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## Differences in physical activity-related injuries between male and female university students in China: a multicenter population-based study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-040865
Article Type:	Original research
Date Submitted by the Author:	25-May-2020
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Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, SPORTS MEDICINE

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4 1 **Differences in physical activity-related injuries between male and female**  
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## 30 Abstract

31 **Objectives:** Data on the problem of physical activity-related injuries (PARI) in university  
32 students and the risk factors for PARI among different genders are scant. We conducted a  
33 multi-center population-based study to explore gender-specific risk factors for PARI among  
34 Chinese university students.

35 **Design:** Population-based study

36 **Participants:** A total of 5341 students graded 1-3 from eight universities in four Chinese  
37 cities were selected to complete the online questionnaire during March and April 2017,  
38 including socio-demographic characteristics, physical activity (PA) involvement, sleep  
39 duration, sedentary behavior, and PARI experience in the past 12 months.

40 Main outcome measures: PARI during the past 12 months period.

41 **Results:** Of 5341 participants, 1293 suffered from at least one PARI in the past 12 months,  
42 with an overall rate of 24.2% (males: 26.2%, females: 23.2%). Over half of the injured  
43 (57.3%) experienced a withdrawal time of PA and nearly two-fifths (39.6%) required medical  
44 attention. Irrespectively of gender, Shantou and Xi'an students, sports team members, and  
45 those engaged in sports and leisure-time vigorous-intensity PA (VPA) with higher frequency  
46 were more likely to suffer from PARI. Those male students who participated in sports and  
47 leisure-time VPA with higher duration had a greater likelihood to sustain PARI while having  
48 a chronic condition and involving in sports and leisure-time moderate-intensity PA with  
49 higher frequency and longer duration were the potential contributors to PARI for females.

50 **Conclusions:** The occurrence of PARI and its risk factors differed in different genders, which  
51 provides a direction to develop targeted and effective gender-specific preventative programs  
52 to protect Chinese university students from PARI.

## 53 Strengths and limitation of this study

- 54 ● To our knowledge, this cross-sectional study is the first to explore the gender-specific  
55 risk factors associated with injuries resulting from PA participation in Chinese university  
56 students.
- 57 ● Data was self-reported, which is subject to reporting bias and recall bias.
- 58 ● The nature of the cross-sectional study limits us from drawing the cause-and-effect  
59 relationship between PARI outcome and the potential risk factors.

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4 60 ● Nearly two-thirds of the study samples were female students, which may limit the  
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6 61 generalizability and representativeness.  
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8 62 ● We did not compare acute and overuse injuries, which may deviate the association  
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10 63 analysis in this study.  
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## 64 Introduction

65 Participation in physical activity (PA) benefits our well-being. It is of help to lower the  
66 risk of non-communicable diseases, increase bone density and muscular fitness, delay the  
67 onset of mental diseases, and maintain a healthy weight <sup>1-3</sup>. In recognition of these  
68 well-known benefits of regular PA participation, member states of the World Health  
69 Organization (WHO) agreed to a 10% relative reduction in the prevalence of insufficient PA  
70 by 2025 <sup>4</sup>. Meanwhile, there exist several recommendations on PA participation for public  
71 health <sup>5-7</sup>.

72 The promotion of PA participation is a public health priority, however, a potential  
73 problem of participation in PA—physical activity-related injury (PARI) needs to be  
74 emphasized. It has been well documented in different genders or age groups and various types  
75 of PAs <sup>8-10</sup>. Moreover, earlier reports identified PARI as the major health threat to  
76 school-aged adolescents and young adults in many countries <sup>5,11</sup>. This means that successful  
77 and effective prevention programs for PARI have great inherent public health gains <sup>12</sup>. To  
78 develop such preventative measures, we first need descriptive injury epidemiology describing  
79 the characteristics and etiology of injuries <sup>13</sup>. Based on previous reports, most injuries  
80 occurred outdoor and involved lower limbs, and sprains and strains were the major types of  
81 PARI <sup>10,14</sup>. Additionally, individual-related indicators like age, grade, body mass index (BMI),  
82 PA level, exercise behaviors, and family status, and environmental factors such as weather,  
83 exercise facilities, and playgrounds were associated with PARI episodes <sup>9,11,15-18</sup>.  
84 Furthermore, earlier studies revealed that there were marked gender differences in the  
85 occurrence and severity of PARI <sup>10,15</sup>. Nevertheless, the evidence in different gender-specific  
86 risk factors for PARI is scarce.

87 In China, students in universities might be more physically active than those in  
88 secondary and primary school due to their free from heavy academic pressure for college  
89 admission <sup>10</sup>. Besides that, most students have to live in the school dormitory, so they are  
90 independent of their guardians and have more free time to take part in relatively risky  
91 activities that are not allowed before <sup>19</sup>. This indicates that university students might have a  
92 higher susceptibility to sustain PARI. However, compared with children and adolescents,  
93 recent reviews on the problem of PARI in university students noted that epidemiological data

94 on this topic are scant <sup>10,19</sup>.

95 Collectively, the purpose of this cross-sectional study was to explore the gender-specific  
96 risk factors associated with injuries resulting from PA participation in Chinese university  
97 students via a multi-center survey.

## 98 **Methods**

### 99 **Study participants**

100 Selected by the method of cluster random sampling, a total of 5628 eligible students  
101 graded 1 to 3 from eight universities (five comprehensive universities and three normal  
102 universities) in four Chinese cities (namely Shantou [Guangdong province], Jinan [Shandong  
103 province], Xi'an [Shanxi province] and Nanchang [Jiangxi province]) were invited to  
104 participate in the survey during March and April 2017. Informed consent forms were obtained  
105 from the potential study participants, with a response rate of 94.9% (n=5341). The purpose of  
106 this study was orally explained by the authors and the quick response code or hyperlink of our  
107 questionnaire was sent to all consenting students.

108 This study was strictly carried out according to the Declaration of Helsinki and approved  
109 by the Shantou University Medical College Ethics Committee (SUMC-2016-22), Xi'an  
110 Innovation College of Yan'an University Ethics Committee, Jiangxi Teachers College Ethics  
111 Committee, and Shandong University Ethics Committee (20161101).

### 112 **Data collection**

113 Wenjuanxing software (Sojump, Changsha, China) was applied as the online platform  
114 for survey. All participants were recruited in nominated classes. The self-administrated online  
115 questionnaire was comprised of socio-demographic characteristics, PA participation, sleep  
116 duration, sedentary behavior, and PARI episodes that occurred in the past 12 months.

117 Socio-demographic characteristics of the participants included university, study major,  
118 grade, gender, age, residence type, any diagnosed chronic disease/symptom, and sports team  
119 membership.

120 The Global Physical Activity Questionnaire (GPAQ) Chinese version was used to  
121 evaluate participants' habitual PA participation during a typical week in the past 12 months <sup>20</sup>.  
122 As one of the most commonly used PA questionnaires, it showed good reliability and validity  
123 in the previous study (Spearman's rho=0.81) <sup>21</sup> and sound reliability in our study (Cronbach's



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4 124  $\alpha=0.721$ ). The GPAQ collects the frequency (days per week) and duration (average minutes  
5 125 each day) of moderate-intensity PA (MPA) and vigorous-intensity PA (VPA) in three  
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7 126 domains: domestic/work/study, transportation (MPA only), and sports and leisure-time  
8  
9 127 activities. The PA volume (total cumulative minutes per week) was then calculated by  
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11 128 multiplying the frequency and duration of each kind of PA (MPA and VPA) in each domain.  
12  
13 129 Given the GPAQ does not collect information on specific PAs that students participated, all  
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15 130 students were further asked if they had any favorite PA that took part in often in the past 12  
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17 131 months. Those with a positive response were required to provide the names of activities less  
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19 132 than three.

20  
21 133 As for sedentary behavior and sleep time (including nap time), the duration (average  
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23 134 hours per day) was requested on both a typical weekday and a typical weekend respectively.  
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25 135 The daily duration in a typical week was then generated and used to classify the participants  
26  
27 136 into five groups (i.e. <4, 4 to <6, 6 to <9, 9 to <12, and  $\geq 12$  hours/day; <6, 6 to <7, 7 to <8, 8  
28  
29 137 to <9, and  $\geq 9$  hours/day respectively).

30  
31 138 PARI occurrence in the past 12 months was also collected. The definition of PARI could  
32  
33 139 be found in the earlier study<sup>22</sup> and a countable PARI episode must meet one or more of the  
34  
35 140 following consequences: the student 1) has to stop the current PA immediately and/or cannot  
36  
37 141 fully participate in the next planned PA and/or; 2) cannot go to the school the next day and/or;  
38  
39 142 3) needs to seek medical attention (e.g. from providers ranging from first aid personnel to  
40  
41 143 general physicians or physiotherapists)<sup>13,22</sup>.

#### 42 144 **Patient and Public Involvement**

43  
44 145 No patient involved.

#### 45 146 **Statistical analysis**

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48 147 All statistical analyses were performed by SPSS version 23.0 (SPSS Inc., Chicago, IL,  
49  
50 148 USA). Categorical data were described using number and percentage, while continuous data  
51  
52 149 that is normally or not normally distributed were presented as mean and standard deviation  
53  
54 150 (SD) or median and interquartile range (IQR). Chi-square tests and independent-sample *t* tests  
55  
56 151 or non-parameter tests were used to test the differences between group-between differences.  
57  
58 152 All significant variables tested by chi-square tests and independent-sample *t* tests or  
59  
60 153 non-parameter tests were included together in the multivariable logistic regression model to

154 explore the potential risk factors for PARI occurrence. The odds ratios (ORs) and 95%  
 155 confidence intervals (95% CIs) were calculated with the selection of forward (LR) manner  
 156 using the criteria of  $\alpha_{in} = 0.05$  and  $\alpha_{out} = 0.10$ . Statistical significance was set at a two-sided  $P <$   
 157 0.05.

## 158 Results

159 A total of 5341 students (males: 1790, females: 3551) participated in this study, with a  
 160 mean age of 19.60 (SD=1.27). Among the whole participants, 1293 students (24.2%)  
 161 experienced at least one PARI episode in the past 12 months, and male students had a  
 162 significantly higher injury incidence than females (26.2% [469/1790] vs. 23.2% [824/3551],  
 163  $\chi^2=5.823$ ,  $P=0.016$ ).

164 As presented in Table 1, chi-square tests revealed significant differences in the injury  
 165 episode by residence type and sports team membership for males (all  $P < 0.05$ ). For female  
 166 students, participating in a sports team, having a disease or symptom, and age affected the  
 167 occurrence of PARI (all  $P < 0.05$ ). Irrespectively of gender, both males and females in Shantou  
 168 and Xi'an had a significantly higher incidence of PARI than those in Jinan and Nanchang (all  
 169  $P < 0.05$ ).

170 Table 1 Comparison of socio-demographics in participants with PARI or not by gender

Characteristics	Males (n=1790)		$\chi^2/t^*$	Females (n=3551)		$\chi^2/t^*$
	PARI (n=469) n (%)	Non-PARI (n=1321) n (%)		PARI (n=824) n (%)	Non-PARI (n=2727) n (%)	
City			157.365 <sup>1</sup>			177.880 <sup>1</sup>
Shantou	230 (40.4)	339 (59.6)		490 (31.5)	1064 (68.5)	
Jinan	58 (17.2)	279 (82.8)		98 (10.5)	832 (89.5)	
Xi'an	76 (46.1)	89 (53.9)		161 (29.3)	388 (70.7)	
Nanchang	105 (14.6)	614 (85.4)		75 (14.5)	443 (85.5)	
Grade			0.873			0.658
Year 1	262 (26.3)	734 (73.7)		328 (23.8)	1050 (76.2)	
Year 2	126 (25.5)	369 (74.5)		261 (22.4)	902 (77.6)	
Year 3	81 (27.1)	218 (72.9)		235 (23.3)	775 (76.7)	
Residence type			6.886 <sup>1</sup>			0.249
Dormitory	325 (25.8)	935 (74.2)		567 (22.6)	1943 (77.4)	
Home	142 (28.3)	359 (71.7)		244 (24.6)	746 (75.4)	
Other	2 (6.9)	27 (93.1)		13 (25.5)	38 (74.5)	
Sports team member			39.753 <sup>3</sup>			37.292 <sup>3</sup>
No	354 (23.4)	1159 (76.6)		697 (21.8)	2504 (78.2)	
Yes	115 (41.5)	162 (58.5)		127 (36.3)	223 (63.7)	
Chronic disease/symptom			1.703			12.111 <sup>2</sup>
No	441 (26.6)	1218 (73.4)		767 (22.7)	2618 (77.3)	
Yes	28 (21.4)	103 (78.6)		57 (34.3)	109 (65.7)	
Age ( $\bar{x} \pm s$ , years)	19.52 $\pm$ 1.30	19.40 $\pm$ 1.32	1.857	19.77 $\pm$ 1.27	19.66 $\pm$ 1.27	2.228 <sup>1</sup>

171 \* Categorical variables (all variables except for age) were tested by Pearson chi-square tests, and continuous variable (i.e.  
 172 age) was tested by independent-sample  $t$  tests; <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury.

173 The majority of students participated in transport-related PA (79.5%) and sports and  
 174 leisure-time PA (58.8%). Male students with PARI had significantly higher frequency or  
 175 longer duration of MPA or VPA in three domains (all  $P < 0.01$ ). Similarly, such significant  
 176 differences could be found between PARI and non-PARI groups for females except for the  
 177 frequency and duration of transport-related PA (all  $P < 0.01$ ). For females, students with  
 178 different sleep duration significantly differed in PARI experience ( $P < 0.05$ ), while sedentary  
 179 behavior had an impact on the occurrence of PARI among male students ( $P < 0.01$ ) (Table 2).  
 180 The means and SDs for all PA indicators are available in Supplementary Table S1.

181 Table 2 Comparison of life-style variables in participants with PARI or not among different genders

Characteristics	Males (n=1790)			Females (n=3551)		
	PARI (n=469) median, IQR	Non-PARI (n=1321) median, IQR	$\chi^2/Z^*$	PARI (n=824) median, IQR	Non-PARI (n=2727) median, IQR	$\chi^2/Z^*$
Domestic/work/study						
VPA						
Frequency, day/week	1 (0, 2)	0 (0, 1)	5.392 <sup>3</sup>	0 (0, 075)	0 (0, 0)	4.624 <sup>3</sup>
Duration, min/day	10 (0, 30)	0 (0, 15)	5.767 <sup>3</sup>	0 (0, 7.5)	0 (0, 0)	4.818 <sup>3</sup>
MPA						
Frequency, day/week	2 (0, 3)	1 (0, 3)	4.235 <sup>3</sup>	1 (0, 3)	0 (0, 2)	5.197 <sup>3</sup>
Duration, min/day	30 (0, 40)	12 (0, 30)	6.593 <sup>3</sup>	10 (0, 30)	0 (0, 30)	5.341 <sup>3</sup>
Transportation						
Frequency, day/week	5 (0, 7)	5 (0, 7)	2.998 <sup>2</sup>	5 (2, 7)	5 (1, 7)	1.816
Duration, min/day	30 (15, 60)	30 (0, 45)	4.156 <sup>3</sup>	30 (12.75, 45)	30 (10, 45)	0.697
Sports and leisure time						
VPA						
Frequency, day/week	1 (0, 2)	0 (0, 1)	9.538 <sup>3</sup>	0 (0, 1)	0 (0, 1)	3.130 <sup>2</sup>
Duration, min/day	20 (0, 60)	0 (0, 20)	10.402 <sup>3</sup>	0 (0, 20)	0 (0, 10)	3.050 <sup>2</sup>
MPA						
Frequency, day/week	2 (0, 3)	1 (0, 2)	5.545 <sup>3</sup>	1 (0, 2)	0 (0, 2)	5.644 <sup>3</sup>
Duration, min/day	20 (0, 40)	10 (0, 30)	7.235 <sup>3</sup>	10 (0, 30)	0 (0, 30)	5.485 <sup>3</sup>
Sleep duration, n (%)			4.055			13.345 <sup>1</sup>
<6 hours/day	33 (20.4)	129 (79.6)		61 (27.0)	165 (73.0)	
6 to <7 hours/day	93 (27.2)	249 (72.8)		145 (28.2)	370 (71.8)	
7 to <8 hours/day	184 (26.4)	513 (73.6)		305 (20.9)	1151 (79.1)	
8 to <9 hours/day	126 (27.9)	325 (72.1)		225 (22.8)	764 (77.2)	
≥9 hours/day	33 (24.1)	104 (75.9)		88 (24.1)	277 (75.9)	
Sedentary behavior, n (%)			18.567 <sup>2</sup>			7.094
<4 hours/day	173 (21.3)	638 (78.7)		269 (24.0)	853 (76.0)	
4 to <6 hours/day	42 (28.4)	106 (71.6)		72 (28.9)	177 (71.1)	
6 to <9 hours/day	40 (30.3)	92 (69.7)		71 (24.0)	225 (76.0)	
9 to <12 hours/day	62 (30.0)	145 (70.0)		89 (20.1)	354 (79.9)	
≥12 hours/day	152 (30.9)	340 (69.1)		323 (22.4)	1118 (77.6)	

182 \* Categorical variables (i.e. sleep duration and sedentary behavior) were tested by Pearson chi-square tests, and continuous  
 183 variables (except for sleep duration and sedentary behavior) were tested by Mann-Whitney tests or independent-sample  $t$  tests  
 184 (the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA,  
 185 vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

186 Based on the significant variables tested by chi-square tests and independent-sample  $t$   
 187 tests or Mann-Whitney tests, a multivariable logistic regression model was used to estimate  
 188 ORs and corresponding 95% CIs for PARI among male students. As shown in Table 3, male

189 students in Shantou and Xi'an had higher odds of sustaining PARI (OR=3.525 and 4.571).  
 190 Sports team members were more likely to suffer from PARI (OR=1.819, 95% CI:  
 191 1.349-2.453) in comparison with their counterparts. Also, the frequency and duration of sports  
 192 and leisure-time VPA were significantly associated with PARI (OR=1.129 and 1.007  
 193 respectively).

