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A retrospective analysis of injury risk in physical education teacher education students between 2000-2014

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To identify primary target groups for injury prevention in physical education teacher education (PETE) students, risk differences between subgroups by sex and curriculum years were compared in a retrospective cohort study (2000-2014). Injuries recorded by healthcare professionals at the medical facility of a Dutch PETE college were used to calculate overall, intra- and extracurricular injury prevalence per sex, curriculum years, and semesters and to compare these by logistic regression analyses. Of 1083 PETE students, 599 (55.3%) reported at least one injury during their curriculum (60.0% intracurricular). Female students had a higher risk for overall (OR 2.29, 95%CI 1.77-2.96) and for intracurricular injuries (OR 3.12, 95%CI 2.41-4.03), but not for extracurricular injuries. Compared to the freshman year, injury risk dropped during the consecutive years (OR 0.56, 95%CI 0.46-0.67; OR 0.33, 95%CI 0.27-0.41; OR 0.04, 95%CI 0.03-0.07, respectively). The first semesters of the freshman and second year showed higher injury prevalence compared to two out of three consecutive semesters ($P < .006$). Primary target groups for injury preventive measures are freshman and female PETE students. Factors contributing to the predominantly higher intracurricular injury risks, most notably in female students, need to be investigated in prospective cohort studies, regardless of sex.

KEYWORDS
athletic injuries, prevention, risk groups, sports, students

1 | INTRODUCTION

Worldwide many students participate in physical activity and sport-related studies. In the Netherlands, every year approximately 8000 students (1.37% of all vocational education students) start in such a study. Around 1000 of these new students, aged about 17 years or older, start yearly at one of six academies for physical education teacher education (PETE).[1] During the course of these studies, a high level of physical activity and exercise skills is demanded. For the first 3 years on average more than 250 hours per year are spent on practical sport classes. In addition, most of the students participate in one or more extracurricular sports as well. Several studies have shown that for PETE students the risk of sustaining a sports injury during the course of their studies is high[2-6] and introduction of preventive measures is warranted.

In order to develop and implement effective preventive measures, insight into the risk of injuries is a necessary step.[7] Identification of specific populations at risk can support researchers and policy makers in specifying target populations for prevention.[8] Compared to participation in regular sports alone, the sudden rise in sports load during the freshman year that remains high during the first 3 years and the participation of male and female students together in mixed sports classes are distinctive factors for PETE and other sports-related studies. The common belief that injury risk is highest during the freshman year has led to several studies investigating these injury risks in either first semester or freshman PETE students.[2,4-6] One study investigated the full curriculum.[3] However, to our knowledge, differences between curriculum years have not been compared previously. Results from injury risk comparisons between sexes in PETE students are equivocal.[2-4] To gain insight in the injury risk of PETE students during sports participation over their full curriculum, and in risk differences between sexes, curriculum years and semesters for intra- and extracurricular activities, large numbers of PETE students need to be studied.[9]

Therefore, our purpose was to retrospectively analyze in Dutch PETE students, the overall, intra- and extracurricular injury prevalence and to compare injury risks by sex, curriculum year, and semester over their full curriculum.

2 | METHODS

In this cohort study, injury data on PETE students from the Hague School of Sport Studies (HSSS) collected over 14 consecutive academic years (August 2000-June 2014) were retrospectively analyzed. Relevant data from injury/student records were used anonymously with permission from the institution and in accordance with European privacy legislation.[10]

The injury definition for this study was "any new musculoskeletal complaint related to sports participation of PETE students, for which medical advice was sought at the medical facility of the HSSS." This corresponds to a medical attention injury.[11] At this medical facility, during the full study period, voluntary free medical consultation on sustained injuries was provided twice a week by the same sports physical therapist and sports physician. The reported injuries were diagnosed and advice was given on treatment and on restrictions regarding participation in extracurricular sports or intracurricular sports classes or examinations. Students could only be excused from (active) participation in sports classes or examinations after timely consultation on injuries at the medical facility.

