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# Physical activity-related injuries among university students: a multicentre cross-sectional study in China

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## ABSTRACT

**Objectives** This study aimed to investigate the epidemiological characteristics and preliminarily explore possible risk factors of physical activity-related injury (PARI) occurrences among Chinese university students via a multicentre mixed survey.

**Design** Cross-sectional study.

**Participants** A total of 4758 undergraduates graded 1–3 in nine universities in three Chinese cities were enrolled via cluster random sampling and completed the self-administered online questionnaires during March and April 2017.

**Main outcome measures** PARI in the past 12 months.

**Results** Of the 4758 participants, 1081 sustained PARI in the past 12 months, with an overall PARI incidence rate of 22.7% (27.3% (367/1343) in males and 20.9%(714/3415) in females). Around one-quarter of the injured (26.4%) suffered from PARI over at least three episodes. More than half of the injured subjects experienced physical activity (PA) absenteeism and sought medical attention. All PA indicators were significantly and positively associated with PARI, with a frequency of sports and leisure-time vigorous-intensity PA (VPA) participation being the strongest (adjusted OR: 1.079, 95% CI: 1.018 to 1.144). Moreover, males (OR=1.199), Shantou students (OR=4.239), year 1 students (OR=1.287), university and other sports team members (OR=1.717–2.360) and those with insufficient sleep time (OR=1.262–1.333) were also at a higher risk of PARI.

**Conclusions** PARI is prevalent among university students in China. The frequency of sports and leisure-time VPA participation was most strongly associated with PARI among all PA indicators. These data can inform future programmes for injury intervention among university students. Safety issues should also be emphasised when promoting PA among the public to reduce PARI.

## Strengths and limitations of this study

- ► This is the first study to explore the epidemic and possible risk factors of physical activity-related injury (PARI) among Chinese general university students.
- ► The cross-sectional study design limits causal and temporal inferences.
- ► All information was self-reported, which may have resulted in recall bias and reporting bias and therefore somewhat limits our results.
- ► We could not investigate activity-specific PARI occurrences because the Global Physical Activity Questionnaire does not capture the specific activities that the participants undertook.

## INTRODUCTION

Physical, social and psychological benefits of engaging in regular physical activity (PA) have been well documented, including increased cardiorespiratory and muscular fitness and bone density and reduced risks for non-communicable diseases.[1–3] Insufficient PA has been recognised as one of the top three risk behaviours in the development of morbidity and mortality associated with cardiovascular diseases and other major chronic diseases, such as diabetes and obesity.[4] To achieve and maintain optimal individual health, the WHO has recommended that adults (18–64 years old) undertake at least 150 min of moderate-intensity PA (MPA) or at least 75 min of vigorous-intensity PA (VPA) or an equivalent combination of moderate and vigorous-intensity PA (MVPA) every week.[4] In light of these advantages and recommendations of PA participation, almost all countries and regions of the world promote PA.

Although the promotion of PA is a public health priority, being physically active can also increase the risk of injury.[5–7]Physical activity-related injury (PARI), also known as sports and recreational activity-related injury, is any injury resulting from participation in physical education (PE) class, sports activities or leisure time PA, for example, sprains, strains, fractures and contusions.[8] In fact, PARI contributes mostly to all non-fatal injuries and is the one health threat to relatively healthy adolescents and young adults in many countries.[4 9] Over the long term, it can also increase the risk of future injuries, osteoarthritis and other health problems later in life.[10] PARI may also be a barrier to adopting

a more active lifestyle, which may further hinder people from achieving optimal health.[11 12]

Injury incidence is well documented among many active populations. For example, the injury incidence densities among soccer players were 8.07–8.44/1000 athlete exposures (AEs),[13] and tennis players were 4.88–4.89/1000 AE.[14] However, there are knowledge gaps about the PARI incidence in the general population. To obtain better understanding on these research questions, we conducted a series of studies. Prior studies revealed that about 25.1%–32.4% of primary and secondary school students in two Chinese cities had suffered from PARI in the past 12 months, suggesting that PARI is prevalent among children and adolescents.[8 15] In China, students in universities might be more active than those in primary and secondary schools because they have been released from heavy academic burdens and pressure for university admission. Moreover, they become independent of their parents and are therefore more likely to engage in relatively risky activities that their parents might not allow prior.[16] Thus, university students might be more vulnerable to PARI.

