Factors Predicting Lower Leg Chronic Exertional Compartment Syndrome in a Large Population

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ABSTRACT

Knowledge about lower leg chronic exertional compartment syndrome (CECS) is largely obtained from highly selected populations. Patient characteristics may therefore not be appropriate for the general population. Our purpose was to describe a heterogeneous population of individuals suspected of lower leg CECS and to identify predictors of CECS. Charts of individuals who were analyzed for exercise-induced lower leg pain in a referral center between 2001 and 2013 were retrospectively studied. Patients were included if history and physical examination were suggestive of CECS and if they had undergone a dynamic intracompartmental pressure measurement. Six hundred ninety-eight of 1411 individuals were diagnosed with CECS in one or more of three lower leg muscle compartments (anterior tibial, deep flexor, lateral). Prevalence of CECS peaked around the age of 20–25 years and decreased thereafter, although a plateau around 50 years was found. Age, gender, bilateral symptoms, previous lower leg pathology, sports (running and skating) and tender muscle compartments were identified as independent predictors of lower leg CECS. The proposed predictive model has moderate discriminative ability (AUC 0.66) and good calibration over the complete range of predicted probabilities. The predictive model, displayed as a nomogram, may aid in selecting individuals requiring an invasive dynamic intracompartmental muscle pressure measurement.

Introduction

Chronic exertional compartment syndrome (CECS) may cause exercise-induced extremity pain in young individuals [20, 26, 29]. CECS is most commonly found in the anterior (ant-CECS), deep flexor (dp-flex-CECS), or lateral (lat-CECS) compartment of the lower leg. [3, 5, 33]. The etiology is a subject of ongoing discussion, but a pathologically elevated muscle compartment pressure is a key factor in the pathogenesis [1, 27]. The diagnosis is based on a suggestive clinical history and is supported by elevated intracompartmental pressure. The latter is mostly determined with a dynamic (rather than static) intracompartmental pressure (ICP) measurement [19].

The stereotypical lower leg CECS patient is a young individual who reports a progressively painful and tense muscle compartment during and after exercise [3, 9, 26]. Cramps, muscle weakness and altered skin sensation are also experienced [14]. Symptoms usually subside within half an hour of rest [34]. The current knowledge on CECS is largely based on small or highly selected cohorts such as athletes or military service members and may therefore be biased [6, 15].

* Both authors contributed equally

The department of Sports Medicine of Máxima Medical Center serves as a referral center for a variety of exercise-induced pain syndromes, exposing it to a large number of individuals who may have CECS [25, 30]. This population is highly diverse with patients of all ages and levels of sports. The goal of the present study was to describe this heterogeneous population of individuals suspected of CECS who were referred for a dynamic ICP measurement. Furthermore, we aimed to identify predictors for lower leg CECS.

Methods

Patient selection

All patients evaluated for lower leg CECS in our department of sports medicine between January 2001 and December 2013 were eligible for this retrospective cohort study. Patients were previously evaluated by a range of clinicians, both from within and from outside of our hospital. As a diagnosis was unclear by then, they were referred to our center for additional analysis. Patients were included for the present study if history and physical examination were suggestive of CECS and if they had undergone a dynamic ICP. A history was considered 'suggestive' if one or more lower leg compartments were reportedly painful or felt tense during training or thereafter. Patients who did not receive an ICP measurement were excluded, as were patients with recurrent CECS or with a CECS of the lower arms or upper legs. The local medical ethical committee judged that the rules laid down in the Medical Research Involving Human Subjects Act (WMO) did not apply to the study protocol. All procedures performed in this study are in accordance with the ethical standards of our institutional research committee, the ethical standards in sports and exercise science research and with the 1964 Declaration of Helsinki and its later amendments [11].