All students who had completed their full PETE curriculum during the study period were included in this study.[3] All new musculoskeletal complaints that were reported at the medical facility by any of these students were recorded and used for this study. Consecutive consultations for persistent complaints or exacerbations were not separately recorded. Multiple injuries to the same location were included, but not separately recorded as re-injuries.[12] Since both intracurricular (school related) and extracurricular activities (private sports activities) contributed to the burden of injuries in this population, injuries incurred in both activities were included in the analysis. Injuries that were sustained before the start of the curriculum were excluded. For all students, sex, age at enrollment (in years), and curriculum duration (in months) were recorded. Complaints were registered per student, curriculum year, and date of consultation. Per complaint, the injury location, the onset (sudden, gradual), the sports activity, and the setting (intra- or extracurricular) were reported. [2,3,12] Furthermore, the severity of injuries as expressed in advice on (partial) removal from sports participation (yes/no) and duration of complaints prior to consultation were reported. In case of incomplete injury reports, missing data on injury information were categorized as unknown for the specific category.

Demographic variables were calculated in frequencies and percentages for sex, and for age at enrollment (years) and curriculum duration (months) as means and standard deviations (SD).

An independent *t* test was used to analyze differences between sexes for mean age and total curriculum duration. Injury prevalences per curriculum (year) and per semester (each curriculum year consisted of four semesters) were calculated by dividing the number of injured students (one or more injuries) in each period by the total number of registered students. To describe time trends, centered 4-year moving averages (2 × 4MA) were calculated using the formula $2 \times 4MA(t) = ½ [(y_{t-2} + y_{t-1} + y_t + y_{t+1})/4] + ½ [(y_{t-1} + y_t + y_{t+1} + y_{t+2})/4]$, where t is the cohort year and y is the prevalence for that cohort. Injury characteristics (onset,

setting, advice on restrictions in participation in sports and duration of complaints prior to consultation) were calculated as frequencies and percentages. Between sex differences in injury onset (sudden or gradual onset), duration of reported complaints and advice on participation in sports were analyzed using χ^2 statistics. For all analyses, α was set at 0.05.

Logistic regression analyses (corrected for curriculum time) were used to compare odds ratios (OR) and 95% CI for overall (combined intra- and extracurricular) injuries, intracurricular injuries, and extracurricular injuries between grouping variables of interest: that is, sex and curriculum year. Prevalence per semester was compared per year using χ^2 statistics. The Holm-Bonferroni correction was used to correct for Type 1 errors in multiple testing.[13] To investigate possible selection bias in only including students who completed their full curriculum, in a sensitivity analysis the prevalence in (male and female) freshman students was compared between included and excluded students. We employed χ^2 statistics to compare (male and female) prevalence between groups and odds ratios (female vs male students) to compare injury odds between groups. IBM SPSS Statistics 24 and Excel 2016 were used for statistical analyses.

3 | RESULTS

3.1 | Demographics

Of 2146 newly enlisted PETE students, data were used for this study from 1083 students (50.5%; male n = 635, 44.5% female n = 448, 62.4%) who completed their full curriculum at the HSSS during the registration period. The dropout rate (ie, students who quitted their study before graduation) over this period was 30% (internal communication: data derived from the institutes' internal registries). The mean age at enrollment of included students was 19.2 years (SD 1.9, range 16.8-29.3). At enrollment, male students (19.7 years, SD 2.1) were significantly older than female students (18.6 years, SD 1.5) ($P < .05$). Mean curriculum duration (53.2 months, SD 15.8) was significantly longer for male students (55.7 months, SD 17.8), compared to female students (49.6 months, SD 11.8) ($P < .05$).

3.2 | Injury prevalence

Overall 599 PETE students (55.3%) had reported at least one injury during their study (male n = 296, 46.6%; female n = 303, 67.6%). Of the 599 injured students, 46.9% (n = 281) had sustained a second injury and 43.4% (n = 122) of those students had sustained three or more injuries during their study period. Time trends for injury prevalence showed a consistent yearly increase in 2 × 4MA from 49.1% for the cohort from 2002% to 62.2% for the cohort from 2009. The 2 × 4MA per sex showed similar, but fluctuating, trends (male 38.7%-54.9%, female 64.4%-71.5%). In total 1075 injuries were reported (male n = 482, 44.8%, female n = 593, 55.2%).

