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Contribution of sex, sports and activity types and curriculum load distribution to intracurricular injury risk in physical education teacher education: a cohort study

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ABSTRACT

Objectives To investigate the influence of sports/activity types and their distribution over the curriculum years on intracurricular injury risk differences between curriculum years and sexes in Physical Education Teacher Education (PETE) studies.

Methods In a cohort study over 14 years (2000–2014), injuries reported at the medical facility of a Dutch vocational institute by PETE students who completed their full curriculum were registered. Intracurricular injury rates (IR) per 1000 hours and 95% CIs were calculated per sport, sex and curriculum year and compared with injury rate ratios (RR) and 95% CI. Exposure times per sports category per curriculum year were compared with the χ^2 test.

Results Intracurricular IR was highest for gymnastics, team ball sports and track and field (0.76–1.23, 95% CI 0.65 to 1.45). IRs were higher for female compared with male students (RR 2.38, 95% CI 1.97 to 2.87). Comparisons for all individual sports and for all three curriculum years showed the same pattern. IR for the first year was higher than for the second (RR 1.79, 95% CI 1.45 to 2.21) and third year (RR 2.74, 95% CI 2.13 to 3.54) with similar patterns for all sports categories. Over the curriculum years, exposure time distributions per sport showed small differences ($p<0.001$, Cramer's V=0.07).

Conclusion Curriculum year, sex and sports types are risk factors to be independently targeted for preventive and rehabilitative measures in PETE studies. The nature and aetiology of injuries in mixed sports, and the adaption to increased loads in first-year and female PETE students, need further investigation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Injury risk is high during physical education teacher education (PETE). Injury odds are higher for first-year students compared with later year students and for female compared with male students. How intracurricular injury risks and exposure times per sport contribute to differences in injury risks between sexes and curriculum years is not known

WHAT THIS STUDY ADDS

⇒ Injury risks in gymnastics, team ball sports and track and field are much higher compared with all other sports. Injury risks for female students compared with males are higher for all sports. Students have higher intracurricular injury risks during the first year compared with later years for all sports. Exposure time per year per sports does not influence injury risks per sport.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ High-risk sports, curriculum year and sex are independent factors to be targeted in research and preventive practice and policies in PETE studies. Novice PETE students should be better prepared for high-risk sports and for the high curricular load. A more gradual increase of the curricular load during the first year could help students to better adapt to that load. For female students, reduction of the total load compared with their male counterparts, could help to decrease their higher injury risk.

INTRODUCTION

The injury risk is high among Physical Education teacher education (PETE) students at university.[1–5] In Dutch first-year PETE students, injury rates (IRs) of 11.7 injuries per 1000 hours have been reported.[4] Injury odds are significantly higher during the first year compared with the second and third years.[6] Furthermore, female PETE students have higher overall injury odds than male students, predominantly in intracurricular sports.[6] Whereas higher injury odds for first-year and female students identify populations at risk, it is not clear what sports activities contribute most to these higher risks. Both differences between sports in exposure time and incidence density can contribute to higher injury odds.

In Dutch PETE studies, gymnastics, track and field, team sports, rackets sports, swimming, skating, martial arts, dance and practical didactics are all part of the

curriculum. These sports classes take place during the first 3 years of the curriculum. The fourth year consists mainly of internships. Intracurricular sports in PETE studies differ from extracurricular and collegiate sports because sports classes are mixed (both sexes participate in the same classes) and comprise many different sports for all students.[6–9] Such a different context implies that (sex-specific) IR from individual collegiate sports or sports in a general population cannot be extrapolated to sports classes in PETE studies.[7–10] Therefore, insight into the contribution of sports types and their exposure times over the curriculum years to the higher injury odds for first-year and female PETE students is needed. This can help stakeholders from PETE and similar sports-related vocational studies to develop adequate preventive measures and adequate load management strategies during the rehabilitation of injuries.[11 12]

