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Cruciate Ligament Injuries in the German Statutory Accident Insurance System: Epidemiology, Work Disability, and Socioeconomic Impact

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Abstract

Background

Anterior and posterior cruciate ligament injuries have increased in recent years and predominantly affect young individuals, posing a growing challenge to the German insurance system. The aim of this study was to analyze the frequency of cruciate ligament injuries and to assess associated work incapacity, treatment costs, and pension payments.

Methods

This retrospective registry study analyzed anonymized data from the rehabilitation database (Reha-DOK) for accident years 2010 to 2020. Cases were identified using the injury site code for cruciate ligaments (code 811) and the injury type code for complete rupture (code 43). Only isolated complete cruciate ligament injuries without associated injuries were included. Annual case numbers, age distribution, time to return to work (RTW), documented long-term impairment in pension cases, reduction in earning capacity, treatment costs, and pension payments were analyzed.

Results

A total of 21,918 cruciate ligament injuries were included, and 65.5% of affected individuals were male, mean age was 32.3 ± 13.6 years. From 2010 to 2019, cruciate ligament injuries increased by 30.4% ($p < 0.0001$), whereas the overall cohort of inpatient accident injuries showed no significant change. Individuals aged 15 to 20 years were most frequently affected (19.0%). Data on RTW were available for 14,875 cases; mean time to RTW was 160 ± 133 days. RTW exceeded 3 months in 67.3% of cases and 1 year in 8.8%, whereas RTW within less than 2 weeks was observed in 7.3%. The most frequent long-term impairments were restriction of motion (50.5%), muscle atrophy (14.3%), and ligament laxity or insufficiency (13.8%). Pension payments due to reduced earning capacity were documented in 6.4% of cases. Average costs increased significantly from 2010 to 2019 by 21.1% ($p < 0.0001$). The lifetime total costs per affected insured individual was calculated to €209,483 ± €119,757.

Conclusions

Frequency of cruciate ligament injuries significantly increased over time and affected predominantly young individuals aged 15 to 20 years. The prolonged RTW and substantial lifetime costs indicate a considerable socioeconomic burden for the German Statutory Accident Insurance system.

Background

In the 2024 annual report of the German Social Accident Insurance (Deutsche Gesetzliche Unfallversicherung, DGUV), knee joint injuries ranked third among all accidents, accounting for 12.2% of cases with 83,398 knee injuries in total (1). Cruciate ligament injuries are therefore of particular relevance within the insurance system. The reported incidence of anterior cruciate ligament (ACL) rupture has been reported to be 68.6 per 100,000 person-years, whereas posterior cruciate ligament (PCL) injuries are considerably less common, with an incidence of 1.8 per 100,000 person-years (2, 3).

Cruciate ligament injuries typically occur in young, physically active individuals (4). Consequently, many affected patients are at the beginning of their working career. These injuries are therefore highly relevant not only from a clinical perspective but also with respect to work incapacity, long-term functional impairment, and insurance-related costs. Although good outcomes can be achieved after ACL reconstruction, failed cruciate ligament reconstruction with recurrent knee instability remains a major clinical challenge. Previous studies have reported considerable failure rates, particularly in young patients(4). Failure of primary ACL reconstruction may lead to recurrent instability with the need for revision surgery, prolonged rehabilitation, and inferior functional outcomes compared with primary reconstruction (5).

Despite the substantial literature on surgical techniques and clinical outcomes, only a limited number of studies have investigated the impact of cruciate ligament injuries on work ability and the associated financial burden on insurance providers (6).

Therefore, the aim of this study was to analyze the frequency of cruciate ligament injuries and to assess associated work incapacity, treatment costs, and pension payments.

It was hypothesized, that (1) the number of cruciate ligament injuries within the German Statutory Accident Insurance system has increased; and that (2) cruciate ligament injuries predominantly affect young insured individuals, resulting in prolonged use of healthcare resources and a substantial long-term financial burden for accident insurance providers.

Methods

This study was designed as a retrospective registry study in cooperation with the University of Applied Sciences of the German Statutory Accident Insurance (HGU) and the DGUV. Data was extracted from the anonymized rehabilitation database Reha-DOK. Ethical review was obtained from the Ethics Committee of the Medical Association of Hamburg (reference number WF-017/21).