Consultation and ICP measurements

At presentation, one of two highly experienced sport physicians reviewed the patient's history. Comorbidities such as intermittent claudication, earlier lower leg surgery, venous insufficiency or neurological deficits were tabulated. Significant previous traumatic events including fractures, extensive soft tissue damage, tendon rupture or major vessel damage were also documented. A physical examination was conducted on all individuals. Signs of arterial or venous insufficiency were identified and distal arterial pulses were palpated. Muscle compartments were tested for tenderness and, when indicated, a neurological examination or pedal pulse test was performed. If history and physical examination were suggestive of CECS, ICP measurements of the anterior tibial muscle compartment, the deep posterior compartment, the lateral compartment, or a combination thereof were performed. The choice and number of compartments that were measured were not standardized but dictated by location of symptoms and findings during physical examination. If a patient reported bilateral pain, an ICP measurement was performed in just one leg. Patients with bilateral symptoms and elevated muscle compartment pressure in one leg were considered as having a bilateral CECS. By doing so, the number of invasive ICP measurements was limited, thus minimizing the risk of potential complications such as pain, bleeding, and nerve damage. Details of the slit-catheter technique were described earlier [4, 32].

Patients were diagnosed with a CECS if they had a suggestive history and physical examination and at least one ICP value above the three suggested cut-off points (≥ 15 mm Hg at rest, ≥ 30 mm Hg 1 min after provocative exercise or ≥ 20 mm Hg 5 min later) [19]. After the diagnosis, most patients were sent back to their referring physician for treatment. However, some patients underwent surgical treatment in our hospital.

Data collection

Data were obtained from two electronic sources. Between January 2001 and March 2010, data were extracted from a custom-made Microsoft Access database. We supplemented this database with recordings from paper patient files. Between April 2010 and December 2013, electronic patient files were used. Both databases were combined into one comprehensive data file.

Statistics

Analyses were performed using SPSS Statistics version 22.0.0.0 (IBM Corp., Armonk, NY, USA) and R version 3.1.3 (R Foundation for Statistical Computing, Vienna, Austria). Data are expressed as mean ($\pm$ SD) when normally distributed, or as median (with range) when nonparametric. A $P \leq 0.05$ was considered significant. The relation between previous history and unilateral complaints was assessed using chi-square testing. Graphs illustrating the relation between age and risk on CECS were smoothed to improve visual clarity (GraphPad Prism 6). Associations of patient-related variables and the diagnosis CECS were determined using univariable logistic regression. Only variables that were present in $>50\%$ of the patients were included. Significant variables were included as covariates in a multivariable logistic regression model. Missing values were handled by means of multiple imputation [24].

The strength of the association of each variable with the diagnosis CECS is displayed by its multivariate odds ratio (OR), together with its 95 % confidence interval. Variables without a significant association with the outcome were excluded from the model in a backward approach. The discriminative ability of the final model was assessed with the area under the receiver operating characteristic curve (AUC). In a useless test, such as a coin flip, the AUC is 0.5; a model that discriminates perfectly has an AUC of 1 [10]. The validity of the model was tested with the Hosmer and Lemeshow test and agreement between predicted probabilities and observed frequencies was visualized with a calibration plot. We used bootstrapping to correct the final AUC for optimism. The final model is presented as a nomogram.

Results

General

We evaluated 1867 individuals suspected of having CECS between 2001 and 2013 in our facility. Based on an atypical clinical history and/or physical examination, CECS was considered highly unlikely in 153 patients. The remaining 1714 patients underwent an ICP measurement. After exclusion (previous CECS analysis, n = 201; symptoms in lower arms or upper legs, n = 102), 1411 unique patients suspected of lower leg CECS were included in the present study (► **Fig. 1**).

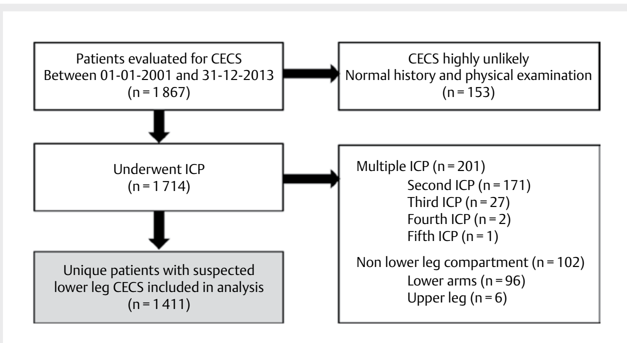
Single or multiple ICP measurements

We performed 1938 ICP measurements in these 1411 patients (► **Fig. 2**). Measurement of just one compartment occurred in 70 % (983/1411, ► **Fig. 2**, left panel), whereas the remaining 30 % of the individuals underwent ICP measurements of multiple compartments (► **Fig. 2**, right panel). Half of these patients (698/1411, 49 %) had elevated intracompartmental pressure in at least one compartment. The number of patients with elevated ICP values depended on type of CECS (ant-CECS, 53 % (433/814); dp-CECS, 38 % (344/904); lat-CECS, 35 % (78/220).