The intracurricular exposure time of Dutch PETE students in mixed sports classes exceeds 250 hours per year during the first 3 years of the curriculum. Compared with the precurricular exposure time, the sudden increase in exposure time may be a main driver for the high injury risk during the first year.[13 14] The uneven distribution between curriculum years of the total amount of all sports classes could further increase first-year students' injury risk. Team ball sports, dance, gymnastics, track and field and several other individual sports are part of the sports curriculum. As injury risks differ between sports, insight into how individual sports contribute to the overall injury risk is needed as well.[7–9] However, apart from injury risk per sport, the distribution of these sports over the curriculum years must also be considered. Injury risks for certain sports could be overestimated when the underlying cause of these risks lies in higher exposure times during the first year (ie, a period of high increase in physical load) than the consecutive years.

No recent studies have investigated intracurricular IR per sport in PETE studies, nor have they compared IR or exposure times per sport between curriculum years.[2 3 15 16] Therefore, the first purpose of this study was to describe and compare intracurricular IR by sport, by sex and by curriculum year in a Dutch PETE facility. Second, this study aimed to describe and compare the distribution of exposure times per sport by curriculum year.

METHODS

Study design and population

In this historical cohort study, injuries reported by PETE students at the medical facility of the Hague School of Sport Studies (HSSS) over 14 consecutive academic years (August 2000–June 2014) were analysed. As this was a retrospective study of medical/student records, according to the Central Committee on Research Involving Human Subjects it is not subject to the requirements of the Dutch research act on human subjects (WMO) and formal research ethical approval was not required.[17 18] Relevant data from injury/student records were used with permission from the institution and following privacy regulations.[19] Findings of this study were reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline[20] and the STROBE (Sports Injury and Illness Surveillance) Statement 1.0.[21]

Injury registration and definition

Intracurricular injuries reported by the PETE students who completed their full curriculum (50%) between August 2000 and June 2014 were used for this investigation. Injuries with a reported onset during participation in a specified sports class and curriculum year were included for analyses and classified per body location and injury type.[22] According to a previously described protocol, injury registration was performed by the same sports physical therapist and sports physician, during the entire study period.[6] The injury definition used was conforming the medical attention definition used in multisports events[23]: 'any new musculoskeletal complaint sustained during intracurricular sports participation of PETE students, for which medical advice was sought at the medical facility of the HSSS'.

Exposure time

Intracurricular exposure time (overall and per sports activity) was calculated based on the scheduled timetable per sports class for each included cohort from 2000 to 2014. The first 3 years of the curriculum were used for analyses, while the fourth year consisted of mainly internships. Male and female students followed the same curriculum in mixed sports classes: team ball sports (ie, basketball, handball, hockey, korfball, rugby, soccer, volleyball) racket sports, gymnastics, martial arts, track and field, dance, swimming, practical didactics (sports classes with special focus on didactical skills), skating and school camps. For each cohort, the total exposure time in hours per sports class was multiplied by the number of male and female students participating in that specific cohort. Exposure time per sport was calculated for each curriculum year separately as well.

Statistical methods

Demographic variables were calculated in frequencies and percentages (sex, injury body locations and types) and in means and SD for age in years and exposure time in hours. An independent t-test was used to compare the mean age in years and the exposure time in hours between sexes.

IR per sport

Intracurricular IR (the number of injuries per 1000 hours of sports participation) and corresponding 95% CIs were calculated per sex and sports class to describe IR per sport over the full 3 years of the sports curriculum.

IR and exposure times per sex per curriculum year

To compare IR per sports per sex per curriculum year, the IR was calculated separately for the three sports categories with the highest overall IR's. To avoid small

Table 1 Total intracurricular exposure times (first, second and third year together), injuries and injury incidence rates (IR) per 1000 hours and 95% CI per sports per sex

