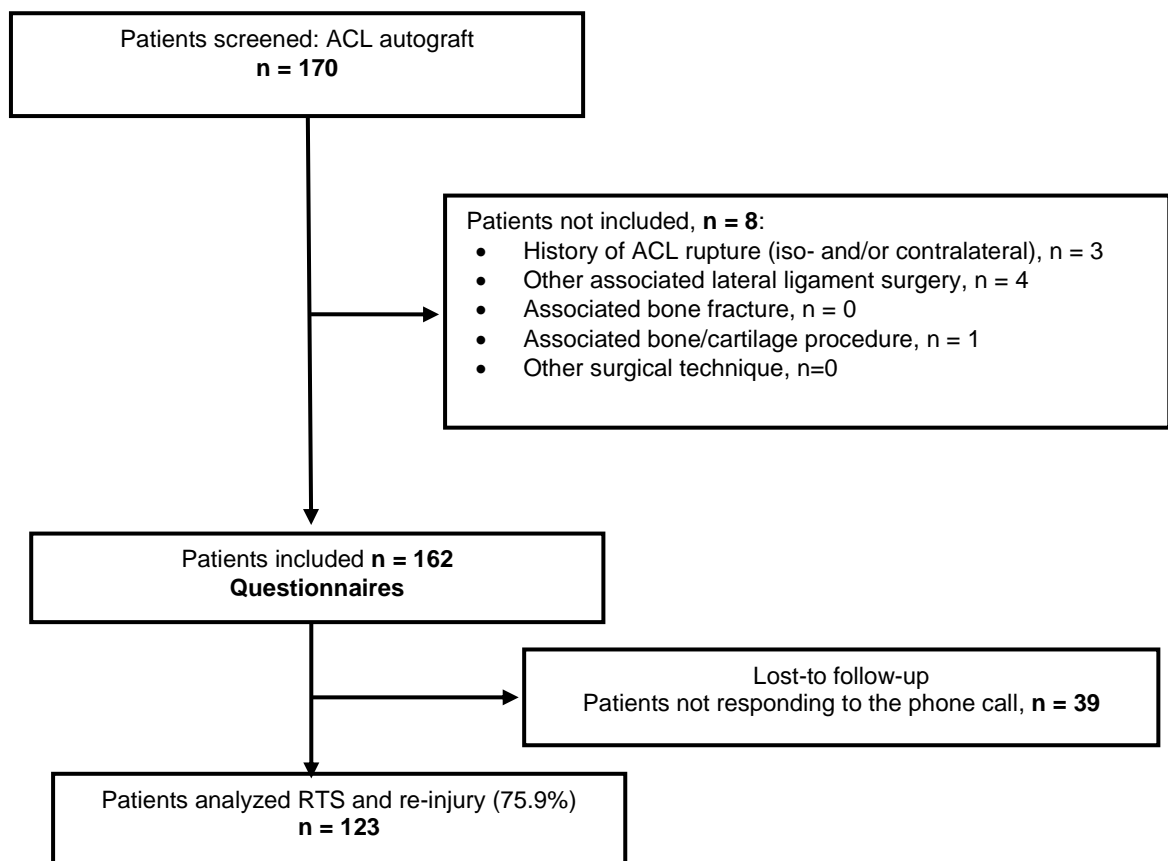
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171 In the second year following the ACL reconstruction, 75.9% of patients (n = 123)  
 172 responded to the phone call regarding return to sport and re-injury.

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

180

181 **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%) |

|     |                            |                               |             |
|-----|----------------------------|-------------------------------|-------------|
| 182 | Level                      | n                             | 162         |
| 183 |                            | International                 | 38 (11.1%)  |
|     |                            | National                      | 81 (50.0%)  |
| 184 |                            | Regional                      | 47 (29.0%)  |
|     |                            | Others                        | 16 (9.9%)   |
| 185 |                            |                               |             |
|     | 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%) |

