Original Article
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Injury Characteristics and Predisposing Effects of Various Outdoor Traumatic Situations in Children and Adolescents

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Background: Many studies have reported injury characteristics of individual traumatic situations. However, a comparative analysis of specific risks is meaningful to better understand injury characteristics and help establish injury-prevention measures. This study was conducted to investigate and compare injury characteristics in children and adolescents by various outdoor traumatic situations.

Methods: Outdoor traumatic situations were determined and classified into physical activity-related injury (n = 3,983) and pedestrian (n = 784) and passenger (n = 1,757) injuries in traffic accidents. Home injury (n = 16,121) was used as the control group. Then, the characteristics of each outdoor trauma were compared with 1:1 matched indoor trauma (among home injuries); each outdoor traumatic situation's predisposing risk for the injured body part, injury type, and injury severity were analyzed; and changes by age of frequency ranking among physical activity-related injuries were investigated.

Results: Outdoor trauma showed higher risks for limb injuries (injured body part), fracture and muscle/tendon injuries (injury type), and severe injuries (severity) than indoor trauma. Various outdoor traumatic situations presented different predisposing effects on injury characteristics. Among physical activity-related injuries, bicycle injury was commonest across all ages, and playing activities were common causes for injury for individuals of age < 9 years, whereas sports activities overwhelmed the common causes thereafter.

Conclusions: The findings would help to better understand the specific injury risk of various outdoor traumatic situations and may potentially facilitate the establishment of more effective injury-prevention measures.

Keywords: *Adolescent, Children, Physical activity, Traffic accident, Trauma*

Outdoor activities, including sports and leisure, have steadily increased among children and adolescents and are associated with a consequent increase in physical activity-related injury.[1,2] Moreover, traffic accidents (TAs) and TA-related injuries of children and adolescents continue to increase with the higher number of cars.[3] Therefore, prevention of outdoor trauma has become important.

Many studies have been conducted to analyze physical activity- and TA-related injuries, but no study has examined the risk factors for detailed injury sites, types, and severity, and control groups were not clearly defined.[4-6] Therefore, it is important to identify risk factors in each outdoor traumatic situation by establishing a clear control

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group, as this can facilitate identification of specific risk factors of each outdoor traumatic situation compared to indoor trauma to help identify strategies to prevent injury.

Trauma can be characterized by frequently-injured body parts. However, only identification of injury-prone body parts is insufficient to establish effective preventive measures in all outdoor traumatic situations. Therefore, with regard to injury prevention, it is important to identify body parts or types of injuries that are relatively common and specific in different outdoor traumatic situations. Some types of injuries are more specific with regard to age or sex, and there are many risk factors that can affect injuries in children. Therefore, correction via statistical techniques, such as matching or multivariate analysis, is required for accurate analysis.

Pursuant to these concerns, to gain an in-depth understanding of pediatric outdoor trauma, we reviewed the data of children (age ≤ 18 years) who were injured in various outdoor traumatic situations, compared them with those of matched controls (children injured at home), analyzed the predisposing effects of each traumatic situation on injury characteristic by multivariate analyses, and ranked the frequent physical activity-related injuries by age groups.

METHODS

This study is a retrospective chart review. This study was approved by Institutional Review Board of the Asan Medical Center, Ulsan University of Medicine (IRB No. 2017-0384). Informed consent was waived by Institutional Review Board for this retrospective study.

Determination of Outdoor Traumatic Situations

The researchers classified outdoor traumatic situations into three types as follows: (1) physical activity-related injuries, (2) extravehicular (pedestrian) injuries in TA, and (3) intravehicular injuries (passenger) in TA. Physical activity-related injuries comprised representative outdoor physical activities that were determined by discussion among the researchers as follows: play activities, including trampoline, slides, swings, bicycles, quick boards, and Heelys (shoes with wheels fitted in the heel); martial arts, including taekwondo (Korean martial art), kendo (Japanese art of fencing), judo (Japanese martial art), and kung fu (Chinese martial art); and sports activities, including soccer, basketball, baseball, tennis, badminton, golf, volleyball, skiing, snowboarding, sledding, skating, swimming, diving, and rafting. TAs were determined by triage registration.