Patient characteristics

► **Table 1** depicts characteristics of individuals with CECS (n = 698) and without CECS (n = 713). Earlier treatment modalities were comparable between the two groups. CECS patients were 8 years younger (median, 25 yr, range 12–81) than non-CECS patients (33 yr, range 14–90). The prevalence of CECS decreased with age (► **Fig. 3**). Patients with unilateral symptoms more often had a history of previous lower leg trauma than patients with bilateral symptoms (14.4 % vs 3.9 %, p < 0.01). Moreover, vascular pathology was more often present in patients with unilateral complaints than in patients with bilateral complaints (7.2 % vs 3.6 %, p < 0.01).

► **Table 2** shows patient characteristics of the three subtypes of isolated lower leg CECS. Patients with dp-CECS were 4 and 2 years younger than patients with ant-CECS or lat-CECS, respectively (p < 0.01). Approximately three quarters of patients with ant-CECS (72 %) and dp-CECS (78 %) had bilateral symptoms compared to just a little over half of the lat-CECS patients (53 %, p = 0.04). Patients with dp-CECS played soccer more often, whereas patients with ant-CECS were more often engaged in speed skating. Patients not engaged in sports were occasionally found to have ant-CECS but seldom suffered from other types of lower leg CECS (► **Table 2**).

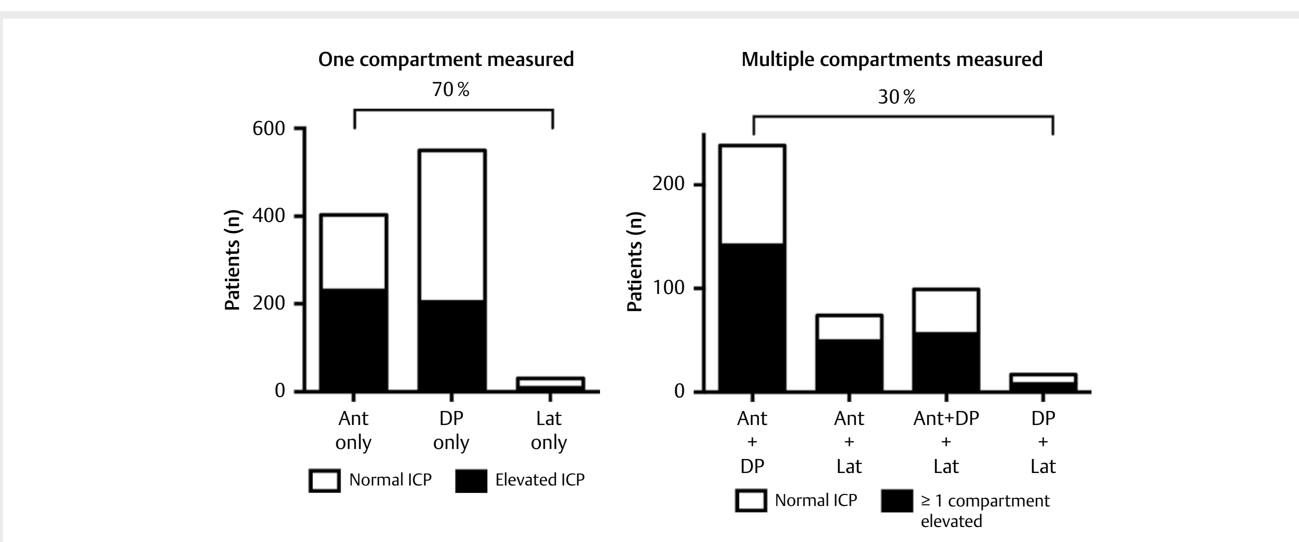


► **Fig. 1** Study flow chart of unique patients undergoing dynamic intracompartmental pressure measurement (ICP) for suspected lower leg chronic exertional compartment syndrome (CECS). Multiple ICP: ≥ 1 previous CECS evaluation including ICPs.