194 Table 3 Multivariable logistic regression to estimate risk factors for PARI among males

Variables	B	S.E.	OR	95% CI	P-value
City					
Shantou	1.260	0.140	3.525	2.680-4.636	<0.001
Jinan	-0.060	0.186	0.941	0.653-1.356	0.745
Xi'an	1.520	0.194	4.571	3.124-6.687	<0.001
Nanchang			1 (ref.)		
Sports team member					
No			1 (ref.)		
Yes	0.598	0.152	1.819	1.349-2.453	<0.001
Sports and leisure-time VPA					
Frequency, day/week	0.121	0.040	1.129	1.043-1.221	0.003
Duration, min/day	0.007	0.002	1.007	1.004-1.011	<0.001

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

196 Similarly, a multivariable logistic regression analysis was also performed to estimate the  
 197 odds of potential factors for PARI among females, and the results of all significant variables  
 198 kept in the final model were displayed in Table 4. Female students in Shantou and Xi'an were  
 199 more vulnerable to experience PARI (OR=2.710 and 2.456 respectively). Those female  
 200 students who participated in a sports team and had a chronic condition would sustain more  
 201 PARI episodes (OR=1.950 and 1.834 respectively). Moreover, higher frequency of sports and  
 202 leisure-time VPA and MPA (OR=1.079 and 1.091 respectively) and longer duration of sports  
 203 and leisure-time MPA increased the possibility to suffer from PARI (OR=1.003).

204 Table 4 Multivariable logistic regression to estimate risk factors for PARI among females

Variables	B	S.E.	OR	95% CI	P-value
City					
Shantou	0.997	0.139	2.710	2.064-3.559	<0.001
Jinan	-0.494	0.169	0.868	0.674-1.092	0.355
Xi'an	0.898	0.159	2.456	1.796-3.357	<0.001
Nanchang			1 (ref.)		
Sports team member					
No			1 (ref.)		
Yes	0.668	0.128	1.950	1.516-2.507	<0.001
Chronic disease/symptom					
No					
Yes	0.607	0.178	1.834	1.293-2.602	0.001
Sports and leisure-time VPA					
Frequency, day/week	0.076	0.034	1.079	1.011-1.153	0.034
Sports and leisure-time MPA					
Frequency, day/week	0.087	0.026	1.091	1.036-1.149	0.001
Duration, min/day	0.003	0.001	1.003	1.001-1.006	0.016

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

206 With regards to favorite activities, nearly three-fifths (58.9%, n=3147) of students had at  
 207 least one PA that they liked and often participated during the past 12-month periods. Running,  
 208 badminton, basketball, bicycling, table tennis, and swimming were the primary activities that  
 209 students participated in the past 12 months. There existed a difference in PA engagement.  
 210 Males favored running, basketball, badminton, table tennis, bicycling, and soccer, while  
 211 females (n=2040) preferred to running, badminton, bicycling, basketball, table tennis, and  
 212 swimming (Supplementary Table S2).

213 The number and consequences of PARI reported by 1293 injured students before and  
 214 after gender stratification were shown in Table 5. During the past 12-month periods, more  
 215 than half (n=666, 51.5%) of the injured participants experienced one PARI episode and over  
 216 one-fifth (n=296, 22.9%) suffered from PARI at least three times (i.e. multiple injuries). Male  
 217 students had a greater tendency to sustain multiple injuries and females had a larger portion to  
 218 experience PARI one time. Over half of the injured (57.3%) experienced a withdrawal time of  
 219 PA and nearly two-fifths (39.6%) received medical treatment due to PARI. A significant  
 220 difference was observed in a break from PA participation between both genders, with male  
 221 injured students being more likely to experience inactivity (64.2% vs. 53.4%,  $P<0.001$ ).

222 Table 5 Number and consequences of PARI among injured university students

Characteristics	Total (N=1293), n (%)	Males (N=469), n (%)	Females (N=824), n (%)	$\chi^2$	P-value
Number of PARI				35.494	<0.001
1	666 (51.5)	198 (42.2)	468 (56.8)		
2	331 (25.6)	124 (26.4)	207 (25.1)		
≥3	296 (22.9)	147 (31.3)	149 (18.1)		
Consequences of PARI					
Stop quickly and/or cannot participate in the next PA				14.199	<0.001
No	552 (42.7)	168 (35.8)	384 (46.6)		
Yes	741 (57.3)	301 (64.2)	440 (53.4)		
Absence of class				0.306	0.580
No	984 (76.1)	361 (77.0)	623 (75.8)		
Yes	309 (23.9)	108 (23.0)	201 (24.2)		
Seek medical attention				1.606	0.205
No	781 (60.4)	294 (62.7)	487 (59.1)		
Yes	512 (39.6)	175 (27.3)	337 (40.9)		

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

## 224 Discussion

225 As one of the top health threats to school-aged adolescents and young adults in the  
 226 majority of countries <sup>5,11</sup>, PARI leads to not only great medically financial burdens on  
 227 families and society as a whole but other indirect negative impacts on individuals like

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4 228 psychological fear and physical discomfort<sup>23,24</sup>. More importantly, PARI causes perception  
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6 229 and fear of injury risk or even hinder students from PA participation<sup>25</sup>, which could be a  
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8 230 barrier for them to improve and maintain individual health. In this study, we found that  
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10 231 appropriately one out of four (24.2%) university students experienced at least one PARI  
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12 232 episode in the past 12 months. Additionally, more than half of the injured students had a  
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14 233 withdrawal time of PA participation and nearly two-fifths of cases required medical attention.  
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16 234 These findings indicated that PARI was rather common and had a great adverse effect on  
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18 235 Chinese university students. In contemporary China, about 48% of secondary students could  
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20 236 be admitted to different levels of universities<sup>26</sup>. The One-Percent National Sample Census in  
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22 237 2015 revealed that the number of current university students hit 39.7 million<sup>26</sup>. This suggests  
23  
24 238 that the problem of PARI among Chinese university students needs to be urgently highlighted  
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26 239 and effective injury-prevention programs should be developed when we take PA promotion as  
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28 240 a public health priority.

29 241 In line with other findings reported elsewhere<sup>27,28</sup>, we found that male students had a  
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31 242 significantly higher PARI incidence than their female counterparts. Several reasons may  
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33 243 underline this gender difference. Firstly, males are prone to be more physically active than  
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35 244 females<sup>29</sup>. This could be supported by our data in terms of different PA indicators in Table 2.  
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37 245 Secondly, males are inclined to take part in more competitive high-intensity activities like  
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39 246 basketball and football that involves a higher rate of contact, jumping, and sprinting, which  
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41 247 are commonly associated with a higher incidence of injuries<sup>30,31</sup>. The difference in favorite  
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43 248 activities between males and females in this study is aligned with this explanation. Even in the  
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45 249 same activity, males tend to have higher competitiveness and resistance with lower individual  
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47 250 safety awareness<sup>32</sup>. This could contribute to their higher incidence of PARI to some extent.  
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49 251 Thirdly, great motivation, impulsiveness, and self-determination inherent in male students  
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51 252 may also play a role<sup>33</sup>. On one hand, these gender-specific characteristics could affect the  
52  
53 253 occurrence of PARI; on the other hand, these might influence the analysis of potential risk  
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55 254 factors for PARI as well. If a risk factor has different impacts on PARI for various genders, it  
56  
57 255 would be quite hard to find the real association when we analyzed the data together<sup>34</sup>. We,  
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59 256 therefore, explore possible contributors to PARI for males and females respectively to avoid  
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257 this problem.

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4 258 Being physically inactive is harmful to our individual well-being<sup>5</sup>, so is being too much  
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6 259 active. Our study revealed that there was a positive significant association between PARI  
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8 260 occurrence and the frequency of sports and leisure-time VPA participation in both genders,  
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10 261 and a longer duration of sports and leisure-time VPA involvement could increase the risk of  
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12 262 PARI for male students. This is highly consistent with other findings that higher intensity,  
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14 263 higher frequency, and longer duration of PA participation contributed to an elevated risk of  
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16 264 PARI event<sup>32,35</sup>. Furthermore, we found that the frequency and duration of sports and  
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18 265 leisure-time MPA engagement was positively associated with the occurrence of PARI for  
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20 266 females. We should place great emphasis on the above results, especially when we promote a  
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22 267 physically active lifestyle for the public. Otherwise, the benefits of PA participation would be  
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24 268 comprised.

25 269 In comparison with their counterparts, sports team members had a higher likelihood to  
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27 270 suffer from PARI among both males (OR=1.819) and females (OR=1.950). This parallels  
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29 271 with previous literature<sup>9,36</sup>, irrespectively of age group. Generally, students participating in  
30  
31 272 sports teams would spend lots of their time on one certain kind of activity, which often  
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33 273 associates with the high risk of overuse injuries like tendinopathies, bursitis, and stress  
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35 274 fracture<sup>37,38</sup>. Moreover, the activities that sports team members participated are usually  
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37 275 structured and their focus is often on improving individual performance<sup>36</sup>. In this way, they  
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39 276 generally have a higher frequency and intensity and longer duration of PA participation<sup>36</sup>.  
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41 277 This further supports that being too much physically active harms individual health. Thus, we  
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43 278 should take this particularly vulnerable population into consideration and effective  
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45 279 preventative measures should be introduced.

46 280 In this study, living with a chronic condition was identified as the potential determinant  
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48 281 of PARI for females. Amongst the whole study sample, nearly 5.7% had a chronic disease  
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50 282 (i.e. near-sightedness). The exact reasons for the association between the chronic condition  
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52 283 and PARI occurrence in female students in the present study are unknown. A possible partial  
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54 284 explanation may be the health issue may affect their PA participation and expose them to  
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56 285 more injuries when undertaking PA. This specific contributor has implications for the  
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58 286 identification of injury mechanisms and interventions in injury prevention among female  
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60 287 students.

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4 288 Surprisingly, our study revealed that there was a difference in the occurrence of PARI  
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6 289 among university students—both males and females in Shantou and Xi'an had markedly  
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8 290 higher PARI incidence than those in Jinan and Nanchang. However, this discrepancy could  
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10 291 not be explained by all potential variables in our study (Supplementary Tables S3 and S4).  
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12 292 Given that four study cities locate in different parts of China and they have various climate,  
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14 293 we assumed that the large between-city difference in the incidence rate of PARI may be  
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16 294 attributed to the geographical factors. PA infrastructure may affect the occurrence of PARI for  
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18 295 students, but all these study cities belong to Mainland China, sharing similar facilities and  
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20 296 surveillance systems. We thereby excluded this possibility. Also, the urban environments out  
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22 297 of the universities might be attributable to this difference, but we could not provide related  
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24 298 evidence for this hypothesis due to the absence of where these injuries occurred. Collectively,  
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26 299 the reasons for the between-city PARI difference needed to be studied further.

27 300 Our study is influenced by several limitations. First, data collection was through a  
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29 301 structured self-reported questionnaire, which would lead to report and recall bias<sup>39</sup>. For  
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31 302 example, students might not have reported accurately their PARI experiences, in particular the  
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33 303 minor and earliest injuries. However, previous studies noted that participants were able to  
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35 304 correctly indicate whether they had been injured or not during the past 12-month periods<sup>40</sup>.  
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37 305 Meanwhile, although the good reliability and validity of GPAQ, we could not fully preclude  
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39 306 the possibility of the over-reported PA exposure time. Despite this drawback, the use of  
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41 307 self-report is a more practical, feasible, and cost-effective way that allows us to carry out a  
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43 308 multi-center survey with such a large sample size. Second, the nature of the cross-sectional  
44  
45 309 study limits us from drawing the cause-and-effect relationship between PARI outcome and  
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47 310 the potential risk factors in this study. Their associations are still warranted to be proven  
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49 311 further by a prospective cohort study. Third, nearly two-thirds of the study samples were  
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51 312 female students, which may limit the generalizability and representativeness of our findings.  
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53 313 Fourth, we did not compare acute and overuse injuries—two injury types with different injury  
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55 314 mechanisms, which may deviate the analysis in the association between PARI and its  
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57 315 potential contributors. Thus, future studies should take these limitations into account to better  
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59 316 reflect the characteristics and risk factors of PARI among university students.

## 317 **Conclusion**



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4 318 With an overall incidence rate of 24.2%, PARI was not uncommon among Chinese  
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6 319 university students. Different genders differed in the occurrence of PARI (males: 26.2%,  
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8 320 females: 23.2%) and were affected by various potential risk factors. For males, those who  
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10 321 were Shantou and Xi'an students, were sports team members, and participated in sports and  
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12 322 leisure-time VPA with higher frequency and longer duration were more likely to suffer from  
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14 323 PARI. For females, studying in Shantou and Xi'an, participating in a sports team, having  
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16 324 chronic disease or symptom, engaging in sports and leisure-time VPA with higher frequency,  
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18 325 and taking part in sports and leisure-time MPA with higher frequency and longer duration  
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20 326 were the potential contributors to PARI. These findings provide a direction to develop  
21  
22 327 targeted gender-specific prophylactic interventions to reduce PARI and to maximize the  
23  
24 328 benefits of PA participation among university students in China.

### 25 329 **Acknowledgments**

26  
27 330 This work was supported by the National Natural Science Foundation of China [grant  
28  
29 331 number 31640038]. The sponsor had no role in study design, data collection, analysis and  
30  
31 332 interpretation, preparation and revision of the manuscript, and decision to submit the article  
32  
33 333 for publication.

### 34 334 **Authors' contributions**

35  
36 335 LPL, YG, and CXJ conceived and designed the study; WCC, PYY, XFY, LJG, and  
37  
38 336 WDY collected data, WCC and SMC performed the statistical analyses, WCC and SMC  
39  
40 337 drafted the manuscript. All authors have read and approved the final version of the  
41  
42 338 manuscript, and agree with the order of the presentation of the authors.

### 43 339 **Competing interests**

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45  
46 340 None declared.  
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## Supplementary materials

Supplementary Table S1 Comparison of life-style variables in participants with PARI or not by gender

Characteristics	Males (n=1790)			Females (n=3551)		
	PARI (n=469) x±s	Non-PARI (n=1321) x±s	$\chi^2/Z^*$	PARI (n=824) x±s	Non-PARI (n=2727) x±s	$\chi^2/Z^*$
Domestic/work/study						
VPA						
Frequency, day/week	1.29±1.75	0.84±1.44	4.971 <sup>3</sup>	0.58±1.26	0.38±1.03	4.271 <sup>3</sup>
Duration, min/day	24.83±46.12	14.82±34.09	4.305 <sup>3</sup>	11.85±36.14	5.80±17.31	4.652 <sup>3</sup>
MPA						
Frequency, day/week	2.10±1.96	1.72±1.95	3.630 <sup>3</sup>	1.66±1.93	1.32±1.82	4.522 <sup>3</sup>
Duration, min/day	31.54±42.39	20.51±29.17	5.213 <sup>3</sup>	24.74±48.56	16.42±33.47	4.602 <sup>3</sup>
Transportation						
Frequency, day/week	4.17±2.64	3.73±2.80	2.998 <sup>2</sup>	3.97±2.60	3.78±2.67	1.816
Duration, min/day	42.66±49.36	32.14±35.69	4.349 <sup>3</sup>	37.59±48.80	34.64±45.06	1.549
Sports and leisure-time						
VPA						
Frequency, day/week	1.56±1.70	0.89±1.52	7.448 <sup>3</sup>	0.71±1.40	0.53±1.20	3.401 <sup>3</sup>
Duration, min/day	34.24±40.90	16.65±31.36	8.471 <sup>3</sup>	13.42±29.23	9.73±22.61	3.330 <sup>3</sup>
MPA						
Frequency, day/week	1.89±1.95	1.41±1.89	4.640 <sup>3</sup>	1.52±1.92	1.16±1.74	4.914 <sup>3</sup>
Duration, min/day	28.95±32.39	18.28±27.95	6.344 <sup>3</sup>	22.96±39.77	16.55±27.89	4.313 <sup>3</sup>
Sleep duration, n (%)			4.055			13.345 <sup>1</sup>
<6 hours/day	33 (20.4)	129 (79.6)		61 (27.0)	165 (73.0)	
6 to <7 hours/day	93 (27.2)	249 (72.8)		145 (28.2)	370 (71.8)	
7 to <8 hours/day	184 (26.4)	513 (73.6)		305 (20.9)	1151 (79.1)	
8 to <9 hours/day	126 (27.9)	325 (72.1)		225 (22.8)	764 (77.2)	
≥9 hours/day	33 (24.1)	104 (75.9)		88 (24.1)	277 (75.9)	
Sedentary behavior, n (%)			18.567 <sup>2</sup>			7.094
<4 hours/day	173 (21.3)	638 (78.7)		269 (24.0)	853 (76.0)	
4 to <6 hours/day	42 (28.4)	106 (71.6)		72 (28.9)	177 (71.1)	
6 to <9 hours/day	40 (30.3)	92 (69.7)		71 (24.0)	225 (76.0)	
9 to <12 hours/day	62 (30.0)	145 (70.0)		89 (20.1)	354 (79.9)	
≥12 hours/day	152 (30.9)	340 (69.1)		323 (22.4)	1118 (77.6)	

\* Categorical variables (i.e. sleep duration and sedentary behavior) were tested by Pearson chi-square tests, and continuous variables (except for sleep duration and sedentary behavior) were tested by Mann-Whitney tests or independent *t* tests (the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

Supplementary Table S2 Primary physical activities that university students participated

Activity items	Total (N=3147), n (%)	Males (N=1107), n (%)	Females (N=2040), n (%)
Basketball	790 (25.1)	462 (41.7)	329 (16.1)
Running	1778 (55.8)	548 (49.5)	1230 (60.3)
Badminton	1518 (48.2)	458 (41.4)	1060 (52.0)
Bicycling	525 (16.7)	156 (14.1)	369 (18.1)
Swimming	391 (12.4)	137 (12.4)	254 (12.5)
Table tennis	545 (17.3)	253 (22.9)	292 (14.3)
Soccer	211 (6.7)	139 (12.6)	72 (3.5)
Dance	187 (5.9)	25 (2.3)	162 (7.9)
Fitness	258 (8.2)	101 (9.1)	157 (7.7)

This table only listed those physical activities of participation rate more than 5%.