Patients with injuries sustained at home (home injuries, including all accidental, unintended, traumatic injuries that occurred at home) were designated as a control group for patients with outdoor traumatic injuries.

Patients

We reviewed the data of patients (age ≤ 18 years) who visited the emergency department at the study institution from January 2006 to December 2017 and received a traumatic injury code (S-code). For patients with more than one claim record with an S-code, only the first entry was included, and the age at the earliest claim was recorded; 52,117 cases met the eligibility criteria for study inclusion.

To identify cases with injuries sustained during outdoor physical activities, keyword searches were initially conducted in the electronic medical records. Then, each searched case was reviewed by the researchers, and cases unrelated to actual activity or with ambiguous situations were excluded; 5,118 cases were identified to have sustained injuries during outdoor physical activities and were included in the study. In total, 4,395 patients visited the emergency departments due to traumatic injuries sustained in TA, and 3,832 patients were included after excluding 320 cases related to motorcycle accidents and 243 cases with ambiguous records of whether they were pedestrians or passengers. Of the 22,288 patients identified to have sustained injuries at home, ambiguous cases with other traumatic situations were excluded; 21,366 patients with home-based injuries were screened for study inclusion. However, we excluded 7,671 cases (1,135 with injuries sustained during outdoor physical activities, 1,291 with injuries by TA, and 5,245 with home injuries) with 0 as the second digit of the diagnostic code, which indicates superficial abrasion because it was considered too mild an injury.

The final analysis dataset included 22,645 cases (3,983 with injuries sustained during outdoor physical activities, 2,541 with injuries by TA [1,757 intravehicular and 784 extravehicular TA], and 16,121 with home injuries).

Subjective Variables and Injury Outcomes

Sex, age at emergency departments visit, visiting season, weekdays or holiday, and obesity were investigated as subjective variables. To assess obesity, we used the patient's body weight and age because height was not routinely measured. According to the national growth chart,[7] a patient with body weight that was higher than the 95th percentile was considered obese/overweight and patients with body weight lower than the 5th percentile were regarded as having low weight.

The injured body part, injury type, and severity of injury were investigated as injury outcomes. Injured body part and injury type were classified using traumatic injury code. The injured body parts were categorized into four types: (1) head and neck, (2) trunk, (3) upper extremity, and (4) lower extremity. Injury types were categorized into five types: (1) open wound, (2) fracture, (3) dislocation/strain/sprain, (4) injury of muscle/tendon, and (5) others. The severity of injury was classified as mild, moderate, and severe; injuries were considered severe when interventional procedures under general anesthesia were needed. Mild cases were considered as those that needed no further treatment other than short-term immobilization or simple dressing. The remaining cases were considered to have moderate injuries.

Data Analysis

For the selection of a case-matched control group among the patients with home injuries, we used propensity score analysis. Among the 16,121 patients with home injuries, 3,983, 784, and 1,757 patients were selected as control groups (1:1 ratio) for the patients with injuries during outdoor physical activities, by extravehicular TA, and by intravehicular TA, respectively. The propensity score was calculated for each patient based on logistic regression analysis of the probability of experiencing each traumatic situation using patient characteristics of age, sex, season and holiday/workday at emergency departments visit, and obesity. Using propensity scores, we undertook 1:1 matching with the nearest neighbor approach (the patient having the nearest score with the case was matched as a control). Because of the inherent nature of observational studies that the investigators cannot control the subjective variables, we tried to match the patients by using the propensity score. The propensity score is the conditional probability of being the case or control group according to the independent variables.

Therefore, the matching technique using the propensity scores can balance the confounding factors in the case and control groups, resulting in reduced bias.[8] It is also reported that the outcomes of a randomized controlled trial and propensity score analysis were similar, and this means that the bias can be effectively eliminated by a propensity score analysis.[9] Propensity score analysis was conducted in R statistical ver. 3.6.0R (R Foundation, Vienna, Austria). The significance of the differences between means and frequencies was calculated using the independent *t*-test and the chi-square test, respectively. In patients with outdoor traumatic situations, predisposing effects for each injured body part, injury type, and injury severity were analyzed using binary logistic regression. Multivariate analysis was used to adjust for confounding factors.