3.3 | Setting and sports types

Intracurricular injuries comprised 60.0% of all injuries (male 49.0%, female 69.0%). Gymnastics (23%), team ball sports (22%), and track and field (11%) contributed most to intracurricular injuries, in both sexes. Soccer (40%; male 57%, female 16%) and other team ball sports (28%; male 14%, female 47%) contributed most to extracurricular injuries.

3.4 | Injury onset, body location, and type

Overall 61.3% of all injuries (intracurricular 65.0% and extracurricular 72.0%) were classified as sudden onset and 34.2% as gradual onset injuries (intracurricular 32.9% and extracurricular 26.5%). Most prevalent injury locations were as follows: the knee (21%), the ankle (20%), the lower leg (10%), the shoulder (10%), and the back (9%). Most prevalent injury types were joint/ligament injuries (45%), muscle and tendon injuries (25%), and fractures/bone stress injuries (10%). More information on injury distributions (per sex) can be found in the supplementary file.

3.5 | Advised restriction in sports and injury duration

For 934 injuries, information on advised restriction in sports participation was registered. For 67.9% (n = 634) of these injuries (partial), removal from participation was advised (Table 1). Injury onset, duration of complaints prior to consultation and the percentage of injuries for which (partial) removal from participation was advised were not significantly different for female and male students.

3.6 | Risk comparisons between sexes

Logistic regression analyses (corrected for curriculum duration) showed significantly higher injury odds in female students, compared to male students for overall injuries (OR 2.29, 95%CI 1.77-2.96) and for intracurricular injuries only (OR 3.12, 95%CI 2.41-0.4.03). No significant differences were found between sexes for injuries sustained during extracurricular activities. Odds ratios between sexes for separate curriculum years showed comparable patterns (Figure 1).

TABLE 1 Injury prevalence per curriculum year and injury characteristics for male and female students for overall (combined intra- and extracurricular) injuries by setting, subsequent time loss (based on advice regarding sports participation) and duration of complaints prior to consultation

Injury prevalence	Total (n = 1083)		Female (n = 448)		Male (n = 635)	
(% injured persons within sex)	N	%	N	%	N	%
Overall	599	55.3%	303	67.6%	296	46.6%
Freshman	395	36.5%	206	46.0%	189	29.8%
2nd y	262	24.2%	147	32.8%	115	18.1%
3rd y	173	16.0%	86	19.2%	87	13.7%
4th y	31	2.9%	14	3.1%	17	2.7%
Injuries (% injuries within sex)	Total (n = 1075)		Female (n = 593)		Male (n = 482)	
Setting	N	%	N	%	N	%
Intracurricular	645	60.0%	409	69.0%	236	49.0%
Extracurricular	257	23.9%	106	17.9%	151	31.3%
Other/unknown	173	16.1%	78	13.1%	95	19.7%
Time loss						
No time loss	300	27.9%	158	26.6%	142	29.5%
Time loss	634	59.0%	349	58.9%	285	59.1%
Unknown	141	13.1%	86	14.5%	55	11.4%
Duration of complaints						
<1 wk	379	35.3%	219	36.9%	160	33.2%
1-4 wk	393	36.6%	211	35.6%	182	37.8%
>4 wk	211	19.6%	122	20.6%	89	18.5%
Unknown	92	8.6%	41	6.9%	51	10.0%