While there is ample evidence about PARI among collegiate athletes, it might not be suitable for general students because of the significant differences in risk factors between the two groups, such as sports skills, training intensity, competition level and cardiorespiratory/muscle fitness.[17 18] We therefore conducted a multicentre cross-sectional study among a sample of general university students in China, funded by the National Natural Science Foundation of China, to obtain a better understanding of the PARI epidemic. This paper presents a baseline survey and reports the epidemiological characteristics and preliminary risk factors of PARI among Chinese university students.

## METHODS

### Study participants

The study was conducted at nine universities in Jinan, Shantou and Hong Kong (eight comprehensive universities and one normal university). Students at normal university in China are trained to become teachers in kindergartens and primary and secondary schools. These cities represent northern, southern and special regions of China, respectively. The cluster random sampling method was used to identify 5115 eligible students in years 1–3. These persons were invited to participate in the study in March and April 2017. Seniors (students in year 4) were excluded because they are in the transition period to work, and their university lives are significantly different from the others. In addition, those majoring in PE were further excluded from data analysis because they differ significantly from the others in terms of PA/sports-related factors. Finally, 4758 students in years 1–3 completed the online survey, with a response rate of about 93.0%.

### Data collection

Qualtrics software (Qualtrics; Provo, Utah, USA) was used as the online platform for the baseline questionnaire survey. Participants were enrolled in classes or dormitories. The online questionnaire was self-administered and consisted of demographics, PA habits, sedentary behaviours, sleep duration and PARI experiences in the past 12 months.

The demographic variables included university, study major, study year, gender, age, residence type (dormitory, home or others), any diagnosed chronic disease/symptom and sports team membership.

Participants' PA levels in a typical week in the past 12 months were evaluated using the Global Physical Activity Questionnaire (GPAQ) Chinese version.[19] It is one of the most commonly used PA questionnaires and has sound reliability and validity (Spearman's rho=0.81, kappa=0.65).[20 21] The GPAQ collects frequency (days/week) and duration (cumulative minutes/day) of VPA and MPA in three domains: domestic/work/study, transportation (MPA only) and sports and leisure-time activities. The PA volume (cumulative minutes/week) was then calculated by duration multiplied by frequency for each category of PA (VPA, MPA and MVPA) in each domain and overall to generate 20 PA-related variables. The GPAQ does not provide information on the students' specific activities, and all participants were further asked whether they had any favourite sports or recreational activities in the past 12 months. Those with a positive answer were further requested to provide the names of the activities (no more than three).

In terms of sedentary behaviours and sleep, the duration (hours/day) was asked on both a typical weekday and a typical weekend. The average daily duration in a week was then calculated and used to group the students into five categories.

For this study, a countable PARI must meet at least one of the following three consequences: (1) the student has to immediately stop the PA and/or cannot participate in the next planned PA; (2) the student is absent from class the next day and/or (3) the student needs to seek medical attention (including local first aids but excluding bandages only).[8] Persons suffering from such a PARI in the past 12 months were asked to report the number of PARI in each category.

### Ethics approval

This study was strictly conducted in accordance with the Declaration of Helsinki. Prior to approaching potential subjects, approval was obtained from Shantou University Medical College ethics committee, Shandong University ethics committee and Hong Kong Baptist University ethics committee. During a plenary session, explanatory statements and consent forms were distributed to all potential participants, and the hyperlink or quick response code of questionnaire was subsequently given to the consenting students in the target classes or dormitories. The purpose and meaning of our study was verbally explained to the

subjects prior to their completion of the questionnaires, and our trained personnel answered any questions that arose during the session.

### Statistical analysis

Statistical analyses were performed using SPSS version 19.0. Continuous data that is normally (ie, age) or not normally distributed (ie, 20 PA-related variables) were described using mean (SD) or median (IQR), respectively; categorical variables were presented as number (percentage). The Pearson $\chi^2$ tests were applied to evaluate the numbers and consequences of PARI between females and males—both univariate and multivariate logistic regression were fitted to estimate the risk of each study variable for PARI, where crude and adjusted ORs and their 95% CIs were generated, respectively.

