doi: 10.4085/1062-6050-0487.24

The socio-economic cost of anterior cruciate ligament injuries and lateral ankle sprains in amateur football and basketball.

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Statements and Declarations

Funding: No funding was received for conducting this study.

Competing interests: The authors have no relevant financial or non-financial interests to disclose.

Ethics approval: This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Medical Ethical Committee of the University Hospital Brussels (B.U.N. 143201526265).

Consent: Written informed consent was signed by all participants prior to participation in this study.

Data: Coded data are available from the corresponding author upon reasonable request

Acknowledgements

We sincerely want to thank Ruben Van Tilburg, Manu Stes, Leen Vandereycken, Justine Loncke, Evi Roelandt, Ann Van Denneucker, Sien Devliegher, Lore Meganck, Stéphanie Michel, Laurence Van Goethem, Kim Pissé and Lize Paridaens for their substantial contribution to the research .

We also want to thank Mr. John Kellen for the technical assistance in the development of the online registration forms.

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Abstract

Context: Football and basketball are high risk sports for anterior cruciate ligament (ACL) injuries and lateral ankle sprains (LAS). These injuries have a high recurrence rate and long-term consequences in terms of early-onset osteoarthritis, as well as lack of return to preinjury level.

Objective: To (1) prospectively record the socio-economic costs associated with non-contact ACL injuries LAS in amateur football and basketball, and (2) to determine the association between costs and the degree of implementing preventive neuromuscular training (NMT).

Design: Prospective cohort study

Setting: Amateur football and basketball teams were followed-up during one season.

Participants: Cohort of 3221 amateur football and basketball players.

Main outcome measures: All direct and indirect costs of sustained non-contact ACL injuries and LAS were registered until return to play and was described on a player-level. The degree of implementing NMT was documented twice per season. The degree of implementing NMT during pre-season and mid-season was documented.

Results: The incidence proportion of ACL injuries and LAS was estimated at 0.01 and 0.03 injuries per player season, respectively. Thirty percent of the ACL injuries and 65% of the LAS represented a recurrent injury. The mean total cost per ACL injury and LAS was €6340.7 and €731.6, respectively. Over 90% of the injured players did not implement preventive NMT or implemented it inadequately.

Conclusions: The high costs of ACL injuries and LAS and the observation that preventive NMT is scarcely implemented in amateur football and basketball emphasizes an urgent need for policy makers to focus on injury prevention.

Keywords: ACL; LAS; health care cost; reinjuries; prevention; sport

Key points:

- ACL injuries and lateral ankle sprains in Belgian amateur football and basketball cause a substantial socioeconomic burden and a very large proportion of these injuries are recurrent.
- Most injured players did not implement preventive neuromuscular training during the preseason and in-season or did in an inadequate way.

Introduction

Football and basketball are popular sports with a high risk for anterior cruciate ligament (ACL) injuries and lateral ankle sprains (LAS), two common non-contact injuries. Both injuries have a high recurrence rate. The pooled incidence proportion of a second ACL injury has been estimated to be up to 14%,[1] and for LAS, it ranges from 12 to 47%.[2] Furthermore, ACL injuries and LAS have negative long-term consequences. Athletes who sustained an ACL injury have a four to six times higher risk for developing knee osteoarthritis compared to the general population[3] and up to 25% of the athletes with a LAS develop chronic ankle instability.[4] Neuromuscular training programmes at least containing stabilisation (i.e. jump-landing) and strengthening/plyometric exercises using feedback on proper technique are effective at reducing the risk for an ACL injury and LAS, as long as these exercises are performed at least twice per week and that the NMT program is performed during the preseason and in -season, whether supervised or unsupervised.[5-7] This is particularly important for amateur players, as they are at higher risk for sports injuries per 1000 playing hours compared to professional players,[8-10] which could result in a substantial socio-economic burden.

The economic burden of ACL injuries and LAS is known to be high. In 2008, the medical cost for an ACL injury in Belgium has been estimated at €1,358 and for a LAS at €197 .[11] However, these costs are based upon retrospective data[11] and may be underestimated. Therefore, the purpose of this study is to prospectively record the socioeconomic costs associated with non-contact ACL and LAS injuries in amateur football and basketball. A secondary objective of this study is to document the degree of implementing NMT in players who sustained an ACL injury or LAS.