Data from accident years 01.01.2010 to 31.12.2020 was available and has been analyzed.

In Reha-DOK, injuries are coded according to an internal coding system based on injury site and injury type. Cases were identified using the injury site code for cruciate ligaments (code 811) and the injury type code for complete rupture (code 43).

To minimize misclassification and avoid statistical distortion caused by knee sprains or unclear knee injuries, only cases coded as “complete rupture” were included. In addition, only isolated cruciate ligament injuries without further associated injuries were analyzed in order to reduce confounding by concomitant trauma that is not related to the cruciate ligaments.

To assess relative frequency, inpatient cases with isolated complete cruciate ligament rupture (ACL or PCL) were compared with the overall dataset of all inpatient accident cases documented in Reha-DOK.

Overall, 1,917,573 inpatient insured cases from the Reha-DOK database were screened for the accident period.

The following variables were analyzed:

- annual number of cruciate ligament injuries and total inpatient cases, including sex distribution
- accident insurance
- age at the time of injury
- duration of work incapacity
- the degree of reduction in earning capacity (“*Minderung der Erwerbsfähigkeit*”, MdE). MdE is calculated percent, 100% represents full capacity for work. An MdE of 20% therefore indicates a 20% reduction in earning capacity.
- documented long-term impairment. Documented long-term impairment is defined as persistent injury-related sequelae documented in cases with pension payments due to a reduction in earning capacity.
- costs of medical treatment, pension payments, and settlements

The analysis of treatment costs was based on the costs documented in Reha-DOK for the accident year and the first three years after the accident

For the present study, total costs per patient were defined as the sum of costs related to outpatient treatment, inpatient treatment, inpatient rehabilitation, social participation benefits, vocational rehabilitation benefits.

In cases with ongoing pension payments, the projected cumulative treatment and compensation costs over the patient’s remaining lifetime were estimated based on the mean age at the time of injury and the statistical life expectancy derived from the life tables of the German Federal Statistical Office (7).

Statistical Analysis

Normality of distribution of the samples was tested with Shapiro-Wilk test. Normality distributed data in this study are expressed as means with standard deviation (SD). Statistical analysis was performed using the Shapiro–Wilk test to assess normality between-group differences in primary and secondary outcome measures of continuously distributed data and were assessed with Mann–Whitney U test to

determine significant differences between groups. A p-value of less than 0.05 was considered statistically significant. Statistical analysis was performed with SPSS V.30 IBM Corp.

Results

Demographics and trends in case numbers

Overall, 1,917,573 inpatient insured cases from the Reha-DOK database were screened. A total of 21,918 cases with complete cruciate ligament injury without further injuries were identified and included, 65.5% of cases were male with a mean age of 32.3 ± 13.6 years. The number of all inpatient accident cases included in Reha-DOK (excluding cruciate ligament cases) remained constant ($p = 0.1080$). Cruciate ligament injuries increased by 30.4% from 2010 to 2019 ($p < 0.0001$). In 2020, case numbers decreased compared with 2019 by 35.9% for cruciate ligament injuries and by 22.1% for total cases ($p < 0.0001$) (Fig. 1).

Insured persons covered by the school accident insurance were most frequently affected (26.9%). The second most common insurer was the Administrative Professional Association (VBG) (24.5%). 9.1% of cruciate ligament injuries were insured by the Construction BG (Bau BG). In 85.9% of cases, injuries occurred during work, while 14.1% occurred during commuting to or from work.

Age of insured persons at the time of injury

Injured persons aged 15–20 years were most frequently affected with 19%. 49.1% of injured persons were younger than 30 years at the time of injury. With increasing age, the occurrence of the injury decreased (Fig. 2).

Time to return to work after cruciate ligament injury

Data on RTW were available for 14,875 of 21,918 individuals (67.9%). Mean time to RTW was 160 ± 133 days. In 7,043 cases (32.1%), no information on RTW was available. Among cases with available data, RTW exceeded 3 months in 67.3% and 1 year in 8.8%, whereas short return-to-work periods of less than 2 weeks were observed in 7.3% (Fig. 3).