Three steps were undertaken in the multivariate analyses. In step 1, all sociodemographic variables were selected in both forward and backward manners (likelihood ratio), with a selection criteria of $\alpha_{in}$=0.10 and $\alpha_{out}$=0.15. Adjusted ORs and 95% CIs of the variables remaining in the final model (ie, significant variables) were calculated and derived from, including city, study year, gender, university/other sports team member and any chronic disease/symptom. For variables outside of the final model (ie, insignificant variables, including age and residence type), their adjusted ORs and 95% CIs were obtained after controlling for the significant variables (table 1). In step 2, the risk of each lifestyle variable (including PA habits, sedentary behaviours and sleep duration) was assessed after controlling for the significant sociodemographic variables in the first step (table 2). In

**Table 1** Risks of sociodemographic characteristics for PARI

| Characteristics | All (N=4758), n (%) | Non-PARI (N=3677), n (%) | PARI (N=1081), n (%) | Adjusted OR | 95% CI |
|---|---|---|---|---|---|
| City | | | | | |
| Jinan | 1267 (26.6) | 1111 (87.7) | 156 (12.3) | 1 (ref.) | |
| Shantou | 2123 (44.6) | 1403 (66.1) | 720 (33.9) | 3.932*** | 3.230 to 4.786 |
| Hong Kong | 1368 (28.8) | 1163 (85.0) | 205 (15.0) | 1.084 | 0.841 to 1.396 |
| Study year | | | | | |
| Year 1 | 1496 (31.4) | 1125 (75.2) | 371 (24.8) | 1.397** | 1.109 to 1.760 |
| Year 2 | 1462 (30.7) | 1121 (76.7) | 341 (23.3) | 1.153 | 0.948 to 1.401 |
| Year 3 | 1800 (37.8) | 1431 (79.5) | 369 (20.5) | 1 (ref.) | |
| Gender | | | | | |
| Male | 1343 (28.2) | 976 (72.7) | 367 (27.3) | 1.404*** | 1.202 to 1.640 |
| Female | 3415 (71.8) | 2701 (79.1) | 714 (20.9) | 1 (ref.) | |
| Residence type | | | | | |
| Dormitory | 2908 (61.1) | 2210 (76.0) | 698 (24.0) | 1 (ref.) | |
| Home | 1742 (36.6) | 1377 (79.0) | 365 (21.0) | 1.016 | 0.861 to 1.198 |
| Others | 108 (2.3) | 90 (83.3) | 18 (16.7) | 0.820 | 0.469 to 1.434 |
| University sports team member | | | | | |
| No | 4262 (89.6) | 3380 (79.3) | 882 (20.7) | 1 (ref.) | |
| Yes | 496 (10.4) | 297 (59.9) | 199 (40.1) | 3.136*** | 2.528 to 3.889 |
| Other sports team member | | | | | |
| No | 4472 (94.0) | 3512 (78.5) | 960 (21.5) | 1 (ref.) | |
| Yes | 286 (6.0) | 165 (57.7) | 121 (42.3) | 2.182*** | 1.678 to 2.838 |
| Any chronic disease/symptom | | | | | |
| No | 4583 (96.3) | 3563 (77.7) | 1020 (22.3) | 1 (ref.) | |
| Yes | 175 (3.7) | 114 (65.1) | 61 (34.9) | 1.561* | 1.111 to 2.195 |
| Age (mean±SD, years) | 20.00±1.382 | 20.01±1.426 | 19.98±1.386 | 0.983 | 0.934 to 1.146 |

Adjusted ORs and 95% CIs of significant variables were calculated after controlling for each other, including city, study year, gender, university/other sports team member and any chronic disease/symptom. Adjusted ORs and 95% CIs of insignificant variables (age and residence type) were obtained after controlling for the significant variables.
*P<0.05, **P<0.01, ***P<0.001.
PARI, physical activity-related injury.

