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Review article

Current study on the influence of psychological factors on returning to sports after ACLR

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ABSTRACT

It is considered that psychological factors are important in determining exercise regression outcomes of patients with anterior cruciate ligament reconstruction (ACLR). This review summarizes the definition and research progress of current undefined psychological factors related to returning to sports (RTS) after ACLR, as well as the application of corresponding measuring scales, and common psychological interventions in the field. The aim is to understand and clarify the impact of psychological factors in the ACL injury and rehabilitation, and to provide a theoretical basis for the application of psychological evaluation and intervention in the later stage. It is believed that there are still many prospects for the research in this field.

1. Introduction

As more people become involved in sports, the incidence of anterior cruciate ligament (ACL) injury has gradually increased, becoming the most common sports-related injury of the knee [1]. Arthroscopic ACL reconstruction (ACLR) using tendon grafting is currently recognized as the preferred surgical treatment option after an ACL injury.

The ultimate goals of treatment and rehabilitation after ACL injury are to restore joint stability, improve joint function, and achieve the target of returning to sports (RTS), and the desire to return to movement with equal to or close to pre-injury levels is an extremely important expectation and psychological response of patients with the ACL injury, so the evaluation criteria for ACL reconstruction surgery has gradually shifted from injury-based angle such as joint stability to sport-participation-based perspective such as RTS rate in recent years [2]. Factors affecting RTS are multifaceted including a series of indicators such as rehabilitation time, the evaluation of joint function and movement quality, as well as the subjective feelings of patients [3]. Kvist et al. [4] considered that at least the following aspects were required for the realization of RTS: strong and symmetrical muscles strength of the lower limbs; the normal range of motion of the joints; no local pain, swelling, or fluid accumulation; dynamic and static stability of the knee; no secondary injury; and no negative social factors (studying, pregnancy, etc.) or psychological factors.

However, in recent years, a growing number of studies have been disappointed to find that even with strong ligament graft support, sophisticated surgery technology, precise anatomical reduction, and the latest concepts and technologies of rehabilitation treatment, there is still a considerable part of the population with unsatisfactory outcomes of RTS after ACLR. Ardern et al. [5, 6] found that about 33% of patients could return to competitive sports in 6–12 months after surgery, and the rate decreased to 29% after 2–7 years. In addition, Ardern et al. [7, 8] believed that about 81–82% of patients could resume some kind of physical activity after ACLR, and 63–65% could return to sports, but only about 44–55% of patients can return to their pre-injury athletic level sports. However, there is no obvious physical problem with the postoperative joint of these non-returnees which is indicated by radiographic imaging, physical examination, and even functional evaluation scores. Therefore, it is believed that the difference between the satisfactory physical results of the joint and the disappointing sport participation outcomes may indicate that psychological factor plays an important role in determining the exercise regression outcome of patients with ACLR [9].

In recent years, more and more attention has been paid to the influence of psychological factors on functional rehabilitation outcomes and

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quality of life satisfaction after ACLR. However, it is regrettable that the vast majority of studies only focus on unrevealing that some psychological factors may be related to RTS after ACLR, but there is little about the specific influence mechanism of these psychological factors on rehabilitation outcomes and the interaction relationships among these psychological factors. Therefore, this review aims to provide a comprehensive overview of the current understanding of the influence of psychological factors on RTS after ACLR by summarizing the psychological factors that have been uncovered to affect RTS after ACLR and the interactions between these factors, and thus to provide a theoretical basis for the application of psychological evaluation and intervention in the later stage. This article highlighted the current research progress of psychological factors in influencing RTS after ACLR rehabilitation combining psychological factors and their relationships, together with psychological assessment tools and psychological intervention applications to the greatest extent.

We searched the PUBMED and Google Scholar databases for related literature on the psychological factors affecting the outcome of returning to exercise after ACLR, including psychological evaluation methods and psychological intervention used in this field, regardless of publication type or study type. Non-English studies were excluded from our review.

2. Psychological factors affecting RTS after ACLR

Specific psychological factors during initial injury, surgery, and rehabilitation are considered to affect whether patients can successfully return to sports after ACLR. Patients with positive psychological reactions can get more satisfactory rehabilitation outcomes, on the contrary, negative psychological factors such as lack of confidence, anxiety, depression and worry about the loss of social identity interfere with the rehabilitation after ACLR in varying degrees [10, 11]. Therefore, in addition to meeting the physical requirements of exercise, ACLR patients should also have sufficient psychological readiness as the standard of RTS before returning to exercise.