Long-term impairment

The most frequently documented long-term impairment in cases receiving a pension was restriction of motion (50.5%), followed by muscle atrophy (14.3%) and ligament laxity/ligament insufficiency (13.8%).

Reduction in earning capacity (MdE)

In 6.4% of cruciate ligament injuries from 2010–2019, a pension was documented. A MdE of 10% was assigned in 13.3% of injured persons, while 74.9% received 20% MdE.

Cost analysis of cruciate ligament injuries

On average, total costs per cruciate ligament injury in the accident year and the first three years after the accident increased significantly from €18,549 in 2010 to €22,457 in 2019 (+ 21.1%) ($p < 0.0001$) (Table 1). In cases with continuous pension payments, the calculated total costs until statistical life expectancy were €209,483 ± 119,757 per individual.

Table 1 Mean total costs for medical treatment, rehabilitation and pension per case increased significantly from €18,549 ± €25,925 in 2010 to €22,457 ± €25,335 in 2019 ($p < 0.0001$), representing an overall increase of 21.1%.

Year	Costs per case, mean ± SD (€)
2010	18,549 ± 25,925
2011	17,764 ± 21,049
2012	18,722 ± 23,345
2013	19,269 ± 24,072
2014	19,730 ± 23,243
2015	19,890 ± 22,780
2016	20,698 ± 23,561
2017	21,700 ± 25,892
2018	21,308 ± 24,685
2019	22,457 ± 25,335

Discussion

In line with our hypothesis, the present study identified a higher proportion of cruciate ligament injuries within the overall cohort of accident injuries in the German Statutory Accident Insurance system, together with a high proportion of affected young insured individuals. The calculated lifetime total costs per affected insured individual amounted to €209,483 ± €119,757.

During the analyzed period, cruciate ligament injuries showed a significant increase compared with the overall cohort of other injuries within the German Statutory Accident Insurance system. Both cruciate ligament injuries and total case numbers declined significantly in 2020, which is most likely attributable to the effects of the COVID-19 pandemic (8).

An increasing incidence of cruciate ligament injuries has also been reported in other study populations (9). A striking finding of the present study is that these injuries predominantly affect young insured individuals, who still have a large proportion of their working life ahead of them. Similar findings have been reported from other authors. A Scandinavian registry study, for example, demonstrated an increase

of up to 143% in cruciate ligament injuries among young individuals between 1997 and 2014 (10). The high proportion of cruciate ligament injuries in children and adolescents represents a particular challenge, as this patient group shows high failure rates and subsequent injuries, while potential physeal injury requires specific surgical expertise to avoid growth disturbances (11) (12) (13). Meta-analyses of non-operative treatment of pediatric cruciate ligament injuries have shown unsatisfactory results, with persistent instability in up to 75% of affected individuals, high rates of secondary meniscal and cartilage damage, and early joint degeneration (14) (15). In contrast, in older adults with non-physical occupations and low daily activity levels, non-operative treatment may also result in favorable outcomes (16).

A notable finding in the present study was the long duration of RTW, averaging 160 ± 133 days; in 8.8% of cases, absence from work exceeded 1 year. Similarly long periods of RTW have been reported in a Swiss cohort (17). In contrast, a Norwegian registry study including 803 patients reported substantially shorter periods of RTW, with a mean of 65 days after surgical treatment of cruciate ligament injuries; this increased to just 78 days in patients performing physical work (6) .

Postoperative rehabilitation is of major importance for regaining the ability to work and return to sports. The risk of graft failure after a cruciate ligament reconstruction is highest during the first year after surgery (18). Premature return to sports or heavy physical work can substantially increase the risk of reinjury (19). Accordingly, sufficient postoperative physiotherapy has been shown to reduce the risk of recurrent injury (20).

One reason for the prolonged work incapacity may be the documented long-term impairment. In particular, restriction of motion was documented in 50.5% of insured individuals receiving a pension and may clinically correspond to arthrofibrosis. Occupations requiring deep squatting may therefore no longer be feasible. According to the literature, this complication occurs in approximately 4–13% of cases after surgical treatment of cruciate ligament injuries. Eggeling et al. reported poor outcomes in patients with persistent restriction of motion. In addition, early diagnosis and treatment with arthroscopic arthrolysis can achieve good to excellent outcomes, with the best results observed when arthrolysis is performed within the first 6 months (21).