Predictors of CECS

Univariable analysis of the whole population of 1411 individuals demonstrated that gender, age, clinical history, bilateral symptoms, type of sports, competitive level of sports and painful palpation during physical examination were associated with the diagnosis CECS (► **Table 3**).

After multiple imputation (5 times), we used the predictive variables that were identified with univariable analysis in a multivariable regression model. Age, gender, history of lower leg pathology, bilateral symptoms, type of sports (running and skating) and a painful/tensed compartment during palpation were identified as independent predictors of CECS (► **Table 4**). The AUC of the final model was 0.68. After bootstrapping to correct for optimism to improve the predictive capabilities in a different population, the AUC of the final model was 0.66. The predicted probabilities were grouped into deciles and the mean probability for each decile was compared with the observed proportions of the diagnosis CECS

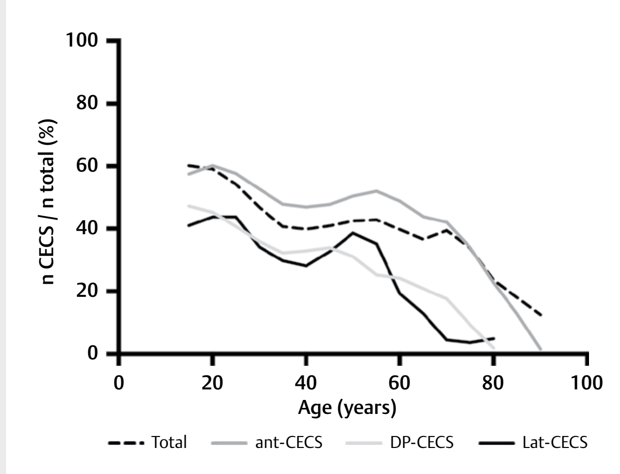


► **Fig. 2** 1938 lower leg muscle compartments of 1411 patients were studied, 70 % of the patients underwent an intracompartmental pressure measurement (ICP) of just one compartment (left), 30 % underwent ICP in > 1 compartment. Ant = anterior tibial compartment, DP = deep flexor compartment, Lat = lateral compartment.

▶ **Table 1** Characteristics of unique patients (n = 1411) who underwent ICP for suspected lower leg CECS.

	CECS	non-CECS	Total
n (%)	698 (50)	713 (50)	1411 (100)
Gender (n = 1411)			
Female n (%)	352 (50)	426 (60)	778 (55)
Age (n = 1411)			
Median (years)	25	33	28
Range (years)	12–81	14–90	12–90
Duration symptoms (n = 1131)			
Median (months)	18	18	18
Range (months)	1–360	1–300	1–360
Clinical history			
Data available, n (%)	595 (85)	610 (86)	1205 (85)
No relevant clinical history, n (%)	429 (72)	362 (59)	791 (66)
Relevant clinical history, n (%)	166 (28)	248 (41)	414 (34)
Surgery leg, n (%)	64 (11)	66 (11)	130 (11)
Trauma leg, n (%)	33 (6)	56 (9)	89 (7)
Peripheral artery disease, n (%)	8 (1)	10 (2)	18 (1)
Peripheral venous disease, n (%)	15 (3)	25 (4)	40 (3)
Other, n (%)	46 (8)	91 (15)	137 (11)
Previous treatment			
Data available, n (%)	455 (65)	495 (69)	950 (67)
Conservative treatment n (%)	433 (95)	472 (95)	905 (95)
Rest, n (%)	266 (61)	260 (56)	526 (58)
Cooling, n (%)	47 (11)	37(8)	84 (9)
Physiotherapy, n (%)	339 (78)	379 (81)	718 (79)
Inlays, n (%)	266 (60)	270 (58)	536 (59)

CECS = chronic exertional compartment syndrome, ICP = intracompartmental pressure measurement



▶ **Fig. 3** Ratio of n patients diagnosed with CECS divided by total n of evaluated patients (y-axis) in relation to age (x-axis). Ant-CECS = isolated anterior tibial compartment CECS, DP-CECS = isolated deep flexor compartment CECS, Lat-CECS = isolated lateral compartment CECS.

(▶ **Fig. 4**). Calibration was good for the complete range of predicted probabilities. The final model is displayed as a nomogram (▶ **Fig. 5**).

