Preoperative psychological competitive ability is associated with emotional states six months after anterior cruciate ligament reconstruction with hamstring autograft

Takuya Sengoku  
Kanazawa University Hospital

Junsuke Nakase (✉ nakase1007@yahoo.co.jp)  
Kanazawa University

Rikuto Yoshimizu  
Kanazawa University

Mitsuhiko Kimura  
Kanazawa University

Tomoyuki Kanayama  
Kanazawa University

Katsuhiko Kitaoka  
Kijima Hospital

Hiroyuki Tsuchiya  
Kanazawa University

Article

Keywords: anterior cruciate ligament (ACL) reconstruction, emotional state, psychological competitive ability

Posted Date: September 28th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2092028/v1

License: © This work is licensed under a Creative Commons Attribution 4.0 International License.  
Read Full License
Abstract

Psychological state has been reported as one of the factors strongly related to return to sports after anterior cruciate ligament (ACL) reconstruction. However, its relationship with the emotional state remains unclear. This study aimed to investigate whether the preoperative psychological competitive ability is related to emotional states preoperatively and six months after ACL reconstruction. Patients who regularly performed sports activities and who underwent ACL reconstruction were divided into two groups according to the Diagnostic Inventory of Psychological Competitive Ability for Athletes (DIPCA.3) score. The emotional states preoperatively and at six months postoperatively were assessed using the Profile of Mood States, 2nd Edition (POMS2) and compared between the groups. Eighty-four patients were included and divided into high (DIPCA.3 score of 4 or higher, n = 23) and low (DIPCA.3 less than 4, n = 61) groups. Vigour-activity and friendliness were significantly higher in the high group than in the low group preoperatively. The difference was even greater at six months after ACL reconstruction. In addition, the high group showed statistically better results postoperatively for fatigue-inertia and total mood disturbance. Athletes with higher psychological competitive ability were in a positive emotional state preoperatively and six months after ACL reconstruction.

Introduction

Anterior cruciate ligament (ACL) injury is a frequent knee trauma in sports [1]. Surgery is the first choice of treatment to regain stable knee joint function and return to sports. Patients have high expectations that ACL reconstruction will result in good knee function and return to a sports level the same as that preoperatively [2]. However, a large-scale study by Ardern et al. [3] reported that the rate of returning to sports at a competitive level after ACL reconstruction is low, with 81% returning to any sports, 65% at the preoperative level, and 55% at the competitive level. These results indicate the difficulty of returning to sports at a competitive level. Many factors have been associated with returning to sports after ACL reconstruction, including age [4], sex [4], knee joint function [5], level of competition [3, 4], and psychological state [5, 6]. In recent years, the psychological state has been reported as one of the factors associated with return to sports, and several reports have concluded that psychological state is the most relevant factor in the return to sports [7, 8].

The Diagnostic Inventory of Psychological Competitive Ability for Athletes (DIPCA.3) is a questionnaire that assesses the psychological aspects of competitive ability. To the best of our knowledge, only one study [9] has so far reported an association between high psychological competitive ability and ACL injury. In recent years, fear has been widely reported as a negative factor involved in the psychological state of patients returning to sports after ACL reconstruction [10, 11]. It is clear that the functional outcome of patients after ACL reconstruction has a considerable impact on their behavioural, cognitive, and emotional status [12]. Although psychological competitive ability reflects psychological competence in a game situation, it does not provide information on perioperative emotional states. Psychological competitive ability and emotional state may also be related to subsequent return to sports.
The aim of this study was to determine whether the preoperative psychological competitive ability of patients who underwent ACL reconstruction was related to their preoperative and 6-month postoperative emotional states. We hypothesized that patients with a better preoperative psychological competitive ability would exhibit a more positive emotional state before and after ACL reconstruction.

**Methods**

**Subjects**

This study was conducted with the principles of the Helsinki Declaration, and was approved by the Ethics Review Committee of Kanazawa University (1860). Written informed consent was obtained from all patients after the purpose, methods and potential risk of this study were fully explained. If the subject was under 20 years old or younger, parental consent was obtained.