Methods

In this prospective cohort study, amateur football (n= 164) and basketball teams (n= 164), were randomly selected and contacted for participation during the seasons 2014-2015 until 2017-2018. After providing written informed consent, all participating players of eligible male and female teams, competing at different levels of inter-regional competition in Flanders (Belgium) were prospectively followed-up for one season (from August till May). Amateur players were defined as non-professional players who do not receive an income from playing sports but are participating to regular competition. Information on NMT for injury prevention, as well as football/basketball exposure, injuries, healthcare, and medication use in case of injury, were prospectively collected over the course of one season. This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Medical Ethical Committee of [BLINDED].

Outcomes

Injury

Non-contact ACL injuries and LAS sustained during one season were registered. Coaches and players were instructed to inform the researchers if a player sustained an ACL injury or a LAS. A LAS was operationally defined as an injury of the lateral ligaments of the ankle joint. In addition to the self-reporting, all coaches were contacted by email every month to verify whether one of their players had sustained an injury, as well as to report sports exposure (i.e., football or basketball) of their team's players, as described by Rommers et al. (2022).[12] Exposure was reported in hours for each week. Coaches who did not respond to the email within two weeks were contacted by phone. In the case a player sustained an ACL injury or LAS, researchers first verified the nature and circumstances of the sustained injury in a standardized phone interview with the player. Only non-contact ACL injuries or LAS were included in this study defined as injuries occurred during landing or changing direction and were not the result of direct contact at the lower limb (e.g., push or pull).[13] We only collected information on medical attention injuries leading to associated costs. A medical attention injury was defined as injuries for which a medical doctor was consulted. It must be noted that a medical

consultation is mandatory in Belgium for the athlete to get insurance coverage for injury-related costs. Each injured player received an electronic injury registration form (see supplement) containing detailed questions about the nature of the injury, date of injury, injury circumstances (e.g. injury sustained during game of practice while running, landing, cutting or by contact (push, pull or tackle)), as well as localization of symptoms.

Healthcare use and costs

On the same electronic registration form, injured players were instructed to continuously collect all medical/healthcare visits, investigations and treatments related to the ACL injury or LAS until they were fully recovered and returned to competition (i.e. participation in an official game).[14] The research team contacted injured players by phone monthly to double-check their medical information. A similar method for collecting health care usage using an electronic diary has been used in a previous study.[15] Direct costs and indirect costs of the sustained non-contact ACL injuries and LAS were registered. Direct costs are costs that are related to the diagnosing and treatment of a health problem (i.e., medical imaging, visits to a general practitioner, sports physician or medical specialist, surgery, hospital stay, physical therapy sessions, medical devices, cast, brace, medication, exercise equipment, etc). Indirect costs are costs that are related to loss of productivity due to absenteeism from paid work. The calculation of the direct costs was estimated based on the National Institute for Health and Disability Insurance (NIHDI).[16] The cost of medication was estimated based on the Belgian Center of Farmaceutical Information (BCFi).[17] Costs related to hospital stay were based upon the standard costs published in the Database of "Federaal Kennis Centrum voor Gezondheid".[18] All prices related to direct costs were standardized to the year 2018 (i.e., costs indications of 2018 were used). Indirect costs are derived from Securex White Paper Absenteeism using the Human Capital Approach, which estimates the indirect costs based on the total duration of absenteeism from paid work (i.e., flat rate per absent day).[19]

Other variables

Before the preparation period, contact information and information about the player's age, sex,

working status, sport history, and previous injuries was collected. Shortly after the preparation period and also during mid-season, players completed an online survey (see supplement). This survey contains football/basketball exposure (training frequency) and specific questions regarding the use of NMT for injury prevention. Players were asked whether they performed specific preventive exercises during training and if so, they were asked about the content of these exercises (type of exercises illustrated by photos or videos, frequency of exercises, duration of exercises, feedback, etc.). The test-retest reliability of the questionnaire has already been demonstrated (Cohen's Kappa ranging from 0.55 to 1).[12] Based on the answers, players were then categorized into the "adequate prevention" group, "inadequate prevention" group or "no prevention" group. The "adequate prevention" group consisted of players performing both stability/balance exercises and plyometric exercises at least twice a week in or out of training", the "inadequate prevention" group consisted of players performing these preventive exercises less than twice a week or the implemented program did not include both stability/balance and plyometric exercises. The "no prevention" group contained players performing no NMT at all. This categorization is supported by results of systematic reviews and meta-analyses demonstrating that the implementation of preventive programs including stability/balance exercises and plyometric exercises significantly reduces the risk for an ACL injury or LAS. [5-7,20,21]