Table 2 Risks of life-style variables for PARI among university students in China

| Characteristics | All (n=4758), median (IQR) | Non-PARI (n=3677), median (IQR) | PARI (n=1081), median (IQR) | Adjusted OR | 95% CI |
|---|---|---|---|---|---|
| Domestic/work/study | | | | | |
| VPA | | | | | |
| Frequency, day/week | 0 (0, 1) | 0 (0, 1) | 0 (0, 2) | 1.168*** | 1.111 to 1.228 |
| Duration, min/day | 0 (0, 20) | 0 (0, 15) | 0 (0, 30) | 1.008*** | 1.006 to 1.010 |
| Volume, min/week | 0 (0, 30) | 0 (0, 20) | 0 (0, 60) | 1.002*** | 1.001 to 1.002 |
| MPA | | | | | |
| Frequency, day/week | 1 (0, 2) | 1 (0, 2) | 1 (0, 3) | 1.124*** | 1.082 to 1.167 |
| Duration, min/day | 10 (0, 30) | 10 (0, 30) | 20 (0, 30) | 1.005*** | 1.004 to 1.007 |
| Volume, min/week | 20 (0, 60) | 10 (0, 60) | 40 (0, 100) | 1.001*** | 1.001 to 1.002 |
| MVPA | | | | | |
| Volume, min/week | 40 (0, 120) | 30 (0, 105) | 60 (0, 180) | 1.001*** | 1.001 to 1.002 |
| Transportation | | | | | |
| MPA | | | | | |
| Frequency, day/week | 5 (1, 7) | 5 (1, 7) | 5 (2, 7) | 1.030* | 1.003 to 1.059 |
| Duration, min/day | 30 (10, 40) | 30 (10, 40) | 30 (15, 50) | 1.002** | 1.001 to 1.004 |
| Volume, min/week | 120 (30, 210) | 105 (30, 210) | 140 (50, 210) | 1.002*** | 1.001 to 1.003 |
| Sports and leisure time | | | | | |
| VPA | | | | | |
| Frequency, day/week | 0 (0, 1) | 0 (0, 1) | 0 (0, 2) | 1.171*** | 1.116 to 1.229 |
| Duration, min/day | 0 (0, 30) | 0 (0, 30) | 0 (0, 47.5) | 1.008*** | 1.006 to 1.011 |
| Volume, min/week | 0 (0, 60) | 0 (0, 38) | 0 (0, 90) | 1.002*** | 1.001 to 1.003 |
| MPA | | | | | |
| Frequency, day/week | 1 (0, 2) | 0 (0, 2) | 1 (0, 3) | 1.125*** | 1.082 to 1.169 |
| Duration, min/day | 10 (0, 30) | 0 (0, 30) | 20 (0, 40) | 1.006*** | 1.004 to 1.008 |
| Volume, min/week | 15 (0, 80) | 0 (0, 75) | 40 (0, 90) | 1.002*** | 1.001 to 1.002 |
| MVPA | | | | | |
| Volume, min/week | 45 (0, 130.5) | 30 (0, 120) | 80 (0, 210) | 1.001*** | 1.001 to 1.002 |
| Total VPA | | | | | |
| Volume, min/week | 0 (0, 100) | 0 (0, 80) | 40 (0, 180) | 1.001*** | 1.001 to 1.002 |
| Total MPA | | | | | |
| Volume, min/week | 60 (0, 150) | 60 (0, 140) | 100 (10, 200) | 1.001*** | 1.001 to 1.001 |
| Total MVPA | | | | | |
| Volume, min/week | 255 (120, 490) | 235 (105, 450) | 340 (180, 630) | 1.001*** | 1.000 to 1.001 |
| | n (%) | n (%) | n (%) | | |
| Sedentary behaviours | | | | | |
| <4.00 hours/day | 590 (12.4) | 459 (77.8) | 131 (22.2) | 1 (ref.) | |
| 4.00–5.99 hours/day | 869 (18.3) | 664 (76.4) | 205 (23.6) | 1.119 | 0.859 to 1.459 |
| 6.00–8.99 hours/day | 1453 (30.5) | 1119 (77.0) | 334 (23.0) | 0.983 | 0.769 to 1.258 |
| 9.00–11.99 hours/day | 978 (20.6) | 752 (76.9) | 226 (23.1) | 0.940 | 0.721 to 1.225 |
| ≥12.00 hours/day | 868 (18.2) | 683 (78.7) | 185 (21.3) | 0.795 | 0.604 to 1.045 |
| Sleep duration | | | | | |
| 7.00–7.99 hours/day | 1882 (39.6) | 1493 (79.3) | 389 (20.7) | 1 (ref.) | |
| <6.00 hours/day | 287 (6.0) | 223 (77.7) | 64 (22.7) | 1.428* | 1.032 to 1.977 |