This prospective study included 173 patients with a Tegner activity scale (TAS) of six or higher who underwent ACL reconstruction at our hospital between 2015 and 2020. The inclusion criteria of this study were primary ACL reconstruction, hamstring autograft, TAS $\geq 6$, and the ability to perform preoperative and postoperative psychological evaluations at six months after ACL reconstruction. The exclusion criteria were revision ACL reconstruction surgery, multiple ligament injuries, and incomplete psychological evaluation. Details of patient extraction are described in the Flow-chart (Fig. 1).

**Psychological evaluation and return to sports**

Two questionnaires for psychological assessment were used in this study, including the DIPCA.3, which assesses psychological competitive ability, and the Profile of Mood States 2nd Edition (POMS2), which assesses mood and emotional states. The DIPCA.3 and POMS2 were performed preoperatively, and POMS2 was also performed six months after ACL reconstruction. Preoperative psychological assessments were performed at the time of hospitalization for ACL reconstruction. A standardized explanation of the questionnaire was provided to all patients according to the instructions.

The DIPCA.3 comprises five main items: volition for competition, mental stability and concentration, confidence, strategic ability, and cooperativeness, which are further subdivided into a total of 12 sub-items. The score is calculated on a scale of 20 to 240 points, with each item rated on a 5-point scale, with higher scores indicating a better psychological competitive ability.

The POMS2 consists of five negative factors: anger-hostility (AH), confusion-bewilderment (CB), depression-dejection (DD), fatigue-inertia (FI), and tension-anxiety (TA), as well as two positive factors: vigour-activity (VA) and friendliness (F). The five negative factors subtracting from VA were calculated as total mood disturbance (TMD), and F was evaluated independently of the other items. All scores were T-scored and normalized for sex and age. The T-score is based on a 50-point threshold, with less than 50 points indicating a negative factor, and 50 points or more indicating a positive factor and good emotional states. The rate of return to participation in the entire practice was added to the 6-month postoperative
evaluation items. In this study, the criterion for returning to sports was defined as participation in the entire practice, with reference to a previous report [13]. Participation in the entire practice shown in this study excludes game-style practices and refers to other practice program.

Patients were classified into two groups based on overall DIPCA.3 grade: grade 4 or higher (high group) and less than 4 (low group). The DIPCA.3 grades are defined as follows; 1: quite low, 2: somewhat low, 3: a bit more, 4: somewhat excellent, and 5: very excellent. The preoperative and 6-month postoperative POMS2 scores were compared between the two groups.

Rehabilitation protocol

The same postoperative rehabilitation protocol was used for most of the patients. Depending on the extent of the meniscus damage, some patients were instructed by their surgeons to be immobilized in the extended position and non-weight bearing for two weeks after ACL reconstruction. All patients were instructed to achieve a knee joint range of motion (ROM) from 0° to 125° before ACL reconstruction. On the day after ACL reconstruction, patients began quadriceps and hamstring isometric contraction exercises, simultaneous contraction exercises, ROM exercises, full weight-bearing standing, and crutch gait pattern. Several goals were set for the postoperative rehabilitation protocol. First, the target ROM was 0° to 90° at two weeks after ACL reconstruction. Second, the target ROM was 0° to 120° at four weeks after ACL reconstruction. If there was no indication of pain at this point, half squats and front lunges were added to the rehabilitation routine of the patients. Third, isokinetic knee extensors and flexors were measured three months after ACL reconstruction, and if the limb symmetry index (LSI) was > 60%, the patient began jogging. All patients underwent rehabilitation wearing an ACL protective knee brace for up to four months after ACL reconstruction. Finally, isokinetic knee extensors and flexors were measured at six months after ACL reconstruction, and the patients were allowed to return to sports activity (return to official competition after game-style practices) if the LSI was > 90%. No active psychological approach was applied to the subjects in this study.