Statistical analysis

Patient's demographic characteristics were described by mean with standard deviation (SD), or median and interquartile range (IQR) for continuous variable, depending on their distribution, or count and percentage for categorical variables. The incidence of non-contact ACL injuries and LAS was calculated per player season with corresponding Wilson 95% confidence intervals (CI). Percentages, mean and standard deviation of the used investigations and treatments per category were presented. Further on, the mean and standard deviation of the direct and indirect costs per injury was calculated. We compared the costs between the index and recurrent injuries and between prevention groups (no prevention versus inadequate and adequate prevention; index versus re-injury) using the Wilcoxon signed rank test or the Kruskal-Wallis test, as appropriate. With very close follow-up, we aimed to ensure high-quality data collection and avoid missing data. All analyses were performed in R (version

4.0.5).

Results

Of the 3221 players (football: 2013 players; basketball: 1208 players) included in this study and followed up for an entire season, 151 players sustained a non-contact ACL injury and/or LAS (see flowchart in **Figures 1** and **2**). The players' demographic characteristics are described in **Table 1**. Most injuries occurred during match play. The ACL injury incidence proportion was calculated at 0.01 injuries per player season (95% CI: 0.009, 0.017) (**Table 2**). Thirty per cent of ACL injuries represented a recurrent injury. Most ACL injuries were observed at the start of the season and shortly after winter break. The LAS incidence proportion was calculated at 0.03 injuries per player season (95% CI: 0.029, 0.041) and 65% per cent of LAS represented a recurrent injury. Comparable to ACL injuries, most LAS were observed during August, September, and October. The median time until return to competition for a LAS was 27 days [IQR: 21, 42], and 326 days [IQR: 259.2, 375.5] for an ACL injury. In the group of injured players, over 90% of the injured players did not use NMT or implemented it inadequately **(Table 1).**

Direct costs and indirect costs

A detailed overview of the costs is presented as median and range in **Table 3**, stratified by injury type. These costs showed a large between-player variation. The mean total cost per ACL injury was €6340.7 (SD 3068.7). The mean direct and indirect costs per ACL injury were €3883.1 (SD 1029.6) and €2533.4 (SD 2582.7), respectively. Most medical costs of ACL injuries can be explained by medical imaging (used by 92.5%), physical therapy (used by all), knee brace (used by 82.5%) and absenteeism from work (52.5% missed at least one day of work). Costs for second ACL re-injuries were not different from index ACL injuries (€6015 [IQR 3900, 8393] vs. €4886 [IQR 3900, 8394], p = 0.924).

The mean total cost per LAS was €731.6 (SD 989.8). The mean direct and indirect cost per LAS were €396.9 (SD 321.9) and €334.7 (SD 883.7), respectively. Most direct medical costs for LAS can be explained by medical imaging (53% had medical imaging), ankle brace (54% received a brace) and

absenteeism from work (15.3% missed at least one day of work). Costs for second LAS were not significantly different from index LAS (€426 [IQR 117, 858] vs. €376 [IQR 146, 818], p=0.593). No significant differences in costs between the prevention groups (no prevention vs. inadequate prevention vs. adequate prevention) were found (see **Figure 3** e and f, LAS p = 0.390, ACL p = 0.924). Neither for direct costs (see **Figure 3** a and b, LAS p=0.974, ACL p = 0.933) nor for indirect costs we found a significant difference (see **Figure 3** c and d, LAS p=0.059, ACL p = 0.896).

Discussion

An important finding of our study is that the total cost of an ACL injury and LAS estimated at €6340 and €731.59, respectively, are considerably higher when compared to earlier published Belgian cost data. Secondly, a high percentage of the sustained injuries is recurrent and even more important, most of the injured players don't (adequately) implement NMT.