Discussion

Most previous studies on CECS were performed in highly selected populations including elite athletes or military personnel [2, 31]. The present study describes a heterogeneous patient population with only one selection criterion: all individuals were suspected of having lower leg CECS by their referring physician. Half of these individuals were indeed diagnosed with lower leg CECS as determined by a suspected clinical history and elevated intracompartmental muscle pressures. Age, gender, history of lower leg pathology, bilateral symptoms and a painful/tensed compartment were identified as predictors of CECS.

Previous studies reporting on the relation between gender and CECS are conflicting. Early literature reported a higher male prevalence [5, 19], whereas two recent large studies suggested a female predominance [3, 31]. It is likely that the earlier suggested male predominance is due to selection bias because mostly military personnel and athletes were studied. Moreover, previous cohorts described only patients who were diagnosed with a CECS whereas patients who tested negative for CECS were not studied. The present study included patients with and without CECS. Our analysis demonstrates an equal prevalence of females and males having CECS. However, the initial population of 1411 individuals contained more females (55 %). As a consequence, the portion of females with exercise-induced lower leg symptoms that was diagnosed with CECS was smaller than their male counterparts. Indeed, multivariable analysis confirmed that male gender was associated with a higher likelihood for the diagnosis of CECS.

The available literature suggests that CECS is associated with young age [5, 13, 15, 27, 31], although CECS was occasionally also identified in older individuals [7]. The present study confirms that young patients are more prone to develop CECS. Median age at time of diagnosis was 25 years. However, our oldest CECS patient was 81 years. The prevalence of CECS decreases with age. Interestingly, the prevalence stabilized in patients aged around 50 years. Moreover, this plateau is consistently observed in all three types of lower leg CECS. We hypothesize that these older individuals increased their sportive activities because leisure time became more available around this age. Univariable and multivariable analysis confirm that age is an influential factor for the occurrence of CECS.

Lower leg CECS is a predominantly bilateral syndrome [3, 7, 16, 17, 21, 28]. Findings of the present study confirm this bilaterality because 74 % of our total population had CECS in both legs. A novel finding is that bilaterality is CECS type-dependent. 53 % of the isolated lat-CECS patients had a bilateral syndrome compared to 72 % of the ant-CECS and 78 % of the dp-CECS patients. Furthermore, multivariable analysis demonstrated that patients with unilateral complaints were less likely to be diagnosed with CECS than patients with bilateral complaints. Higher preva-

▶ **Table 2** Characteristics of patients with isolated tibial anterior (Ant), deep flexor (DP), or lateral (Lat) chronic exertional compartment syndrome.

	Ant	DP	Lat	Chi square	p-value
n (%)	300 (43)	239 (34)	19 (3)		
Gender					
Female n (%)	155 (52)	115 (48)	10 (53)	0.72	0.70
Age					
Median (years)	27	23	25	8.9 #	<0.01 *
Range (years)	14–81	12–70	17–77		
Duration symptoms					
Median (months)	18	21	18	0.2 #	0.75
Range (months)	1–360	3–284	4–120		
Bilaterality					
Bilateral symptoms, n (%)	214 (72)	184 (78)	10 (53)	6.68	0.04 *
Type of sport n(%)	273	218	19		
No	26 (10)	5 (2)	1 (5)	10.81	<0.01 *
Soccer	35 (13)	69 (32)	4 (21)	25.75	<0.01 *
Running	54 (20)	45 (21)	3 (16)	0.28	0.87
Hiking	28 (10)	12 (6)	1 (5)	3.91	0.14
Hockey	22 (8)	12 (6)	1 (5)	1.32	0.52
Skating	24 (9)	2 (1)	1 (5)	14.99	<0.01 *
Handball	11 (4)	6 (3)	0 (0)	1.29	0.52
Military service	14 (5)	4 (2)	0 (0)	4.58	0.10
Level of sport n(%)	189	164	10		
No	26 (14)	5 (3)	1 (10)	13.43	<0.01 *
Social	66 (35)	44 (27)	3 (30)	2.69	0.26
Local	56 (30)	90 (55)	5 (50)	23.34	<0.01 *
National	17 (9)	13 (8)	1 (10)	0.16	0.93
International	5 (3)	2 (1)	0 (0)	1.15	0.56
Professional	18 (10)	10 (6)	0 (0)	2.31	0.32
Influence complaints	173	158	9		
Ceased sports	45 (26)	36 (23)	1 (11)	1.32	0.52
Different sport	2 (1)	4 (3)	0 (0)	1.07	0.59
Lower level	62 (36)	67 (42)	6 (67)	4.29	0.12
Same level with complaints	38 (22)	46 (29)	1 (11)	3.20	0.20