Sports classes	Sex	n	Exposure (hours)	Injuries	IR	95% CI		RR f:m	95% CI
Team ball sports	Male	635	107 168	52	0.49	0.37	– 0.64		
	Female	448	75 001	87	1.16	0.94	– 1.43	2.39	1.70 to 3.37
	Total	1083	182 168	139	0.76	0.65	–0.90		
Racket sports	Male	635	29 195	0	0.00	–	–		
	Fmale	448	20 573	3	0.15	0.05	– 0.45	–	–
	Total	1083	49 768	3	0.06	0.02	– 0.19		
Gymnastics	Male	635	70 260	56	0.80	0.61	– 1.04		
	Female	448	49 243	91	1.85	1.50	– 2.27	2.32	1.66 to 3.23
	Total	1083	119 503	147	1.23	1.05	– 1.45		
Martial arts	Male	635	33 322	14	0.42	0.25	– 0.71		
	Female	448	23 149	14	0.60	0.36	– 1.02	1.44	0.69 to 3.02
	Total	1083	56 471	28	0.50	0.34	– 0.72		
Track and field	Male	635	51 151	25	0.49	0.33	– 0.72		
	Female	448	35 838	45	1.26	0.94	– 1.68	2.57	1.58 to 4.19
	Total	1083	86 989	70	0.80	0.64	– 1.02		
Dance	Male	635	47 452	0	0.00	–	–		
	Female	448	33 254	1	0.03	0.00	– 0.21	–	–
	Total	1083	80 706	1	0.01	0.00	– 0.09		
Swimming	Male	635	44 797	2	0.04	0.01	– 0.18		
	Female	448	31 359	10	0.32	0.17	– 0.59	7.14	1.56 to 32.60
	Total	1083	76 156	12	0.16	0.09	– 0.28		
Practical didactics	Male	635	148 383	4	0.03	0.01	– 0.07		
	Female	448	103 488	9	0.09	0.05	– 0.17	3.23	0.99 to 10.48
	Total	1083	251 870	13	0.05	0.03	– 0.09		
Skating	Male	635	7478	2	0.27	0.07	– 1.07		
	Female	448	5207	4	0.77	0.29	– 2.05	2.87	0.53 to 15.68
	Total	1083	12 685	6	0.47	0.21	– 1.05		
School camps	Male	635	50 800	20	0.39	0.25	– 0.61		
	Female	448	35 840	27	0.75	0.52	– 1.10	1.91	1.07 to 3.41
	Total	1083	86 640	47	0.54	0.41	– 0.72		
Overall	Male	635	590 005	175	0.30	0.26	– 0.34		
	Female	448	412 952	291	0.70	0.63	– 0.79	2.38	1.97 to 2.87
	Total	1083	1 002 957	466	0.46	0.42	– 0.51		

RR and 95% CI per sports are calculated for female (F) vs male (M) students.
RR, rate ratios.

subgroups without injuries or exposure times in a certain curriculum year, for all other sports categories together a fourth IR was calculated. Exposure time per curriculum year was compared for these same four sports categories. The percentual distributions of exposure times between the three separate curriculum years were compared using the χ^2 test. The effect size was calculated using Cramer's V.[24] Cramer's V values of 0.071, 0.212 and 0.354 correspond to a small, medium and large effect size for a minimal of three rows or columns, respectively.[25] To describe time trends, centred 4-year moving averages (2×4 MA) were calculated using the formula $2\times4\text{MA}(t) = \frac{1}{2}[\{(x_{t-2} * y_{t-2}) + (x_{t-1} * y_{t-1}) + (x_t * y_t) + (x_{t+1} * y_{t+1})\} / (y_{t-2}+y_{t-1}+y_t+y_{t+1})] + \frac{1}{2}[\{(x_{t-1} * y_{t-1}) + (x_t * y_t) + (x_{t+1} * y_{t+1}) + (x_{t+2} * y_{t+2})\} / (y_{t-1}+y_t+y_{t+1}+y_{t+2})]$, where t is the cohort year and x is the incidence for that year and y is the number of students (male/female) of that cohort.

Comparisons of IR

To compare IR between subgroups (ie, sex, sports categories and curriculum years), injury rate ratios (RRs) and the corresponding 95% CI were calculated.

For all analyses, α was set at 0.05. IBM SPSS Statistics V.25 (IBM) and Excel V.16.30 (Microsoft, Redmond, USA) were used for statistical analyses.