2.1. Self-efficacy

Self-efficacy is an individual's belief that he or she can succeed and realize himself, or that he or she can successfully perform a certain task. It reflects the belief that individuals can take appropriate actions to face environmental challenges and belongs to the important category of self-awareness. Patients with high self-efficacy tend to have a higher quality of life and overall health but less disability [12].

A number of studies have shown that self-efficacy is related to the improvement of prognosis and satisfaction of patients after ACLR. Thomeé et al. [13] proved that postoperative self-efficacy was positively correlated with activity level and knee joint injury/osteoarthritis outcome score (KOOS) through compiling the knee self-efficacy scale (K-SES). Then they further found that preoperative self-efficacy could predict the level of physical activity, joint symptoms and function, and muscle function one year after ACLR [14]. It is considered that psychological factors, especially motivation, self-efficacy, and personal control, are positively correlated with rehabilitation persistence and rehabilitation effect by systematically reviewing the relationship between psychosocial factors, compliance, and rehabilitation effect after ACL injury and surgery [15]. In addition, self-efficacy is believed to affect the outcome indicators related to rehabilitation [16, 17]. It was found that for every 1-point increase in self-efficacy level, the probability of patients being satisfied with the surgical results increased by 50%, which indicated that self-efficacy was the most important psychological factor affecting patient satisfaction after ACLR [18].

2.2. Affect

Affect is mainly composed of emotions, feelings, and moods, in which psychological negative emotion mainly refers to psychological conflict, stress, and emotional negative performance [19]. Common negative emotions include depression, anxiety, confusion, anger, fatigue, sadness, tiredness, etc., which are related to the occurrence and outcome of the disease or the performance in the individual recovery process and can adversely affect the outcome of rehabilitation after an operation such as ACLR [11, 20].

It is reported that negative emotions can be predicted by personal variables (e.g., sports identity, neuroticism, optimism) and situational variables (e.g., daily stress, sports activity). These feelings are positively correlated with individual neuroticism and the degree of stress but negatively correlated with sports identity and optimism [21]. It is believed that optimism and self-identity can positively predict the outcome of ACLR, while pressure has a negative predictive effect on knee symptoms and rehabilitation compliance [16]. In addition, studies have shown that less fear and anxiety are positively correlated with RTS, so patients with positive psychological emotions are more likely to get better rehabilitation results [17, 22].

Continuous studies have found that there is a close relationship between pain and negative emotions. Everhart et al. [16] believed that pain was positively related to negative emotion, and pain could be used as a predictor of negative emotion. After considering the effect of demographic and clinical factors, depression, stress, and optimism are considered to have nothing to do with pain intervention but can predict the severity of pain [23].

2.3. Fear of reinjury

Fear of reinjury or kinesiophobia is defined as an excessive, irrational special phobia of exercise due to fear of injury or reinjury caused by activity or physical exercise [24]. There is a certain risk of returning to the field after for ACL injured. Studies have shown that the risk of ipsilateral or contralateral ACL injury again and secondary meniscus injury significantly increases after ACL injury [25]. It is reported that the rate of secondary ACL reinjury is 25%–35% within 24 months after ACLR, which is 6 times higher than that of one with no ACL injury history [26]. Therefore, fear of reinjury is much more common in the rehabilitation stage after ACLR, which is characterized by hesitation or vigilance to some activities or movements and avoidance behavior.

Some studies have suggested that kinesiophobia is an independent predictor of RTS and has a negative impact on the outcomes. It is pointed out that about 24%–52% of the non-returnees expressed fear of reinjury as the main reason for their delayed or failed RTS [27, 28, 29], and it is informed by long postoperative recovery time and limited function [30]. Ardern et al. [2] not only believed that the athlete patients with ACLR who show a higher level of fear during their rehabilitation are less likely to achieve the RTS but also pointed out that such kind of patients have a higher risk of reinjury once they return to sports. By investigating 97 patients' satisfaction with their current process of returning to pre-injury exercise one year after the operation, it was found that fear was significantly correlated with satisfaction [31]. Markström et al. [32] found that patients with ACL injury could have a high fear of reinjury after reconstruction surgery, which will change the activation of muscles around the joint during rehabilitation. Therefore, they believed that the fear of reinjury after ACL injury should be evaluated as an independent psychological outcome in the process of rehabilitation after ACLR, to improve the effect of returning to the sports state. In addition, Van Wyngaarden et al. [33] found that fear of reinjury was significantly related to the long-term results reported by patients with ACLR, and believed that relieving the fear in the later stage of ACLR rehabilitation could improve the long-term self-reporting function of patients.