Only isolated CECS are shown (77 % of total, 538/698), combinations are excluded from this table. Only sports with >20 patients are depicted, for categorical variables chi-square test was used, for continuous variables a one-way ANOVA test was used (marked with #). Statistically significant differences are marked with *.

lence of previous trauma or vascular pathology in patients with unilateral complaints may explain this finding. Thus, bilateral lower leg symptoms are predictive of CECS, whereas unilateral symptoms may be associated with vascular or traumatic pathology.

Evidence indicates that CECS predominantly occurs in populations engaged in sports activities and military service [2, 3, 31]. Nevertheless, less active individuals or diabetics can also suffer from CECS [7, 8]. Results of the present study are in line with previous literature. Although not significant, we found a trend that increasing sport intensity appeared to associate with a higher likelihood of the diagnosis of CECS. However, we also found that patients who are not engaged in sports at all may also suffer from CECS, usually of the ant-CECS type. In our population, a wide variety of sports was practiced. Interestingly, only speed skating was associated with an increased likelihood of (ant-)CECS. We suspect that this type of CECS is related to posture during skating, and this finding may also be applicable for inline skating, rollerblading and other types of skating. In contrast to previous studies, running was associated with a reduced likelihood of CECS. Furthermore, soccer conferred a higher risk on dp-CECS.

The present study has several limitations. Firstly, due to its retrospective nature and the 13-year study period, we were not able to obtain complete datasets in all patients. Therefore, the number of variables that were analyzed was suboptimal and the power of the univariable analysis was reduced. Also, the potential of introducing bias is larger in retrospective studies. Secondly, the current study used ICP measurements (and the Pedowitz criteria) to confirm the diagnosis CECS. Recent literature debates the discriminative value and the role of proposed cut-off points [12, 22, 23]. However, the methods and cutoff points used in the current manuscript

▶ **Table 3** Univariable associations of potential predictors of CECS (n = 1411).

				95 % CI		
Predictors		**n**	**OR**	**LL**	**UP**	**p-value**
Gender	Female	778	ref	ref	ref	ref
	Male	633	1.46	1.18	1.80	< 0.01 *
Age (years)		1411	0.98	0.97	0.99	< 0.01 *
Duration symptoms (Months)		1131	1.00	1.00	1.00	0.46
Clinical history	Not relevant	789	ref	ref	ref	ref
	Lower leg pathology	416	0.57	0.45	0.72	< 0,01 *
Bilaterality	Bilateral	941	ref	ref	ref	ref
	Unilateral	449	0.54	0.45	0.72	< 0,01 *
Type of sport	None	98	ref	ref	ref	ref
	Soccer	218	2.16	1.33	3.51	< 0.01 *
	Running	303	0.91	0.69	1.44	0.58
	Hiking	105	1.00	0.57	1.74	0.99
	Hockey	79	1.69	0.93	3.08	0.08
	Fitness	52	1.49	2.93	0.76	0.25
	Cycling	48	0.64	0.31	1.32	0.22
	Skating	39	5.85	2.35	14.53	< 0,01 *
	Tennis	37	0.61	0.28	1.36	0.23
	Handball	36	1.79	0.83	3.88	0.14
	Military service	31	3.13	1.31	7.48	0.01 *
	Other	207	1.32	0.81	2.14	0.26
Level of sports	None	98	ref	ref	ref	ref
	Social	328	0.98	0.62	1.54	0.92
	Local	341	1.65	1.05	2.59	0.031 *
	National	56	2.30	1.17	4.53	0.016 *
	International	14	4.69	1.23	17.87	0.024 *
	Professional	56	1.98	1.01	3.86	0.046 *
Influence complaints	Ceased sports	231	ref	ref	ref	ref
	Different sport	14	0.83	0.28	2.45	0.73
	Lower level	325	1.13	0.81	1.59	0.46
	Same level with complaints	205	1.13	0.78	1.65	0.52
Painful anterior tibia	No	648	ref	ref	ref	ref
	Yes	332	0.89	0.68	1.15	0.37
Painful/tensed	No	483	ref	ref	ref	ref
Compartment	Yes	687	1.88	1.49	2.39	< 0,01 *