In 13.8% of insured individuals, ligament laxity or ligament insufficiency consistent with insufficient cruciate ligament reconstruction was documented. This represents a substantial burden both for the patient and for the treatment process overall. Many physically demanding occupations cannot be performed with an unstable knee. Treatment usually requires a revision cruciate ligament reconstruction, although inferior clinical outcomes compared with primary reconstruction have been reported (5). Recurrent instability should therefore be prevented whenever possible and remains a major focus of current knee surgery advancements. Additional surgical treatment of concomitant lateral or medial instability, for example, have shown to be highly effective to reduce the risk of graft failure (22, 23). However, the German reimbursement system currently does not provide any incentive for additional medial or lateral stabilization, as there is no additional reimbursement to compensate for the additional procedural complexity. This lack of additional reimbursement appears difficult to justify in view of recent

evidence showing that the addition of a lateral extra-articular procedure in revision ACL reconstruction significantly shortened time to RTW and reduced graft failure rates without increasing complications (24). Bony deformities increase the risk of ACL graft failure as well. An increased posterior tibial slope significantly raises the forces on the ACL, and a high tibial slope of 12° or more has been associated with a higher risk of graft failure. Several studies have demonstrated that slope-reducing osteotomy can achieve good to very good functional outcomes in patients with cruciate ligament rupture and high tibial slope (25) (26).

The mean total costs per cruciate ligament injury in the year of the accident and the first 3 follow-up years were €18,549 in 2010 and increased to €22,457 in 2019. A US study including 14,713 patients reported mean surgical costs of $24,707 ± $15,644 just for ther surgery (27). The increasing total costs associated with the treatment of cruciate ligament injuries and increasing numbers represent an economic challenge. A systematic review suggested that early surgical treatment is the more cost-effective strategy for cruciate ligament injuries in athletes and young individuals with a high activity level. In contrast, non-operative treatment with optional delayed cruciate ligament reconstruction appeared to be the more cost-effective strategy in middle-aged individuals with a moderate activity level (28).

Limitations

This study has several limitations.

First, data collection in Reha-DOK is systematic but was not designed specifically for clinical research questions and does not distinguish between ACL and PCL injuries. Therefore, literature data on ACL injuries cannot be directly compared with the data of the present study.

Second, work incapacity is recorded only for up to 78 weeks and cannot be differentiated beyond this period; for children, no work incapacity data have been recorded.

Third, a reduction in earning capacity was only documented in Reha-DOK if pension payments are made; therefore, the proportion of injured individuals with a reduction in earning capacity of less than 20% is likely to be higher.

Fourth, the data were derived from a specific cohort of statutorily insured individuals without leisure-time injuries, which limits the generalizability of the findings.

Fifth, data analysis was subject to delay, as reimbursement-related data and information on reduced earning capacity became available only after a time lag.

Conclusion

Frequency of cruciate ligament injuries increased significantly in recent years and predominantly affected individuals aged 15 to 20 years. The resulting prolonged use of healthcare resources was

associated with a substantial financial burden for accident insurance providers. This challenge should be met by ensuring a high quality of care.

Abbreviations

ACL
Anterior cruciate ligament
PCL
Posterior cruciate ligament
DGUV
German Social Accident Insurance
Reha
DOK–Anonymized rehabilitation database
RTW
Return to work
MdE
Reduction in earning capacity
SD
Standard deviation
DGUV
German Social Accident Insurance (DGUV; Deutsche gesetzliche Unfallversicherung)

Declarations

Clinical trial number

Not applicable.

Funding

No funding was received for this study.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical review was obtained from the Ethics Committee of the Medical Association of Hamburg (reference number WF-017/21). The study was based on anonymized retrospective registry data from the rehabilitation database Reha-DOK. Therefore, individual informed consent to participate was waived by the Ethics Committee of the Medical Association of Hamburg. This waiver also applied to consent from parents or legal guardians for any

participants younger than 16 years of age, as no identifying personal data were used and no direct participant contact was involved.

Consent for publication

Not applicable. The manuscript does not contain any identifying individual person's data, images, videos, or clinical details.