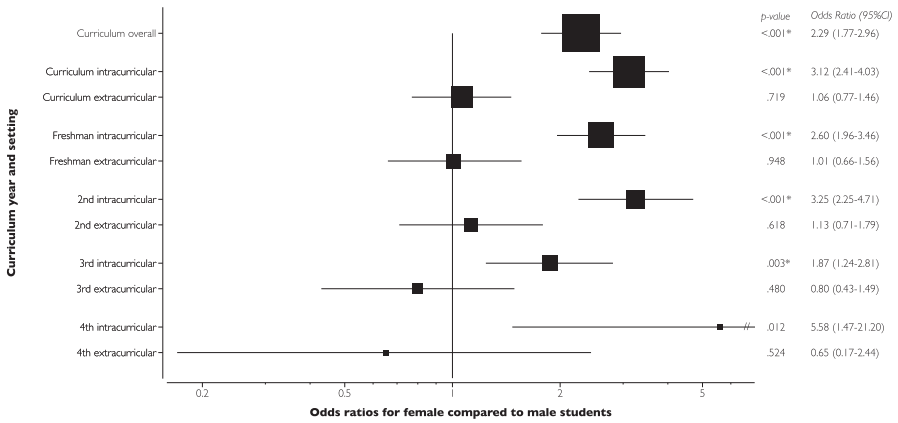

FIGURE 1 Odds ratios (the odds of sustaining an injury vs not sustaining an injury) and their 95% confidence intervals (95%CI) for female versus male PETE students. Separate models were used to calculate odds ratios over the full curriculum and per curriculum year as well as for intracurricular and extracurricular injuries. Odds ratios higher than 1 implicate higher injury odds for female students (*significant after Holm-Bonferroni correction). Sizes of the blocks relate to the total number of injured students per comparison (injured students were categorized per year/category)

3.7 | Risk comparisons between curriculum years

As can be seen in Figure 2, the freshman year had a significantly higher overall and intracurriricular injury odds, compared to all subsequent years. Extracurricular injury odds for the fresman year were significantly higher compared to the third and fourth year but not compared to the second year (Figure 2). All separate analyses per sex showed similar significant odds between curriculum years (Figure 2).

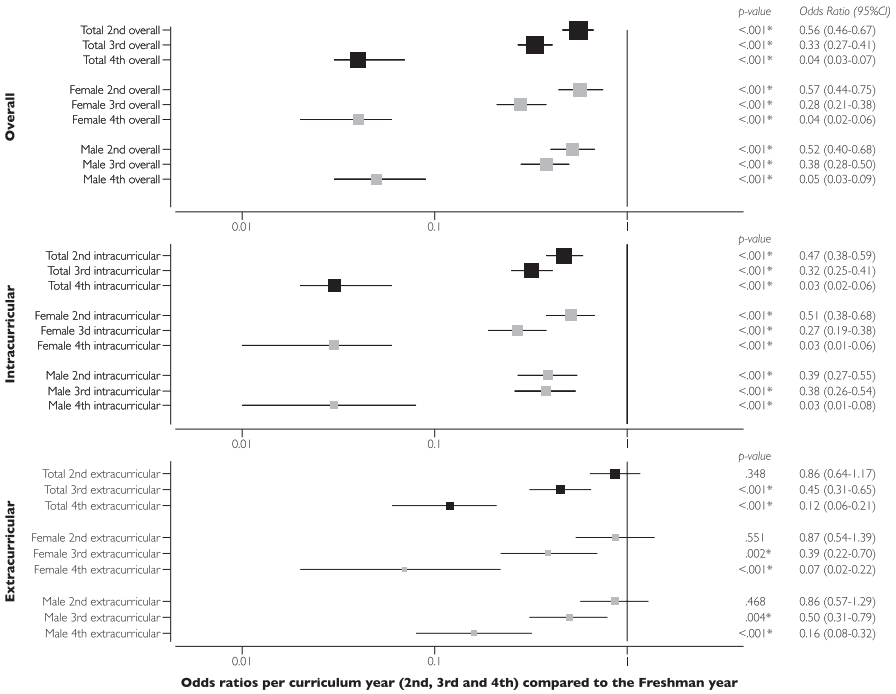

FIGURE 2 Odds ratios (the odds of sustaining an injury vs not sustaining an injury) and their 95% confidence intervals (95%CI) from logistic regression analyses comparing curriculum years (reference year: freshman year) per sex for overall, intracurricular and extracurricular injuries. Odds ratios lower than 1 implicate higher injury odds for freshman students (*significant after Holm-Bonferroni correction). Sizes of the blocks relate to the total number of injured students per comparison (injured students were categorized per year/category)

3.8 | Risk comparisons within curriculum years

Comparison of overall injury prevalence per semester (Figure 3) showed that semester prevalence decreased from 16% in the first semester of the freshman year to 3% in the last semester of the third year. The overall prevalence per semester in the fourth year did not exceed 1% and was not compared separately. Within curriculum years, significant differences between semesters were predominantly found during the first 2 years, with the first semesters showing the highest prevalences. Injury prevalences per semester for male and female students showed similar patterns, with female prevalences being consistently higher than male prevalences (Figure 3).