Odds ratio (OR) > 1.0 indicates a positive predictive value of the variable for the diagnosis chronic exertional compartment syndrome (CECS). Odds ratio < 1.0 indicates a negative predictive value for CECS. CI = confidence interval, LL = lower limit, UL = upper limit. Statistically significant predictors are marked with *

are widely accepted and the best currently available. Moreover, it must be appreciated that CECS is not solely based on ICP measurements but also requires a suggestive history and physical examination. Thirdly, results of surgery were not available. A favorable outcome after invasive therapy is likely the most valid parameter supporting the diagnosis. Most patients underwent surgery in their referring hospitals and surgical results were, therefore, not available. Lastly, we corrected for optimism with bootstrapping. Although this is an accepted method to test external validity, validation of the current predictive model in a different population is desirable. Also, with an AUC of 0.66, the predictive model is far from perfect (AUC 1.0). Clinicians should therefore use this model to support decision-making but should not blindly rely on its outcome. The predictive model should not be considered a substitute for dynamic ICP measurements. Strengths of the study are its volume and the heterogeneous population. Furthermore, it is one of few studies to include individuals without CECS, thereby enabling us to provide independent predictors for lower leg CECS.

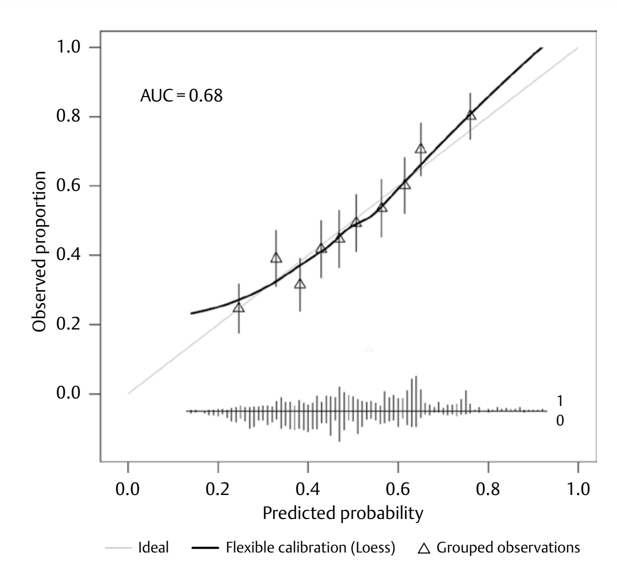
The differential diagnosis in lower leg pain is extensive. This often results in delay of diagnosis and treatment, with a consequential negative impact on the quality of life, especially in athletes and military personnel [18, 31]. Furthermore, the CECS diagnosis is

▶ **Table 4** Multivariable associations of predictors of CECS.