2.4. Self-confidence

Self-confidence is the subjective judgment that individuals think they can successfully solve different problems and adapt to different environments, also is the self-perception of their ability level [34].

Some researchers consider that the sports confidence level of the injured athletes is much lower than that of the uninjured ones, and self-confidence is very important for athletes to return to competitive sports [35, 36]. It is reported that the proportion of reasons of distrust the joint after reconstruction is as high as 28% among the main reasons for the final failure to return to sports [2]. In the process of rehabilitation after ACLR, patients will pay special attention to the affected knee, and consciously wear protective gear to strengthen the protection of the joint, but at the same time, they will also lack self-confidence and express distrust of the reconstructed joint, worry about the occurrence of unsatisfactory rehabilitation such as knee disability or reinjury, hesitation to participate in sports activities, thus affecting rehabilitation persistence and rehabilitation effect [37]. Webster et al. [38] suggested that clinicians should incorporate confidence-building strategies into rehabilitation plans, and the intervention should focus on enhancing patients' confidence in the injured site.

2.5. Locus of control

Locus of control refers to the individual's belief in the relationship between actions and results. There are three types including internal locus of control, external locus of control, and accidental locus of control [39]. People with a high internal locus of control usually think that the result is the direct result of their actions, so such kind of individuals tends to be independent, goal-oriented, and motivated. On the contrary, people with an external locus of control believe that the results are determined by the actions and influences of others, and they are more likely to suffer stress and depression [40, 41]. Accidental locus of control is between the two, which hold the idea that the results are considered to be mostly determined by fate or opportunity [39].

It was reported that locus of control was associated with rehabilitation outcomes after ACLR, and patients with a more internal locus of control scored higher in terms of satisfaction, physical function, social function, mental health and vitality, and overall knee function [42, 43]. In the process of compiling the sports rehabilitation locus of control scale (SRLC), Murphy et al. [44] found that there was a significant positive correlation between the internal locus of control and patients' treatment compliance. Nyland et al. [45] found that patients with a higher internal locus of control tended to score higher in subjective outcome indicators, including KOOS-activity of daily living scale (KOOS-ADLS), KOOS-sport activity scale (KOOS-SAS) and international knee documentation committee score (IKDC score), and were more satisfied with knee function. Ardern et al. [22] believed that psychological factors, including locus of control, could be used as important independent contributors to return to the pre-injury level sports within 12 months after surgery. Kvist et al. [46] found that more internal health control points were associated with greater psychological readiness to return to sports. Christino et al. [47] concluded that the internal locus of control was significantly related to the results of knee objective function tests, and suggested that appropriate intervention could help to improve the likelihood of RTS.

2.6. Self-motivation

Motivation refers to the internal psychological power of individual activities guided, stimulated, and maintained by a goal or object [48]. It can also be defined as a process, reflecting the intensity, direction, and persistence of individual efforts to achieve the goal [49]. Among all kinds of motivation, the one caused by the individual's internal needs is just called self-motivation [50].

A systematic retrospective analysis concluded that psychological factors such as self-motivation were positively correlated with rehabilitation compliance and rehabilitation results [15]. Gobbi et al. [51] found that the athletes who resumed sports after ACLR had significantly higher scores of the mental vitality questionnaire which indicated a greater motivation to participate in sports. Sonesson et al. [52] also found that the patients with higher motivation and expectations in the process of rehabilitation had more satisfactory rehabilitation results, which promotes them to support the idea that improving motivation was much important to help individuals to achieve the goal of RTS after surgery.

2.7. Self-esteem

Self-esteem is described as a stable and lasting personality trait, an evaluative part of self-concept, which is represented by the individual's judgment and feelings about the level of self-respect or self-importance based on social self-worth and self-intention [53, 54].

It was mentioned in Heijne's study [55] that once the patients with ACL injury felt that their actual recovery period was longer than expected, they would be easy to have a lot of frustration and loss of confidence and self-esteem in their process of rehabilitation. Previous studies have demonstrated that reduced self-esteem has a negative impact on RTS and has a negative prediction of the rehabilitation outcome [20, 42]. Christino et al. [47] found that the level of self-esteem of sports returnees was significantly higher than that of non-returnee and believed that there was a significant correlation between the level of self-esteem and the functional test scores and verification results after ACLR. Vutescu et al. [56] considered that psychological factors, including self-esteem, were related to the RTS potential of young athletes.

