Patient characteristics of non-operative anterior cruciate ligament injury associated with poor knee functions on activities of daily living: a cross-sectional study

I Putu Gde Surya Adhitya1,2,*, Ida Bagus Amertha Putra Manuaba3,4, Lalu Suprawesta1,5, Yosika Septi Mauludina1, Siti Ainun Marufa6

ABSTRACT

**INTRODUCTION**

Worldwide, the anterior cruciate ligament (ACL) injury is a common injury in the younger adult population.1 The incidence of ACL injury is more than 200,000 cases, with 100,000 of these knees reconstructed annually.2 The references found that the amateur sporting groups generally had a higher incidence of ACL than the entire population and lower than among professional athletes.3 Besides, the ACL injury has commonly occurred in a greater number of athletes, in which women have 2 – 9 times greater risk of the ACL injury than men.4 Since most people with ACL injury are younger adults, the long term consequences of the ACL injury has highly contributed to the poor knee function that causes chronic medical pain, joint functional limitation, decrease quality of life, and disability.5 While the ACL has a critical role in the knee movement and proprioception, when it is injured, then it will cause poor lower body movement and normal human performance that affect the limitation of activity daily living and quality of life.6

While studies published about the ACL injury in the patient with knee reconstruction in the multiple dimension,7 8 Less publication is about poor knee function and ACL injury in the patient with non-operative treatment. This study has to describe the characteristics of patients with ACL injury non-operative, which are associated with poor knee function on daily living activities.

**METHODS**

We included patients with ACL injury that has been diagnosed for ACL injury by an orthopedic surgeon or physiotherapist in a hospital or private clinic. All participants were recruited from February 2019 to April 2019. The inclusion criteria were patients who at least 18 years old. We used the KOOS ADL function cut-off score ≤80 to dichotomous the patient with knee problems, and score >80 have no statistical analysis problem. We calculated using binary logistic regression on the KOOS ADL function for each variable.

**Results:** The mean score of KOOS daily living was 72.8 points, of which 66 participants had poor scores, and 37 were acceptable. Women were 9.2 times more likely to have poor KOOS daily living scores than men in non-operative ACL injury patients (p=0.044), and non-elite athletes had a higher possibility by 8.5 times higher than those who were participated in sports only for leisure or recreation (p=0.002).

**Conclusion:** This study confirmed that patients who did not undergo the ACL reconstruction had a poor knee function in daily living. It was associated with women and non-elite athlete participants, yet the concomitant injuries were possibly confounder for the association.

**Keywords:** non-operative ACL injury, knee function, activities of daily living, KOOS

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design study were the patients who had joined the ACL community of Indonesia. This community is a national wide community that members by ACL patient, orthopedic surgeon, physical therapist, and other sports professionals that aims to share injury experience and educate the treatement of the ACL injury (including the reconstruction and rehabilitation phases). We included patients with ACL injury that has been diagnosed for ACL injury by an orthopedic surgeon or physiotherapist in a hospital or private clinic. Non–operative ACL was defined by patients who decided not to undergo surgical treatment on their injury condition. All participants were recruited from February 2019 to April 2019. Data on the demographic characteristics and knee functions for daily living were collected via telephone interviews and a website. The inclusion criteria were 1) patients who at least 18 years old and 2) willing to filled and signed the informed consent to participate in this study. Exclusion criteria were 1) patient who had previous injury history at the current knee or opposite knee, 2) patient had an injury or another knee disability on the opposite knee, 3) patient who had cognitive impairment to avoid the uncooperative behavior. There are 103 participants eligible for the statistical analysis. Ethical Committee of the Institutional Review Board College of Medicine Universitas Udayana/ Central Public Hospital Sanglah Denpasar, Bali, Indonesia, has approved the study protocol with the permission number of 60/UN14.2.2.VII.14/LP/2019. All participants have given inform consent before included in this study.