Statistical analysis

All statistical analyses were performed using the JMP 14 software (SAS Institute, Cary, NC, USA). We evaluated parametric data using the Shapiro-Wilk test and F-test. Student’s t-test or Welch’s t-test was performed to assess normally distributed data, and non-parametric data were analysed using the Wilcoxon test or Pearson’s chi-square test. Statistical significance was set at α = 0.05. G*Power 3.1.9.4 (Franz Paul, Kiel, Germany) was used to determine the power of the study. The a priori power analysis for the sample size was calculated, with a sample of 84 patients calculated as required for an effect size of 0.8, an α level of 0.05, and a power of 0.95. In this study, 84 patients participated in the power analysis to determine the sample size. Furthermore, post hoc power analysis was used to calculate the effect size and power of F preoperatively, and FI, VA, TMD, as well as F at six months after ACL reconstruction. The power analysis of 0.97 for F was strong. At six months after ACL reconstruction, a strong power analysis was observed for FI: 0.85, VA: 0.99, F: 0.99, and TMD: 0.90. R version 4.2.1 (The R Foundation for
Statistical Computing, Austria) was used to calculate the effect size ($r$). The $r$ value indicated that 0.1, 0.3 and 0.5 were small, medium, and large, respectively.

**Results**

A total of 84 patients, including 36 men and 48 women with an average age of $21.1 \pm 8.5$ years who met all the criteria, were enrolled. Twenty-three patients, including 11 men and 12 women with an average age of $23.1 \pm 8.0$ years, were included in the high group, and 61 patients, including 25 men and 36 women with an average age of $20.3 \pm 8.5$ years, were included in the low group.

There were no significant differences in basic characteristics, such as age, height, weight, or competition level, between the high and low groups (Table 1). The preoperative psychological competitive ability was $201.0 \pm 12.7$ points in the high group and $155.1 \pm 19.5$ points in the low group ($p < 0.01$). There was no significant difference in the preoperative negative items (Table 2 and Fig. 2). However, there was a significant difference in the positive items VA and F (Table 2 and Fig. 2). There was also a significant difference in the negative item FI, the positive items VA and F, and in TMD at six months after ACL reconstruction (Table 3 and Fig. 3). The return to sports rate at six months after ACL reconstruction was 56.5% in the high group and 54.1% in the low group, as with significant difference between groups.
<table>
<thead>
<tr>
<th></th>
<th><strong>High group</strong> (n = 23)</th>
<th><strong>Low group</strong> (n = 61)</th>
<th><strong>p value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (male : female)</td>
<td>11:12</td>
<td>25:36</td>
<td>0.57</td>
</tr>
<tr>
<td>Age (years)</td>
<td>23.1 ± 8.0</td>
<td>20.3 ± 8.5</td>
<td>0.11</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>166.2 ± 7.9</td>
<td>165.8 ± 8.9</td>
<td>0.85</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.5 ± 14.4</td>
<td>61.8 ± 11.1</td>
<td>0.97</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.4 ± 3.5</td>
<td>22.4 ± 2.9</td>
<td>0.84</td>
</tr>
<tr>
<td>TAS</td>
<td>8 (6–9)</td>
<td>7 (6–9)</td>
<td>0.32</td>
</tr>
<tr>
<td>Injury status (contact : noncontact)</td>
<td>6:17</td>
<td>12:49</td>
<td>0.53</td>
</tr>
<tr>
<td>Preoperative period</td>
<td>44.0 ± 28.9</td>
<td>60.2 ± 38.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Meniscus tear</td>
<td>10 (43.5%)</td>
<td>32 (52.5%)</td>
<td>0.46</td>
</tr>
<tr>
<td>Meniscus repair</td>
<td>10 (100%)</td>
<td>31 (96.9%)</td>
<td>0.57</td>
</tr>
<tr>
<td>Meniscectomy</td>
<td>0 (0%)</td>
<td>1 (3.1%)</td>
<td>0.57</td>
</tr>
</tbody>
</table>