Continued

Table 2 Continued

| | n (%) | n (%) | n (%) | | |
|---|---|---|---|---|---|
| 6.00–6.99 hours/day | 969 (20.4) | 708 (73.0) | 261 (27.0) | 1.425*** | 1.175 to 1.729 |
| 8.00–8.99 hours/day | 1186 (24.9) | 916 (77.2) | 270 (22.8) | 1.131 | 0.939 to 1.361 |
| ≥9.00 hours/day | 434 (9.1) | 337 (77.6) | 97 (22.4) | 1.020 | 0.782 to 1.331 |

Adjusted ORs and 95% CIs of each life style variable were calculated after controlling for the significant sociodemographic variables in table 1, including city, study year, gender, university/other sports team member and any chronic disease/symptom.
*P<0.05, **P<0.01, ***P<0.001.
MPA, moderate-intensity physical activity; MVPA, moderate and vigorous-intensity physical activity; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity.

step 3, a hierarchical model was performed to consider all significant study variables together, with sociodemographic variables selected in the first block and lifestyle variables in the second (table 3). A two-sided P<0.05 was considered statistically significant for all tests.

### Patient involvement

No patients were involved in the development of the research question or the outcome measures, nor were they involved in developing plans for design or implementation of the study. There are no plans to disseminate the results of the research to study participants.

## RESULTS

Table 1 presents the distribution of the sociodemographic characteristics and their risk estimations for PARI. Overall, the 4758 participants aged from 17 to 25 years old, with a mean age of 20.00 (SD: 1.382). More students were females (71.8%), living in dormitory (61.1%) and studying in Shantou (44.6%). Few students were university/other sports team members (10.4%/6.0%) or living with any chronic condition (3.7%). About 1081 students (22.7%) suffered from at least one PARI in the past 12 months, with a significantly higher incidence found in both types of sports team members and those living with chronic conditions (adjusted ORs: 1.561–3.136). In addition, students in Shantou, males and those in year 1 were more likely to experience PARI than their counterparts (adjusted ORs: 1.397–3.932). Age and residence type were not significantly associated with PARI.

Table 2 shows the distribution of lifestyle variables and their risk assessments for PARI. Most students were engaged in sports and leisure-time PA (87.5%) and transport-related PA (82.1%). Medians and IQRs for total volumes of VPA, MPA and MVPA (min/week) were 0 (0–100), 60 (0–150) and 255 (120–490), respectively. The means and SDs for these 20 PA-related variables are available in online supplementary table S1. Overall, 70.2% of university students were physically active according to the WHO's recommended PA for adults.[4] All PA indicators were positively and significantly related with PARI (adjusted ORs: 1.001–1.171), with a risk of the frequency of sports and leisure-time VPA participation being the highest. About 26.4% of students slept less than 7 hours per day, and they sustained more PARI events (adjusted ORs: 1.425–1.428).

Finally, we performed a hierarchical analysis, and table 3 presents the results of its final model. Risk estimations of sociodemographic variables in block 1 (including city, gender, study year and chronic disease/symptom) did not change markedly before and after controlling for lifestyle variables. However, the risks of the two sports team membership variables reduced markedly after adjustment for lifestyle variables. In addition, the frequency and duration of sports and leisure-time VPA, duration of sports and leisure-time MPA and sleep duration (in block 2) were significantly related to PARI, with adjusted ORs slightly decreasing after controlling for sociodemographic variables.

In terms of favourite activities, three fifths of the students (59.7%) reported at least one specific activity that they often enjoyed in the past 12 months. Common favourite activities included running (36.0%), badminton (27.2%), basketball (25.2%), cycling (24.3%), swimming (18.1%), table tennis (15.1%), soccer (14.3%), dance (13.8%) and volleyball (10.1%). Gender difference existed in choosing PA participation with male students favouring basketball (54.1%) and football (32.2%), and females preferring badminton (26.9%) and dance (14.6%).