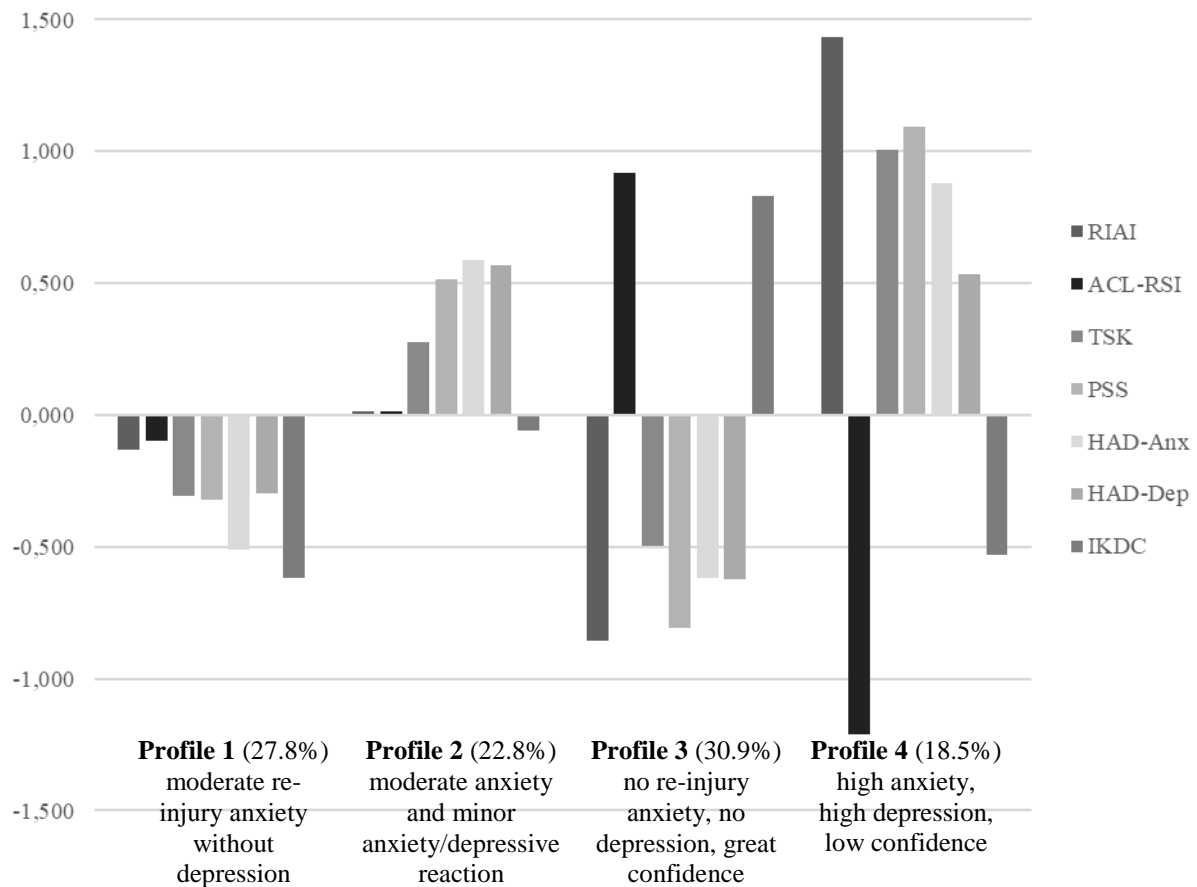
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### 186 *Determining psychological profiles*

187  
188 A hierarchical cluster analysis (Ward's method) using a two-step procedure allowed us  
189 to identify four clusters of emotional profiles. In Figure 2, the mean levels of each of the  
190 seven dimensions of emotional profiles are shown separately for each cluster. This solution  
191 explained 69.2% of the variance in re-injury anxiety, 55.7% for perceived stress, 32.7% for  
192 kinesiophobia, 56.8% for fear of re-injury, 43.7% for general anxiety, 30.4% for depression,  
193 and 36.9% for confidence in knee. A discriminant function analysis supported this final  
194 cluster solution ( $\chi^2(21) = 428.59$ ,  $\lambda = .064$ ;  $p < .001$ ; 96.9% of cross-validated grouped cases  
195 correctly classified).