BMI: Body mass index, TAS: Tegner activity scale. Values are reported as the mean ± standard deviation. TAS is reported as the median (range). Statistical significance at \( \alpha = 0.05 \). There was one patient in each group with lack of data for the preoperative period.
Table 2
Preoperative Profile of Mood States 2nd Edition (POMS2)

<table>
<thead>
<tr>
<th></th>
<th>High group (n = 23)</th>
<th>Low group (n = 61)</th>
<th>p value</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH</td>
<td>43.0 ± 8.3</td>
<td>43.6 ± 7.7</td>
<td>0.64</td>
<td>0.08</td>
</tr>
<tr>
<td>CB</td>
<td>46.5 ± 12.0</td>
<td>49.3 ± 8.7</td>
<td>0.10</td>
<td>0.18</td>
</tr>
<tr>
<td>DD</td>
<td>49.6 ± 11.5</td>
<td>51.2 ± 10.0</td>
<td>0.24</td>
<td>0.13</td>
</tr>
<tr>
<td>FI</td>
<td>43.3 ± 9.3</td>
<td>43.6 ± 8.2</td>
<td>0.67</td>
<td>0.05</td>
</tr>
<tr>
<td>TA</td>
<td>50.0 ± 11.8</td>
<td>48.4 ± 9.3</td>
<td>0.52</td>
<td>0.04</td>
</tr>
<tr>
<td>VA</td>
<td>54.2 ± 14.5</td>
<td>47.1 ± 10.4</td>
<td>0.02</td>
<td>0.23</td>
</tr>
<tr>
<td>TMD</td>
<td>45.5 ± 12.2</td>
<td>47.6 ± 8.6</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>F</td>
<td>61.0 ± 9.4</td>
<td>52.4 ± 10.1</td>
<td>&lt;0.01</td>
<td>0.36</td>
</tr>
</tbody>
</table>

AH: Anger-Hostility, CB: Confusion-Bewilderment, DD: Depress-Dejection, FI: Fatigue-Inertia, TA: Tension-Anxiety, VA: Vigour-Activity, TMD: Total Mood Disturbance, F: Friendliness. Values are reported as mean ± standard deviation. Statistical significance at $\alpha = 0.05$.

Table 3
Results of the Profile of Mood States 2nd Edition (POMS2) six months after anterior cruciate ligament reconstruction

<table>
<thead>
<tr>
<th></th>
<th>High group (n = 23)</th>
<th>Low group (n = 61)</th>
<th>p value</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH</td>
<td>42.0 ± 5.4</td>
<td>43.3 ± 6.8</td>
<td>0.51</td>
<td>0.07</td>
</tr>
<tr>
<td>CB</td>
<td>42.3 ± 7.5</td>
<td>45.9 ± 7.5</td>
<td>0.07</td>
<td>0.20</td>
</tr>
<tr>
<td>DD</td>
<td>44.0 ± 5.8</td>
<td>46.7 ± 7.5</td>
<td>0.11</td>
<td>0.18</td>
</tr>
<tr>
<td>FI</td>
<td>38.4 ± 5.4</td>
<td>42.7 ± 7.5</td>
<td>&lt;0.01</td>
<td>0.28</td>
</tr>
<tr>
<td>TA</td>
<td>42.2 ± 7.3</td>
<td>44.6 ± 8.0</td>
<td>0.29</td>
<td>0.12</td>
</tr>
<tr>
<td>VA</td>
<td>61.0 ± 8.6</td>
<td>51.1 ± 9.7</td>
<td>&lt;0.01</td>
<td>0.41</td>
</tr>
<tr>
<td>TMD</td>
<td>38.9 ± 7.0</td>
<td>43.9 ± 6.9</td>
<td>&lt;0.01</td>
<td>0.29</td>
</tr>
<tr>
<td>F</td>
<td>64.8 ± 8.2</td>
<td>52.8 ± 10.2</td>
<td>&lt;0.01</td>
<td>0.49</td>
</tr>
</tbody>
</table>

AH: Anger-Hostility, CB: Confusion-Bewilderment, DD: Depress-Dejection, FI: Fatigue-Inertia, TA: Tension-Anxiety, VA: Vigour-Activity, TMD: Total Mood Disturbance, F: Friendliness. Values are reported as mean ± standard deviation. Statistical significance at $\alpha = 0.05$.