Table 4 summarises the numbers and consequences of reported PARI among the 1081 injured participants before and after being stratified by gender. In the past 12 months, around one-quarter of the injured participants (26.4%) experienced PARIs three times or more. More than half of the students reported that they immediately stopped the activity and/or could not participate in the next planned activity (58.5%) or sought medical care (55.0%) after getting injured. Males were inclined to experience multiple PARI episodes (≥three injury episodes) and breaks from PA participation than their counterparts.

## DISCUSSION

A total of 4758 university students in China completed the online questionnaire. PARI experiences in the past 12 months were prevalent among the samples, with an overall incidence rate of 22.7%. Of the 1081 injured participants,

Table 3 Final model of hierarchical logistic regression to estimate risks of both sociodemographic and life-style variables for PARI among university students in China

| Characteristics | P value | Adjusted OR | 95% CI |
|---|---|---|---|
| Block 1 | | | |
| City | | | |
| Jinan | | 1 (ref.) | |
| Shantou | 0.000 | 4.239 | 3.475 to 5.171 |
| Hong Kong | 0.468 | 0.913 | 0.713 to 1.168 |
| Study year | | | |
| Year 1 | 0.039 | 1.287 | 1.099 to 1.515 |
| Year 2 | 0. 883 | 1.014 | 0.846 to 1.215 |
| Year 3 | | 1 (ref.) | |
| Gender | | | |
| Male | 0.028 | 1.199 | 1.020 to 1.410 |
| Female | | 1 (ref.) | |
| University sports team member | | | |
| No | | 1 (ref.) | |
| Yes | 0.000 | 2.360 | 1.881 to 2.961 |
| Other sports team member | | | |
| No | | 1 (ref.) | |
| Yes | 0.000 | 1.717 | 1.309 to 2.253 |
| Any chronic disease/symptom | | | |
| No | | 1 (ref.) | |
| Yes | 0.013 | 1.548 | 1.096 to 2.187 |
| Block 2 | | | |
| Sports and leisure-time VPA, frequency (day/week) | 0.010 | 1.079 | 1.018 to 1.144 |
| Sports and leisure-time VPA, duration (min/day) | 0.000 | 1.006 | 1.003 to 1.008 |
| Sports and leisure-time MPA, duration (min/day) | 0.000 | 1.004 | 1.002 to 1.006 |
| Sleep duration | | | |
| 7.00–7.99 hours/day | | 1 (ref.) | |
| <6.00 hours/day | 0.045 | 1.333 | 1.006 to 1.766 |
| 6.00–6.99 hours/day | 0.014 | 1.262 | 1.048 to 1.519 |
| 8.00–8.99 hours/day | 0.314 | 1.111 | 0.905 to 1.365 |
| ≥9.00 hours/day | 0.692 | 1.061 | 0.791 to 1.425 |

MPA, moderate-intensity physical activity; PARI, physical activity -related injury; VPA, vigorous-intensity physical activity.

most injured students experienced a time loss from PA or required medical care due to the injuries. Multivariate analyses indicated that males, Shantou students, year 1 students, sports team members and those with a chronic disease/symptom were more vulnerable to sustain PARI. PA engagements—regardless of the intensity (MPA, VPA or MVPA), domain (domestic/work/study, transportation or sports and leisure time) or parameter (frequency, duration or volume) were all significantly and positively related with PARI. The frequency of sports and leisure-time VPA participation was the strongest PA indicator after controlling for both sociodemographic and lifestyle variables (adjusted OR: 1.079, 95% CI: 1.018 to 1.144). Moreover, insufficient sleep was common, and these students tended to suffer from PARI—especially those with a sleep duration of less than 6 hours/day.