Incidence proportion

In our study, most injuries occurred during the game and were sustained during the first part of the season (August-October) which is in accordance to previous studies.[13,22] Therefore, to obtain a possible effect in the early phase of the season in preventing ACL injuries, the NATA (National Athletic Trainer Association) recommends that sport teams should already start NMT in the preseason.[5]

The incidence proportion of ACL injuries in our study was 1.5% (female) and 1.1% (male) per player season, respectively. In other studies following up amateur athletes, the incidence proportion of ACL injuries in female athletes ranged from 0.4% to 1.4% and in male athletes from 0.6% to 3%.[23-25] The incidence proportion of ACL injuries may vary because of differences in studied populations or differences in type of injuries (contact and noncontact). In a recent meta-analysis, the incidence proportion of second ACL injuries in studies rated as studies with a low risk of bias may vary from 10% to 32%,[26] which is comparable to the recurrence rate observed in our study (30%).

Results of the systematic review indicate that basketball is a high-risk sport for LAS which is confirmed by our results.[27] Indeed, in or study, particular basketball players have a higher risk for sustaining a non-contact LAS when compared to football players. So maybe basketball teams need to implement preventive NMT even more than football teams.

With respect to LAS injuries, a systematic review revealed that in amateur athletes, the incidence proportion of these injuries ranges from 4% to 30% per player season.[28] The incidence proportion of LAS injuries in our study (3%) is comparable to previous studies reporting 4% and 5%,

respectively,[29,30] but considerable lower than the highest observed incidence proportion of 30%.[31] These authors also included other type of injuries such as medial ankle sprains, unspecified injuries, tibiofibular injuries or "other" which may have affected the observed difference in injury proportion. Also, in their study, it is unclear what percentage of lateral ankle sprains were classified as non-contact injuries as most reported ankle sprains represented contact injuries.

Socio-economic burden

From a socio-economic point of view, it is important to prevent injuries resulting in costs, in absence from sport competition and absenteeism from work. In our study, the mean direct cost for treating an ACL injury (€3383) or LAS injury (€397) was considerably higher compared to the costs presented in the study of Cumps et al, being €1358 (ACL; 2018 Belgian price: €1577,1) and 197€ (LAS; 2018 Belgian price: €228,8) respectively.[11] As well for ACL injuries as for LAS, the large difference is caused by a higher number of medical consultations, more physical therapy visits, more medical imaging, and a higher use of braces by the injured players.

The mean total cost for treating a LAS in our study (€731.6) largely exceeds cost data of LAS in the Netherlands, estimated at being 418€ (2018 Belgian price: €466,1) and 446€ (2018 Belgian price: €538,8), respectively.[15,32] Particularly the direct costs are responsible for this difference, explained by an increased use of medical imaging, physical therapy visits and the use of an ankle brace for treating a LAS injury.

Preventive neuromuscular training.

As already mentioned, a substantial part of the observed injuries in our study were recurrent. Particularly with respect to second LAS injuries, the Dutch guideline of Vuurberg et al. (2018)[33] and a recent meta-analysis of Wagemans et al. (2022)[34] indicates that exercise-based rehabilitation; merely being balance training, can significantly reduce the reinjury risk. Moreover, injury prevention programs are cost-effective.[35] However, only 7% of the injured players implemented adequate NMT during preseason or in-season (i.e. jump-landing exercises and strengthening exercises performed at least twice a

week), which is in line with the general population in the cohort.[12] This implementation gap is remarkable as, in our study, 30 % of the ACL injuries and 65% of the LAS represent recurrent injuries. Results of an earlier study (Rommers et al; 2022) indicated that the most important barriers of players (N= 1253) and coaches (N= 140) for implementing NMT in football were "a lack of knowledge which exercises to perform" (players and coaches), " the belief that stretching is sufficiently enough to prevent injuries" (players and coaches), "having no time to implement NMT during training" (coaches) and " I don't need exercises" (players).[12] Therefore, the awareness and knowledge of the benefits and content of NMT, especially for the prevention of recurrent injuries, needs to be increased in both players and coaches. If we extrapolate the calculated costs in our study to all competitive amateur football and basketball players in Belgium, with the injury incidence of our study, the annual total cost of ACL injuries and LAS would be approximately € 7.5 million. Costs may probably be underestimated as our study mainly consists of students resulting in much lower indirect costs. From both a medical and a socio-economic point of view, the responsible authorities should therefore undertake more action and focus their future policies on preventing these injuries.