Measures
Demographic data including age, sex, height, weight, and education level were collected using a website and confirmed by telephone interview. The knee functions for daily living were measured using activities of daily living (ADL) subscale as a part of the self-administered Knee Osteoarthritis Outcome Score (KOOS). This part has 17 items with a Likert scale used to score each item from 0 (no problems) to 4 (extreme problems). The KOOS ADL score was estimated from the mean of ADL functions, then divided by 4, multiplied by 100, then subtracted this number from 100, with zero representing extreme knee problems and 100 representing no knee problems. The information about the time of injury was determined as the date of an ACL injury that was defined as the first time the involved knee injured with symptoms such as a “pop” sound and sharp pain until the date of our data collection. The assessment time was defined as the first ACL injury until an orthopedic surgeon or physiotherapist confirmed the case. Injury leg was defined from the answer of “Which leg has an injury?” and “Which leg that you use to shoot a ball or which one is your strongest leg?” then the answer would be categorized into non-dominant and dominant. Injury methods were defined as the type of sport that causes current injury and separated into contact sports (e.g., football, basketball, futsal, rugby, martial arts, etc.) with contact injury (i.e., kicked, hit, crushed, pushed, tackled) or non–contact injury (i.e., twisted, slipped, collapsed); and non-contact sports (e.g., tennis, badminton, volleyball, cycling, running, gymnastic).

The level of participation was defined as an indication of professional experience and competitiveness in sports that consists of three categories: 1) leisure or recreational athletes, 2) non–elite athlete, 3) and elite athlete. We also collected data on each patient's first aid treatment, which was defined as the self-reported of any first aid intervention of the patient's ACL injury on the incidence during the sports activity.

Statistical Analysis
We did the descriptive analysis to explain the distribution of variables using arithmetical means and standards deviations for continuous variables and proportions percentages for categories variables. We used the KOOS ADL function cut-off score ≤80 to dichotomous the patient with knee problems, and score >80 have no statistical analysis problem. We calculated univariate analysis using binary logistic regression on the KOOS ADL function for each variable. The variables with p-value <0.25 were included in the multivariate analysis, and the variables would be statistically significant if p-value<0.05. We performed all the statistical tests using SPSS for Windows (19.0 version).

RESULTS
All patients who participated in this study had data on demographic characteristics and knee functions of activities daily living. As shown in Table 1, the mean of age, body mass index, time of injury, time of examination was 27.5 years, 24.7 kg/m², 34.0 months, respectively. Of 89.3% of participants were male, 54.4% achieved college level, and 64.1% injured the dominant leg’s ACL. Most of the participants by 55.3% got injury by the contact sports (such as soccer, futsal, basketball) with the non-contact method (such as collapsed the knee and tackled, pushed, and crashed by opponents), 43.7% during a recreational sport, and 72.8% participants received first aids after an ACL injury. The mean score of KOOS daily living was 72.8 points, of which 66 participants had poor scores, and 37 were acceptable.
**Table 1. Characteristics of the non-operative anterior cruciate ligament injury patients (n=103)**

| Characteristics                      | mean±SD or n (%) |
|--------------------------------------|------------------|
| Age, years                           | 27.5±6.6         |
| Sex                                   |                  |
| Women                                | 11 (10.7)        |
| Men                                  | 92 (89.3)        |
| BMI, kg/m²                            | 24.7±6.3         |
| Education                            |                  |
| >12 years                            | 56 (54.4)        |
| ≤12 years                            | 47 (45.6)        |
| Injury leg                            |                  |
| Non-dominant                         | 37 (35.9)        |
| Dominant                             | 66 (64.1)        |
| Injury methods                        |                  |
| Contact sports – contact injury      | 57 (55.3)        |
| Contact sports – non-contact injury  | 32 (31.1)        |
| Non-contact sports                   | 5 (4.9)          |
| Others                               | 9 (8.7)          |
| Injury to baseline, months           | 34.0±52.9        |
| Injury to examination, months        | 16.9±48.1        |
| Level of participations              |                  |
| Leisure/Recreation                   | 45 (43.7)        |
| Non-elite athlete                    | 29 (28.2)        |
| Elite athlete                        | 29 (28.2)        |
| First aid                            |                  |
| Yes                                  | 75 (72.8)        |
| No                                   | 28 (27.2)        |
| KOOS activities of daily living      | 72.8±18.9        |