2.8. Interactions among psychological factors

There are different degrees of interaction relationships among the above psychological factors (Figure 1).

One of the important determinants of self-efficacy in patients with an ACL injury is the internal locus of control [13] and the degree of internal locus of control can predict the degree of self-efficacy [9].

Individuals with high self-efficacy consciously set challenging goals, improve individual self-esteem, have a high level of motivation, and use their personal strengths to achieve their goals [57, 58]. Self-efficacy regulates human functioning through cognitive, motivational, affective and decisional processes which arise from self-confidence in handling field events that an individual engages [57, 59].

Emotions can predict and influence self-efficacy and patients' perception of pain respectively [23, 60]. It is reported that athletes interviewed in a study experienced a variance of emotions throughout their injury to recovery phase that dictated the degree of confidence in returning to their preinjury level of sport [20]. On the contrary, affective self-regulatory efficacy, a kind of self-efficacy, is considered to can concern perceived capability to manage one's emotional life including perceived efficacy to discern one's emotional states, understand one's feelings toward others, and manage the expression of positive and negative affect [61].

Similarly, it is reported that patients with ACL injury would show 7 times the baseline level of depression which can further lead to mood disorders and reduced self-esteem, thus forming a vicious circle [62].

It was confirmed that days characterized by relatively higher levels of pain would be characterized by relatively higher levels of negative mood. And vice versa [21].

Besides, it is mentioned in fear-avoidance model of pain that when patients experience a recurrent painful stimulus, an exaggerated negative psychological response to pain or the anticipation of pain (pain catastrophizing) leads to an active avoidance of movement out of fear of recurrent pain or reinjury [16]. Even in the absence of current pain, pain recall may also influence fear of reinjury [30].

It is reports that the athletes with low self-motivation may also have fear of reinjury [30], but improving self-efficacy can reduce the fear of reinjury by improving knee joint pain and function [63].

In 1998, Wiese-Bjornstal et al. [64] proposed a Biopsychosocial model, which combines biological, psychological, and sociological attributes and provides a comprehensive understanding of the complex and diverse psychological responses that occur after trauma. In the model, it is believed that the psychosocial response of an individual after the injury

is mainly composed of cognitive, emotional, and behavioral factors. The majority of psychological factors in the process of RTS after ACLR were fitted into Wiese's model, in which the locus of control and self-efficacy were included in the cognitive part, emotion, pain, and fear of reinjury were summed up in the emotional part, and the behavioral part mainly included avoidance coping and rehabilitation compliance.

3. Common psychological evaluation methods after ACLR

3.1. Tampa scale for kinesiophobia

As a clinical measurement tool, the Tampa scale for kinesiophobia (TSK) has been developed to objectively identify and quantify fear of reinjury caused by exercise and physical activity. The scale was originally applied to patients with musculoskeletal pain [65] and consists of 17 statements about the subjective experience of injuries and physical activity. Each statement provides a four-point Likert scale, and the higher the total score, the greater the fear. Cronbachs' α values of the TSK-11 range from 0.7 to 0.9, indicating acceptable to excellent internal consistency [66]. For concurrent validity, significantly strong correlations were demonstrated between the TSK-J versions and PCS total score and subscales (r = 0.602–0.680) [67].

It is reported that the higher the TSK score, the lower the self-reported knee function and the possibility of RTS after ACLR [28, 68, 69]. Therefore, the use of TSK as a measurement and assessment of kinasiophobia can give clinicians a better understanding of how individuals deal with fear and related pain.

3.2. Knee self-efficacy scale

The knee self-efficacy scale (K-SES) was designed to assess patients' perception of their ability to participate in pre-injury level physical activity. The scale contains 22 items, which can be used to evaluate individuals' ability to participate in activities such as daily life, leisure and entertainment, sports, and other activities, as well as their cognition of knee function in the future [70]. In a study to determine measurement properties of the Dutch version of K-SES (K-SES-D), internal consistency for both subscales was excellent (Cronbachs' $\alpha > 0.80$), and test-retest reliability absolute agreement was 0.95 [71]. And then the English version of K-SES was also considered as a valid and reliable measure for knee-specific self-efficacy in individuals with a sport-related knee injury [70].