Strengths and limitations

Our study is the first study prospectively investigating the socio-economic cost of non-contact ACL injuries and LAS in Belgian amateur athletes, including a large and representative sample. We also investigated the association between the costs of injuries and the degree of implementing NMT, thereby increasing the clinical and societal significance of the results of our study. However, it is important to acknowledge the limitations of our study. Despite our rigorous follow-up of athletes, it is possible that certain injuries and medical interventions may have been overlooked, or that medical use has been underreported (potential missing data), leading to an underestimation of the estimated socio-economic costs. Additionally, we did not differentiate between ipsilateral or contralateral ACL re-injuries, and although we employed clear criteria to classify the registered injuries as non-contact, we could not independently verify the exact nature of these injuries. Furthermore, we did not factor in indirect costs incurred by injured students or travel expenses related to medical appointments as part of the nonmedical costs, signaling a potential underestimation of the overall expenses.

Conclusions

In Belgian amateur football and basketball, the mean total cost per ACL injury and LAS are estimated at €6340 and €731, respectively, which are substantially higher than previously published Belgian data. Importantly, 30 % of the ACL injuries and 65% of the LAS were recurrent. More than 90% of the injured players don't implement NMT at all or implement it in inadequate way. Therefore, there is an urgent need for policy makers to focus on injury prevention in sports like amateur football and basketball.

Acknowledgements

We sincerely want to thank Ruben Van Tilburg, Manu Stes, Leen Vandereycken, Justine Loncke, Evi Roelandt, Ann Van Denneucker, Sien Devliegher, Lore Meganck, Stéphanie Michel, Laurence Van Goethem, Kim Pissé and Lize Paridaens for their substantial contribution to the research .

We also want to thank Mr. John Kellen for the technical assistance in the development of the online registration forms.

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Table 1. Demographic Characteristics of Injured Players

	Overall	ACL	LAS
n	151	40	111
Age (years)	24.1 (5.2)	24.7 (5.9)	23.7 (4.9)
Female sex	76 (50.3)	21 (52.5)	55 (49.5)
Football	62 (41.1)	20 (50.0)	42 (37.8)
Recurrent injury	84 (55.6)	12 (30.0)	72 (64.9)
Use of tape or brace	58 (38.9)	16 (42.1)	42 (37.8)
Match injury	107 (70.9)	32 (80.0)	75 (67.6)
Injury leading to related absenteeism	38 (25.5)	21 (55.3)	17 (15.3)
Injury reported to sports federation	95 (63.8)	38 (100.0)	57 (51.4)
NMT			
No	114 (75.5)	27 (67.5)	87 (78.4)
Inadequate	26 (17.2)	11 (27.5)	15 (13.5)
Adequate	11 (7.3)	2 (5.0)	9 (8.1)

n, number; age is presented as mean (standard deviation), categorical variables as frequency (percentage); ACL, anterior cruciate ligament, LAS, lateral ankle sprain, NMT, neuromuscular training.

Figure. 1 Flow-chart of Anterior Cruciate Ligament (ACL) Injuries.