To the best of our knowledge, this is the first publication to investigate the epidemic and risk factors of PARI among general university students. In this study, one out of five participants (22.7%) experienced PARI in the past 12 months, suggesting that PARI was common among this population. The problem should not be

Table 4 Number and consequences of PARI among injured university students in China (N=1081)

| Characteristics | All (N=1081), n (%) | Male (N=367), n (%) | Female (N=714), n (%) | $\chi^2$ | P value |
|---|---|---|---|---|---|
| Number of PARI episodes | | | | 29.837 | <0.001 |
| 1 | 534 (49.4) | 146 (39.8) | 388 (54.3) | | |
| 2 | 262 (24.2) | 89 (24.3) | 173 (24.2) | | |
| ≥3 | 285 (26.4) | 132 (36.0) | 153 (21.4) | | |
| Consequences of PARI | | | | | |
| Stop quickly and/or can't participate in the next PA | | | | 4.084 | 0.044 |
| No | 449 (41.5) | 137 (37.3) | 312 (43.7) | | |
| Yes | 632 (58.5) | 230 (62.7) | 402 (56.3) | | |
| Being absent from class | | | | 2.416 | 0.120 |
| No | 778 (72.0) | 275 (74.9) | 503 (70.4) | | |
| Yes | 303 (28.0) | 92 (25.1) | 211 (29.6) | | |
| Seeking medical attention | | | | 0.267 | 0.605 |
| No | 486 (45.0) | 169 (46.0) | 317 (44.4) | | |
| Yes | 595 (55.0) | 198 (54.0) | 397 (55.6) | | |

PA, physical activity; PARI, physical activity-related injury.

ignored—especially under the contemporary global campaign to promote PA for health. Other than the direct adverse effects on physical health, PARI can also result in fear or can even prevent people from exercising, leading to further reduced PA levels.[11 12] Such a consequence is against the initial purpose of PA promotion for health. Though we did not investigate detailed consequences for each PARI episode, our results still revealed that more than half of the injured students experienced PA absenteeism or required medical attention. There is an urgent need for effective strategies to reduce injuries when undertaking physical activities. Otherwise, the effectiveness of the global campaign would be compromised.

We found that males were more vulnerable to PARI than females, which is highly consistent with most previous studies.[22 23] This might be males being more active than females. In our study, male students had higher values than females for all PA indicators (see online supplementary tables S2 and S3). Also, males are more likely to participate in competitive team sports, such as basketball and football. Most of these sports involve a high rate of contact, jumping, sprinting and/or pivoting, which are often involved in the mechanism of injury.[24] The gender difference in favourite activities in this study is in line with this explanation. Furthermore, even in the same activity, males are often more prone to experience injuries due to high competitiveness and resistance than females.[25] Collectively, males have a greater tendency to experience PARI than females. Future sex-specific interventions should address the discrepancy.

Our study shows that approximately 70% of the participants were physically active according to the WHO's recommendations (70.2%), with the prevalence being higher than those found in other similar studies on Chinese university students (in which PA levels were also self-reported).[26] Increased PA has been reported in several recent studies as a result of the global PA promotion campaign.[27] In the past decades, the Chinese government has actively promoted PA. Our results may also reflect its positive effect on university students. Nevertheless, individuals often over-report their PA levels because it is a socially desirable behaviour.[28] We could not avoid this possibility, which might have resulted in overestimated PA levels of the participants. However, it may not be reasonable to assume that students with PARI would be more (or less) likely to over-report their PA than non-PARI ones. Thus, the estimates of the elevated participation of PA might still be robust.

We found that PA involvements were positively and significantly related with PARI occurrences—the frequency of sports and leisure-time VPA participation was the predominant factor. Highly consistent results have also been found on the elevated risks of some training characteristics for injuries, including high frequency, high vigorous intensity and long duration.[25 29] These should receive sufficient attentions from researchers and policy-makers when promoting PA among the public. Unfortunately, the WHO's information sheet on recommended PA (commonly disseminated to the public) does not provide any suggestion on frequency and duration for safety (nor does the WHO's full report).[4] The full report does state that 'activity-related adverse events such as musculoskeletal injuries are common but are usually minor especially for moderate-intensity activities such as walking.'[4] However, PARI may not be minor if we fully considerate both short-term and long-term adverse effects on health.[11 30] For instance, acute PARI is the largest proportion of non-fatal injuries, which is a top health

problem among young adults.[9] Chronically, joint injury (a major type of PARI) was found to increase the likelihood of osteoarthritis by 2.8-fold to 6.4-fold.[30] Osteoarthritis is the most common single cause of disability in the elderly. It affects about 15% of the entire population.[31]