Availability of data and materials

The datasets analysed during the current study are not publicly available due to data protection regulations and restrictions regarding statutory accident insurance data. Aggregated data may be made available from the corresponding author upon reasonable request and with permission of the German Statutory Accident Insurance.

Competing interests

The authors declare that they have no competing interests.

Author Contribution

TCD conceived and designed the study, performed the data analysis and wrote the manuscript.JD, MMM and LE contributed to drafting and reviewing of the manuscript.SM contributed to data acquisition and analysis.KHF and RA contributed to data analysis.All authors critically revised the manuscript and approved the final version.

Data Availability

The datasets supporting this publication are not publicly available due to data protection regulations of the German Social Accident Insurance (DGUV) but are available from the corresponding author on reasonable request and with permission of the DGUV.

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Figures

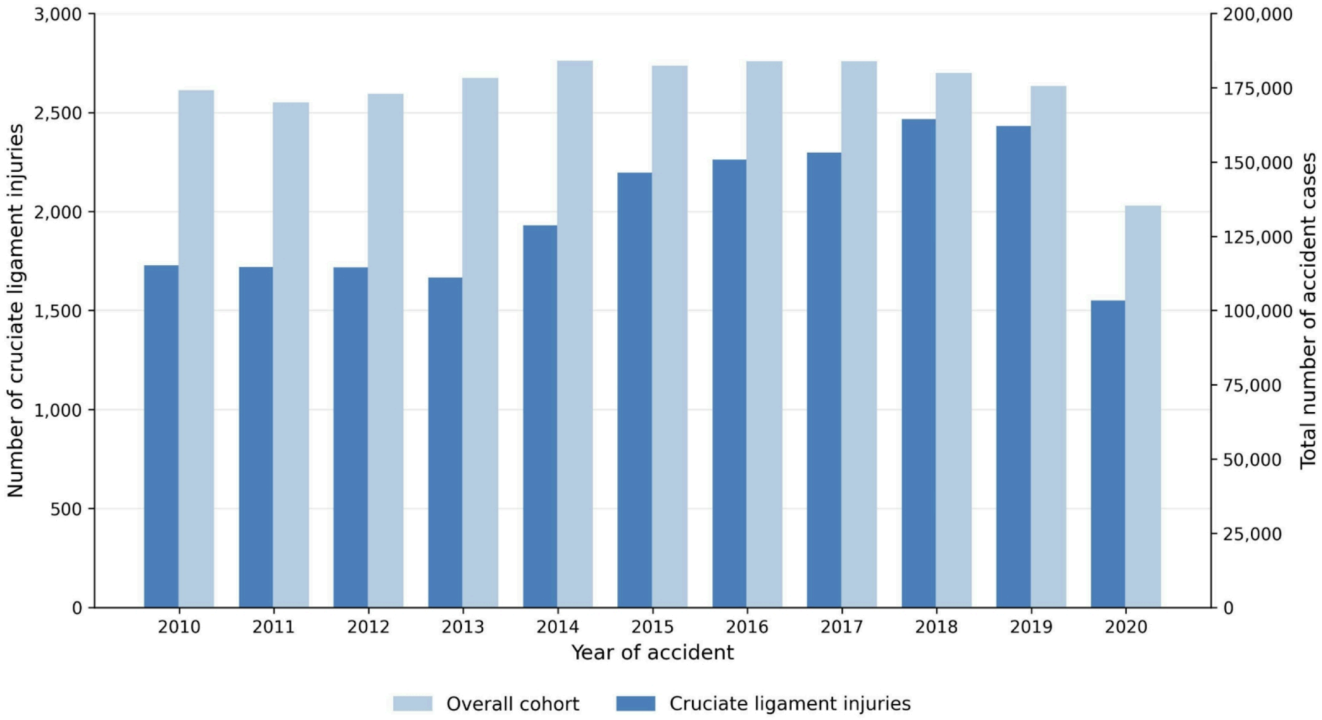


Figure 1

Cases with anterior and posterior cruciate ligament injuries (dark blue on left y-axis) and total number of accident cases (light blue on right y axis) from 2010 to 2020. The number of all inpatient accident cases did not change significantly ($p = 0.1080$) whereas cruciate ligament injuries increased by 30.4% from 2010 to 2019 ($p < 0.001$). Both groups demonstrated a significant decline compared with 2019 ($p < 0.001$).