Supplementary Table S3 Comparison of all related variables among university students in different cities

Characteristics	Shantou (n=2123) median, IQR	Jinan (n=1267) median, IQR	Xi'an (n=714) median, IQR	Nanchang (n=1237) median, IQR	$\chi^2/F^*$
Domestic/work/study					
VPA					
Frequency, day/week	0 (0, 0)	0 (0, 1)	0 (0, 1)	0 (0, 1)	110.025 <sup>3</sup>
Duration, min/day	0 (0, 0)	0 (0, 10)	0 (0, 20)	0 (0, 10)	87.325 <sup>3</sup>
MPA					
Frequency, day/week	1 (0, 2)	1 (0, 3)	1 (0, 2)	0 (0, 3)	39.878 <sup>3</sup>
Duration, min/day	10 (0, 30)	15 (0, 30)	10 (0, 30)	0 (0, 30)	28.091 <sup>3</sup>
Transportation					
Frequency, day/week	5 (2, 7)	5 (2, 7)	2 (1, 5)	5 (0, 5)	63.323 <sup>3</sup>
Duration, min/day	30 (10, 40)	30 (15, 50)	30 (15, 60)	30 (0, 45)	20.658 <sup>3</sup>
Sports and leisure time					
VPA					
Frequency, day/week	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	31.724 <sup>3</sup>
Duration, min/day	0 (0, 15)	0 (0, 30)	0 (0, 20)	0 (0, 10)	41.852 <sup>2</sup>
MPA					
Frequency, day/week	0 (0, 2)	1 (0, 3)	1 (0, 2)	0 (0, 1)	112.709 <sup>3</sup>
Duration, min/day	0 (0, 30)	20 (0, 30)	10 (0, 30)	0 (0, 10)	181.535 <sup>3</sup>
	n (%)	n (%)	n (%)	n (%)	
Grade					515.974 <sup>3</sup>
Year 1	698 (32.9)	453 (35.8)	432 (60.5)	791 (63.9)	
Year 2	691 (32.5)	443 (35.0)	180 (25.2)	344 (27.8)	
Year 3	734 (34.6)	371 (29.3)	102 (14.3)	102 (8.2)	
Gender					441.055 <sup>3</sup>
Male	569 (26.8)	337 (26.6)	165 (23.1)	719 (58.1)	
Female	1554 (73.2)	930 (73.4)	549 (76.9)	518 (41.9)	
Residence type					204.376 <sup>3</sup>
Dormitory	1511 (71.2)	1050 (82.9)	393 (55.0)	816 (66.0)	
Home	587 (27.6)	210 (16.6)	309 (43.3)	385 (31.1)	
Other	25 (1.2)	7 (0.6)	12 (1.7)	36 (2.9)	
Sports team member					16.045 <sup>2</sup>
No	1861 (87.7)	1096 (86.5)	659 (92.3)	1098 (88.8)	
Yes	262 (12.3)	171 (13.5)	55 (7.7)	139 (11.2)	
Chronic disease/symptom					72.979 <sup>3</sup>
No	2028 (95.5)	1226 (96.8)	681 (95.4)	1109 (89.7)	
Yes	95 (4.5)	41 (3.2)	33 (4.6)	128 (10.3)	
Sleep duration, n (%)					193.604 <sup>1</sup>
<6 hours/day	110 (5.2)	58 (4.6)	68 (9.5)	152 (12.3)	
6 to <7 hours/day	365 (17.2)	158 (12.5)	70 (9.8)	264 (21.3)	
7 to <8 hours/day	841 (39.6)	608 (48.0)	260 (36.4)	444 (35.9)	
8 to <9 hours/day	563 (26.5)	353 (27.9)	236 (33.1)	288 (23.3)	
≥9 hours/day	244 (11.5)	90 (7.0)	80 (11.2)	89 (7.2)	
Sedentary behavior, n (%)					748.383 <sup>3</sup>
<4 hours/day	537 (25.3)	298 (23.5)	306 (42.9)	792 (64.0)	
4 to <6 hours/day	157 (7.4)	79 (6.2)	62 (8.7)	99 (8.0)	
6 to <9 hours/day	146 (6.9)	118 (9.3)	78 (10.9)	86 (7.0)	
9 to <12 hours/day	300 (14.1)	176 (13.9)	84 (11.8)	90 (7.3)	
≥12 hours/day	983 (46.3)	596 (47.0)	184 (25.8)	170 (13.7)	
Age ( $\bar{x}\pm s$ , years)	19.92±1.27	19.69±1.16	19.46±1.29	19.03±1.17	54.227 <sup>3</sup>

\* Categorical variables were tested by Pearson chi-square tests, and continuous variables were tested by one-way ANOVA tests (i.e. age and the frequency of transport-related PA) or Kruskal-Wallis tests (except for age and the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

Supplementary Table S4 Comparison of all related variables among university students in different cities

Characteristics	Shantou (n=2123) $\bar{x}\pm s$	Jinan (n=1267) $\bar{x}\pm s$	Xi'an (n=714) $\bar{x}\pm s$	Nanchang (n=1237) $\bar{x}\pm s$	$\chi^2/F^*$
Domestic/work/study					
VPA					
Frequency, day/week	0.49±1.21	0.65±1.36	0.69±1.37	0.71±1.27	110.025 <sup>3</sup>
Duration, min/day	9.54±30.39	11.95±26.86	14.55±33.39	8.89±27.25	87.325 <sup>3</sup>
MPA					
Frequency, day/week	1.37±1.80	1.39±1.82	1.50±1.81	1.56±1.85	39.878 <sup>3</sup>
Duration, min/day	22.04±46.98	20.96±28.38	21.26±34.46	14.97±19.79	28.091 <sup>3</sup>
Transportation					
Frequency, day/week	4.19±2.68	4.19±2.72	2.96±2.45	3.35±2.64	63.323 <sup>3</sup>
Duration, min/day	33.48±37.86	36.06±36.29	45.62±73.68	31.18±36.82	20.658 <sup>3</sup>
Sports and leisure time					
VPA					
Frequency, day/week	0.66±1.33	0.91±1.59	0.72±1.32	0.69±1.32	31.724 <sup>3</sup>
Duration, min/day	13.43±28.85	18.12±30.86	16.68±32.85	9.92±22.76	41.852 <sup>2</sup>
MPA					
Frequency, day/week	1.29±1.79	1.73±2.03	1.38±1.77	1.00±1.67	112.709 <sup>3</sup>
Duration, min/day	19.49±31.62	25.21±39.45	21.99±35.78	10.32±19.76	181.535 <sup>3</sup>
Age (years)	19.92±1.27	19.69±1.16	19.46±1.29	19.03±1.17	54.227 <sup>3</sup>
	n (%)	n (%)	n (%)	n (%)	
Grade					515.974 <sup>3</sup>
Year 1	698 (32.9)	453 (35.8)	432 (60.5)	791 (63.9)	
Year 2	691 (32.5)	443 (35.0)	180 (25.2)	344 (27.8)	
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9 to <12 hours/day	300 (14.1)	176 (13.9)	84 (11.8)	90 (7.3)	
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# BMJ Open

## Differences in physical activity-related injuries between male and female university students in China: a multicenter population-based study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-040865.R1
Article Type:	Original research
Date Submitted by the Author:	12-Oct-2020
Complete List of Authors:	Cai, Weicong; Shantou University Medical College, Injury Prevention Research Center; Shenzhen Center for Chronic Disease Control Chen, Shangmin; Shantou University Medical College, Injury Prevention Research Center Li, Liping; Shantou University Medical College, Injury Preventive Research Center yue, pengying; Xi'an Innovation College of Yan'an University, School of Nursing Yu, Xiaofan; Jiangxi Teachers College, School of Nursing & Optometry Gao, Lijie; Shandong University School of Public Health, Department of Epidemiology Yang, Wenda; Shantou University Medical College, Injury Prevention Research Center Gao, Yang; Hong Kong Baptist University, Department of Sport and Physical Education Jia, Cun-Xian; Shandong University School of Public Health, Department of Epidemiology
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Public health, Sports and exercise medicine
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, SPORTS MEDICINE

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4 1 **Differences in physical activity-related injuries between male and female**  
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6 2 **university students in China: a multicenter population-based study**  
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## 30 Abstract

31 **Objectives:** Data on the problem of physical activity-related injury (PARI) in university  
32 students and the risk factors for PARI among different genders are scant. We conducted a  
33 multicenter population-based study to investigate the occurrence of PARI and to explore the  
34 gender-specific risk factors for PARI among Chinese university students.

35 **Design:** Cross-sectional study

36 **Participants:** A total of 5341 students graded 1-3 from eight universities in four Chinese  
37 cities were selected to complete the online questionnaires during March and April 2017,  
38 including socio-demographic characteristics, physical activity (PA) involvement, sleep  
39 duration, sedentary behavior, and PARI experience in the past 12 months.

40 Main outcome measures: PARI during the past 12 months period.

41 **Results:** Of 5341 participants, 1293 suffered from at least one PARI in the past 12 months,  
42 with an overall incidence rate of 24.2% (males: 26.2%, females: 23.2%) and an injury risk of  
43 0.38 injuries/student/year (males: 0.48, females: 0.32). Over half of the injured (57.3%)  
44 experienced a withdrawal time of PA and nearly two-fifths (39.6%) required medical  
45 attention. Irrespectively of gender, Shantou and Xi'an students, sports team members, and  
46 those engaged in sports and leisure-time vigorous-intensity PA (VPA) with higher frequency  
47 were more likely to suffer from PARI. Those male students who participated in sports and  
48 leisure-time VPA with higher duration had a greater likelihood to sustain PARI, while having  
49 a chronic condition and involving in sports and leisure-time moderate-intensity PA with  
50 higher frequency and longer duration were the potential contributors to PARI for females.

51 **Conclusions:** The occurrence of PARI and its risk factors differed in different genders, which  
52 provides a direction to develop targeted and effective gender-specific preventative programs  
53 to protect Chinese university students from PARI.

## 54 Strengths and limitation of this study

- 55 ● To our knowledge, this cross-sectional study is the first to explore the gender-specific  
56 risk factors associated with injuries resulting from PA participation in Chinese university  
57 students.
- 58 ● Data was self-reported, which is subject to reporting bias and recall bias.
- 59 ● The nature of the cross-sectional study limits us from drawing the cause-and-effect

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4 60 relationship between PARI outcome and the potential risk factors.

5 61 ● Nearly two-thirds of the study samples were female students, which may limit the  
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7 62 generalizability and representativeness.

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9 63 ● We did not compare acute and overuse injuries, which may deviate the association  
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11 64 analysis in this study.  
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For peer review only

## 65 Introduction

66 Participation in physical activity (PA) benefits our well-being. It is of help to lower the  
67 risk of non-communicable diseases, increase bone density and muscular fitness, delay the  
68 onset of mental diseases, and maintain a healthy weight <sup>1-3</sup>. In recognition of these  
69 well-known benefits of regular PA participation, member states of the World Health  
70 Organization (WHO) agreed to a 10% relative reduction in the prevalence of insufficient PA  
71 by 2025 <sup>4</sup>. Meanwhile, there exist several recommendations on PA participation for public  
72 health <sup>5-7</sup>.

73 The promotion of PA participation is a public health priority, however, a potential  
74 problem of participation in PA—physical activity-related injury (PARI) needs to be  
75 emphasized. It has been well documented in different genders or age groups and various types  
76 of PAs <sup>8-10</sup>. Moreover, earlier reports identified PARI as the major health threat to  
77 school-aged adolescents and young adults in many countries <sup>5,11</sup>. This means that successful  
78 and effective prevention programs for PARI have great inherent public health gains <sup>12</sup>. To  
79 develop such preventative measures, we first need descriptive injury epidemiology describing  
80 the characteristics and etiology of injuries <sup>13</sup>. Based on previous reports, most injuries  
81 occurred outdoor and involved lower limbs, and sprains and strains were the major types of  
82 PARI <sup>10,14</sup>. Additionally, individual-related indicators like age, grade, body mass index (BMI),  
83 PA level, exercise behaviors, and family status, and environmental factors such as weather,  
84 exercise facilities, and playgrounds were associated with PARI episodes <sup>9,11,15-18</sup>.  
85 Furthermore, earlier studies revealed that there were marked gender differences in the  
86 occurrence and severity of PARI <sup>10,15</sup>. Nevertheless, the evidence in different gender-specific  
87 risk factors for PARI is scarce.

88 In China, students in universities might be more physically active than those in  
89 secondary and primary school due to their free from heavy academic pressure for college  
90 admission <sup>10</sup>. Besides that, most students have to live in the school dormitory, so they are  
91 independent of their guardians and have more free time to take part in relatively risky  
92 activities that are not allowed before <sup>19</sup>. This indicates that university students might have a  
93 higher susceptibility to sustain PARI. However, compared with children and adolescents,  
94 recent reviews on the problem of PARI in university students noted that epidemiological data

95 on this topic are scant <sup>10,19</sup>.

96 Collectively, the purpose of this cross-sectional study was to investigate the occurrence  
97 of PARI and to explore the gender-specific risk factors associated with injuries resulting from  
98 PA participation in Chinese university students via a multi-center survey.

## 99 **Methods**

### 100 **Study participants**

101 Selected by the method of cluster random sampling, a total of 5628 eligible students  
102 graded 1 to 3 from eight universities (five comprehensive universities and three normal  
103 universities) in four Chinese cities (namely Shantou [Guangdong province], Jinan [Shandong  
104 province], Xi'an [Shanxi province] and Nanchang [Jiangxi province]) were invited to  
105 participate in the survey during March and April 2017. Informed consent forms were obtained  
106 from the potential study participants, with a response rate of 94.9% (n=5341). The purpose of  
107 this study was orally explained by the authors and the quick response code or hyperlink of the  
108 questionnaire was sent to all consenting students.

109 This study was strictly carried out according to the Declaration of Helsinki and approved  
110 by the Shantou University Medical College Ethics Committee (SUMC-2016-22), Xi'an  
111 Innovation College of Yan'an University Ethics Committee, Jiangxi Teachers College Ethics  
112 Committee, and Shandong University Ethics Committee (20161101).

### 113 **Data collection**

114 Wenjuanxing software (Sojump, Changsha, China) was applied as the online platform  
115 for survey. All participants were recruited in nominated classes. The self-administrated online  
116 questionnaire was comprised of socio-demographic characteristics, PA participation, sleep  
117 duration, sedentary behavior, and PARI episodes that occurred in the past 12 months.

118 Socio-demographic characteristics of the participants included university, study major,  
119 grade, gender, age, residence type, any diagnosed chronic disease/symptom (such as heart  
120 disease, near-sightedness, hearing disorder, and asthma), and sports team membership.