Discussion
The most important finding of this study is that patients with higher preoperative psychological competitive ability were more likely to have stronger positive emotional states at six months after ACL reconstruction, although emotional state did not seem to be associated with the rate of returning to sports at six months. Individuals with higher preoperative psychological competitive ability scored significantly higher in preoperative positive factors, although there was no statistically significant difference in preoperative TMD. At six months after ACL reconstruction, there was a significant difference in TMD, and the difference in positive factors increased.

To the best of our knowledge, this is the first prospective study to demonstrate the relationship between psychological competitive ability and emotional states after ACL reconstruction. Psychological factors have been associated with performance in competitive sports and the risk of developing disorders, such as overuse injuries [14]. Many reports [15, 16] have indicated that associations between ACL injury, fatigue, and overuse could be an important indicator of recovery. The DIPCA.3 diagnoses psychological and mental abilities as general characteristics necessary for athletes in game situations, and those with higher performance show higher scores [17–19]. Based on these reports, patients in the present study were grouped according to DIPCA.3 to assess the changes in the emotional state and rate of returning to sports of athletes with higher performance. The results show a statistically significant difference in VA and F items of the POMS2 before ACL reconstruction, and in FI, VA, F, and TMD at six months after ACL reconstruction.

The main goal of ACL reconstruction for athletes at the competitive level is a safe return to sports after reconstruction, while those with good psychological and functional status preoperatively have been reported to show good results after ACL reconstruction [20]. In addition, optimism [20] and self-efficacy [21, 22] have been reported to contribute to the association between preoperative psychological factors and favourable postoperative outcomes, and negative emotions may have a negative impact on return to sports, daily life situation, and quality of life [23, 24]. These findings suggest that positive emotions may have a favourable effect on postoperative outcomes. In this study, the positive items VA and F were significantly higher in the high group than in the low group preoperatively and six months after ACL reconstruction. The high group was shown to have significantly higher cooperation in DIPCA.3. In light of these results, the high group was thought to exhibit more positive feelings about interacting with others, suggesting that this had a synergistic effect on vitality and other factors. Furthermore, FI was significantly lower and VA was significantly higher in the high group than in the low group, indicating that they were more active and energetic, and felt less fatigue at six months after ACL reconstruction. As a result, TMD was also significantly lower in the high group than in the low group. The mood profile of POMS2 in the high group at six months after ACL reconstruction was the iceberg profile reported by Morgan et al. [25], which is said to be exhibited by top athletes and athletes who have achieved success in sports. In the iceberg profile, AH, CB, DD, FI, TA and TMD are low and VA is high, and the figure shows an iceberg shape with VA being prominent. In a recent meta-analysis [26], it was concluded that the iceberg profile of POMS2 is an effective indicator for understanding and improving the performance of athletes. Glazer [27] also reported that psychological readiness to return to sports was negatively correlated with TMD. These results may indicate that athletes with higher preoperative psychological
competitive ability have better emotional states at six months after ACL reconstruction and are more psychologically ready to return to sports.

However, we found no statistically significant difference in the rate of returning to sports at six months after ACL reconstruction between the two groups, indicating that preoperative psychological competitive ability was not associated with the return to sports at six months after ACL reconstruction. Thus far, there have been no reports on the relationship between the DIPCA.3 and return to sports after ACL reconstruction; therefore, it is difficult to draw a strong conclusion from this study alone. Recent reports have recommended that the time to return to sports after ACL reconstruction should be nine months or later from the perspective of functional improvement and re-injury [22, 28]. Based on these considerations, an evaluation nine months after the surgery is considered necessary.