196

## Psychological profiles of ACL injured athletes



197  
 198 **Fig 2.** Final solution of clusters analysis on psychological profiles of ACL injured athletes. Z-scores for re-injury  
 199 anxiety (RIAI), fear of re-injury (ACL-RSI), kinesiophobia (TSK), perceived stress scale (PSS), anxiety (HAD-  
 200 Anx), depression (HAD-Dep), and confidence in knee (IKDC).  
 201  
 202

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

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

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

216         The **third profile** (30.9%) is characterized by the absence of negative emotions (low  
217 re-injury anxiety (RIAI = 4.3) and kinesiophobia (TSK = 33.3), absence of fear of re-injury  
218 (ACL RSI = 104), low stress (PSS = 7.6), anxiety (HAD A = 3.2), and depression (HAD D =  
219 1.1). and by high knee confidence (IKDC = 73). This profile was interpreted in terms of “no  
220 re-injury anxiety, no depression, great confidence”. In this case, the patient is almost  
221 "overconfident and is often eager to return to sports as soon as possible".

222         Finally, the **last profile** (18.5%) is characterized by high re-injury anxiety (RIAI =  
223 25.7), kinesiophobia (TSK = 42.7), severe fear of re-injury (ACL RSI = 54.7), high stress  
224 (PSS = 21.2), anxiety (HAD A = 8), and depression (HAD D = 3.7), and low knee confidence  
225 (IKDC = 57.6). This profile was interpreted in terms of “high anxiety, high depression, low  
226 confidence”. The profile indicates that this patient is very cautious and very low in  
227 confidence, which has an adverse impact on his mood.

228

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

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

230 Data are presented as mean ± SD <sup>a, b, c, d</sup>; each letter indicate the same mean between profiles or different scores.  
 231 Reading note : for re-injury anxiety, the highest scores were reported by profile 4 (exponent a), followed by  
 232 profile 2 and profile 3 (exponent b), and the lowest scores were reported by profiles 3 (exponent c). \* for  
 233 significant differences

234

235 ***Relationship of psychological profiles with morphostatic characteristics, type of surgery,***  
 236 ***pain and psychological resources***

237

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

241

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

|   | <b>Profile 1<br/>(27.8%)</b> | <b>Profile 2<br/>(22.8%)</b> | <b>Profile 3<br/>(30.9%)</b> | <b>Profile 4<br/>(18.5%)</b> | <b><i>p</i><br/>value</b> |
|---|------------------------------|------------------------------|------------------------------|------------------------------|---------------------------|
| <b><i>Demographic characteristics</i></b> |                              |                              |                              |                              |                           |
| <b><i>Gender</i></b>                      |                              |                              |                              |                              | <.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%)                   |                           |
| <b><i>Age</i></b>                         | 24.7 ± 4.1 <sup>a</sup>      | 24.1 ± 5.9 <sup>a</sup>      | 23.4 ± 4.9 <sup>a</sup>      | 25.4 ± 6.4 <sup>a</sup>      | 0.71                      |
| <b><i>Sport characteristics</i></b>       |                              |                              |                              |                              |                           |
| <b><i>Level of sport</i></b>              |                              |                              |                              |                              | 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%)                     |                           |
| <b><i>Sport type</i></b>                  |                              |                              |                              |                              | 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%)                   |                           |
| <b><i>Surgical characteristics</i></b>    |                              |                              |                              |                              |                           |
| <b><i>ACL graft type</i></b>              |                              |                              |                              |                              | 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%)                    |                           |
| <b><i>Meniscus associated lesion</i></b>  |                              |                              |                              |                              | 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%)                   |                           |
| <b><i>Pain</i></b>                        | 2.4 ± 2.4 <sup>a</sup>       | 2.5 ± 2.0 <sup>a</sup>       | 1.8 ± 2.3 <sup>a</sup>       | 3.0 ± 2.3 <sup>a</sup>       | 0.07                      |
| <b><i>Psychological resources</i></b>     |                              |                              |                              |                              |                           |
| <b><i>Self-esteem (RSES)</i></b>          | 34.8 ± 2.8 <sup>a</sup>      | 31.0 ± 4.3 <sup>b</sup>      | 35.9 ± 3.6 <sup>a</sup>      | 30.9 ± 5.3 <sup>b</sup>      | <.001*                    |
| <b><i>Optimism (LOT-R)</i></b>            | 27.5 ± 4.4 <sup>b</sup>      | 24.2 ± 3.8 <sup>c</sup>      | 30.4 ± 4.5 <sup>a</sup>      | 24.4 ± 6.7 <sup>c</sup>      | <.001*                    |
| <b><i>Coping (WCC-R)</i></b>              |                              |                              |                              |                              |                           |
| Problem-focused                           | 31.8 ± 4.5 <sup>b</sup>      | 30.7 ± 4.4 <sup>b</sup>      | 34.2 ± 5.0 <sup>a</sup>      | 30.5 ± 4.0 <sup>b</sup>      | <.001*                    |
| Emotion-focused                           | 19.5 ± 4.5 <sup>c</sup>      | 22.5 ± 5.7 <sup>b</sup>      | 18.6 ± 5.6 <sup>c</sup>      | 26.0 ± 5.2 <sup>a</sup>      | <.001*                    |
| Social support-seeking                    | 24.1 ± 4.5 <sup>a</sup>      | 23.1 ± 5.2 <sup>a</sup>      | 22.7 ± 5.7 <sup>a</sup>      | 24.0 ± 4.0 <sup>a</sup>      | 0.84                      |