Thomeé et al [14] found that the K-SES has good responsiveness in self-efficacy evaluation of patients with an ACL injury during rehabilitation and the preoperative K-SES score can predict the probability of patients' RTS, and knee function and symptoms one year after ACLR. In addition, this scale can be used in the study to uncover the relationship between self-efficacy and satisfaction within 2–5 years after ACLR [11].

3.3. ACL return to sport after injury scale

Inspired by the research of Morrey and Johnston, Webster et al. [38] considered that patients' mood fluctuation, confidence in rehabilitation performance, and risk assessment of RTS were also the key psychological readiness factors that affect the outcome of RTS during the rehabilitation process after ACLR. To evaluate the psychological readiness of patients to return to sports and recreational activities, the ACL return to sport after injury (ACL-RSI) scale was developed by Webster's team and applied to clinical research in 2008. The scale consists of 3 dimensions (12 items), including emotion (5 items), confidence in exercise (5 items), and risk assessment (2 items). Each item is scored on an 11-point Likert scale, ranging from "highly probable" to "impossible". It was proved that the scale had high internal consistency (Cronbachs' α: 0.96) and the participants who had given up sport scored significantly lower on the scale (reflecting a more negative psychological response) than those who had returned or were planning to return to sport ($F = 34.39$, $p < 0.0001$). In recent years, the ACL-RSI scale has been more and more frequently used in research, and a certain number of national translated versions have been derived [46, 72, 73]. In addition, to adapt to the complex clinical working environment, Webster's team improved the development of the ACL-RSI scale in 2018 by eliminating 2 items in the original emotion, 3 items in the confidence aspect, and 1 item in the risk assessment aspect [74]. The 6-item short version still has a high internal consistency (Cronbachs' α: 0.92) through verification, which has the same good ability to predict the outcomes recovery after ACLR [52].

It was shown that the potential non-returnees could be screened out by ACL-RSI measurement which could be regarded as the best predictor of RTS in patients with ACLR one year after surgery [20, 75]. The latest

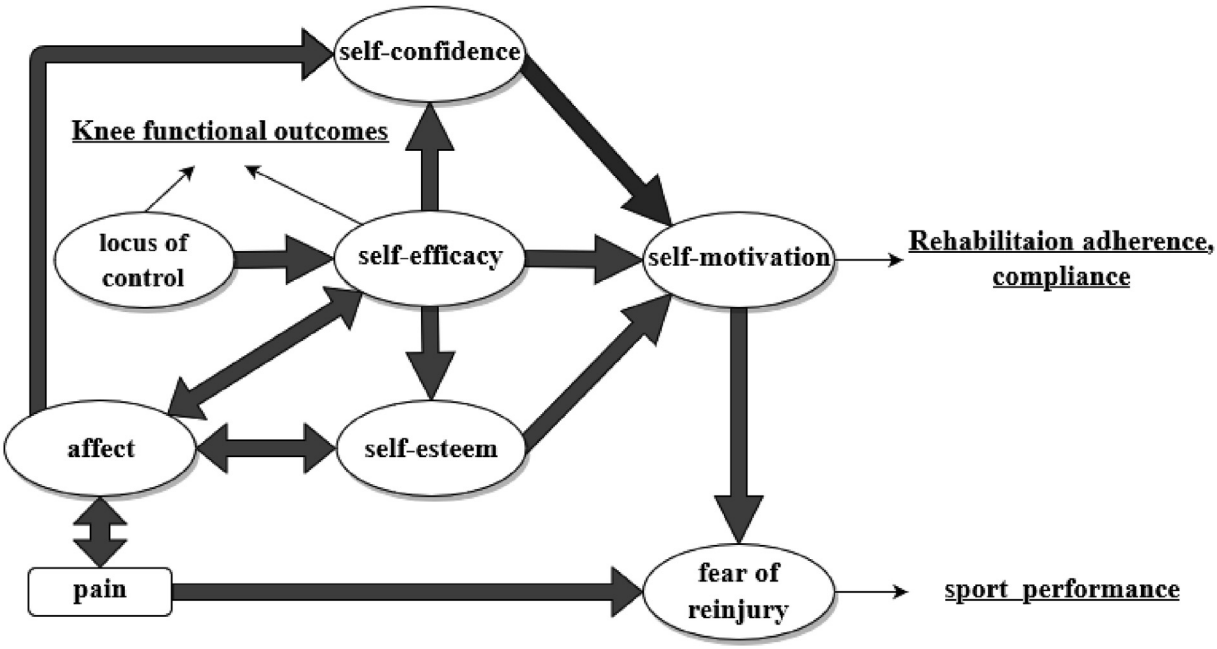

Figure 1. Interaction relationships among psychological factors during rehabilitation after ACLR.

systematic review evaluated psychometric questionnaires based on six attributes (internal consistency, reliability, content validity, construct validity, hypothesis testing, and cross-cultural validity). The results suggested that the ACL-RSI scale has positive evidence, reliable and effective, and it was the highest measurement tool to measure the prognostic quality of patients with ACL injury [76].