3.9 | Sensitivity analysis

Sensitivity analyses for the freshman year showed that, compared to students included in our study (36.5%), a significantly higher injury prevalence (40.8%) was found for excluded students (male students 29.8% vs. 36.9%, $P = .005$; female students 46.0% vs 52.4%, $P = .095$). The odds ratios for female vs male freshman students were not significantly higher for included (OR 2.01, 95%CI 1.56-2.58), compared to excluded (OR 1.89, 95%CI 1.43-2.49) students.

4 | DISCUSSION

Our study showed two important new outcomes. First, we found higher overall injury odds for female students compared to male students, mainly based on differences in intracurricular injury odds. Second, comparisons between curriciulum years showed higher odds for the freshman year, compared to all other years (overall and per sex). Prevalence per semester over the curriculum years showed similar patterns.

The higher overall injury odds for female compared to male students found in our study were contradictory to earlier studies on PETE students. Twellaar et al[3] found no difference in overall injury risk over the full curriculum between male and female students. Prevalence for female freshman students in our study (46.0%) was compatible to the 53.3% found by Goossens in 2010.[2] However, our 29.8% prevalence for male freshman students was much lower than their 57.8%. Our time trends fluctuated differently for sexes between cohorts indicating that results from single cohorts should be interpreted with caution. On the other hand, in our study injuries were reported by students who had sought medical advice at their own initiative only. This limitation of our retrospective analysis may have led to an underestimation of injury prevalence, compared to the study by Goossens et al,[2] who prospectively assessed all injuries (including those only causing pain or the inability to fully participate in the next planned sports class) in all students on a weekly basis. Medical advice was sought for 81.7% of all their registered injuries. Differences in injury registration and definitions make comparisons between the outcomes of different studies difficult, but cannot explain the observed differences in injury risks between sexes.[14,15]

Comparisons for intra- and extracurricular injury odds ratios, however, can partially explain the differences between our results and the results found by Goossens et al[2] In our study, the higher overall injury odds for female compared to male students were based mainly on higher intracurricular