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243 Data are presented as mean  $\pm$  SD or no. (%). Chi-square test for qualitative variables. ANOVA and Tukey post-  
244 hoc for quantitative variables. <sup>a, b, c, d</sup>: each letter indicates the same mean between profiles or different scores.  
245 *Reading note* : for emotion focused coping, the highest scores were reported by profile 4 (exponent a), followed  
246 by profile 2 (exponent b), and the lowest scores were reported by profiles 1 and 3 (exponent c). \* for significant  
247 differences

249 Results from ANOVA showed significant differences between profiles on self-esteem  
250 [ $F(3,153) = 16.7; p < .001; \omega^2 = .231$ ], optimism [ $F(3,154) = 15.0; p < .001; \omega^2 = .209$ ], problem-  
251 focused [ $F(3,155) = 6.19; p < .001; \omega^2 = .089$ ], and emotions-focused [ $F(3,155) = 14.8; p < .001;$   
252  $\omega^2 = .207$ ]. Results showed higher percentage of men in profile 3 (84%) and lower percentage  
253 (46.7%) in profile 4 ( $\chi^2(3) = 11.35, p < .01$ ). No other difference was found for demographic,  
254 sport, surgical characteristics and pain. Tukey post hoc tests for the scores for psychological  
255 resources highlighted that profiles 1 and 3 reported higher scores for self-esteem than those  
256 for profiles 2 and 4 ( $p < .001$ ). Profile 3 reported the highest scores of optimism, and the  
257 lowest for profiles 2 and 4 ( $p < .001$ ). Profile 3 also reported higher scores of problem focused  
258 coping than every other profile ( $p < .001$ ), whereas profile 4 reported the highest scores for  
259 emotion focused coping and profiles 1 and 3 the lowest ( $p < .001$ ). No significant difference  
260 was found for social support seeking.

261

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

263

264 Finally, chi-squared test were conducted in order to test the differences between the  
265 profiles for the outcomes (Table 4), and highest rates was highlighted for no return to sport  
266 observed in profile 4 with 45.8% (Profile 1: 85.7%,  $p = 0.001$ , Profile 2: 75.0%,  $p = 0.031$ ,  
267 Profile 3: 77.8%,  $p = 0.011$ ). The highest return to sport rate was 77.8% for profile 3 and  
268 85.7% for profile 1. However, it is interesting to note significant difference in re-injury  $p =$   
269 0.047 between athletes in profile 3 (13.9% of re-injury) and those in profile 4 (0% of re-