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

A total of 1083 PETE students (male n=635, female n=448) completed their full curriculum at the HSSS from August 2000 to June 2014. The mean age of all students at enrolment was 19.2 years (SD 1.9). Compared with male students (19.7 years, SD 2.1), female students were significantly younger (18.6 years, SD 1.5). The mean total exposure time per student was 929 (SD 71) hours for male students and 922 (SD 74) for female students (p=0.10). Thirty-nine per cent of all students (n=426; male 28%, n=177; female 56%, n=249) reported at least one intracurricular injury. Of the 633 reported intracurricular injuries, 74% (n=466) could be attributed to a specific sports activity (see table 1) and were used for analysis.

The majority of these injuries were sustained during gymnastics (n=147, 32%), team ball sports (n=139, 30%) and track and field (n=70, 15%). The remaining 110 injuries (24%) were sustained during other sports (ie, racket sports, martial arts, dance, swimming, practical didactics, skating and school camps).

Most injuries were to the lower limb (n=309, 66%) and upper limb (n=102, 22%). Most frequently reported injury locations were the ankle (n=122, 26%), the knee (n=63, 14%), the shoulder (n=50, 11%) and the lower leg (n=45, 10%). Joint and ligament injuries (n=229, 49%) and muscle and tendon injuries (n=121, 26%) were most common. All distributions per sex showed similar patterns.

Three-year injury rates per sports activity

As shown in table 1, the overall 3-year IR was 0.46 injuries per 1000 hours of sports activities (95% CI 0.42 to 0.51). The highest IR were found for gymnastics (IR 1.23, 95% CI 1.05 to 1.45), track and field (IR 0.80, 95% CI 0.64 to 1.02) and team ball games (IR 0.76, 95% CI 0.65 to 0.90). For all other sports classes together, the IR was 0.18 (95%CI 0.15 to 0.22). For all individual sports classes, IRs were higher for female students than male students (table 1).

IR per curriculum year

The IR during the first year (IR 0.70, 95% CI 0.62 to 0.79) was significantly higher compared with the second (IR 0.39, 95% CI 0.33 to 0.46; RR 1.79, 95% CI 1.45 to 2.21) and third years (IR 0.26, 95% CI 0.20 to 0.32; RR 2.74, 95% CI 2.13 to 3.54). For all four sports categories, IRs were highest during the first year and decreased over the second and third years (see figure 1). The only exception were IR for gymnastics in male students over the third year (IR 0.58, 95% CI 0.35 to 0.94) compared with the second year (IR 0.52, 95% CI 0.29 to 0.94).

IR per sex

The overall IR in female students (IR 0.70, 95% CI 0.63 to 0.79) was significantly higher (RR 2.38, 95% CI 1.97 to 2.87) compared with male students (IR 0.30, 95% CI 0.26 to 0.34). For all separate curriculum years, female students' IR were significantly higher (RR 2.12–2.89,