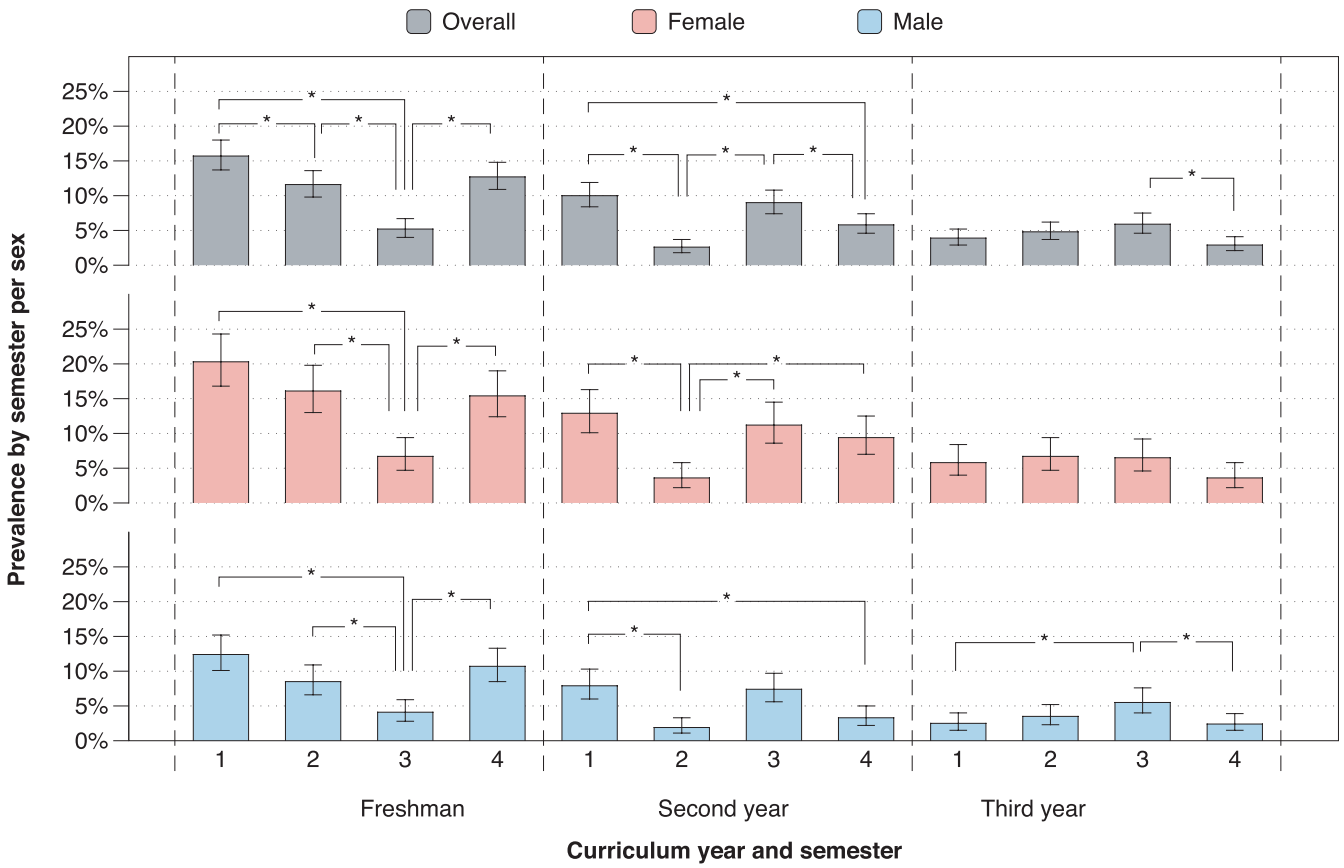

FIGURE 3 Injury prevalence and 95% confidence interval by semester (11 wk) for all students and per sex for the first three curriculum years (*significant difference between semesters within a curriculum year after Holm-Bonferroni correction)

odds, whereas the extracurricular odds were similar. Although non-significant, the intracurricular injury risk in the study by Goossens et al was also higher in female students, but the contrary was the case for extracurricular injury risk.[2] A possible explanation for a higher intracurricular risk for female students might be the participation in mixed sports classes in which female students have to interact and compete with relatively stronger, faster and more agile male students.[16,17] These interactions would be more evident in team ball sports, but female students would also suffer more from similar physical loads in mixed sports classes. In army recruits, comparable cumulative physical loads required female recruits to work at a higher percentage of their maximal capacity, compared to male recruits.[18] In these recruits, relative risks between sexes ranging from approximately 2.0-1.0 decreased to 1.1-1.0, when corrected for physical fitness parameters such as aerobic fitness, muscle strength/endurance, flexibility, and body composition.[19] To study whether risk patterns between sexes in PETE students show comparable trends, when screening for risk factors for intracurricular injury risk, male and female students should be analyzed together in future research.

The fact that extracurricular injury risk in our study was not significantly different between sexes is in line with results from this age category in other studies[2,20,21] and in the general sports population in the Netherlands.[22] Also, our time trends showed increases in prevalence compatible with injury trends in the general Dutch sports population over the same period.[22] Decreased motor fitness in Dutch youth could partially explain these trends.[23] Our results should be interpreted with caution as extracurricular exposure times and sports types might differ between sexes. Goossens et al found a 1.23 higher extracurricular exposure time per student for male compared to female students.[2] In our study, the much higher prevalence of soccer injuries for male students compared to the higher prevalence of injuries in other team sports for female students reflects the differences in participation rates between sexes in Dutch sports. Although our findings for extracurricular injury risk are not fully in line with the non-significant difference found by Goossens et al,[2] these results further support the theory that specifically the participation in mixed sports classes puts female PETE students at higher risk than male students. Therefore, preventive measures should be primarily targeted at factors contributing to that higher risk in intracurricular activities. These factors need to be identified, based on further analyses of intracurricular sports injury risks and associated injury locations.