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

273  
 274

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

|                        | <b>Profile 1</b><br><b>(27.8%)</b> | <b>Profile 2</b><br><b>(22.8%)</b> | <b>Profile 3</b><br><b>(30.9%)</b> | <b>Profile 4</b><br><b>(18.5%)</b> |
|------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|
| <i>Outcomes</i>        |                                    |                                    |                                    |                                    |
| <i>Re-injury</i>       |                                    |                                    |                                    |                                    |
| 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%)                           |
| <i>Return to Sport</i> |                                    |                                    |                                    |                                    |
| 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 = 0.047*                         |                                    |
|                        |                                    | p = 0.011*                         |                                    |                                    |
|                        | p = 0.031*                         |                                    |                                    |                                    |
|                        | p = 0.001*                         |                                    |                                    |                                    |

276 Data are presented as mean ± SD or no. (%). Chi-square test for qualitative variables. ANOVA and Tukey post-  
 277 hoc for quantitative variables. \*for significant differences.

278

## 279 **DISCUSSION**

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

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



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

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

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

300 One of these intermediate profiles has been described as characterized by moderate  
301 anxiety and minor anxiety/depressive symptoms. This cluster suggests that these athletes  
302 should not be regrouped with those who will experience high levels of re-injury anxiety. On  
303 the other hand, studies based on kinesiophobia cut-off scores of TSK>37, as used in previous  
304 literature to describe high levels of fear of re-injury<sup>56</sup> correspond to 59% of athletes<sup>3</sup> and  
305 43.1% of athletes<sup>50</sup>. Furthermore, another intermediate profile was identified as having  
306 intermediate scores but low confidence in the knee (profile 1). This result confirms the  
307 findings of Papadopoulos et al.<sup>42</sup> who concluded that further study of the relationship between  
308 re-injury anxiety and knee confidence should be undertaken. Our results allow us to precise  
309 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<sup>6</sup>, whereas other showed no significant differences<sup>50</sup>. 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<sup>7,38</sup>.

317 There is no difference between the levels of competition. These results are consistent  
318 with those reported with gymnasts<sup>9</sup> but they are contrary to those of De Pero et al.<sup>17</sup>, 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<sup>43</sup>. Low fear of re-injury was associated with high risk activities according to a  
325 study<sup>23</sup>. 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<sup>36</sup>.

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

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

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

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

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

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

379

380 *Limitations of the study*

381 While there are several classification methods available, cluster analysis and latent  
382 class analysis are the two most commonly used. In both analyses, the objective is to identify  
383 different groups and classify their members on the basis of their similarities. Cluster analysis  
384 is based on a geometric approach, defining clusters based on Euclidean distances (i.e.,  
385 geometric proximity in a space) whereas latent class analysis is based on a probabilistic  
386 approach. Latent class method is currently popular and may be considered here as an  
387 alternative to the geometric distance approach, since it takes a probabilistic approach instead  
388 of one based on geometric distance. In addition, return to sport was determined by the date of  
389 return to competition. The authors of this study have proposed several classifications to  
390 distinguish the return to sport, namely return to running, return to training, return to  
391 competition, and return to the same level of competition<sup>32</sup>. In studies interested in  
392 classification, this could enhance the quality of information collected about return to sport.  
393 This study has a limitation of 25% lost to follow-up, which is common to studies of this type.  
394 There have been similar percentages (34-43%) of losses to follow-up reported in comparable  
395 studies<sup>11,52</sup>, illustrating its prevalence in longitudinal studies of patients. Furthermore, the  
396 study has three important limitations, 1) the high percentage of men, 2) the high percentage of  
397 team sports, and 3) the high percentage of competitive sports make this study difficult to  
398 generalize to all injured athletes. Furthermore, we did not quantify post-op activity and level  
399 of frequency of participation which might explain part or all the difference in reinjury rates  
400 between profile 3 and 4. Studies should focus on individual sports to provide better insight  
401 into psychological profiles associated with injuries among these athletes. Furthermore,  
402 psychological profiles applied to the sports domain, and in particular injury, are quite  
403 uncommon in the literature. Research on specific types of injuries, or on the impact of an  
404 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.

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