The results of this study suggest that enhancing preoperative psychological competitive ability may influence success in sports activities after ACL reconstruction. In order to increase preoperative DIPCA.3, adopting a psychological approach, including active goal setting, having a role model the patient can relate to, relaxation techniques, and mental practice, has been proposed as a strategy to target psychological factors [29, 30]. The POMS2 results obtained in this study also suggest that a favourable surrounding environment, including friendship, is also an important factor in improving psychological competitive ability. Although psychological responses improve with general rehabilitation [20], this study indicates the importance of psychological approaches in improving preoperative DIPCA.3.

This study has several limitations. First, other factors not considered in this study are associated with the return to sports after ACL reconstruction. Further, this study did not investigate the relationship between ROM, muscle strength, and other criteria described in the rehabilitation protocol. Second, we did not conduct a psychological approach to the patients, and it is unclear how a psychological approach would affect the results of this study. This is a major issue that needs to be addressed in the future, and collaboration with more specialized professionals, such as sports psychologists and clinical psychologists, is necessary. Third, DIPCA.3 was performed only preoperatively and was not assessed six months after ACL reconstruction. Although a psychological approach is required to improve psychological competitive ability, DIPCA.3 was not assessed at six months postoperatively because no psychological approach was used in this study.

**Conclusion**

Athletes with higher preoperative psychological competitive ability were in a more positive emotional state preoperatively than those with lower preoperative psychological competitive ability, and the difference was even greater at six months after ACL reconstruction. The results of TMD, including negative emotional states, were also more favourable in the high group at six months after ACL reconstruction.

**Declarations**
Acknowledgements

We would like to express our deepest gratitude to Editage for their careful proofreading of the manuscript.

Author’s Contributions

(i) Conception and design: all authors. (ii) Analysis and interpretation of the data: J.N., T.S., R.Y., M.K., T.K. and K.K. (iii) Drafting of the paper: J.N. and T.S. (iv) Revising it critically for intellectual content: R.Y., M.K., T.K., K.K. and H.T. (v) Final approval of the version to be published: all authors. All authors agree to be accountable for all aspects of the work.

Data availability

This study is a prospective study and will continue to be analysed as data accumulates. Therefore, it is not available to the public. The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Competing interests

The authors declare no competing interests.

References


18. Samełko, A., Guszkowska, M. & Kuk, A. Subjective Rank of the Competition as a Factor Differentiating Between the Affective States of Swimmers and Their Sport Performance. Front


Figures

Figure 1

Flow-chart showing patient extraction


A total of 173 patients with Tegner 6 or higher who underwent ACL reconstruction in 2015-2020 were included. A total of 89 patients were excluded at the time of their preoperative, inpatient, follow-up period,
and 6-month postoperative assessments. Finally, 23 patients in the high group and 61 patients in the low group were included.

**Preoperatively POMS 2**

![Graph showing preoperative results of the Profile of Mood State 2nd Edition (POMS2)](image)

*Figure 2*

Preoperative results of the Profile of Mood State 2nd Edition (POMS2)

AH: Anger-Hostility, CB: Confusion-Bewilderment, DD: Depress-Dejection, FI: Fatigue-Inertia, TA: Tension-Anxiety, VA: Vigour-Activity, TMD: Total Mood Disturbance. Statistical significance was set at $\alpha = 0.05$. In this graph, the only significant difference was found in the VA of the positive items.
Figure 3

Results of the Profile of Mood States 2\textsuperscript{nd} Edition (POMS2) six months after anterior cruciate ligament reconstruction

AH: Anger-Hostility, CB: Confusion-Bewilderment, DD: Depress-Dejection, FI: Fatigue-Inertia, TA: Tension-Anxiety, VA: Vigour-Activity, TMD: Total Mood Disturbance. Statistical significance was set at $\alpha = 0.05$. In this graph, the POMS2 mood profile in the high group showed the iceberg profile, which is exhibited by top athletes. In the iceberg profile, AH, CB, DD, FI, and TA are lower, and VA is higher.