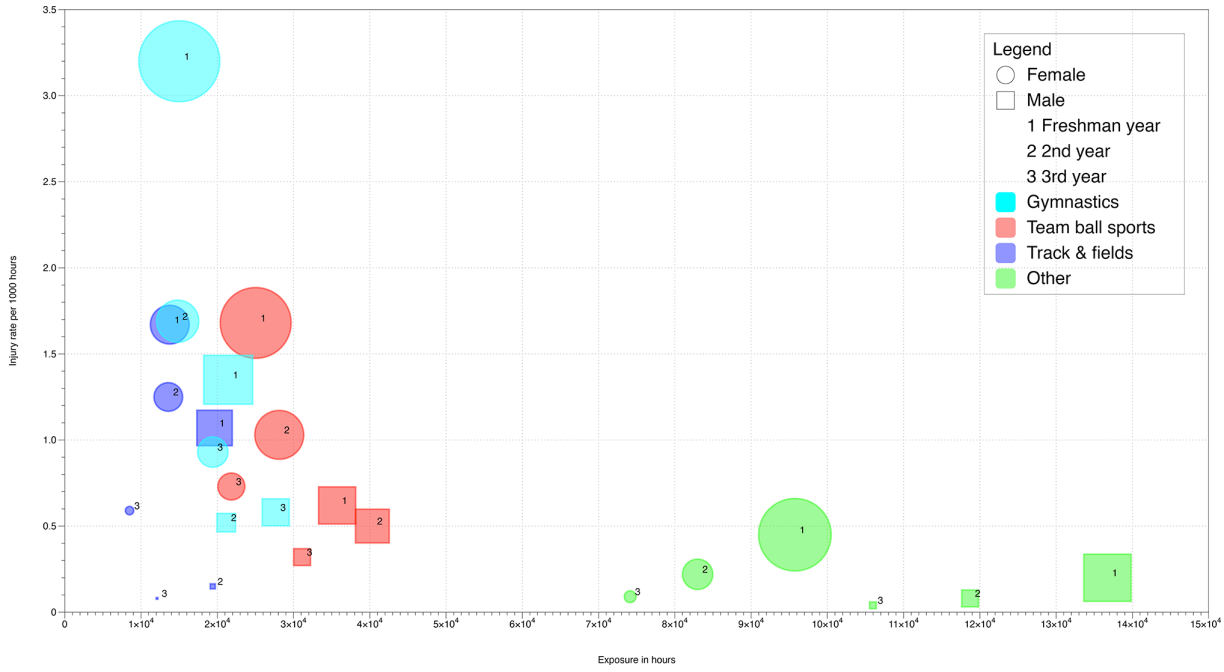

Figure 1 Injury incidence rate versus exposure time in hours for intracurricular injuries per sports category, curriculum year and sex. Sizes of the dots represent the number of injuries for specified sports types, sex and curriculum years.