BMI, body mass index; KOOS, knee injury and osteoarthritis outcome score; n, number of participants; SD, standard deviation

DISCUSSION

In the present study, we evaluate the non-operative ACL injury patients, including non-elite athletes and women participants, against poor knee function. KOOS scores were significantly poor in the non-elite athlete than those who did sport in leisure or recreation and were significantly poor in women compared to men. As the instrument we used in this study, KOOS is a specific knee instrument developed by Ewa M. Roos and colleagues in 1995, which evaluate the short and long-term due to the injury. This KOOS was used to predict pre-injury level activity, where the poorer score highly related to the fear of getting re-injury among athletes.

The previous study showed that sex differences are one of the risk factors in sports injury incidents. In agility sports, such as volley, basketball, and soccer, the risk number increases 3-5 times to experience ACL injury in females compared to males. Females also have a high risk of ACL injury and knee osteoarthritis (OA) compared to males. The differences anatomically and biomechanically have been studied to contribute to the risk of injury. The morphology of the knee joint between sexes also had an important role in the risk of injury. The investigation of muscle size and mass between the different sexes has been demonstrated in the previous study. Female has a 30% smaller muscle size of knee flexor (KF) and 25% of knee extensor (KE) compared to male but larger in vastus lateral (VL) and biceps femoris (BF) morphologically, which underlined as a trigger for decreased knee joint stability to lead the incidence of ACL injury. The lower strength of hamstrings muscle to quadriceps (H/Q) in female-led the cause of muscular stability reduction of the knee. The strong hamstring can counteract the shear of anterior tibial muscle to protect the ACL by increasing the joint stability. Yet, less knee joint stability in female-led to the quadriceps’ contraction then elicit the translation of anterior tibial, especially when the knee in full extension position, causing ACL ruptured. Hence, the smaller size of female muscle quadriceps and hamstrings is highly related to knee joint injury. Those balance differences in muscle morphology are the primary reason to reduce knee joint functional stability joint and the great factor of ACL injury in females.

The ratio strength of KF and KE muscles in females was 50%, while 56% in males, indicating that females have a lower strength. In detail, sartorius (SA) and gracilis (GR) muscles, which part of KF has a smaller ratio size in females compared to males (44% and 42% respectively). Moreover, both SA and GR are important in controlling valgus knee forces; the greater ratio of...
size and strength produces higher forces.23 Those factors also underlined the occurrence number of ACL rupture in the female. From several studies that have been completed, a lower ratio of muscle size and strength among females than males supports the result in our study where KOOS in the patient of non-operative ACL injury has a worse score among females. Besides morphology, men and women have a different psychological response against injury.24 The hormonal changes and different neuromuscular control are the underlying stark difference post-injury.25 More than that, many women athletes did not return to the sport despite undergoing knee reconstruction post-ACL injury.26 The mental conflict after the injury among women build anxiety and establish psychological distress. The coping mechanism is also affected by emotional stress.

ACL rupture is a common injury that occurred among elite and non-elite athletes.27 Thirty-four of seventy-eight athletes did not return to the sport for several reasons, such as inflammation, instability, joint stiffness, and failure to perform the same as pre-injury. However, one study successfully revealed that 54% of the athlete could return to sport at 9-12 months and maintain to play until 60 months of post-ACL injury. Among them, the elite athlete can return to sport compared to the non-elite athletes. For instance, rugby athlete has 100% able to return to sport after 6 months, while another source mentioned 81% they were able to return to sport at 12 months, and 71.4% at 43 months.28 There are various reasons behind not return to sport between the athletes. The five highest reasons are fear of the second injury, lack of confidence, failure to regain pre-injury fitness performance, and pain sensation after the injury.29 A non-elite athlete has a higher Kinesiophobia score, which represents fear of re-injury caused by activities.29 Yet, fear of the second injury is not a significant variable because it may underlie activity limitations.30 The factors of self-efficacy, optimism, and motivation are also important among the athlete during the rehabilitation process. The functional knee score between elite athletes was also greater than non-elite athletes.30 From this previous study, they found that non-elite athlete has a significant number to not return to sport after ACL-injury.30 Those findings support our result where the KOOS score is significantly poor among non-elite athletes after non-operative ACL-injury.