3.4. Profile of mood states scale

The profile of mood states (PMOS) scale is an emotional state rating scale that requires subjects to choose the corresponding description according to their feelings in the last week [77]. After being improved by Grove to add the dimension of "emotion-related to self-esteem", now the new scale contains a 40-item questionnaire containing 7 subscales of which 2 measure positive affect and 5 measure negative affect [78]. In a past research the internal consistencies (Cronbachs' α) of the 7 subscales were found to be: fatigue = 0.90, anger = 0.90, vigor = 0.93, esteem = 0.70, tension = 0.87, confusion = 0.76 and depression = 0.93. The higher the score, the worse the emotional state of the subjects [79].

Mainwaring et al. [80] compared the natural emotional responses of athletes to concussion and ACL damage using the POMS scale, and found that athletes with ACL injury had a higher level of depression over a longer period than athletes with concussion. Brewer et al. [21] used the POMS scale to reveal a pattern of improved psychological function over the early stages of post-operative ACL rehabilitation that the participants with a high level of sports identity and low level of optimism reported more decline in daily negative emotions over time. Tripp et al. [81] used the short version of the POMS scale (S-POMS) to find out that the more negative emotions, the lower confidence of athletes to return to sports, and the greater fear of reinjury [56].

3.5. Sport rehabilitation locus of control scale

The items of the sport rehabilitation locus of control (SRLC) scale are selected from the multi-dimensional health locus of control (MHLC) questionnaire, and the scale is designed as a set of assessment questionnaires specially applied to specific sports areas according to the basic principles of MHLC. Murphy et al. [44] reported that the SRLC scale is specially used to evaluate the locus of control of injured athletes and make it more helpful to study the behavior of injured convalescent athletes which showed good internal consistency (Cronbachs' α: 0.72–0.79) and test-retest reliability (0.75–0.85). In the subsequent verification study with injured athletes as samples, the SRLC scale was used to uncover that there was a significant positive correlation between the intrinsic locus of control and treatment compliance.

Ardern et al. [22] used the SRLC scale to study the correlation between locus of control and RTS in 187 patients with ACLR and concluded that psychological factors including locus of control could be used as important independent contributors to RTS within 12 months after the operation. However, during the further 2 years of follow-up which continued to study the exercise participation of 122 athletes who did not achieve the goal of RTS in the first year after ACLR, researchers found that there was no significant difference in the degree of internal locus of control between returnees and non-returnees [82].

3.6. Emotional response of athletes to injury questionnaire

To understand the actual emotional changes of the injured athletes to help the injured athletes to recover more successfully, the emotional response of athletes to injury questionnaire (ERAIQ) was designed and developed. Participants are required to record the information including injury-related sports situation, the goal of rehabilitation after injury, recovery status, RTS-related fear, experienced support or stress, emotional response, etc. within an interval of two weeks, and then were asked to list the highest-ranked emotional responses in the study, and score the listed emotions using the Likert 5-point rating scale [83]. Through measurement and calculation, the fluctuation of the subjects' emotional response after injury can be obtained [84].

According to the results of the ERAIQ, Morrey et al. [62] obtained the total disturbance ERAIQ score (TERAIQ) by adding the scores of negative emotions and subtracting the scores of positive emotions, thus found the "U" pattern change of athletes' emotional response after the injury, and further concluded that the emotional state of athletes after injury was non-static and non-linear. Langford et al. [84] found that the ERAIQ scores of athletes who returned to sports 12 months after the operation were lower than those who did not return to sports, but the authors still considered that the subjects' emotional response to injury has little to do with the recovery of pre-injury sports outcomes.

3.7. Hospital anxiety and depression scale

The hospital anxiety and depression scale (HADS) is a psychological measurement tool designed by Zigmond's team to examine the degree of depression and anxiety of individuals based on the form of patient reports [85]. The scale includes two different subscales containing 7 items for assessing two aspects of emotional health respectively: anxiety and depression. The item of anxiety subscale aims to detect the degree of generalized anxiety, while the depression subscale mainly evaluates the degree of loss of pleasure, and both the two subscales have high internal consistency (Cronbachs'α: 0.85). The scale was scored with a 4-point Likert scale, and the higher the score, the higher the degree of anxiety or depression.