121 The Global Physical Activity Questionnaire (GPAQ) Chinese version was used to  
122 evaluate participants' habitual PA participation during a typical week in the past 12 months <sup>20</sup>.  
123 As one of the most commonly used PA questionnaires, it showed good reliability and validity  
124 in the previous study (Spearman's rho=0.81) <sup>21</sup> and sound reliability in our study (Cronbach's

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4 125  $\alpha=0.721$ ). The GPAQ collects the frequency (days per week) and duration (average minutes  
5 126 each day) of moderate-intensity PA (MPA) and vigorous-intensity PA (VPA) in three  
6  
7 127 domains: domestic/work/study, transportation (MPA only), and sports and leisure-time  
8  
9 128 activities. The PA volume (total cumulative minutes per week) was then calculated by  
10  
11 129 multiplying the frequency and duration of each kind of PA (MPA and VPA) in each domain.  
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13 130 Given the GPAQ does not collect information on specific PAs that students participated, all  
14  
15 131 students were further asked if they had any favorite PA that took part in often in the past 12  
16  
17 132 months. Those with a positive response were required to provide the names of activities less  
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19 133 than three.

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21 134 As for sedentary behavior and sleep time (including nap time), the duration (average  
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23 135 hours per day) was requested on both a typical weekday and a typical weekend respectively.  
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25 136 The daily duration in a typical week was then generated and used to classify the participants  
26  
27 137 into five groups based on the average daily sedentary duration (i.e. <4, 4 to <6, 6 to <9, 9 to  
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29 138 <12, and  $\geq 12$  hours/day) and sleep time (i.e. <6, 6 to <7, 7 to <8, 8 to <9, and  $\geq 9$  hours/day)  
30  
31 139 respectively.

32  
33 140 PARI occurrence in the past 12 months was also collected. The definition of PARI could  
34  
35 141 be found in the earlier study<sup>22</sup> and a countable PARI episode must meet one or more of the  
36  
37 142 following consequences: the student 1) has to stop the current PA immediately and/or cannot  
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39 143 fully participate in the next planned PA and/or; 2) cannot go to the school the next day and/or;  
40  
41 144 3) needs to seek medical attention (e.g. from providers ranging from first aid personnel to  
42  
43 145 general physicians or physiotherapists)<sup>13,22</sup>.

#### 44 146 **Patient and Public Involvement**

45  
46 147 No patient involved.

#### 47 48 148 **Statistical analysis**

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50 149 All statistical analyses were performed by SPSS version 23.0 (SPSS Inc., Chicago, IL,  
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52 150 USA). The person-based incidence rates of PARI were calculated, and the injury risk was  
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54 151 calculated as the total number of injuries per number of students per year<sup>23</sup>. Categorical data  
55  
56 152 were described using number and percentage, while continuous data that is normally or not  
57  
58 153 normally distributed were presented as mean and standard deviation (SD) or median and  
59  
60 154 interquartile range (IQR). Chi-square tests and independent-sample *t* tests or non-parameter

155 tests were used to test the differences between group-between differences. All significant  
 156 variables tested by chi-square tests and independent-sample *t* tests or non-parameter tests  
 157 were included together in the multivariable logistic regression model to explore the potential  
 158 risk factors for PARI occurrence. The odds ratios (ORs) and 95% confidence intervals (95%  
 159 CIs) were calculated with the selection of forward (LR) manner using the criteria of  $\alpha_{in} = 0.05$   
 160 and  $\alpha_{out} = 0.10$ . Statistical significance was set at a two-sided  $P < 0.05$ .

## 161 Results

162 A total of 5341 students (males: 1790, females: 3551) participated in this study, with a  
 163 mean age of 19.60 (SD=1.27). Among the whole participants, 1293 students (24.2%)  
 164 experienced at least one PARI episode in the past 12 months, and male students had a  
 165 significantly higher injury incidence than females (26.2% [469/1790] vs. 23.2% [824/3551],  
 166  $P=0.016$ ). Totally, 2008 PARI episodes (males: 864, females: 1144) were reported by all  
 167 injured students. This equals an overall injury risk of 0.38 injuries/student/year, with a  
 168 significantly higher risk among males than females (0.48 vs. 0.32,  $P<0.05$ )

169 As presented in Table 1, chi-square tests revealed significant differences in the injury  
 170 occurrence by residence type and sports team membership for males (both  $P<0.05$ ). For  
 171 female students, participating in a sports team, having a disease or symptom, and age affected  
 172 the occurrence of PARI (all  $P<0.05$ ). Irrespectively of gender, both males and females in  
 173 Shantou and Xi'an had a significantly higher incidence of PARI than those in Jinan and  
 174 Nanchang (both  $P<0.05$ ).

175 Table 1 Comparison of socio-demographics in participants with PARI or not by gender

Characteristics	Males (n=1790)			Females (n=3551)		
	PARI (n=469) n (%)	Non-PARI (n=1321) n (%)	$\chi^2/t^*$	PARI (n=824) n (%)	Non-PARI (n=2727) n (%)	$\chi^2/t^*$
City			157.365 <sup>1</sup>			177.880 <sup>1</sup>
Shantou	230 (40.4)	339 (59.6)		490 (31.5)	1064 (68.5)	
Jinan	58 (17.2)	279 (82.8)		98 (10.5)	832 (89.5)	
Xi'an	76 (46.1)	89 (53.9)		161 (29.3)	388 (70.7)	
Nanchang	105 (14.6)	614 (85.4)		75 (14.5)	443 (85.5)	
Grade			0.873			0.658
Year 1	262 (26.3)	734 (73.7)		328 (23.8)	1050 (76.2)	
Year 2	126(25.5)	369 (74.5)		261 (22.4)	902 (77.6)	
Year 3	81 (27.1)	218 (72.9)		235 (23.3)	775 (76.7)	
Residence type			6.886 <sup>1</sup>			0.249
Dormitory	325 (25.8)	935 (74.2)		567 (22.6)	1943 (77.4)	
Home	142 (28.3)	359 (71.7)		244 (24.6)	746 (75.4)	
Other	2 (6.9)	27 (93.1)		13 (25.5)	38 (74.5)	
Sports team member			39.753 <sup>3</sup>			37.292 <sup>3</sup>
No	354 (23.4)	1159 (76.6)		697 (21.8)	2504 (78.2)	

Yes	115 (41.5)	162 (58.5)		127 (36.3)	223 (63.7)	
Chronic disease/symptom			1.703			12.111 <sup>2</sup>
No	441 (26.6)	1218 (73.4)		767 (22.7)	2618 (77.3)	
Yes	28 (21.4)	103 (78.6)		57 (34.3)	109 (65.7)	
Age ( $\bar{x}\pm s$ , years)	19.52 $\pm$ 1.30	19.40 $\pm$ 1.32	1.857	19.77 $\pm$ 1.27	19.66 $\pm$ 1.27	2.228 <sup>1</sup>

\* Categorical variables (all variables except for age) were tested by Pearson chi-square tests, and continuous variable (i.e. age) was tested by independent-sample *t* tests; <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury.

The majority of students participated in transport-related PA (79.5%) and sports and leisure-time PA (58.8%). Male students with PARI had significantly higher frequency or longer duration of MPA or VPA in three domains (all  $P < 0.01$ ). Similarly, such significant differences could be found between PARI and non-PARI groups for females except for the frequency and duration of transport-related PA (all  $P < 0.01$ ). For females, students with different sleep duration significantly differed in PARI experience ( $P < 0.05$ ), while sedentary behavior had an impact on the occurrence of PARI among male students ( $P < 0.01$ ) (Table 2). The means and SDs for all PA indicators are available in Supplementary Table S1.

Table 2 Comparison of life-style variables in participants with PARI or not among different genders

Characteristics	Males (n=1790)		$\chi^2/Z^*$	Females (n=3551)		$\chi^2/Z^*$
	PARI (n=469) median, IQR	Non-PARI (n=1321) median, IQR		PARI (n=824) median, IQR	Non-PARI (n=2727) median, IQR	
Domestic/work/study						
VPA						
Frequency, day/week	1 (0, 2)	0 (0, 1)	5.392 <sup>3</sup>	0 (0, 0.75)	0 (0, 0)	4.624 <sup>3</sup>
Duration, min/day	10 (0, 30)	0 (0, 15)	5.767 <sup>3</sup>	0 (0, 7.5)	0 (0, 0)	4.818 <sup>3</sup>
MPA						
Frequency, day/week	2 (0, 3)	1 (0, 3)	4.235 <sup>3</sup>	1 (0, 3)	0 (0, 2)	5.197 <sup>3</sup>
Duration, min/day	30 (0, 40)	12 (0, 30)	6.593 <sup>3</sup>	10 (0, 30)	0 (0, 30)	5.341 <sup>3</sup>
Transportation						
Frequency, day/week	5 (0, 7)	5 (0, 7)	2.998 <sup>2</sup>	5 (2, 7)	5 (1, 7)	1.816
Duration, min/day	30 (15, 60)	30 (0, 45)	4.156 <sup>3</sup>	30 (12.75, 45)	30 (10, 45)	0.697
Sports and leisure time						
VPA						
Frequency, day/week	1 (0, 2)	0 (0, 1)	9.538 <sup>3</sup>	0 (0, 1)	0 (0, 1)	3.130 <sup>2</sup>
Duration, min/day	20 (0, 60)	0 (0, 20)	10.402 <sup>3</sup>	0 (0, 20)	0 (0, 10)	3.050 <sup>2</sup>
MPA						
Frequency, day/week	2 (0, 3)	1 (0, 2)	5.545 <sup>3</sup>	1 (0, 2)	0 (0, 2)	5.644 <sup>3</sup>
Duration, min/day	20 (0, 40)	10 (0, 30)	7.235 <sup>3</sup>	10 (0, 30)	0 (0, 30)	5.485 <sup>3</sup>
Sleep duration, n (%)			4.055			13.345 <sup>1</sup>
<6 hours/day	33 (20.4)	129 (79.6)		61 (27.0)	165 (73.0)	
6 to <7 hours/day	93 (27.2)	249 (72.8)		145 (28.2)	370 (71.8)	
7 to <8 hours/day	184 (26.4)	513 (73.6)		305 (20.9)	1151 (79.1)	
8 to <9 hours/day	126 (27.9)	325 (72.1)		225 (22.8)	764 (77.2)	
$\geq 9$ hours/day	33 (24.1)	104 (75.9)		88 (24.1)	277 (75.9)	
Sedentary behavior, n (%)			18.567 <sup>2</sup>			7.094
<4 hours/day	173 (21.3)	638 (78.7)		269 (24.0)	853 (76.0)	
4 to <6 hours/day	42 (28.4)	106 (71.6)		72 (28.9)	177 (71.1)	
6 to <9 hours/day	40 (30.3)	92 (69.7)		71 (24.0)	225 (76.0)	
9 to <12 hours/day	62 (30.0)	145 (70.0)		89 (20.1)	354 (79.9)	
$\geq 12$ hours/day	152 (30.9)	340 (69.1)		323 (22.4)	1118 (77.6)	

\* Categorical variables (i.e. sleep duration and sedentary behavior) were tested by Pearson chi-square tests, and continuous variables (except for sleep duration and sedentary behavior) were tested by Mann-Whitney tests or independent-sample *t* tests (the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.



191 Based on the significant variables tested by chi-square tests and independent-sample *t*  
 192 tests or Mann-Whitney tests, a multivariable logistic regression model was used to estimate  
 193 ORs and corresponding 95% CIs for PARI among male students. As shown in Table 3, male  
 194 students in Shantou and Xi'an had higher odds of sustaining PARI (OR=3.525 and 4.571).  
 195 Sports team members were more likely to suffer from PARI (OR=1.819, 95% CI:  
 196 1.349-2.453) in comparison with their counterparts. Also, the frequency and duration of sports  
 197 and leisure-time VPA were significantly associated with PARI (OR=1.129 and 1.007  
 198 respectively).

199 Table 3 Multivariable logistic regression to estimate risk factors for PARI among males

Variables	B	S.E.	OR	95% CI	P-value
City					
Shantou	1.260	0.140	3.525	2.680-4.636	<0.001
Jinan	-0.060	0.186	0.941	0.653-1.356	0.745
Xi'an	1.520	0.194	4.571	3.124-6.687	<0.001
Nanchang			1 (ref.)		
Sports team member					
No			1 (ref.)		
Yes	0.598	0.152	1.819	1.349-2.453	<0.001
Sports and leisure-time VPA					
Frequency, day/week	0.121	0.040	1.129	1.043-1.221	0.003
Duration, min/day	0.007	0.002	1.007	1.004-1.011	<0.001

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

201 Similarly, a multivariable logistic regression analysis was also performed to estimate the  
 202 odds of potential factors for PARI among females, and the results of all significant variables  
 203 kept in the final model were displayed in Table 4. Female students in Shantou and Xi'an were  
 204 more vulnerable to experience PARI (OR=2.710 and 2.456 respectively), and those who  
 205 participated in a sports team and had a chronic condition would be more prone to sustain  
 206 PARI (OR=1.950 and 1.834 respectively). Moreover, higher frequency of sports and  
 207 leisure-time VPA and MPA (OR=1.079 and 1.091 respectively) and longer duration of sports  
 208 and leisure-time MPA (OR=1.003) increased the possibility to suffer from PARI.

209 Table 4 Multivariable logistic regression to estimate risk factors for PARI among females

Variables	B	S.E.	OR	95% CI	P-value
City					
Shantou	0.997	0.139	2.710	2.064-3.559	<0.001
Jinan	-0.494	0.169	0.868	0.674-1.092	0.355
Xi'an	0.898	0.159	2.456	1.796-3.357	<0.001
Nanchang			1 (ref.)		
Sports team member					
No			1 (ref.)		
Yes	0.668	0.128	1.950	1.516-2.507	<0.001
Chronic disease/symptom					
No					
Yes	0.607	0.178	1.834	1.293-2.602	0.001

Sports and leisure-time VPA					
Frequency, day/week	0.076	0.034	1.079	1.011-1.153	0.034
Sports and leisure-time MPA					
Frequency, day/week	0.087	0.026	1.091	1.036-1.149	0.001
Duration, min/day	0.003	0.001	1.003	1.001-1.006	0.016

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

211 With regards to favorite activities, nearly three-fifths (58.9%, n=3147) of students had at  
 212 least one PA that they liked and participated often during the past 12-month periods. Running,  
 213 badminton, basketball, bicycling, table tennis, and swimming were the primary activities that  
 214 students participated in the past 12 months. There existed a difference in PA engagement.  
 215 Males (n=1107) favored running, basketball, badminton, table tennis, bicycling, and football,  
 216 while females (n=2040) preferred to running, badminton, bicycling, basketball, table tennis,  
 217 and swimming (Supplementary Table S2).

218 The number and consequences of PARI reported by 1293 injured students before and  
 219 after gender stratification were shown in Table 5. During the past 12-month periods, more  
 220 than half (n=666, 51.5%) of the injured participants experienced one PARI episode and over  
 221 one-fifth (n=296, 22.9%) suffered from PARI at least three times (i.e. multiple injuries). Male  
 222 students had a greater tendency to sustain multiple injuries and females had a larger portion to  
 223 experience PARI one time. Over half of the injured (57.3%) experienced a withdrawal time of  
 224 PA and nearly two-fifths (39.6%) received medical treatment due to PARI. A significant  
 225 difference was observed for both genders in a break from PA participation, with male injured  
 226 students being more likely to experience inactivity (64.2% vs. 53.4%,  $P<0.001$ ).

227 Table 5 Number and consequences of PARI among injured university students

Characteristics	Total (N=1293), n (%)	Males (N=469), n (%)	Females (N=824), n (%)	$\chi^2$	P-value
Number of PARI				35.494	<0.001
1	666 (51.5)	198 (42.2)	468 (56.8)		
2	331 (25.6)	124 (26.4)	207 (25.1)		
$\geq 3$	296 (22.9)	147 (31.3)	149 (18.1)		
Consequences of PARI					
Stop quickly and/or cannot participate in the next PA				14.199	<0.001
No	552 (42.7)	168 (35.8)	384 (46.6)		
Yes	741 (57.3)	301 (64.2)	440 (53.4)		
Absence of class				0.306	0.580
No	984 (76.1)	361 (77.0)	623 (75.8)		
Yes	309 (23.9)	108 (23.0)	201 (24.2)		
Seek medical attention				1.606	0.205
No	781 (60.4)	294 (62.7)	487 (59.1)		
Yes	512 (39.6)	175 (27.3)	337 (40.9)		

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

## 229 Discussion

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4 230 As one of the top health threats to school-aged adolescents and young adults in the  
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6 231 majority of countries <sup>5,11</sup>, PARI could lead to medically financial burdens and prevent  
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8 232 individuals from being physically active to improve and maintain physical, cognitive, and  
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10 233 mental health <sup>24-26</sup>. In this study, we found that approximately one out of four university  
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12 234 students experienced at least one PARI episode in the past 12 months, with an overall injury  
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14 235 risk of 0.38 injuries/student/year. Additionally, more than half of the injured students had a  
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16 236 withdrawal time of PA participation and nearly two-fifths of cases required medical attention.  
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18 237 These findings indicated that PARI was rather common and had a great adverse effect on  
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20 238 Chinese university students. In contemporary China, about 48% of secondary students could  
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22 239 be admitted to different levels of universities <sup>27</sup>. The One-Percent National Sample Census in  
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24 240 2015 revealed that the number of current university students hit 39.7 million <sup>27</sup>. This suggests  
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26 241 that the problem of PARI among Chinese university students needs to be urgently highlighted  
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28 242 and effective injury-prevention programs should be developed when we take PA promotion as  
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30 243 a public health priority.