In this study, several limitations need to be explained. Firstly, this study's results cannot represent all ACL patients who did not undergo the ACL reconstruction in Indonesia. Our participants were relatively small, and only those accessible to the internet would participate in this study. Secondly, a lack of objective measures to identify the concomitant injuries probably has confounded our results. Most of our participants did not undergo the MRI assessment; thus, it seemed very difficult to determine concomitant injuries on the knee index.

### Table 2. Univariate analysis using logistic regression model of patient characteristics to the KOOS activities of daily living (n=103)

| Characteristics                  | OR (95% CI)   | p-value |
|----------------------------------|---------------|---------|
| **Age**                          | 1.01 (0.95-1.07) | 0.869   |
| **Sex**                          |               |         |
| Women                            | 6.43 (0.79-52.38) | 0.082   |
| Men                              | reference     |         |
| **BMI, kg/m²**                   | 1.08 (0.98-1.19) | 0.141   |
| **Education**                    |               |         |
| >12 years                        | 1.02 (0.46-2.29) | 0.962   |
| ≤12 years                        | reference     |         |
| **Injury leg**                   |               |         |
| Non-dominant                     | 1.27 (0.54-2.97) | 0.581   |
| Dominant                         | reference     |         |
| **Injury methods**               |               |         |
| Contact sports – non-contact injury | 0.90 (0.37-2.21) | 0.820   |
| Non-contact sports               | 0.36 (0.06-2.34) | 0.285   |
| Others                           | 1.89 (0.36-9.98) | 0.452   |
| Contact sports – contact injury  | reference     |         |
| **Injury to baseline, months**   | 1.01 (1.00-1.02) | 0.217   |
| **Injury to examination, months**| 1.01 (0.99-1.03) | 0.279   |
| **Level of participations**      |               |         |
| Non-elite athlete                | 8.29 (2.19-31.36) | 0.002   |
| Elite athlete                    | 1.36 (0.53-3.48) | 0.527   |
| Leisure/Recreation               | reference     |         |
| **First aid**                    |               |         |
| No                               | 0.67 (0.27-1.62) | 0.371   |
| Yes                              | reference     |         |

BMI, body mass index; CI, confidence interval; KOOS, knee injury and osteoarthritis outcome score; n, number of participants; OR, odd ratio; SD, standard deviation.

### Table 3. Multivariate analysis using logistic regression model of patient characteristics to the KOOS activities of daily living (n=103)

| Characteristics                  | Adjusted OR (95% CI) | p-value |
|----------------------------------|----------------------|---------|
| **Sex**                          |                      |         |
| Women                            | 9.22 (1.06-79.85)    | 0.044   |
| Men                              | Reference            |         |
| **BMI, kg/m²**                   | 1.08 (0.98-1.18)     | 0.133   |
| **Injury to baseline, months**   | 1.01 (0.99-1.02)     | 0.430   |
| **Level of participations**      |                      |         |
| Non-elite athlete                | 8.51 (2.19-32.99)    | 0.002   |
| Elite athlete                    | 0.90 (0.32-2.53)     | 0.527   |
| Leisure/Recreation               | reference            |         |

BMI, body mass index; CI, confidence interval; KOOS, knee injury and osteoarthritis outcome score; n, number of participants; OR, odd ratio; SD, standard deviation.
CONCLUSION

This study confirmed that patients who did not undergo the ACL reconstruction had a poor knee function in daily living. Further, it was associated with women and non-elite athlete participants, and yet, concomitant injuries on a first-time knee injury and following ACL injury might confound this association. For further study, we suggest performing a longitudinal follow up for non-operative ACL injury to achieve the cause-effect association.

CONFLICT OF INTEREST

The author declares there is no conflict of interest regarding publication of the study.

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