HADS was initially conceived and validated to assess the structure of anxiety and depression in hospitalized patients, but subsequent studies have shown that it is also effective, sensitive and specific in assessing the severity of depression and anxiety symptoms in a range of disease-specific patients and the general population [86]. With the use of the HADS, Mutrie et al. [87] considered that there was a variable relationship between depression scores and different physical activity environments. Brunet et al. [88] pointed out that the degree and type of physical activity were significantly negatively correlated with depressive symptoms. Filbay et al. [89] even found that patients who returned to the sport after ACLR reported slighter depressive symptoms than those who did not return.

3.8. Other psychological evaluation methods

It is suggested that the additional use of the Marx scale and psychological characteristics questionnaire can provide additional data on joint function and psychological characteristics of patients and can help to improve the ability of athletes to recover to their pre-injury sports level [51].

In addition, Schilaty et al. [90] thought that the scales including the ACL-RSI scale and TSK were the patient-report-based questionnaire, which would have some limitations, so they suggested that neurocognitive measurement techniques such as electroencephalogram (EEG), magnetic resonance imaging (MRI), electrocorticogram or transcranial magnetic stimulation can be used to evaluate and treat psychological factors in patients who want to return to sports. However, due to cost, instrument portability or surgical invasion and other reasons, many of the mentioned above evaluation methods still have not been widely implemented yet.

4. Progress of psychological intervention after ACLR

The purpose of psychological intervention is mainly in two aspects: (1) to change the cognitive evaluation of patients, and (2) to change the physiological/psychological characteristics of patients [91, 92]. At present, the available effective psychotherapy interventions are mainly achieved by promoting the improvement of self-efficacy, accumulating emotions, reducing pain perception and fear, and enhancing rehabilitation compliance [93].

4.1. Relaxing/guided imagination

After a sports injury, the combination of relaxation and guided imagination has been found to be an effective psychological intervention [94]. Johnson et al. [95] evaluated the therapeutic efficacy by giving intervention measures such as breathing, relaxation, image training, and imaginative rehabilitation of injured sites to the intervention group athletes, and found that relaxation/guided imagination had a significant positive effect on improving the mood as a whole. In the study of Cupal et al. [96], 30 athletes with ACLR were randomly divided into treatment group (standard physiotherapy + adjuvant intervention), control group (standard treatment only), and placebo group (standard physiotherapy + auxiliary placebo). The intervention was to receive relaxation and imagination training every 2 weeks for 6 months. It was found that the pain and reinjury anxiety in the intervention group were significantly relieved at the end of the course. Maddison et al. [97] evaluated the intervention efficacy of 21 male athletes with ACLR according to the methods of Cupal. The results showed that the knee relaxation of the intervention group was greatly improved than before, and the levels of norepinephrine and dopamine which were related to stress levels decreased significantly.

4.2. Positive self-talk

Positive self-talk which is also known as positive internal dialogue and self-encouragement can help to increase sports compliance and promote the completion of rehabilitation exercises [98]. With the use of the subscale of sports injury investigation, the differences in the rehabilitation compliance of 54 patients five weeks after ACLR were compared, and the results showed that there was a significant positive correlation between positive self-dialogue and the completion of at-home exercise [99].

4.3. Goal setting and adjustment

Setting short-term or long-term goals postoperatively is important for maintaining motivation during rehabilitation [100]. Grindem et al. [101] believed that motivation is generated and maintained in at least three ways: (1) high-quality patient education, (2) goal setting, and (3) repetitive functional tests to provide feedback. Scherzer et al. [99] took goal setting as an intervention to study its effect on rehabilitation compliance after ACLR. By investigating and tracking participation in rehabilitation courses, the authors found that goal setting was positively correlated with higher exercise compliance at home and the arrival rate of rehabilitation clinic appointments. Johnson's study showed that the intervention could also improve the mood of injured athletes during rehabilitation by teaching the participants the skills of goal setting [95]. Similarly, Evans et al. [102] conducted a goal-setting intervention on 39 injured people who underwent knee surgery and found that the self-reported rehabilitation compliance and the degree of self-efficacy of the intervention group were significantly higher than these of the control group.

4.4. Counseling

Rock et al. [103] found that counseling intervention gradually promoted rehabilitation compliance with time by carrying out a counseling intervention on 3 athletes with ACLR.