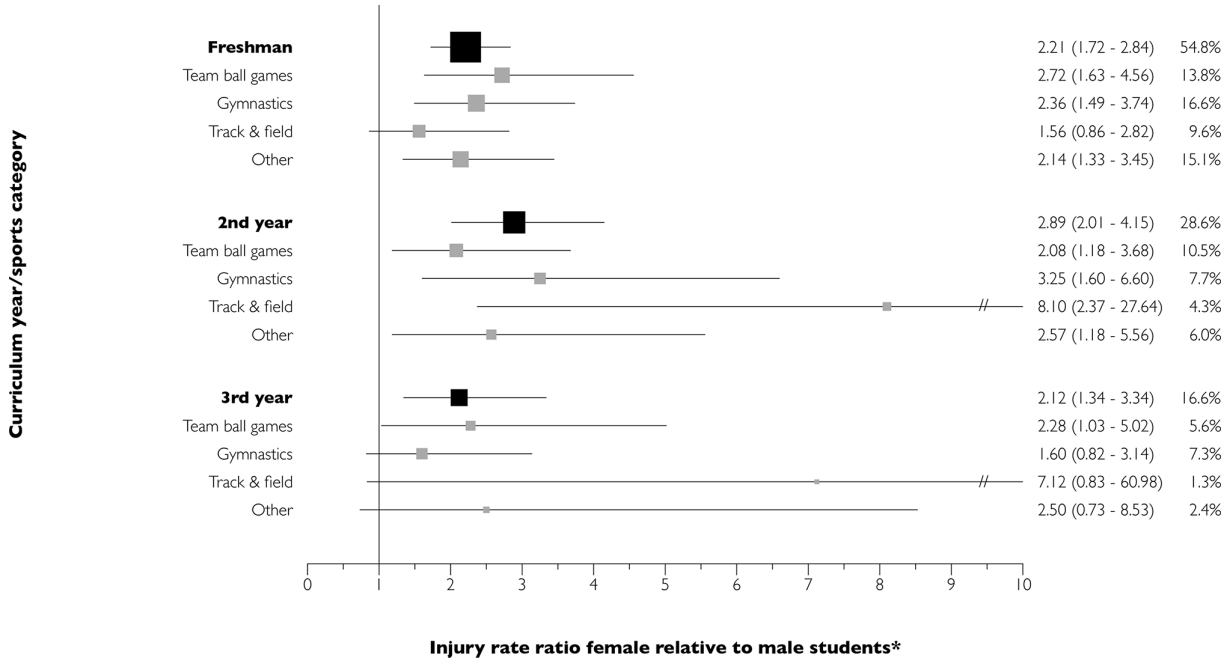

Figure 2 Intracurricular injury rate ratios and their 95% CIs for female relative to male PE students per curriculum year per sports category for team ball sports, gymnastics, track and field and other sports. *Injury rate ratios higher than 1 implicate higher risks for female students compared with male students. Percentages are calculated as the number of injuries per year and/or sports category compared with the overall total number of injuries. PE, physical education.

95% CI 1.34 to 4.15). Analyses for separate sports categories showed similar patterns for all curriculum years (see figure 2).

Time trends

Time trends showed an increase in 2×4 MA of the overall IR in both male (IR 0.23–0.42) and female (IR 0.58–0.90) students. Time trends for separate sports/activities showed various patterns. Compared with other sports/activities (male IR 0.10–0.19; female IR 0.33–0.26), the 2×4 MA of track and field (male IR 0.19–1.03; female IR 1.10–1.53), gymnastics (male IR 0.76–0.80; female IR 1.32–2.60) and team ball sports (male IR 0.33–0.67; female IR 0.67–1.60) remained higher.

Exposure time per curriculum year

The total exposure time in sports classes over the first three curriculum years was 1 002 957 hours. The cumulative exposure time for gymnastics, team ball sports and track and field comprised 39% (388 660 hours) of the total exposure time. Together, all other sports accounted for 61% (614 296 hours) of the total exposure time.

The overall exposure time distribution was 36% (363,083 hours) in the first year, 34% (339 135 hours) in the second year and 30% (300,739 hours) in the third year. When compared with the overall distribution, exposure time distribution for the four sports categories was different (χ^2 (6, N=1 002 959) = 8735.2, p<0.001, Cramer's V=0.07). Team ball sports (33%) and gymnastics (31%) showed relatively lower percentages for the first year. Exposure times for track and field (38%) and other sports (38%) were relatively higher. Figure 1 shows exposure times per sports category and sex for all curriculum years.

DISCUSSION

This study aimed to describe and compare intracurricular IR and exposure times by sport, by sex and by curriculum year in a Dutch PETE facility.

Intracurricular IRS were highest during gymnastics, team ball games, and track and field. Within 39% of the total intracurricular exposure time, 76% of all injuries were sustained during participation in one of these three sports. The remaining 24% of injuries occurred in the other sports in 61% of the total intracurricular exposure time. Over the curriculum years, distributions of exposure times for sports categories showed only small deviations from the overall distribution (Cramer's V=0.07). Therefore, the much higher IR for gymnastics, team ball sports and track and field compared with other sports could not be attributed to the high increase in exposure time (thus physical load) during the first year and vice versa. This assumption is confirmed by the fact that, after the first year, IR's for all sports categories decreased in similar patterns. The second finding of our study was the consistently higher IR for female PETE students over all intracurricular sports and all curriculum years.

The higher IR for gymnastics, team ball sports and track and field are compatible with previous studies.[1 5] Our new findings show that high IR for these activities are not directly associated with the higher IR during the first year. These findings suggest that differential

preventive measures should be considered. On the one hand, results from this study stress the importance of identifying factors that modify physical fitness and (spikes in) load for first-year students.[12 26] Both intracurricular planning of sports classes and the congestion of intracurricular and extracurricular loads (ie, senior level sports, student life, travel) should be considered.[27] On the other hand, high-risk activities and risk factors contributing to the high IR's for gymnastics, team ball sports and track and field need to be investigated.[11 28] More insight into these injuries' exact nature and locations per sports and curriculum year is needed.[11] Next to known specific risk factors for injuries in the sports mentioned above,[29] their combined load and factors related to learning new motor skills need to be considered.