There are several recommendations related to frequency and duration of exercise. For example, the American Diabetes Association suggests a frequency of MVPA at least 3 days per week with a non-exercise interval less than 2 consecutive days. Resistance exercise is recommended at least twice per week on non-consecutive days.[32] A training frequency of 3 to 5 days per week at an intensity level of 55/65% to 90% of maximum heart rate and a duration of 20–60 min of continuous or intermittent aerobic activity are recommended for developing and maintaining fitness effects.[33] However, none of these recommendations are from a safety perspective. Obviously, there is a knowledge gap in the safe frequency and duration of PA (in particular VPA), which warrants further study. In addition, safety issues should be emphasised and disseminated to the public along with the recommendations.

In this study, year 1 students, sports team members and those with insufficient sleep duration were more likely to suffer from PARI. The higher injury among year 1 students might be because they do more PA after being released from the heavy academic burdens undertaken in secondary schools and becoming independent from their parents.[16] They are younger than those in years 2 and 3. Thus, the adventurousness and impulsiveness inherent in youth might also play a role.[34 35] Compared with their counterparts, sports team members had a twofold greater possibility of suffering from PARI. This further proves that we may not simply apply the results observed from collegiate athletes to the general students. Insufficient sleep duration may increase the risk for PARI via physical fatigue and impaired cognitive performance, such as cognitive slowing and decreased vigilance.[36]

To our surprise, we found that the PARI incidence rate among Shantou students was twice as high as that in the other two cities (33.9% vs 12.3% and 15.0%), which could not be explained by all variables in this study, including study year, sports team members, PA indicators and sleep duration (see online supplementary tables S4 and S5). In addition, the incidence rates of the two participating universities in Shantou were also similarly high (30.1% and 35.4%, respectively). Both Shantou and Hong Kong are located in southern China. They have a similar climate and its related sports habits while Jinan is a northern city. Thus, it may be impossible that the large between-city difference in PARI was attributable to the geographical factors. Though the sports infrastructure of a university might impact PARI among the students, both Shantou and Jinan belong to Mainland China where sports facilities and surveillance systems across universities are similar. We therefore ruled out this possibility. Economically, Shantou is the least developed of the three cities.[37] The less-developed urban environments outside of the universities might have contributed to its higher PARI incidence rate. Unfortunately, we could not provide supporting evidence for this hypothesis because we did not collect detailed information about the location of PARI incidents; however, the possible reasons underlying the large between-city PARI differences should be studied.

Several limitations should be considered. First, the cross-sectional study design limits causal and temporal inferences in the risk evaluation analyses. For example, it is plausible that some injured students would rate their PA levels higher if not injured because their PA levels might have been affected by their injuries—this may have resulted in an underestimation of the PA's risk for injuries. It is also plausible that students who were more often engaged in PA would be more likely to remember their injuries because the injuries might have a greater impact on these students. This possibility may have led us to overestimate the relationship between PA levels and PARI. PA levels in this study were measured once only, and we could not explain the rationale that PARI contributes to a PA reduction. Our team is conducting a prospective cohort study to confirm these findings. Second, all information was self-reported, which may have resulted in recall bias (eg, some participants may have forgotten to report minor and earlier injury episodes) and reporting bias (eg, some participants may have over-reported their PA levels because it is a socially desirable behaviour). This limits our results somewhat. Finally, we could not investigate activity-specific PARI occurrences because the GPAQ does not capture the specific activities that the participants undertook.

## CONCLUSIONS

We concluded that PARI was common among university students in China. The frequency of sports and leisure-time VPA participation was most strongly associated with PARI among all PA variables. In addition, males, Shantou students, year 1 students, sports team members and those with insufficient sleep were more vulnerable to PARI. Further prospective studies that adopt both objective and subjective PA measurements are warranted to confirm our findings. Nevertheless, there is an urgent call for actions to prevent university students from PARI with a full consideration of the possible risk factors involved. Safety issues should also be involved and emphasised when promoting PA among the public.

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