4.5. Emotion written record/disclosure

Experimental studies confirm that suppressing emotional expression disrupts one's physiological state [104]. Written disclosure of the depressive emotions which means encouraging patients to write down their feelings about injuries has been shown to help them counteract the adverse effects of their negative emotions [105]. Mankad et al. [106] randomly selected 9 athlete patients 3–4 months after the operation and asked the patients to write down their negative emotions and feelings related to the injury for 20 min every day for 3 consecutive days. After that, the psychological response scale of sports injuries was used to measure the psychological reaction of these subjects. The results showed that this disclosure intervention method could reduce the sadness-related response of patients, meanwhile increasing patients' self-reporting motivation and acceptance of injury.

4.6. Modeling video watching

Maddison et al. [107] conducted a randomized controlled trial (RCT) on 58 athletes with ACLR and used the model video which load a rehabilitation training model and a coping model containing the rehabilitation difficulties discussion and ways to overcome them as postoperative intervention. The patients of each group were asked to complete the psychological questionnaire and expected pain score scale after each intervention. The results showed that the modeling video-watching intervention significantly reduced the perception of expected pain and improved the degree of self-efficacy. In addition, compared with the control group, the IKDC score of the intervention group was significantly higher. Zaffagnini et al. [108] conducted an RCT on the short-term clinical effects of a new modeling video-watching method named Videoinsight® after ACLR. 106 patients were randomly divided into two groups and asked to watch their corresponding model video 3 times per week during the first 2 months of the rehabilitation period. The results showed that the subjective IKDC score of the intervention group was significantly higher than that of the control one, and the TSK score was lower. Therefore, the authors believed that proper rehabilitation treatment with the Videoinsight ®method can improve the short-term clinical effect of ACLR patients. However, in an RCT of 32 ACLR patients, the researchers considered that although simulated video intervention is feasible, it could not effectively solve the postoperative psychological risk factors of patients [109].

5. Conclusions and perspectives

This review summarizes the current uncovered psychological factors related to RTS after ACLR, corresponding tools for measuring psychological factors, and common psychological interventions in this field. It is believed that there are different degrees of correlations between psychological factors and the outcome of RTS after ACLR. These relationships can be obtained by using the corresponding psychological assessment scales. The current psychological interventions also show a certain degree of clinical effect. However, there are still some limitations in our article. (1) This study is designed to be similar with a narrative review but not a systematic review. The selection of the articles was that solely of the authors, so not all relevant literature was considered for inclusion and the quality of the articles' content was not critically evaluated. Therefore, there was potential for selection and interpretation bias. (2) Some of the refences related to the conceptual definition and origin and development of the described objects are relatively reliable, but they may not be so current.

A large number of studies have shown that adverse psychosocial reactions can become a potential obstacle to the successful recovery of motor and functional activities after ACLR. Understanding and clarifying the influence of psychological factors on the ACL injury and rehabilitation process after the repair is useful to help patients recover better and faster after ACLR and achieve the goal of RTS. Therefore, clinicians should not only pay attention to the physical aspects related to injury, but also pay attention to the role of psychology and have overall consciousness. For the psychological factors that can be measured and changed, we can improve the preoperative evaluation plan and postoperative rehabilitation plan in the clinic, and incorporate the intervention and treatment of corresponding psychological factors, to solve the psychological

impact that may increase the risk of patients returning to sports failure, meanwhile increase the positive degree of patients' psychological status.

In the past 10 years, the research on psychological factors related to sports injury, especially rehabilitation after ACL injury has gradually increased, and some progress has been made, but there are still some aspects to be solved. (1) Under the current situation of low RTS rate, what is the contrast between psychological factors and physical readiness? Is it because the two are independent of each other? Or is it because the existing psychological scales can not accurately reflect the actual physiological state? (2) Most of the existing research did not fully take into account the different psychological changes of individuals of different ages on sports injury and treatment and rehabilitation, and the different effects of these psychological changes. (3) Most of the measurement tools used in the psychological research of sports injury are borrowed from other fields of psychology, but the scales compiled by sports psychologists are very few. (4) There is still a lack of research on the correlation of psychological factors per and post ACLR, psychological screening, and even follow-up psychological intervention.

In short, through preventive and therapeutic psychological intervention, improving the clinical outcomes of patients with ACLR (including increasing the rate of return to exercise and improving psychosocial factors) will be the goal of clinical efforts in the future.

Declarations

Author contribution statement

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