31 244 In line with other findings reported elsewhere <sup>23,28,29</sup>, we found that male students had a  
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33 245 significantly higher PARI incidence and risk than their female counterparts. Several reasons  
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35 246 may underline this gender difference. Firstly, males are prone to be more physically active  
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37 247 than females <sup>30</sup>. This could be supported by our data in terms of different PA indicators in  
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39 248 Table 2. Secondly, Ristolainen et al <sup>31</sup> and Hootman et al <sup>32</sup> revealed that males are inclined to  
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41 249 take part in more competitive high-intensity activities like basketball and football that  
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43 250 involves a higher rate of contact, jumping, and sprinting, which are commonly associated with  
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45 251 a higher incidence of injuries . The difference in favorite activities between males and females  
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47 252 in this study is aligned with this explanation. Even in the same activity, males tend to have  
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49 253 higher competitiveness and resistance with lower individual safety awareness <sup>33</sup>. This could  
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51 254 contribute to their higher incidence of PARI to some extent. Thirdly, Deci et al <sup>34</sup> indicated  
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53 255 that male students had great motivation, impulsiveness, and self-determination, which may  
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55 256 also play a role. On one hand, these gender-specific characteristics could affect the occurrence  
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57 257 of PARI; on the other hand, these might influence the analysis of potential risk factors for  
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59 258 PARI as well. Previous studies revealed that there were marked gender-specific differences in  
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259 PARI occurrences and relevant risk factors <sup>15,35,36</sup>. If a risk factor has different impacts on

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4 260 PARI for various genders, it would be quite hard to find the real association when we  
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6 261 analyzed the data together <sup>35</sup>. We thus explore possible contributors to PARI for males and  
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8 262 females respectively.

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10 263 Being physically inactive is harmful to our individual well-being <sup>5</sup>, so is being too much  
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12 264 active. Our study revealed that there was a positive significant association between PARI  
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14 265 occurrence and the frequency of sports and leisure-time VPA participation in both genders,  
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16 266 and a longer duration of sports and leisure-time VPA involvement could increase the risk of  
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18 267 PARI for male students. This is highly consistent with other findings that higher intensity,  
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20 268 higher frequency, and longer duration of PA participation contributed to an elevated risk of  
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22 269 PARI event <sup>33,37</sup>. Furthermore, we found that the frequency and duration of sports and  
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24 270 leisure-time MPA engagement was positively associated with the occurrence of PARI for  
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26 271 females. Collectively, different levels of PA participation between males and females cause  
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28 272 differences in the occurrence of PARI. This is in line with other reports <sup>35,36</sup>. In addition,  
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30 273 though the relationship between sedentary behavior and PARI occurrence did not observed in  
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32 274 our study, earlier literature indicated that sedentary behavior would affect individual physical  
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34 275 function and increase the risk of injury <sup>38-40</sup>. We should place great emphasis on the above  
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36 276 results, especially when we promote a physically active lifestyle for the public. Otherwise, the  
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38 277 benefits of PA participation would be comprised.

39 278 In comparison with their counterparts, sports team members had a higher likelihood to  
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41 279 suffer from PARI among both males (OR=1.819) and females (OR=1.950). This parallels  
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43 280 with previous literature <sup>9,41</sup>, irrespectively of age group. Generally, students participating in  
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45 281 sports teams would spend lots of their time on one certain kind of activity, which often  
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47 282 associates with the high risk of overuse injuries like tendinopathies, bursitis, and stress  
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49 283 fracture <sup>42,43</sup>. Moreover, the activities that sports team members participated are usually  
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51 284 structured and their focus is often on improving individual performance <sup>41</sup>. In this way, they  
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53 285 generally have a higher frequency and intensity and longer duration of PA participation <sup>41</sup>.  
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55 286 This further supports that being too much physically active harms individual health. Thus, we  
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57 287 should take this particularly vulnerable population into consideration and effective  
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59 288 preventative measures should be introduced.

60 289 In this study, living with a chronic condition was identified as the potential determinant

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4 290 of PARI for females. Amongst the whole study sample, nearly 5.7% had a chronic disease  
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6 291 (i.e. near-sightedness). The exact reasons for the association between the chronic condition  
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8 292 and PARI occurrence in female students in the present study are unknown. A possible partial  
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10 293 explanation may be the health issue may affect their PA participation and expose them to  
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12 294 higher injury risk when undertaking PA. This specific contributor has implications for the  
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14 295 identification of injury mechanisms and interventions in injury prevention among female  
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16 296 students.

17 297 Surprisingly, our study revealed that there was a difference in the occurrence of PARI  
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19 298 among university students—both males and females in Shantou and Xi'an had markedly  
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21 299 higher PARI incidence than those in Jinan and Nanchang. However, this discrepancy could  
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23 300 not be explained by all potential variables in our study (Supplementary Tables S3 and S4).  
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25 301 Given that four study cities locate in different parts of China and they have various climate,  
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27 302 we assumed that the large between-city difference in the incidence rate of PARI may be  
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29 303 attributed to the geographical factors. PA infrastructure may affect the occurrence of PARI for  
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31 304 students, but all these study cities belong to Mainland China, sharing similar facilities and  
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33 305 surveillance systems. We thereby excluded this possibility. Also, the urban environments out  
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35 306 of the universities might be attributable to this difference, but we could not provide related  
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37 307 evidence for this hypothesis due to the absence of where these injuries occurred. Collectively,  
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39 308 the reasons for the between-city PARI difference needed to be studied further.

40 309 Our study is influenced by several limitations. First, data collection was through a  
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42 310 structured self-reported questionnaire, which would lead to reporting bias and recall bias <sup>44</sup>.  
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44 311 For example, students might not have reported accurately their PARI experiences, in  
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46 312 particular the minor and earliest injuries. However, previous studies noted that participants  
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48 313 were able to correctly indicate whether they had been injured or not during the past 12-month  
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50 314 periods <sup>45</sup>. Meanwhile, although the good reliability and validity of GPAQ, we could not fully  
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52 315 preclude the possibility of the over-reported PA exposure time. Despite this drawback, the use  
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54 316 of self-report is a more practical, feasible, and cost-effective way that allows us to carry out a  
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56 317 multi-center survey with such a large sample size. Second, the nature of the cross-sectional  
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58 318 study limits us from drawing the cause-and-effect relationship between PARI outcome and  
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60 319 the potential risk factors in this study. Their associations are still warranted to be proven

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4 320 further by a prospective cohort study. Third, nearly two-thirds of the study samples were  
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6 321 female students, which may limit the generalizability and representativeness of our findings.  
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8 322 Fourth, we did not compare acute and overuse injuries—two injury types with different injury  
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10 323 mechanisms, which may deviate the analysis in the association between PARI and its  
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12 324 potential contributors. Thus, future studies should take these limitations into account to better  
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14 325 reflect the characteristics and risk factors of PARI among university students.

## 15 326 **Conclusion**

17 327 With an overall incidence rate of 24.2% and an injury risk of 0.38 injuries/student/year,  
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19 328 PARI was not uncommon among Chinese university students. Different genders differed in  
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21 329 the occurrence of PARI and were affected by various potential risk factors. For males, those  
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23 330 who were Shantou and Xi'an students, were sports team members, and participated in sports  
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25 331 and leisure-time VPA with higher frequency and longer duration were more likely to suffer  
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27 332 from PARI. For females, studying in Shantou and Xi'an, participating in a sports team, having  
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29 333 chronic disease or symptom, engaging in sports and leisure-time VPA with higher frequency,  
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31 334 and taking part in sports and leisure-time MPA with higher frequency and longer duration  
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33 335 were the potential contributors to PARI. These findings provide a direction to develop  
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35 336 targeted gender-specific prophylactic interventions to reduce PARI and to maximize the  
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37 337 benefits of PA participation among university students in China.

## 39 338 **Acknowledgments**

41 339 This work was supported by the National Natural Science Foundation of China [grant  
42  
43 340 number 31640038]. The sponsor had no role in study design, data collection, analysis and  
44  
45 341 interpretation, preparation and revision of the manuscript, and decision to submit the article  
46  
47 342 for publication.

## 49 343 **Authors' contributions**

51 344 LPL, YG, and CXJ conceived and designed the study; WCC, PYY, XFY, LJG, and  
52  
53 345 WDY collected data, WCC and SMC performed the statistical analyses and drafted the  
54  
55 346 manuscript. All authors have read and approved the final version of the manuscript, and agree  
56  
57 347 with the order of the presentation of the authors.

## 59 348 **Competing interests**

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4 349 None declared.  
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For peer review only

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## Supplementary materials

Supplementary Table S1 Comparison of life-style variables in participants with PARI or not by gender

Characteristics	Males (n=1790)		$\chi^2/Z^*$	Females (n=3551)		$\chi^2/Z^*$
	PARI (n=469) x±s	Non-PARI (n=1321) x±s		PARI (n=824) x±s	Non-PARI (n=2727) x±s	
Domestic/work/study						
VPA						
Frequency, day/week	1.29±1.75	0.84±1.44	4.971 <sup>3</sup>	0.58±1.26	0.38±1.03	4.271 <sup>3</sup>
Duration, min/day	24.83±46.12	14.82±34.09	4.305 <sup>3</sup>	11.85±36.14	5.80±17.31	4.652 <sup>3</sup>
MPA						
Frequency, day/week	2.10±1.96	1.72±1.95	3.630 <sup>3</sup>	1.66±1.93	1.32±1.82	4.522 <sup>3</sup>
Duration, min/day	31.54±42.39	20.51±29.17	5.213 <sup>3</sup>	24.74±48.56	16.42±33.47	4.602 <sup>3</sup>
Transportation						
Frequency, day/week	4.17±2.64	3.73±2.80	2.998 <sup>2</sup>	3.97±2.60	3.78±2.67	1.816
Duration, min/day	42.66±49.36	32.14±35.69	4.349 <sup>3</sup>	37.59±48.80	34.64±45.06	1.549
Sports and leisure-time						
VPA						
Frequency, day/week	1.56±1.70	0.89±1.52	7.448 <sup>3</sup>	0.71±1.40	0.53±1.20	3.401 <sup>3</sup>
Duration, min/day	34.24±40.90	16.65±31.36	8.471 <sup>3</sup>	13.42±29.23	9.73±22.61	3.330 <sup>3</sup>
MPA						
Frequency, day/week	1.89±1.95	1.41±1.89	4.640 <sup>3</sup>	1.52±1.92	1.16±1.74	4.914 <sup>3</sup>
Duration, min/day	28.95±32.39	18.28±27.95	6.344 <sup>3</sup>	22.96±39.77	16.55±27.89	4.313 <sup>3</sup>
Sleep duration, n (%)			4.055			13.345 <sup>1</sup>
<6 hours/day	33 (20.4)	129 (79.6)		61 (27.0)	165 (73.0)	
6 to <7 hours/day	93 (27.2)	249 (72.8)		145 (28.2)	370 (71.8)	
7 to <8 hours/day	184 (26.4)	513 (73.6)		305 (20.9)	1151 (79.1)	
8 to <9 hours/day	126 (27.9)	325 (72.1)		225 (22.8)	764 (77.2)	
≥9 hours/day	33 (24.1)	104 (75.9)		88 (24.1)	277 (75.9)	
Sedentary behavior, n (%)			18.567 <sup>2</sup>			7.094
<4 hours/day	173 (21.3)	638 (78.7)		269 (24.0)	853 (76.0)	
4 to <6 hours/day	42 (28.4)	106 (71.6)		72 (28.9)	177 (71.1)	
6 to <9 hours/day	40 (30.3)	92 (69.7)		71 (24.0)	225 (76.0)	
9 to <12 hours/day	62 (30.0)	145 (70.0)		89 (20.1)	354 (79.9)	
≥12 hours/day	152 (30.9)	340 (69.1)		323 (22.4)	1118 (77.6)	

\* Categorical variables (i.e. sleep duration and sedentary behavior) were tested by Pearson chi-square tests, and continuous variables (except for sleep duration and sedentary behavior) were tested by Mann-Whitney tests or independent *t* tests (the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

Supplementary Table S2 Primary physical activities that university students participated

Activity items	Total (N=3147), n (%)	Males (N=1107), n (%)	Females (N=2040), n (%)
Basketball	790 (25.1)	462 (41.7)	329 (16.1)
Running	1778 (55.8)	548 (49.5)	1230 (60.3)
Badminton	1518 (48.2)	458 (41.4)	1060 (52.0)
Bicycling	525 (16.7)	156 (14.1)	369 (18.1)
Swimming	391 (12.4)	137 (12.4)	254 (12.5)
Table tennis	545 (17.3)	253 (22.9)	292 (14.3)
Football	211 (6.7)	139 (12.6)	72 (3.5)
Dance	187 (5.9)	25 (2.3)	162 (7.9)
Fitness	258 (8.2)	101 (9.1)	157 (7.7)

This table only listed those physical activities of participation rate more than 5%.

Supplementary Table S3 Comparison of all related variables among university students in different cities

Characteristics	Shantou (n=2123) median, IQR	Jinan (n=1267) median, IQR	Xi'an (n=714) median, IQR	Nanchang (n=1237) median, IQR	$\chi^2/F^*$
Domestic/work/study					
VPA					
Frequency, day/week	0 (0, 0)	0 (0, 1)	0 (0, 1)	0 (0, 1)	110.025 <sup>3</sup>
Duration, min/day	0 (0, 0)	0 (0, 10)	0 (0, 20)	0 (0, 10)	87.325 <sup>3</sup>
MPA					
Frequency, day/week	1 (0, 2)	1 (0, 3)	1 (0, 2)	0 (0, 3)	39.878 <sup>3</sup>
Duration, min/day	10 (0, 30)	15 (0, 30)	10 (0, 30)	0 (0, 30)	28.091 <sup>3</sup>
Transportation					
Frequency, day/week	5 (2, 7)	5 (2, 7)	2 (1, 5)	5 (0, 5)	63.323 <sup>3</sup>
Duration, min/day	30 (10, 40)	30 (15, 50)	30 (15, 60)	30 (0, 45)	20.658 <sup>3</sup>
Sports and leisure time					
VPA					
Frequency, day/week	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	31.724 <sup>3</sup>
Duration, min/day	0 (0, 15)	0 (0, 30)	0 (0, 20)	0 (0, 10)	41.852 <sup>2</sup>
MPA					
Frequency, day/week	0 (0, 2)	1 (0, 3)	1 (0, 2)	0 (0, 1)	112.709 <sup>3</sup>
Duration, min/day	0 (0, 30)	20 (0, 30)	10 (0, 30)	0 (0, 10)	181.535 <sup>3</sup>
	n (%)	n (%)	n (%)	n (%)	
Grade					515.974 <sup>3</sup>
Year 1	698 (32.9)	453 (35.8)	432 (60.5)	791 (63.9)	
Year 2	691 (32.5)	443 (35.0)	180 (25.2)	344 (27.8)	
Year 3	734 (34.6)	371 (29.3)	102 (14.3)	102 (8.2)	
Gender					441.055 <sup>3</sup>
Male	569 (26.8)	337 (26.6)	165 (23.1)	719 (58.1)	
Female	1554 (73.2)	930 (73.4)	549 (76.9)	518 (41.9)	
Residence type					204.376 <sup>3</sup>
Dormitory	1511 (71.2)	1050 (82.9)	393 (55.0)	816 (66.0)	
Home	587 (27.6)	210 (16.6)	309 (43.3)	385 (31.1)	
Other	25 (1.2)	7 (0.6)	12 (1.7)	36 (2.9)	
Sports team member					16.045 <sup>2</sup>
No	1861 (87.7)	1096 (86.5)	659 (92.3)	1098 (88.8)	
Yes	262 (12.3)	171 (13.5)	55 (7.7)	139 (11.2)	
Chronic disease/symptom					72.979 <sup>3</sup>
No	2028 (95.5)	1226 (96.8)	681 (95.4)	1109 (89.7)	
Yes	95 (4.5)	41 (3.2)	33 (4.6)	128 (10.3)	
Sleep duration, n (%)					193.604 <sup>1</sup>
<6 hours/day	110 (5.2)	58 (4.6)	68 (9.5)	152 (12.3)	
6 to <7 hours/day	365 (17.2)	158 (12.5)	70 (9.8)	264 (21.3)	
7 to <8 hours/day	841 (39.6)	608 (48.0)	260 (36.4)	444 (35.9)	
8 to <9 hours/day	563 (26.5)	353 (27.9)	236 (33.1)	288 (23.3)	
≥9 hours/day	244 (11.5)	90 (7.0)	80 (11.2)	89 (7.2)	
Sedentary behavior, n (%)					748.383 <sup>3</sup>
<4 hours/day	537 (25.3)	298 (23.5)	306 (42.9)	792 (64.0)	
4 to <6 hours/day	157 (7.4)	79 (6.2)	62 (8.7)	99 (8.0)	
6 to <9 hours/day	146 (6.9)	118 (9.3)	78 (10.9)	86 (7.0)	
9 to <12 hours/day	300 (14.1)	176 (13.9)	84 (11.8)	90 (7.3)	
≥12 hours/day	983 (46.3)	596 (47.0)	184 (25.8)	170 (13.7)	
Age ( $\bar{x}\pm s$ , years)	19.92±1.27	19.69±1.16	19.46±1.29	19.03±1.17	54.227 <sup>3</sup>