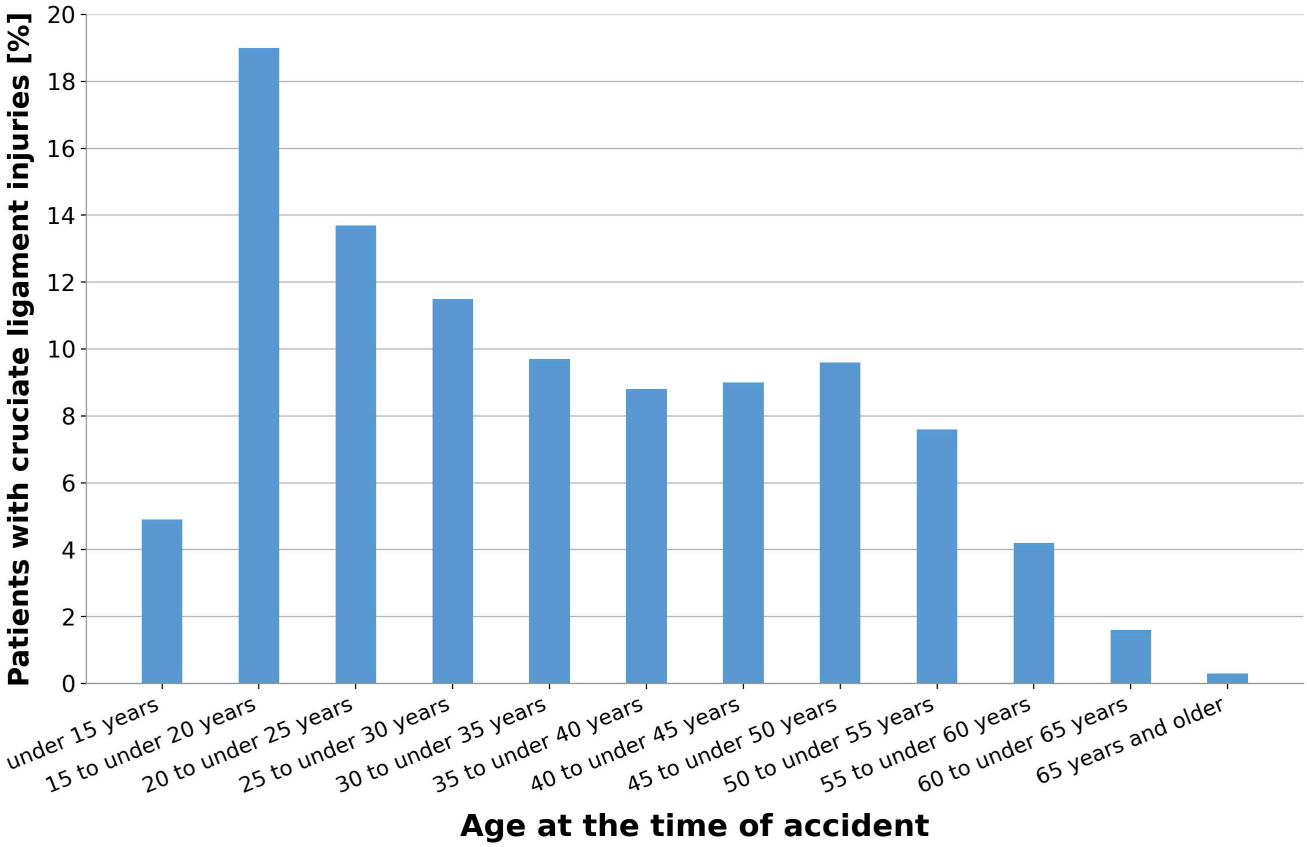


Figure 2

Age distribution of anterior and posterior cruciate ligament injuries (n = 21,918) from 2010 to 2020. Injured individuals aged 15–20 years were most frequently affected (19%). In addition, 49.1% were younger than 30 years at the time of injury. Cruciate ligament injuries were less frequently observed with increasing age.