Although a high injury risk (1.91-11.7 injuries/1000 h) for freshman PETE students has been found in previous

studies,[2,5,6] our study was the first to investigate and find higher injury odds for the freshman year, compared to the following years of the curriculum (Figure 1). Our lower odds for the 4th year could be explained by the fact that intracurricular exposure to sports classes is minimal, because it consists mainly of internships. However, compared to freshman students, our odds for the 2nd and 3rd year were also much lower (Figure 2), whereas in regular teacher students a significantly lower ratio was only found for 3rd year students (OR 0.78, 95%CI 0.66-0.91).[24] These results indicate that, also in comparison with regular students, freshman PETE students are at a higher risk for injuries, compared to students from later years and should be specifically targeted for preventive measures. Our results per semester show comparable patterns of decrease in prevalence, except for the higher prevalence in the fourth semester of the freshman year (Figure 3). Possibly the stress around examinations at the end of the freshman year, in combination with the decisive period in extracurricular sports competitions, has led to a higher prevalence in this period. Whether the high initial injury risk is related to the sudden increase in sports activity of more than 10 hours per week for freshman students[4] or to differences in exposure times between curriculum years, needs further investigation in risk comparisons based on incidence rates. Many previous studies in PETE students have investigated intrinsic risk factors for specific injuries per sex, but did not compare risk differences between sexes, settings, or curriculum years.[25-34] Results from two studies on the relationship between extrinsic risk factors and injury risk are equivocal.[3,4] Possibly the interaction between intrinsic risk factors and the ratio of pre-curricular sports activities, compared to current sports activities, can explain the higher intracurricular injury risk found for female PETE students.[35] Furthermore possible risk differences between sexes for intracurricular sports and injury types and locations need to be investigated.

Interpretation of our results should take several methodological issues into consideration. We used prevalence to compare the risk for groups of interest in this study. Prevalence is the number of cases in a certain population at a certain timepoint (point prevalence) or the number of cases in a certain population over a certain period of time (eg, year prevalence), but can by definition not account for exposure time. However, in our study male and female students participated in the same curriculum, hence having comparable exposure times making within year prevalence comparisons valid. However, differences in exposure times between curriculum years and/or extracurricular injuries could have influenced between year comparisons. Further investigations are needed to identify how exposure times, sports types, and other factors contributed to the found odds ratios between sexes and curriculum years. Odds ratios as calculated from the logistic regression analyses should be interpreted with caution, as they overestimate risk ratios when the prevalence is higher. The overall odds ratio of 2.29 for female (prevalence 67.6%) compared to male students (prevalence 46.6%) corresponds to a risk ratio of 1.45. The odds ratio of 1.93 for female (prevalence 46.0%) compared to male (prevalence 29.8%) freshman students corresponds to a risk ratio of 1.54. However, for the purpose of our study to identify primary target groups for injury prevention, the same conclusions can be drawn from either analysis. Similar to the methods used in earlier studies on PETE students, we excluded students who did not complete their full curriculum.[2-4,6] Sensitivity analysis showed even higher injury prevalences in dropouts. Including these dropouts did not affect our findings on higher injury odds for female students, but would have increased the observed differences between curriculum years. Finally, male and female students in our study showed comparable distributions for onset, time to registration and advised removal from sports participation. An exact measure of time to (full) participation in sports or the use of an injury severity measure would have made this comparison more valid.[12]

Extrapolation of our results to sport-related studies with mixed classes (male and female students) in other institutions and/or countries seems justifiable, but should take into consideration possible variations in student age, curriculum, and presented sports. Prospective multi-center studies are needed to address these issues and confirm our observed results for students in sport-related studies in other institutions and countries.

4.1 | Perspectives

In PETE studies, the primary target groups for injury preventive measures are freshman and female students. The much higher contribution of intracurricular injuries compared to extracurricular injuries, most notably in female students implies that primary focus is needed on factors contributing to these intracurricular injuries. How injury risks per sex for separate intracurricular sports and different curriculum years contribute to the risk differences found in this study, as well as the anatomical locations and nature of these injuries, needs further investigation.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could appear to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

Author elects to not share data.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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