The higher IRs for all sports (categories) for female than for male PETE students shows that this difference cannot be attributed to specific sports. The higher rate for female students in mixed sport classes is not in line with the almost equal incidence rates found for male and female athletes between 15 and 24 years in the general Dutch sports population.[8] In collegiate sports, sex-specific injury risks differ between sports.[7 9] Like sports in the general population collegiate sports are not mixed, an important difference in comparison with PETE sports. Previous studies on PETE students did not find significantly increased overall intracurricular IRs for female students during the first year[2 3 16] or the full curriculum.[1] The more than 1000 included students resulted in the current study being more statistically powered than all previous studies. Our results, however, are in line with results from studies on mixed military populations.[30] Differences between sexes in anthropometric, biomechanical and physical fitness parameters have been identified as risk factors in military populations.[31 32] Such differences could lead to unlevelled interactions in mixed team sports and a higher relative cumulative load for female students, making them more injury-prone than male students. A sex-based approach implies that these intrinsic factors cannot be influenced. Parsons *et al* argue that a gender-based difference in approach as a social construct is a modifiable extrinsic factor.[33] This implies that a more gender-neutral approach could reduce anthropometric, biomechanical and physical differences between sexes. Whether these differences between sexes are present in PETE students, requires further context-specific investigation.[10] The higher IRs we found for female students were also consistent for all curriculum years. This implies that preventive strategies for female PETE students need to target all sports and all curriculum years. For that, the exact nature and location of sustained injuries, and possible (gender-based) differences between sports, curriculum years and sexes need to be investigated.

A limitation of our study was that IR, similar to previous studies on PETE students, were calculated by dividing the number of injuries by the total exposure time for all students. The fact that a student may not have actively participated in classes due to injury (or other reasons) was not corrected. Therefore, true exposure times were presumably lower than reported.[34] In addition, our retrospective analysis was based on voluntary medical consultations of new injuries only, and not all registered injuries (in particular gradual onset injuries) could be attributed to a single sport. Combined with differences in injury definitions,[35] these will have led to lower IR's than other studies on injury risks in PETE students.[1–3 15] Another limitation of our study was that extracurricular injuries were not included in our analysis because extracurricular exposure times were not recorded. High increases in cumulative intracurricular and extracurricular exposure times might contribute to higher injury risks during the first year. In contrast, expertise from extracurricular sports participation might influence injury risks for specific intracurricular sports.[36] These and other possible factors contributing to intracurricular injury risks need to be investigated from a socioecological perspective to develop adequate preventive and rehabilitative measures.[10]

A limitation of our analyses based on incidence rates is that the burden of injuries, apart from incidence rate, exposure time and the number of participants, is affected by the injury duration. Therefore, future studies should include registration of all relevant parameters to compare the true burden of injuries in PETE studies.[37]

Our study period from 2000 to 2014 is another limitation. However, time trends showed considerable increases in the 2×4 MA for overall IR in both male and female students and for gymnastics, team ball sports and track and field. These trends, combined with the fact that current curricula still include 280 hours of sports classes per year, make extrapolation of our results to current PETE studies plausible. Intercultural differences in sports participation need to be considered when extrapolating our results to populations in other countries.[2 5 16] A higher risk for first-year students can also be expected in other studies with high sporting loads in the first year. The compatibility of the higher injury risk for female PETE students, found in our study, with results from military studies, suggests that mixed sports participation between sexes puts female participants at higher risk of injury.[30 38]

CONCLUSIONS

In PETE students, IRs for gymnastics, team ball sports and track and field are significantly higher than for all other intracurricular sports. IRs for the first year are higher compared with consecutive years. On top of that, all mixed sports classes' IR are higher in females than in males. Therefore, curriculum year, sex and sports types are risk factors to be independently targeted for preventive and rehabilitative measures in PETE studies. How first-year PETE students adapt to high sporting loads needs to be investigated. As team ball sports, gymnastics and track and field show the highest IRs over the full curriculum, most notably in female students, the nature and aetiology of injuries in these sports need to be investigated in mixed populations of sports students.

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