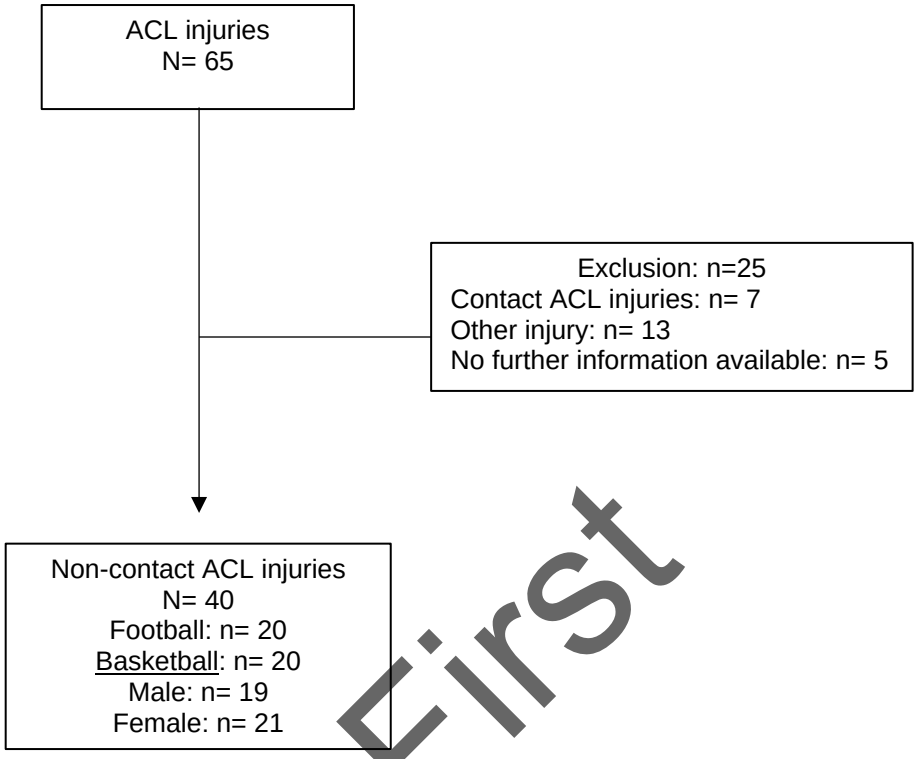


Figure. 2 Flow-chart of Noncontact Lateral Ankle Sprains (LAS).