\* Categorical variables were tested by Pearson chi-square tests, and continuous variables were tested by one-way ANOVA tests (i.e. age and the frequency of transport-related PA) or Kruskal-Wallis tests (except for age and the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

Supplementary Table S4 Comparison of all related variables among university students in different cities

Characteristics	Shantou (n=2123) x±s	Jinan (n=1267) x±s	Xi'an (n=714) x±s	Nanchang (n=1237) x±s	$\chi^2/F^*$
Domestic/work/study					
VPA					
Frequency, day/week	0.49±1.21	0.65±1.36	0.69±1.37	0.71±1.27	110.025 <sup>3</sup>
Duration, min/day	9.54±30.39	11.95±26.86	14.55±33.39	8.89±27.25	87.325 <sup>3</sup>
MPA					
Frequency, day/week	1.37±1.80	1.39±1.82	1.50±1.81	1.56±1.85	39.878 <sup>3</sup>
Duration, min/day	22.04±46.98	20.96±28.38	21.26±34.46	14.97±19.79	28.091 <sup>3</sup>
Transportation					
Frequency, day/week	4.19±2.68	4.19±2.72	2.96±2.45	3.35±2.64	63.323 <sup>3</sup>
Duration, min/day	33.48±37.86	36.06±36.29	45.62±73.68	31.18±36.82	20.658 <sup>3</sup>
Sports and leisure time					
VPA					
Frequency, day/week	0.66±1.33	0.91±1.59	0.72±1.32	0.69±1.32	31.724 <sup>3</sup>
Duration, min/day	13.43±28.85	18.12±30.86	16.68±32.85	9.92±22.76	41.852 <sup>2</sup>
MPA					
Frequency, day/week	1.29±1.79	1.73±2.03	1.38±1.77	1.00±1.67	112.709 <sup>3</sup>
Duration, min/day	19.49±31.62	25.21±39.45	21.99±35.78	10.32±19.76	181.535 <sup>3</sup>
Age (years)	19.92±1.27	19.69±1.16	19.46±1.29	19.03±1.17	54.227 <sup>3</sup>
	n (%)	n (%)	n (%)	n (%)	
Grade					515.974 <sup>3</sup>
Year 1	698 (32.9)	453 (35.8)	432 (60.5)	791 (63.9)	
Year 2	691 (32.5)	443 (35.0)	180 (25.2)	344 (27.8)	
Year 3	734 (34.6)	371 (29.3)	102 (14.3)	102 (8.2)	
Gender					441.055 <sup>3</sup>
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Residence type					204.376 <sup>3</sup>
Dormitory	1511 (71.2)	1050 (82.9)	393 (55.0)	816 (66.0)	
Home	587 (27.6)	210 (16.6)	309 (43.3)	385 (31.1)	
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Sports team member					16.045 <sup>2</sup>
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Chronic disease/symptom					72.979 <sup>3</sup>
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Yes	95 (4.5)	41 (3.2)	33 (4.6)	128 (10.3)	
Sleep duration, n (%)					193.604 <sup>1</sup>
<6 hours/day	110 (5.2)	58 (4.6)	68 (9.5)	152 (12.3)	
6 to <7 hours/day	365 (17.2)	158 (12.5)	70 (9.8)	264 (21.3)	
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9 to <12 hours/day	300 (14.1)	176 (13.9)	84 (11.8)	90 (7.3)	
≥12 hours/day	983 (46.3)	596 (47.0)	184 (25.8)	170 (13.7)	

\* Categorical variables were tested by Pearson chi-square tests, and continuous variables were tested by one-way ANOVA tests (i.e. age and the frequency of transport-related PA) or Kruskal-Wallis tests (except for age and the frequency of transport-related PA); <sup>1</sup>  $P < 0.05$ ; <sup>2</sup>  $P < 0.01$ ; <sup>3</sup>  $P < 0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	6
		(c) Explain how missing data were addressed	
		(d) If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	7, 10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	8-9

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	8
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	10-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Gender-specific physical activity-related injuries and risk factors among university students in China: a multicentre population-based cross-sectional study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-040865.R2
Article Type:	Original research
Date Submitted by the Author:	20-Nov-2020
Complete List of Authors:	Cai, Weicong; Shantou University Medical College, Injury Prevention Research Center; Shenzhen Center for Chronic Disease Control Chen, Shangmin; Shantou University Medical College, Injury Prevention Research Center Li, Liping; Shantou University Medical College, Injury Preventive Research Center yue, pengying; Xi'an Innovation College of Yan'an University, School of Nursing Yu, Xiaofan; Jiangxi Teachers College, School of Nursing & Optometry Gao, Lijie; Shandong University School of Public Health, Department of Epidemiology Yang, Wenda; Shantou University Medical College, Injury Prevention Research Center Jia, Cun-Xian; Shandong University School of Public Health, Department of Epidemiology Gao, Yang; Hong Kong Baptist University, Department of Sport, Physical Education and Health; Hong Kong Baptist University, Centre for Health and Exercise Science Research
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Epidemiology, Public health, Sports and exercise medicine
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, SPORTS MEDICINE

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4 1 **Gender-specific physical activity-related injuries and risk factors among**  
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6 2 **university students in China: a multicentre population-based**  
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9 3 **cross-sectional study**  
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## 30 Abstract

31 **Objectives:** Data on the problem of physical activity-related injury (PARI) in university  
32 students and the risk factors for PARI among different genders are rare. We conducted a  
33 multicenter population-based study to investigate the occurrence of PARI and to explore the  
34 gender-specific risk factors for PARI among Chinese university students.

35 **Design:** Cross-sectional study.

36 **Participants:** A total of 5341 students in grades 1-3 at eight universities in four Chinese cities  
37 were selected to complete the online questionnaires during March and April 2017. The  
38 questionnaires assessed sociodemographic characteristics, physical activity (PA) involvement,  
39 sleep duration, sedentary behaviour, and PARI experiences in the past 12 months.

40 **Main outcome measures:** PARI during the past 12 months.

41 **Results:** Among the 5341 participants, 1293 suffered from at least one PARI in the past 12  
42 months, with an overall incidence rate of 24.2% (males: 26.2%, females: 23.2%) and an  
43 injury risk of 0.38 injuries/student/year (males: 0.48, females: 0.32). Over half of the injured  
44 (57.3%) experienced a withdrawal time of PA and nearly two-fifths (39.6%) required medical  
45 attention. Irrespective of gender, Shantou and Xi'an students, sports team members, and those  
46 who engaged in sports and leisure-time vigorous-intensity PA (VPA) at a higher frequency  
47 were more likely to suffer from PARI. Male students who participated in sports and  
48 leisure-time VPA for long durations had a greater likelihood of sustaining PARI, while having  
49 a chronic condition and being involved in sports and leisure-time moderate-intensity PA at a  
50 higher frequency and longer duration were potential contributors to PARI among females.

51 **Conclusions:** The occurrence of PARI and its risk factors differed by gender, which provides  
52 a direction towards developing targeted and effective gender-specific preventative  
53 programmes to protect Chinese university students from PARI.

## 54 Strengths and limitation of this study

- 55 ● To our knowledge, this cross-sectional study is the first to explore the gender-specific  
56 risk factors associated with injuries resulting from PA participation in Chinese university  
57 students.
- 58 ● Data were self-reported, which is subject to reporting bias and recall bias.
- 59 ● The nature of the cross-sectional study limits us from drawing the cause-and-effect

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4 60 relationship between PARI outcome and the potential risk factors.  
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6 61 ● Nearly two-thirds of the study samples were female, which may have limited the  
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8 62 generalizability and representativeness.  
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10 63 ● We did not compare acute and overuse injuries, which may have deviated the association  
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12 64 analysis in this study.  
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For peer review only

## 65 Introduction

66 Participation in physical activity (PA) benefits our well-being by lowering the risk of  
67 non-communicable diseases, increasing bone density and muscular fitness, delaying the onset  
68 of mental diseases, and maintaining a healthy weight <sup>1-3</sup>. In recognition of these well-known  
69 benefits of regular PA participation, member states of the World Health Organization (WHO)  
70 agreed to a 10% relative reduction in the prevalence of insufficient PA by 2025 <sup>4</sup>. Meanwhile,  
71 there exist several recommendations on PA participation for public health <sup>5-7</sup>.

72 The promotion of PA participation is a public health priority, however, a potential  
73 problem of participation in PA, physical activity-related injury (PARI), needs to be  
74 emphasized, as it has been well documented in different genders or age groups and various  
75 types of PAs <sup>8-10</sup>. Moreover, earlier reports identified PARI as the major health threat to  
76 school-aged adolescents and young adults in many countries <sup>5,11</sup>. This means that successful  
77 and effective prevention programmes for PARI have great inherent public health gains <sup>12</sup>. To  
78 develop such preventative measures, we first need descriptive injury epidemiology describing  
79 the characteristics and aetiology of injuries <sup>13</sup>. Based on previous reports, most injuries occur  
80 outdoor and involve lower limbs, and sprains and strains are the major types of PARI <sup>10,14</sup>.  
81 Additionally, individual-related indicators, such as age, grade, body mass index (BMI), PA  
82 level, exercise behaviors, and family status, and environmental factors such as weather,  
83 exercise facilities, and playgrounds were associated with PARI episodes <sup>9,11,15-18</sup>.  
84 Furthermore, earlier studies revealed that there were marked gender differences in the  
85 occurrence and severity of PARI <sup>10,15</sup>. Nevertheless, the evidence of different gender-specific  
86 risk factors for PARI is scarce.

87 In China, students in universities might be more physically active than those in  
88 secondary and primary schools due to being free from heavy academic pressure for college  
89 admission <sup>10</sup>. In addition to that, most students have to live in the school dormitory and are  
90 therefore independent of their guardians, having more free time to take part in relatively risky  
91 activities that were not previously allowed <sup>19</sup>. This indicates that university students might  
92 have a higher susceptibility of sustaining PARI. However, compared with children and  
93 adolescents, recent reviews on the problem of PARI in university students noted that  
94 epidemiological data on this topic are scant <sup>10,19</sup>.

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4 95 Collectively, the purpose of this cross-sectional study was to investigate the occurrence  
5 96 of PARI and to explore the gender-specific risk factors associated with injuries resulting from  
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7 97 PA participation in Chinese university students via a multi-centre survey.  
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## 9 98 **Methods**

### 10 99 **Study participants**

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13 100 Selected by the method of cluster random sampling, 5628 eligible students graded 1 to 3  
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15 101 from eight universities (five comprehensive universities and three normal universities) in four  
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17 102 Chinese cities (namely, Shantou [Guangdong province], Jinan [Shandong province], Xi'an  
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19 103 [Shanxi province] and Nanchang [Jiangxi province]) were invited to participate in the survey  
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21 104 during March and April 2017. Informed consent was obtained from the potential study  
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23 105 participants, with a response rate of 94.9% (n=5341). The purpose of this study was orally  
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25 106 explained by the authors and the quick response code or hyperlink of the questionnaire was  
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27 107 sent to all consenting students.  
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29 108 This study was strictly carried out according to the Declaration of Helsinki and approved  
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31 109 by the Shantou University Medical College Ethics Committee (SUMC-2016-22), Xi'an  
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33 110 Innovation College of Yan'an University Ethics Committee, Jiangxi Teachers College Ethics  
34  
35 111 Committee, and Shandong University Ethics Committee (20161101).  
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### 37 112 **Data collection**

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39 113 Wenjuanxing software (Sojump, Changsha, China) was applied as the online platform  
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41 114 for the survey. All participants were recruited in nominated classes. The self-administered  
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43 115 online questionnaire was comprised of socio-demographic characteristics, PA participation,  
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45 116 sleep duration, sedentary behaviour, and PARI episodes that occurred in the past 12 months.  
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47 117 Socio-demographic characteristics of the participants included university, study major,  
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49 118 grade, gender, age, residence type, any diagnosed chronic disease/symptom (such as heart  
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51 119 disease, near-sightedness, hearing disorder, and asthma), and sports team membership.  
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53 120 The Global Physical Activity Questionnaire (GPAQ) Chinese version was used to  
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55 121 evaluate participants' habitual PA participation during a typical week in the past 12 months<sup>20</sup>.  
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57 122 As one of the most commonly used PA questionnaires, it showed good reliability and validity  
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59 123 in the previous study (Spearman's rho=0.81)<sup>21</sup> and sound reliability in our study (Cronbach's  
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124  $\alpha=0.721$ ). The GPAQ collects the frequency (days per week) and duration (average minutes

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4 125 each day) of moderate-intensity PA (MPA) and vigorous-intensity PA (VPA) in three  
5 126 domains: domestic/work/study, transportation (MPA only), and sports and leisure-time  
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7 127 activities. The PA volume (total cumulative minutes per week) was then calculated by  
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9 128 multiplying the frequency and duration of each kind of PA (MPA and VPA) in each domain.  
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11 129 Given that the GPAQ does not collect information on specific PAs in which students  
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13 130 participated, all students were further asked if they had any favourite PA in which they often  
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15 131 took part in the past 12 months. Those with a positive response were required to provide the  
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17 132 names of fewer than three activities.

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19 133 One additional item of time spent in sedentary behavior was also collected by the GPAQ,  
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21 134 and the duration (average hours per day) was requested on both a typical weekday and a  
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23 135 typical weekend. Furthermore, sleep time (including nap time) was also collected using  
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25 136 similar questions. The daily duration in a typical week was then generated and used to classify  
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27 137 the participants into five groups based on the average daily sedentary duration (i.e., <4, 4 to  
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29 138 <6, 6 to <9, 9 to <12, and  $\geq 12$  hours/day) and sleep time (i.e., <6, 6 to <7, 7 to <8, 8 to <9,  
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31 139 and  $\geq 9$  hours/day).

32  
33 140 PARI occurrence in the past 12 months was also collected. The definition of PARI could  
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35 141 be found in an earlier study<sup>22</sup> and a countable PARI episode must have met one or more of  
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37 142 the following consequences, which was proven reliably and validly<sup>12,22</sup>: the student 1) has to  
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39 143 stop the current PA immediately and/or cannot fully participate in the next planned PA and/or;  
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41 144 2) cannot go to the school the next day and/or; 3) needs to seek medical attention (e.g., from  
42  
43 145 providers ranging from first aid personnel to general physicians or physiotherapists)<sup>13,22</sup>.

#### 44 146 **Patient and Public Involvement**

45  
46 147 No patients involved.

#### 47 48 148 **Statistical analysis**

49  
50 149 All statistical analyses were performed by SPSS version 23.0 (SPSS Inc., Chicago, IL,  
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52 150 USA). The person-based incidence rates of PARI were calculated, and the injury risk was  
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54 151 calculated as the total number of injuries per number of students per year<sup>23</sup>. Categorical data  
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56 152 were described using numbers and percentages, while continuous data that were normally or  
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58 153 not normally distributed were presented as the means and standard deviations (SD) or  
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60 154 medians and interquartile ranges (IQR). Chi-square tests and independent-sample *t* tests or

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4 155 non-parameter tests were used to test between-group differences. All significant variables  
5 156 tested by chi-square tests and independent-sample *t* tests or non-parameter tests were included  
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7 157 together in the multivariable logistic regression model to explore the potential risk factors for  
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9 158 PARI occurrence. The odds ratios (ORs) and 95% confidence intervals (95% CIs) were  
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11 159 calculated with the selection of forward (LR) manner using the criteria of  $\alpha_{in} = 0.05$  and  $\alpha_{out} =$   
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14 160 0.10. Statistical significance was set at a two-sided  $P < 0.05$ .

## 161 Results

162 In total, 5341 students (males: 1790, females: 3551) participated in this study, with a  
163 mean age of 19.60 (SD=1.27). Among the participants, 1293 students (24.2%) experienced at  
164 least one PARI episode in the past 12 months, and male students had a significantly higher  
165 injury incidence than females (26.2% [469/1790] vs. 23.2% [824/3551],  $P = 0.016$ ). Overall,  
166 2008 PARI episodes (males: 864, females: 1144) were reported by all injured students. This  
167 equals an overall injury risk of 0.38 injuries/student/year, with a significantly higher risk  
168 among males than females (0.48 vs. 0.32,  $P < 0.05$ ).

169 As presented in Table 1, chi-square tests revealed significant differences in the injury  
170 occurrence by residence type and sports team membership for males (both  $P < 0.05$ ). For  
171 female students, participating in a sports team, having a disease or symptom, and age affected  
172 the occurrence of PARI (all  $P < 0.05$ ). Irrespective of gender, both males and females in  
173 Shantou and Xi'an had a significantly higher incidence of PARI than those in Jinan and  
174 Nanchang (both  $P < 0.05$ ).