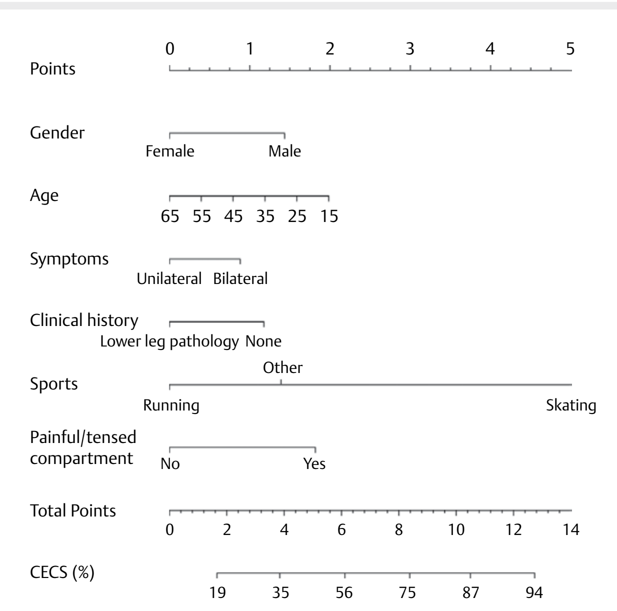
			95 % CI		
Predictors		**OR**	**LL**	**UL**	**p-value**
Full set					
Gender	Female	ref	ref	ref	ref
	Male	1.69	1.32	2.16	< 0.01 *
Age (years)		0.99	0.98	1.00	0.02 *
Bilaterality	Unilateral	ref	ref	ref	ref
	Bilateral	1.35	1.05	1.74	0.02 *
Clinical history	Not relevant	ref	ref	ref	ref
	Lower leg pathology	0.63	0.49	0.81	< 0.01 *
Type of sport	None	ref	ref	ref	ref
	Soccer	1.19	0.57	2.48	0.65
	Running	0.57	0.35	0.93	0.03 *
	Hockey	1.01	0.43	2.35	0.98
	Handball	1.15	0.45	2.95	0.76
	Fitness	1.30	0.65	2.60	0.46
	Hiking	0.84	0.44	1.59	0.59
	Cycling	0.54	0.25	1.15	0.11
	Skating	3.22	1.01	10.26	0.05 *
	Tennis	0.47	0.17	1.25	0.13
	Military service	1.55	0.36	6.58	0.55
	Other	0.84	0.43	1.65	0.61
Level of sports	Social	ref	ref	ref	ref
	Local	0.95	0.61	1.47	0.80
	National	1.16	0.57	2.36	0.68
	International	3.02	0.77	11.83	0.11
	Professional	0.90	0.30	2.70	0.85
Painful/tensed	No	ref	ref	ref	ref
Compartment	Yes	2.03	1.57	2.62	< 0.01 *
Final Selected model					
Gender	Female	ref	ref	ref	ref
	Male	1.73	1.37	2.17	< 0.01
Age (years)		0.98	0.98	0.99	< 0.01
Bilaterality	Unilateral	ref	ref	ref	ref
	Bilateral	1.39	1.09	1.78	0.01
Clinical history	Not relevant	ref	ref	ref	ref
	Lower leg pathology	0.64	0.50	0.83	0.01
Type of sport	Other	ref	ref	ref	ref
	Running	0.61	0.46	0.80	< 0.01
	Skating	4.03	1.70	9.59	< 0.01
Painful/tensed	No	ref	ref	ref	ref
Compartment	Yes	1.98	1.54	2.55	< 0.01

Multivariate analysis performed on variables that were predictive during univariable analysis (full set). OR = odds ratio, CI = confidence interval, LL = lower limit, UL = upper limit. Statistically significant predictors (*) were included in the final model

largely based on a suggestive history and physical examination, but additional invasive testing, such as an ICP measurement, is pivotal [1, 3]. The literature may suggest characteristics associated with CECS but predictors were hitherto not identified. A simple diagnostic bedside tool for CECS is currently lacking. The present study is the first to provide non-expert clinicians with a method to assist in predicting the likelihood of CECS in a patient with exercise-induced lower leg complaints. By inserting gender, age, bilaterality, previous lower leg pathology, sports (skating and running), and a tensed/painful compartment into the included nomogram, less experienced clinicians can approximate the risk for CECS in a patient with exercise-induced lower leg complaints. This bedside tool may



▶ **Fig. 4** Calibration plot of the final model for predicting CECS. The distribution of predicted risks is displayed at the bottom of the graph. Triangles indicate the observed proportion by deciles (y-axis) of predicted risks (x-axis). AUC = area under the receiving operating characteristic curve.



▶ **Fig. 5** Nomogram predicting CECS. To calculate an individual's probability of having CECS, first determine his or her risk factor values (e. g., male, 20 years old, speed skater, bilateral complaints, no previous medical history, painful compartment during palpation). Once determined, individual risk points associated with each risk factor are obtained by drawing a line straight up from each predictor value towards the "points axis" (1.4, 1.8, 5, 0.8, 1.2, and 1.8 respectively). Lastly, all points are totaled to obtain a sum risk score (12 points). The probability of having CECS is then calculated by drawing a line down from the "total points" axis to the probability "CECS" axis (approximately 91 %).

reduce a delay in diagnosis and may aid in selecting individuals that require invasive ICP measurements. In the near future, we plan to validate the current predictive model in a different population.

Conflict of Interest

The authors have no conflict of interest to declare.

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