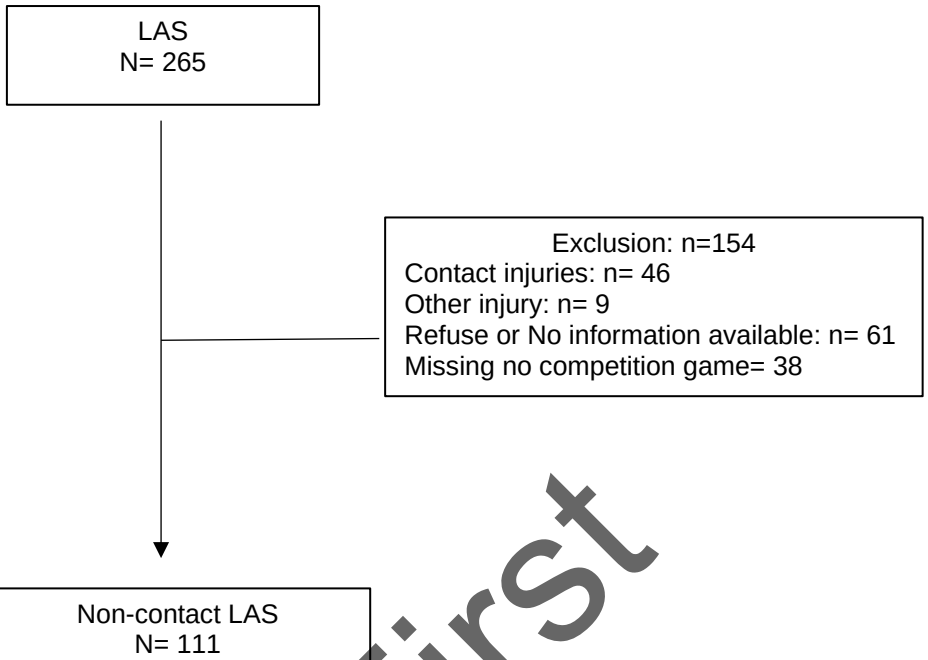
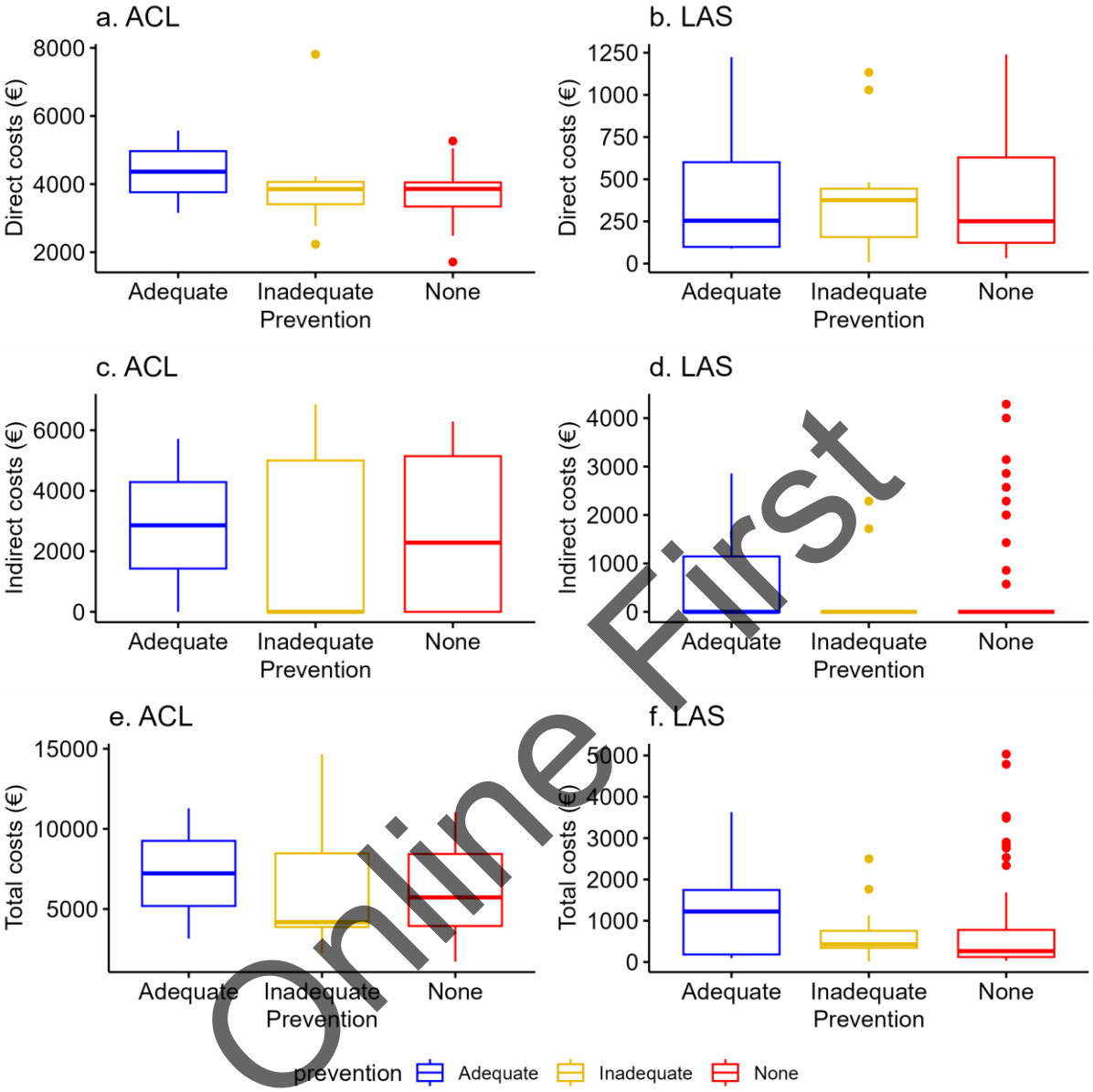


Table 2. Incidence of ACL Injuries and LAS with 95% Wilson Confidence Interval.

	Football		**Basketball**	
	Male	Female	Male	Female
Athletes (n)	1205	808	600	608
ACL injuries (n)	11	9	8	12
Incidence proportion	0.009 (0.005, 0.016)	0.011 (0.006, 0.021)	0.013 (0.007, 0.026)	0.020 (0.011, 0.034)
LAS (n)	18	24	38	31
Incidence proportion	0.015 (0.009, 0.023)	0.030 (0.020, 0.044)	0.063 (0.046, 0.086)	0.051 (0.036, 0.071)

n, number; incidence (95% Wilson CI); ACL, anterior cruciate ligament, LAS, lateral ankle sprain

Figure 3. Direct (a, b), indirect (c, d) and total costs (e, f) by prevention group, stratified by injury (ACL: a, c, e, LAS: b, d, f).



437

Table 3. Overview of the costs per injury.