175 Table 1 Comparison of socio-demographics in participants with PARI or not by gender

Characteristics	Males (n=1790)			Females (n=3551)		
	PARI (n=469) n (%)	Non-PARI (n=1321) n (%)	$\chi^2/t^*$	PARI (n=824) n (%)	Non-PARI (n=2727) n (%)	$\chi^2/t^*$
City			157.365 <sup>1</sup>			177.880 <sup>1</sup>
Shantou	230 (40.4)	339 (59.6)		490 (31.5)	1064 (68.5)	
Jinan	58 (17.2)	279 (82.8)		98 (10.5)	832 (89.5)	
Xi'an	76 (46.1)	89 (53.9)		161 (29.3)	388 (70.7)	
Nanchang	105 (14.6)	614 (85.4)		75 (14.5)	443 (85.5)	
Grade			0.873			0.658
Year 1	262 (26.3)	734 (73.7)		328 (23.8)	1050 (76.2)	
Year 2	126 (25.5)	369 (74.5)		261 (22.4)	902 (77.6)	
Year 3	81 (27.1)	218 (72.9)		235 (23.3)	775 (76.7)	
Residence type			6.886 <sup>1</sup>			0.249
Dormitory	325 (25.8)	935 (74.2)		567 (22.6)	1943 (77.4)	
Home	142 (28.3)	359 (71.7)		244 (24.6)	746 (75.4)	
Other	2 (6.9)	27 (93.1)		13 (25.5)	38 (74.5)	
Sports team member			39.753 <sup>3</sup>			37.292 <sup>3</sup>
No	354 (23.4)	1159 (76.6)		697 (21.8)	2504 (78.2)	



Yes	115 (41.5)	162 (58.5)		127 (36.3)	223 (63.7)	
Chronic disease/symptom			1.703			12.111 <sup>2</sup>
No	441 (26.6)	1218 (73.4)		767 (22.7)	2618 (77.3)	
Yes	28 (21.4)	103 (78.6)		57 (34.3)	109 (65.7)	
Age ( $\bar{x}\pm s$ , years)	19.52 $\pm$ 1.30	19.40 $\pm$ 1.32	1.857	19.77 $\pm$ 1.27	19.66 $\pm$ 1.27	2.228 <sup>1</sup>

\* Categorical variables (all variables except for age) were tested by Pearson chi-square tests, and continuous variables (i.e., age) were tested by independent-sample *t* tests; <sup>1</sup>  $P<0.05$ ; <sup>2</sup>  $P<0.01$ ; <sup>3</sup>  $P<0.001$ ; PARI, physical activity-related injury.

The majority of students participated in transport-related PA (79.5%) and sports and leisure-time PA (58.8%). Male students with PARI had a significantly higher frequency or longer duration of MPA or VPA in three domains (all  $P<0.01$ ). Similarly, such significant differences could be found between PARI and non-PARI groups for females except for the frequency and duration of transport-related PA (all  $P<0.01$ ). For females, students with different sleep duration significantly differed in PARI experience ( $P<0.05$ ), while sedentary behaviour had an impact on the occurrence of PARI among male students ( $P<0.01$ ) (Table 2). The means and SDs for all PA indicators are available in Supplementary Table S1.

Table 2 Comparison of life-style variables in participants with PARI or not among different genders

Characteristics	Males (n=1790)		$\chi^2/Z^*$	Females (n=3551)		$\chi^2/Z^*$
	PARI (n=469) median, IQR	Non-PARI (n=1321) median, IQR		PARI (n=824) median, IQR	Non-PARI (n=2727) median, IQR	
Domestic/work/study						
VPA						
Frequency, day/week	1 (0, 2)	0 (0, 1)	5.392 <sup>3</sup>	0 (0, 0.75)	0 (0, 0)	4.624 <sup>3</sup>
Duration, min/day	10 (0, 30)	0 (0, 15)	5.767 <sup>3</sup>	0 (0, 7.5)	0 (0, 0)	4.818 <sup>3</sup>
MPA						
Frequency, day/week	2 (0, 3)	1 (0, 3)	4.235 <sup>3</sup>	1 (0, 3)	0 (0, 2)	5.197 <sup>3</sup>
Duration, min/day	30 (0, 40)	12 (0, 30)	6.593 <sup>3</sup>	10 (0, 30)	0 (0, 30)	5.341 <sup>3</sup>
Transportation						
Frequency, day/week	5 (0, 7)	5 (0, 7)	2.998 <sup>2</sup>	5 (2, 7)	5 (1, 7)	1.816
Duration, min/day	30 (15, 60)	30 (0, 45)	4.156 <sup>3</sup>	30 (12.75, 45)	30 (10, 45)	0.697
Sports and leisure time						
VPA						
Frequency, day/week	1 (0, 2)	0 (0, 1)	9.538 <sup>3</sup>	0 (0, 1)	0 (0, 1)	3.130 <sup>2</sup>
Duration, min/day	20 (0, 60)	0 (0, 20)	10.402 <sup>3</sup>	0 (0, 20)	0 (0, 10)	3.050 <sup>2</sup>
MPA						
Frequency, day/week	2 (0, 3)	1 (0, 2)	5.545 <sup>3</sup>	1 (0, 2)	0 (0, 2)	5.644 <sup>3</sup>
Duration, min/day	20 (0, 40)	10 (0, 30)	7.235 <sup>3</sup>	10 (0, 30)	0 (0, 30)	5.485 <sup>3</sup>
Sleep duration, n (%)			4.055			13.345 <sup>1</sup>
<6 hours/day	33 (20.4)	129 (79.6)		61 (27.0)	165 (73.0)	
6 to <7 hours/day	93 (27.2)	249 (72.8)		145 (28.2)	370 (71.8)	
7 to <8 hours/day	184 (26.4)	513 (73.6)		305 (20.9)	1151 (79.1)	
8 to <9 hours/day	126 (27.9)	325 (72.1)		225 (22.8)	764 (77.2)	
$\geq 9$ hours/day	33 (24.1)	104 (75.9)		88 (24.1)	277 (75.9)	
Sedentary behavior, n (%)			18.567 <sup>2</sup>			7.094
<4 hours/day	173 (21.3)	638 (78.7)		269 (24.0)	853 (76.0)	
4 to <6 hours/day	42 (28.4)	106 (71.6)		72 (28.9)	177 (71.1)	
6 to <9 hours/day	40 (30.3)	92 (69.7)		71 (24.0)	225 (76.0)	
9 to <12 hours/day	62 (30.0)	145 (70.0)		89 (20.1)	354 (79.9)	
$\geq 12$ hours/day	152 (30.9)	340 (69.1)		323 (22.4)	1118 (77.6)	

\* Categorical variables (i.e., sleep duration and sedentary behaviour) were tested by Pearson chi-square tests, and continuous variables (except for sleep duration and sedentary behaviour) were tested by Mann-Whitney tests or independent-sample *t* tests (the frequency of transport-related PA); <sup>1</sup>  $P<0.05$ ; <sup>2</sup>  $P<0.01$ ; <sup>3</sup>  $P<0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

191 Based on the significant variables tested by chi-square tests and independent-sample *t*  
 192 tests or Mann-Whitney tests, a multivariable logistic regression model was used to estimate  
 193 ORs and corresponding 95% CIs for PARI among male students. As shown in Table 3, male  
 194 students in Shantou and Xi'an had higher odds of sustaining PARI (OR=3.525 and 4.571).  
 195 Sports team members were more likely to suffer from PARI (OR=1.819, 95% CI:  
 196 1.349-2.453) in comparison with their counterparts. Additionally, the frequency and duration  
 197 of sports and leisure-time VPA were significantly associated with PARI (OR=1.129 and  
 198 1.007, respectively).

199 Table 3 Multivariable logistic regression to estimate risk factors for PARI among males

Variables	B	S.E.	OR	95% CI	P-value
City					
Shantou	1.260	0.140	3.525	2.680-4.636	<0.001
Jinan	-0.060	0.186	0.941	0.653-1.356	0.745
Xi'an	1.520	0.194	4.571	3.124-6.687	<0.001
Nanchang			1 (ref.)		
Sports team member					
No			1 (ref.)		
Yes	0.598	0.152	1.819	1.349-2.453	<0.001
Sports and leisure-time VPA					
Frequency, day/week	0.121	0.040	1.129	1.043-1.221	0.003
Duration, min/day	0.007	0.002	1.007	1.004-1.011	<0.001

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

201 Similarly, a multivariable logistic regression analysis was also performed to estimate the  
 202 odds of potential factors for PARI among females, and the results of all significant variables  
 203 kept in the final model are displayed in Table 4. Female students in Shantou and Xi'an were  
 204 more vulnerable to experiencing PARI (OR=2.710 and 2.456, respectively), and those who  
 205 participated in a sports team and had a chronic condition were more prone to sustain PARI  
 206 (OR=1.950 and 1.834, respectively). Moreover, a higher frequency of sports and leisure-time  
 207 VPA and MPA (OR=1.079 and 1.091, respectively) and longer duration of sports and  
 208 leisure-time MPA (OR=1.003) increased the possibility of suffering from PARI.

209 Table 4 Multivariable logistic regression to estimate risk factors for PARI among females

Variables	B	S.E.	OR	95% CI	P-value
City					
Shantou	0.997	0.139	2.710	2.064-3.559	<0.001
Jinan	-0.494	0.169	0.868	0.674-1.092	0.355
Xi'an	0.898	0.159	2.456	1.796-3.357	<0.001
Nanchang			1 (ref.)		
Sports team member					
No			1 (ref.)		
Yes	0.668	0.128	1.950	1.516-2.507	<0.001
Chronic disease/symptom					
No					
Yes	0.607	0.178	1.834	1.293-2.602	0.001

Sports and leisure-time VPA					
Frequency, day/week	0.076	0.034	1.079	1.011-1.153	0.034
Sports and leisure-time MPA					
Frequency, day/week	0.087	0.026	1.091	1.036-1.149	0.001
Duration, min/day	0.003	0.001	1.003	1.001-1.006	0.016

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

211 With regards to favourite activities, nearly three-fifths (58.9%, n=3147) of students had  
 212 at least one PA that they liked and participated often during the past 12 month. Running,  
 213 badminton, basketball, bicycling, table tennis, and swimming were the primary activities in  
 214 which students participated in the past 12 months. There was a difference in PA engagement.  
 215 Males (n=1107) favoured running, basketball, badminton, table tennis, bicycling, and football,  
 216 while females (n=2040) preferred running, badminton, bicycling, basketball, table tennis, and  
 217 swimming (Supplementary Table S2).

218 The number and consequences of PARI reported by 1293 injured students before and  
 219 after gender stratification are shown in Table 5. During the past 12 month, more than half  
 220 (n=666, 51.5%) of the injured participants experienced one PARI episode and over one-fifth  
 221 (n=296, 22.9%) suffered from PARI at least three times (i.e., multiple injuries). Male students  
 222 had a greater tendency to sustain multiple injuries, whereas a larger portion of females  
 223 experienced PARI only once. Over half of the injured (57.3%) experienced a withdrawal time  
 224 of PA and nearly two-fifths (39.6%) received medical treatment due to PARI. A significant  
 225 difference was observed for both genders in a break from PA participation, with male injured  
 226 students being more likely to experience inactivity (64.2% vs. 53.4%,  $P<0.001$ ).

227 Table 5 Number and consequences of PARI among injured university students

Characteristics	Total (N=1293), n (%)	Males (N=469), n (%)	Females (N=824), n (%)	$\chi^2$	P-value
Number of PARI				35.494	<0.001
1	666 (51.5)	198 (42.2)	468 (56.8)		
2	331 (25.6)	124 (26.4)	207 (25.1)		
$\geq 3$	296 (22.9)	147 (31.3)	149 (18.1)		
Consequences of PARI					
Stop quickly and/or cannot participate in the next PA				14.199	<0.001
No	552 (42.7)	168 (35.8)	384 (46.6)		
Yes	741 (57.3)	301 (64.2)	440 (53.4)		
Absence of class				0.306	0.580
No	984 (76.1)	361 (77.0)	623 (75.8)		
Yes	309 (23.9)	108 (23.0)	201 (24.2)		
Seek medical attention				1.606	0.205
No	781 (60.4)	294 (62.7)	487 (59.1)		
Yes	512 (39.6)	175 (27.3)	337 (40.9)		

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

## 229 Discussion

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4 230 As one of the top health threats to school-aged adolescents and young adults in the  
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6 231 majority of countries <sup>5,11</sup>, PARI could lead to financial medical burdens and prevent  
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8 232 individuals from being physically active to improve and maintain physical, cognitive, and  
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10 233 mental health <sup>24-26</sup>. In this study, we found that approximately one out of four university  
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12 234 students experienced at least one PARI episode in the past 12 months, with an overall injury  
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14 235 risk of 0.38 injuries/student/year. Additionally, more than half of the injured students had a  
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16 236 withdrawal time of PA participation, and nearly two-fifths of cases required medical attention.  
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18 237 These findings indicated that PARI is rather common and has a great adverse effect on  
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20 238 Chinese university students. In contemporary China, approximately 48% of secondary  
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22 239 students could be admitted to different levels of universities <sup>27</sup>. The One-Percent National  
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24 240 Sample Census in 2015 revealed that the number of current university students hit 39.7  
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26 241 million <sup>27</sup>. This suggests that the problem of PARI among Chinese university students needs  
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28 242 to be urgently highlighted, and effective injury-prevention programmes should be developed  
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30 243 when PA promotion is made a public health priority.

31 244 In line with other findings reported elsewhere <sup>23,28,29</sup>, we found that male students had a  
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33 245 significantly higher PARI incidence and risk than their female counterparts. Several reasons  
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35 246 may underline this gender difference. First, males are prone to be more physically active than  
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37 247 females <sup>30</sup>. This could be supported by our data in terms of different PA indicators in Table 2.  
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39 248 Second, Ristolainen et al <sup>31</sup> and Hootman et al <sup>32</sup> revealed that males are inclined to take part  
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41 249 in more competitive high-intensity activities, such as basketball and football, that involve a  
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43 250 higher rate of contact, jumping, and sprinting, which are commonly associated with a higher  
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45 251 incidence of injuries. Though the GPAQ could not allow us to access the type of PA, our  
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47 252 study found differences in favourite activities by gender—more male students favoured  
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49 253 basketball and football. This might support the relationship between the intensity and type of  
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51 254 PA to a certain extent. Even in the same activity, males tend to have higher competitiveness  
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53 255 and resistance with lower individual safety awareness <sup>33</sup>. This could contribute to their higher  
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55 256 incidence of PARI to some extent. Third, Deci et al <sup>34</sup> indicated that male students had great  
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57 257 motivation, impulsiveness, and self-determination, which may also play a role. On one hand,  
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59 258 these gender-specific characteristics could affect the occurrence of PARI; on the other hand,  
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259 these might influence the analysis of potential risk factors for PARI. Previous studies have

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4 260 revealed marked gender-specific differences in PARI occurrence and relevant risk factors  
5 261 <sup>15,35,36</sup>. If a risk factor has different impacts on PARI for various genders, it would be difficult  
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7 262 to find true associations when the data were analyzed together <sup>35</sup>. We thus explored possible  
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9 263 contributors to PARI for males and females separately.

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11 264 Being physically inactive is harmful to our individual well-being <sup>5</sup>, but so is being too  
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13 265 active. Our study revealed a positive and significant association between PARI occurrence  
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15 266 and the frequency of sports and leisure-time VPA participation in both males and females,  
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17 267 and a longer duration of sports and leisure-time VPA involvement could increase the risk of  
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19 268 PARI for male students. This is highly consistent with other findings showing that higher  
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21 269 intensity, higher frequency, and longer duration of PA participation contributed to an elevated  
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23 270 risk of PARI <sup>33,37</sup>. Furthermore, we found that the frequency and duration of sports and  
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25 271 leisure-time MPA engagement were positively associated with the occurrence of PARI for  
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27 272 females. Collectively, different levels of PA participation between males and females cause  
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29 273 differences in the occurrence of PARI. This is in line with other reports <sup>35,36</sup>. In addition,  
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31 274 though a relationship between sedentary behaviour and PARI occurrence was not observed in  
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33 275 our study, earlier literature indicated that sedentary behaviour would affect individual  
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35 276 physical function and increase the risk of injury <sup>38-40</sup>. We should place great emphasis on the  
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37 277 above results, especially when we promote a physically active lifestyle for the public.  
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39 278 Otherwise, the benefits of PA participation would be comprised.

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41 279 In comparison with their counterparts, sports team members had a higher likelihood of  
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43 280 suffering from PARI among both males (OR=1.819) and females (OR=1.950). This parallels  
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45 281 previous literature <sup>9,41</sup>, irrespective of age group. Generally, students participating in sports  
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47 282 teams would spend lots of their time on one certain kind of activity, which often associates  
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49 283 with the high risk of overuse injuries, such as tendinopathies, bursitis, and stress fracture <sup>42,43</sup>.  
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51 284 Moreover, the activities in which sports team members participate are usually structured, and  
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53 285 their focus is often on improving individual performance <sup>41</sup>. In this way, they generally have a  
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55 286 higher frequency and intensity and longer duration of PA participation <sup>41</sup>. This further  
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57 287 supports the idea that too much physical activity can harm individual health. Thus, we should  
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59 288 take this particularly vulnerable population into consideration, and effective preventative  
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289 measures should be introduced.