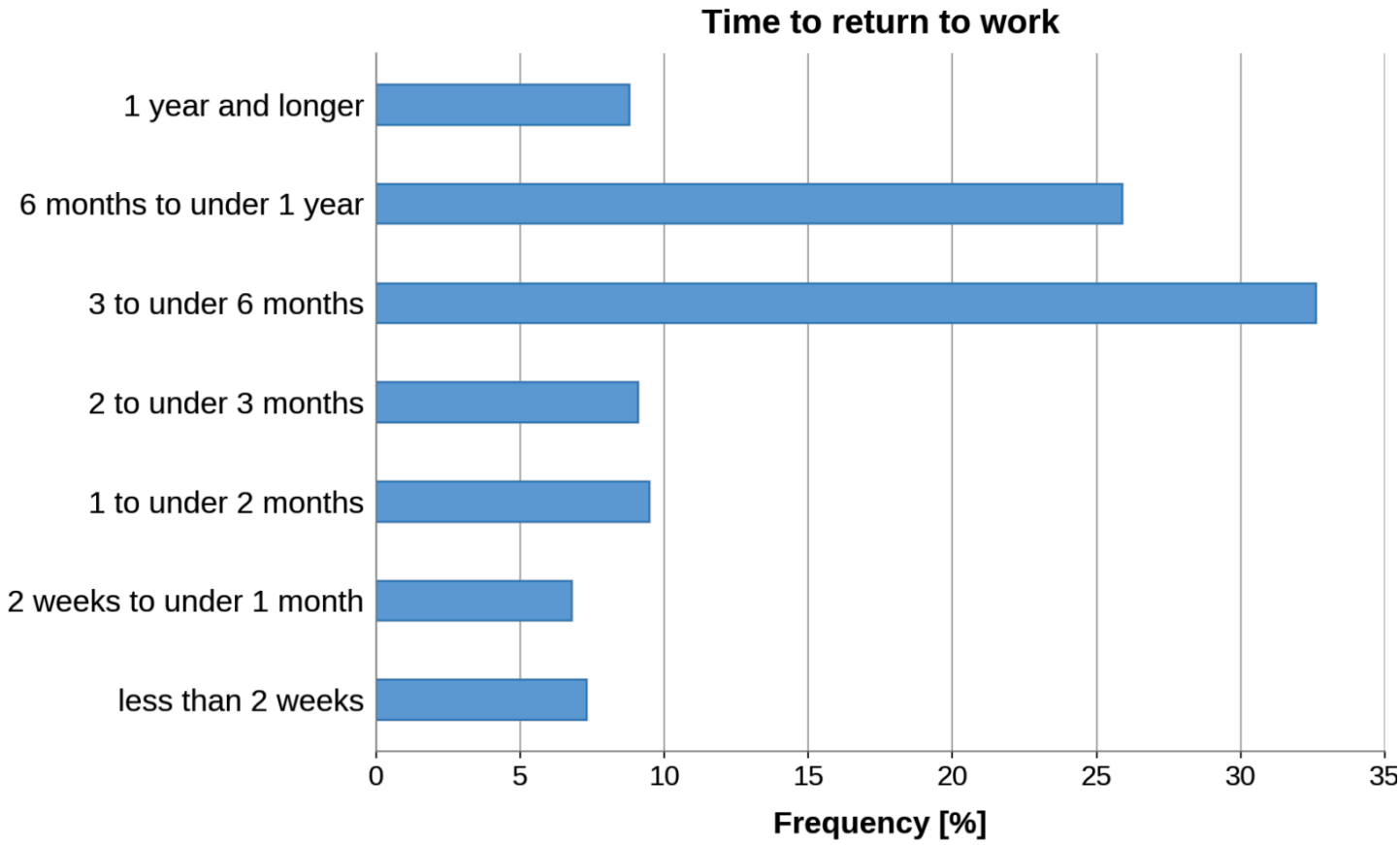


Figure 3

Distribution of time to return to work among 14,875 individuals with anterior and posterior cruciate ligament injuries. Mean time to return to work was 160 ± 133 days. Return to work exceeded 3 months in 67.3% and 1 year in 8.8%, while 7.3% returned within 2 weeks.