	ACL (n = 40)			LAS (n = 111)		
	n (%)	**Use* (min, max)**	**Cost* (sd)**	**n (%)**	**Use* (min, max)**	**Cost (sd)**
Consultations						
General practitioner	28 (73.7)	1.5 (1, 5)	36 (29)	62 (55.9)	1.3 (1, 4)	31 (15)
Sports physician	9 (23.7)	1.7 (1, 3)	40 (17)	15 (13.5)	1.1 (1, 2)	27 (8)
Orthopedic surgeon	37 (97.4)	3.9 (1, 10)	94 (59)	14 (12.6)	1.8 (1, 4)	43 (19)
Emergency room	20 (52.6)	1.0 (1, 1)	41 (0)	41 (0)	1.0 (1, 1)	41 (0)
Medical imaging						
X-ray	19 (50.0)	1.6 (1, 4)	32 (22)	49 (44.1)	1.1 (1, 2)	15 (3)
CT scan	4 (10.5)	1.2 (1, 1)	51 (0)	2 (1.8)	1.0 (1, 1)	51 (0)
MRI scan	35 (92.1)	1.2 (1, 3)	61 (27)	8 (7.2)	1.0 (1, 1)	52 (0)
Ultrasound	2 (5.3)	1.0 (1, 1)	28 (0)	19 (17.1)	1.1 (1, 2)	30 (6)
Arthroscopy	2 (5.3)	1.0 (1, 1)	59 (0)	1 (0.9)	1.0 (1, 1)	59 (0)
Medical imaging reading	37 (97.4)	2.1 (1, 6)	53 (39)	59 (53.2)	1.4 (1, 4)	37 (16)
Medical interventions						
Cast	2 (5.3)	1.0 (1, 1)	68 (0)	9 (8.1)	1.0 (1, 1)	59 (0)
Use of plaster room	1 (2.6)	1.0 (1, 1)	30 (0)	9 (8.1)	1.0 (1, 1)	30 (0)
ACL reconstructive surgery	37 (97.4)	1.1 (1, 3)	450 (160)			
Menisectomy	2 (5.4)	1.0 (1, 1)	260 (0)			
Meniscal suture	7 (18.9)	1.0 (1, 1)	279 (0)			
Surgery scar tissue	1 (2.7)	1.0 (1, 1)	70			
Physical therapy visits	40 (100.0)	28.5 (13, 42)	607 (157)	66 (59.5)	9.2 (1, 19)	207 (110)
Drugs						
Analgetics	35 (92.1)	1.1 (1, 2)	3 (1)	21 (18.9)	1.0 (1, 1)	3 (0)
Anti-thrombotics	32 (88.9)	2.1 (1, 4)	62 (24)			
NSAIDs	29 (78.4)	1.2 (1, 3)	7 (3)	23 (20.7)	1.0 (1, 1)	6 (0)
Anti-inflammatory				16 (14.4)	1.0 (1, 1)	9 (0)

	ACL (n = 40)			LAS (n = 111)		
	n (%)	**Use* (min-max)**	**Cost* (sd)**	**n(%)**	**Use (min-max)**	**Cost (sd)**
Therapeutic material						
Brace	31 (81.6)	1.0 (1, 2)	794 (138)	60 (54.1)	1.0 (1, 2)	98 (17)
Tape				32 (28.8)	2.1 (1, 8)	17 (16)
Crutches	34 (89.5)	1.1 (1, 2)	13 (3)	23 (20.7)	1.0 (1, 1)	12 (0)
Airex	2 (5.4)	1.0 (1, 1)	60 (0)	3 (2.7)	1.0 (1, 1)	60 (0)
Elastic exercise band	4 (10.8)	1.3 (1, 2)	6 (2)			
Individual costs	11 (30.6)		130 (135)	11 (9.9)		12 (9)
Hospitalisation days	37 (97.4)	2.0 (1, 4)	808 (286)			
Total direct cost			3883 (1030)			397 (322)
Indirect costs						
Absenteism from paid work	21 (56.8)	15.6 (1, 24)	4464 (1721)	17 (15.3)	7.7 (2, 15)	2185 (1035)
Total indirect cost			2533 (2583)			335 (884)
Total cost			6341 (3069)			732 (990)

n= number of patients; use =number of usage; *=presented as mean