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4 290 In this study, living with a chronic condition was identified as the potential determinant  
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6 291 of PARI for females. Amongst the whole study sample, nearly 5.7% had a chronic disease  
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8 292 (i.e., near-sightedness). The exact reasons for the association between the chronic condition  
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10 293 and PARI occurrence in female students in the present study are unknown. A possible partial  
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12 294 explanation may be that the health issue affects their PA participation and exposes them to  
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14 295 higher injury risk when undertaking PA. This specific contributor has implications for the  
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16 296 identification of injury mechanisms and interventions in injury prevention among female  
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18 297 students.

19 298 Surprisingly, our study revealed a difference in the occurrence of PARI among  
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21 299 university students—both males and females in Shantou and Xi'an had markedly higher PARI  
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23 300 incidence than those in Jinan and Nanchang. However, this discrepancy could not be  
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25 301 explained by all the potential variables in our study (Supplementary Tables S3 and S4). Given  
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27 302 that the four study cities are located in different parts of China and have varied climates, we  
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29 303 assumed that the large between-city differences in the incidence rate of PARI may be  
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31 304 attributed to geographical factors. PA infrastructure may affect the occurrence of PARI for  
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33 305 students, but all these study cities belong to Mainland China, sharing similar facilities and  
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35 306 surveillance systems. We thereby excluded this possibility. Additionally, the urban  
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37 307 environments outside of the universities might be attributable to this difference, but we could  
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39 308 not provide related evidence for this hypothesis due to the absence of data on where these  
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41 309 injuries occurred. Collectively, the reasons for the between-city PARI difference need to be  
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43 310 studied further.

44 311 Our study is influenced by several limitations. First, data collection was through a  
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46 312 structured self-reported questionnaire, which could lead to reporting bias and recall bias <sup>44</sup>.  
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48 313 For example, students might not have accurately reported their PARI experiences, in  
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50 314 particular the minor and earliest injuries. Though previous studies noted that participants were  
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52 315 able to correctly indicate whether they had been injured or not during the past 12-month  
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54 316 period <sup>45</sup>, we should consider a shorter recall period, i.e. 6 months, especially when collecting  
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56 317 detailed information of each identified PARI episode. Meanwhile, despite the good reliability  
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58 318 and validity of the GPAQ, we could not fully preclude the possibility of over-reported PA  
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60 319 exposure time. Despite this drawback, the use of self-report is a more practical, feasible, and

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4 320 cost-effective way that allows us to carry out a multi-centre survey with such a large sample  
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6 321 size. Second, the nature of the cross-sectional study limited us from drawing the  
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8 322 cause-and-effect relationship between PARI outcome and the potential risk factors in this  
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10 323 study. Their associations still warrant further investigation by a prospective cohort study.  
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12 324 Third, nearly two-thirds of the study samples were female students, which may have limited  
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14 325 the generalizability and representativeness of our findings. Fourth, we did not compare acute  
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16 326 and overuse injuries, two injury types with different injury mechanisms, which may have  
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18 327 deviated the analysis in the association between PARI and its potential contributors. Thus,  
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20 328 future studies should take these limitations into account to better reflect the characteristics and  
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22 329 risk factors of PARI among university students.

### 23 330 **Conclusion**

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25 331 With an overall incidence rate of 24.2% and an injury risk of 0.38 injuries/student/year,  
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27 332 PARI was not uncommon among Chinese university students. Different genders differed in  
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29 333 the occurrence of PARI and were affected by various potential risk factors. For males, those  
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31 334 who were Shantou and Xi'an students, were sports team members, and participated in sports  
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33 335 and leisure-time VPA with higher frequency and longer duration were more likely to suffer  
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35 336 from PARI. For females, studying in Shantou and Xi'an, participating in a sports team, having  
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37 337 a chronic disease or symptom, engaging in sports and leisure-time VPA with higher  
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39 338 frequency, and taking part in sports and leisure-time MPA with higher frequency and longer  
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41 339 duration were the potential contributors to PARI. These findings provide a direction to  
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43 340 develop targeted gender-specific prophylactic interventions to reduce PARI and to maximize  
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45 341 the benefits of PA participation among university students in China.

### 46 342 **Acknowledgements**

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48  
49 343 We thank all university students for their participation in our questionnaire survey.

### 50 51 344 **Funding statement**

52  
53 345 This work was supported by the National Natural Science Foundation of China (grant  
54  
55 346 number 31640038). The sponsor had no role in the study design, data collection, analysis and  
56  
57 347 interpretation, preparation and revision of the manuscript, or decision to submit the article for  
58  
59 348 publication.  
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4 349 **Authors' contributions**

5 350 LPL, CXJ, and YG conceived and designed the study; WCC, PYY, XFY, LJG, and  
6  
7 351 WDY collected data; and WCC and SMC performed the statistical analyses and drafted the  
8  
9 352 manuscript. All authors have read and approved the final version of the manuscript, and agree  
10  
11 353 with the order of the presentation of the authors.  
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13  
14 354 **Competing interests**

15  
16 355 None declared.  
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18 356 **Data availability statement**

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21 357 No additional data available.  
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For peer review only

## Supplementary materials

Supplementary Table S1 Comparison of life-style variables in participants with PARI or not by gender

Characteristics	Males (n=1790)			Females (n=3551)		
	PARI (n=469) x±s	Non-PARI (n=1321) x±s	$\chi^2/Z^*$	PARI (n=824) x±s	Non-PARI (n=2727) x±s	$\chi^2/Z^*$
Domestic/work/study						
VPA						
Frequency, day/week	1.29±1.75	0.84±1.44	4.971 <sup>3</sup>	0.58±1.26	0.38±1.03	4.271 <sup>3</sup>
Duration, min/day	24.83±46.12	14.82±34.09	4.305 <sup>3</sup>	11.85±36.14	5.80±17.31	4.652 <sup>3</sup>
MPA						
Frequency, day/week	2.10±1.96	1.72±1.95	3.630 <sup>3</sup>	1.66±1.93	1.32±1.82	4.522 <sup>3</sup>
Duration, min/day	31.54±42.39	20.51±29.17	5.213 <sup>3</sup>	24.74±48.56	16.42±33.47	4.602 <sup>3</sup>
Transportation						
Frequency, day/week	4.17±2.64	3.73±2.80	2.998 <sup>2</sup>	3.97±2.60	3.78±2.67	1.816
Duration, min/day	42.66±49.36	32.14±35.69	4.349 <sup>3</sup>	37.59±48.80	34.64±45.06	1.549
Sports and leisure-time						
VPA						
Frequency, day/week	1.56±1.70	0.89±1.52	7.448 <sup>3</sup>	0.71±1.40	0.53±1.20	3.401 <sup>3</sup>
Duration, min/day	34.24±40.90	16.65±31.36	8.471 <sup>3</sup>	13.42±29.23	9.73±22.61	3.330 <sup>3</sup>
MPA						
Frequency, day/week	1.89±1.95	1.41±1.89	4.640 <sup>3</sup>	1.52±1.92	1.16±1.74	4.914 <sup>3</sup>
Duration, min/day	28.95±32.39	18.28±27.95	6.344 <sup>3</sup>	22.96±39.77	16.55±27.89	4.313 <sup>3</sup>
Sleep duration, n (%)			4.055			13.345 <sup>1</sup>
<6 hours/day	33 (20.4)	129 (79.6)		61 (27.0)	165 (73.0)	
6 to <7 hours/day	93 (27.2)	249 (72.8)		145 (28.2)	370 (71.8)	
7 to <8 hours/day	184 (26.4)	513 (73.6)		305 (20.9)	1151 (79.1)	
8 to <9 hours/day	126 (27.9)	325 (72.1)		225 (22.8)	764 (77.2)	
≥9 hours/day	33 (24.1)	104 (75.9)		88 (24.1)	277 (75.9)	
Sedentary behavior, n (%)			18.567 <sup>2</sup>			7.094
<4 hours/day	173 (21.3)	638 (78.7)		269 (24.0)	853 (76.0)	
4 to <6 hours/day	42 (28.4)	106 (71.6)		72 (28.9)	177 (71.1)	
6 to <9 hours/day	40 (30.3)	92 (69.7)		71 (24.0)	225 (76.0)	
9 to <12 hours/day	62 (30.0)	145 (70.0)		89 (20.1)	354 (79.9)	
≥12 hours/day	152 (30.9)	340 (69.1)		323 (22.4)	1118 (77.6)	

\*Categorical variables (i.e., sleep duration and sedentary behaviour) were tested by Pearson chi-square tests, and continuous variables (except for sleep duration and sedentary behaviour) were tested by Mann-Whitney tests or independent-sample *t* tests (the frequency of transport-related PA); <sup>1</sup> *P*<0.05; <sup>2</sup> *P*<0.01; <sup>3</sup> *P*<0.001; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

Supplementary Table S2 Primary physical activities that university students participated

Activity items	Total (N=3147), n (%)	Males (N=1107), n (%)	Females (N=2040), n (%)
Basketball	790 (25.1)	462 (41.7)	329 (16.1)
Running	1778 (55.8)	548 (49.5)	1230 (60.3)
Badminton	1518 (48.2)	458 (41.4)	1060 (52.0)
Bicycling	525 (16.7)	156 (14.1)	369 (18.1)
Swimming	391 (12.4)	137 (12.4)	254 (12.5)
Table tennis	545 (17.3)	253 (22.9)	292 (14.3)
Football	211 (6.7)	139 (12.6)	72 (3.5)
Dance	187 (5.9)	25 (2.3)	162 (7.9)
Fitness	258 (8.2)	101 (9.1)	157 (7.7)

This table only listed those physical activities of participation rate more than 5%.

Supplementary Table S3 Comparison of all related variables among university students in different cities

Characteristics	Shantou (n=2123) median, IQR	Jinan (n=1267) median, IQR	Xi'an (n=714) median, IQR	Nanchang (n=1237) median, IQR	$\chi^2/F^*$
Domestic/work/study					
VPA					
Frequency, day/week	0 (0, 0)	0 (0, 1)	0 (0, 1)	0 (0, 1)	110.025 <sup>3</sup>
Duration, min/day	0 (0, 0)	0 (0, 10)	0 (0, 20)	0 (0, 10)	87.325 <sup>3</sup>
MPA					
Frequency, day/week	1 (0, 2)	1 (0, 3)	1 (0, 2)	0 (0, 3)	39.878 <sup>3</sup>
Duration, min/day	10 (0, 30)	15 (0, 30)	10 (0, 30)	0 (0, 30)	28.091 <sup>3</sup>
Transportation					
Frequency, day/week	5 (2, 7)	5 (2, 7)	2 (1, 5)	5 (0, 5)	63.323 <sup>3</sup>
Duration, min/day	30 (10, 40)	30 (15, 50)	30 (15, 60)	30 (0, 45)	20.658 <sup>3</sup>
Sports and leisure time					
VPA					
Frequency, day/week	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	31.724 <sup>3</sup>
Duration, min/day	0 (0, 15)	0 (0, 30)	0 (0, 20)	0 (0, 10)	41.852 <sup>2</sup>
MPA					
Frequency, day/week	0 (0, 2)	1 (0, 3)	1 (0, 2)	0 (0, 1)	112.709 <sup>3</sup>
Duration, min/day	0 (0, 30)	20 (0, 30)	10 (0, 30)	0 (0, 10)	181.535 <sup>3</sup>
	n (%)	n (%)	n (%)	n (%)	
Grade					515.974 <sup>3</sup>
Year 1	698 (32.9)	453 (35.8)	432 (60.5)	791 (63.9)	
Year 2	691 (32.5)	443 (35.0)	180 (25.2)	344 (27.8)	
Year 3	734 (34.6)	371 (29.3)	102 (14.3)	102 (8.2)	
Gender					441.055 <sup>3</sup>
Male	569 (26.8)	337 (26.6)	165 (23.1)	719 (58.1)	
Female	1554 (73.2)	930 (73.4)	549 (76.9)	518 (41.9)	
Residence type					204.376 <sup>3</sup>
Dormitory	1511 (71.2)	1050 (82.9)	393 (55.0)	816 (66.0)	
Home	587 (27.6)	210 (16.6)	309 (43.3)	385 (31.1)	
Other	25 (1.2)	7 (0.6)	12 (1.7)	36 (2.9)	
Sports team member					16.045 <sup>2</sup>
No	1861 (87.7)	1096 (86.5)	659 (92.3)	1098 (88.8)	
Yes	262 (12.3)	171 (13.5)	55 (7.7)	139 (11.2)	
Chronic disease/symptom					72.979 <sup>3</sup>
No	2028 (95.5)	1226 (96.8)	681 (95.4)	1109 (89.7)	
Yes	95 (4.5)	41 (3.2)	33 (4.6)	128 (10.3)	
Sleep duration, n (%)					193.604 <sup>1</sup>
<6 hours/day	110 (5.2)	58 (4.6)	68 (9.5)	152 (12.3)	
6 to <7 hours/day	365 (17.2)	158 (12.5)	70 (9.8)	264 (21.3)	
7 to <8 hours/day	841 (39.6)	608 (48.0)	260 (36.4)	444 (35.9)	
8 to <9 hours/day	563 (26.5)	353 (27.9)	236 (33.1)	288 (23.3)	
≥9 hours/day	244 (11.5)	90 (7.0)	80 (11.2)	89 (7.2)	
Sedentary behavior, n (%)					748.383 <sup>3</sup>
<4 hours/day	537 (25.3)	298 (23.5)	306 (42.9)	792 (64.0)	
4 to <6 hours/day	157 (7.4)	79 (6.2)	62 (8.7)	99 (8.0)	
6 to <9 hours/day	146 (6.9)	118 (9.3)	78 (10.9)	86 (7.0)	
9 to <12 hours/day	300 (14.1)	176 (13.9)	84 (11.8)	90 (7.3)	
≥12 hours/day	983 (46.3)	596 (47.0)	184 (25.8)	170 (13.7)	
Age ( $\bar{x}\pm s$ , years)	19.92±1.27	19.69±1.16	19.46±1.29	19.03±1.17	54.227 <sup>3</sup>

\*Categorical variables were tested by Pearson chi-square tests, and continuous variables were tested by one-way ANOVA tests (i.e., age and the frequency of transport-related PA) or Kruskal-Wallis tests (except for age and the frequency of transport-related PA); <sup>1</sup>  $P<0.05$ ; <sup>2</sup>  $P<0.01$ ; <sup>3</sup>  $P<0.001$ ; PARI, physical activity-related injury; VPA, vigorous-intensity physical activity; MPA, moderate-intensity physical activity.

Supplementary Table S4 Comparison of all related variables among university students in different cities

Characteristics	Shantou (n=2123) x±s	Jinan (n=1267) x±s	Xi'an (n=714) x±s	Nanchang (n=1237) x±s	$\chi^2/F^*$
Domestic/work/study					
VPA					
Frequency, day/week	0.49±1.21	0.65±1.36	0.69±1.37	0.71±1.27	110.025 <sup>3</sup>
Duration, min/day	9.54±30.39	11.95±26.86	14.55±33.39	8.89±27.25	87.325 <sup>3</sup>
MPA					
Frequency, day/week	1.37±1.80	1.39±1.82	1.50±1.81	1.56±1.85	39.878 <sup>3</sup>
Duration, min/day	22.04±46.98	20.96±28.38	21.26±34.46	14.97±19.79	28.091 <sup>3</sup>
Transportation					
Frequency, day/week	4.19±2.68	4.19±2.72	2.96±2.45	3.35±2.64	63.323 <sup>3</sup>
Duration, min/day	33.48±37.86	36.06±36.29	45.62±73.68	31.18±36.82	20.658 <sup>3</sup>
Sports and leisure time					
VPA					
Frequency, day/week	0.66±1.33	0.91±1.59	0.72±1.32	0.69±1.32	31.724 <sup>3</sup>
Duration, min/day	13.43±28.85	18.12±30.86	16.68±32.85	9.92±22.76	41.852 <sup>2</sup>
MPA					
Frequency, day/week	1.29±1.79	1.73±2.03	1.38±1.77	1.00±1.67	112.709 <sup>3</sup>
Duration, min/day	19.49±31.62	25.21±39.45	21.99±35.78	10.32±19.76	181.535 <sup>3</sup>
Age (years)	19.92±1.27	19.69±1.16	19.46±1.29	19.03±1.17	54.227 <sup>3</sup>
	n (%)	n (%)	n (%)	n (%)	
Grade					515.974 <sup>3</sup>
Year 1	698 (32.9)	453 (35.8)	432 (60.5)	791 (63.9)	
Year 2	691 (32.5)	443 (35.0)	180 (25.2)	344 (27.8)	
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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2-3
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6
		(b) Describe any methods used to examine subgroups and interactions	6
		(c) Explain how missing data were addressed	
		(d) If applicable, describe analytical methods taking account of sampling strategy	
		(e) Describe any sensitivity analyses	
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	7, 10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	8-9

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	8
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	10-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

\*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).