A *p*-values < 0.05 were considered indicative of statistical significance. All statistical analyses were carried out in IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA) except for the propensity score analysis. For injuries sustained during outdoor physical activities, we ranked the physical activities that caused traumatic injuries for further evaluation.

RESULTS

The frequencies and demographics according to traumatic situations and their comparisons with corresponding data from the control group with home injuries are presented in Tables 1 and 2. All three patients groups with outdoor

Table 1. Incidence of Traumatic Situations by Activity Type

Traumatic situation	No. (%)
Physical activity	3,983 (17.6)
Bicycle	595 (14.9)*
Slide	544 (13.7)*
Soccer	454 (11.4)*
Swing	319 (8.0)*
Trampoline	286 (7.2)*
Baseball	226 (5.7)*
Basketball	253 (6.4)*
Swimming	217 (5.5)*
Skating	179 (4.5)*
Skiing	165 (4.1)*
Taekwondo (Korean martial art)	148 (3.7)*
Others	597 (15.0)*
Extra-vehicular (pedestrian) TA	784 (3.5)
Intra-vehicular (passenger) TA	1,757 (7.8)
With appropriate car seat or seat belt	103 (5.9)*
Without appropriate car seat or seat belt	521 (29.7)*
Unknown appropriate car seat or seat belt	1,133 (64.5)*
Home injury (control, unmatched)	16,121 (71.2)
Total	22,645 (100.0)*

TA: traffic accident.
*The percentages within each subcategory.

Table 2. Comparisons among the Injuries According to Various Traumatic Situations

Characteristic	Physical activity (n = 3,983)	Matched control* (n = 3,983)	Extra-vehicular TA (n = 784)	Matched control* (n = 784)	Intra-vehicular TA (n = 1,757)	Matched control* (n = 1,757)	Home injury (unmatched, n = 16,121)
Matched variable							
Sex							
Boy	2,911 (73.1)	2,684 (67.4)	515 (65.7)	510 (65.1)	1,241 (70.6)	1,103 (62.8)	9,631 (59.7)[†,‡]
Girl	1,072 (26.9)	1,299 (32.6)	269 (34.3)	274 (34.9)	516 (29.4)	654 (37.2)	6,490 (40.3)
Age (yr)	8.63 ± 4.70	6.93 ± 4.24	8.02 ± 4.35	8.05 ± 4.41	9.11 ± 5.20	9.12 ± 5.2	2.97 ± 3.29[†,‡,§]
Season							
Spring	1,153 (28.9)	1,193 (30.0)	262 (33.4)	263 (33.5)	525 (29.9)	532 (30.3)	4,249 (26.4)[§]
Summer	1,186 (29.8)	1,226 (30.8)	216 (27.6)	218 (27.8)	589 (33.5)	543 (30.9)	3,911 (24.3)[†,‡]
Fall	966 (24.3)	896 (22.5)	210 (26.8)	204 (26.0)	445 (25.3)	442 (25.2)	3,949 (24.5)
Winter	678 (17.0)	668 (16.8)	96 (12.2)	99 (12.6)	198 (11.3)	240 (13.7)	4,012 (24.9)[†,‡]
Obesity							
Low weight	168 (4.2)	217 (5.4)	44 (5.6)	43 (5.5)	61 (3.5)	68 (3.9)	862 (5.3)
Normal	3,299 (82.8)	3,330 (83.6)	643 (82.0)	657 (83.8)	1,397 (79.5)	1,435 (81.7)	14,266 (88.5)[†,‡,§]
Overweight/obese	266 (6.7)	250 (6.3)	45 (5.7)	38 (4.8)	112 (6.4)	93 (5.3)	720 (4.5)[†,‡]
Undetermined	250 (6.3)	186 (4.7)	52 (6.6)	46 (5.9)	187 (10.6)	161 (9.2)	273 (1.7)
Holiday vs. workday							
Holiday	1,602 (40.2)	1,785 (44.8)	273 (34.8)	271 (34.6)	802 (45.6)	845 (48.1)	6,681 (41.4)[§]
Workday	2,381 (59.8)	2,198 (55.2)	511 (65.2)	513 (65.4)	955 (54.4)	912 (51.9)	9,440 (58.6)
Outcome (unmatched)							
Injured body part	$p < 0.001$[∥]		$p < 0.001$[∥]		$p = 0.003$[∥]		
Head and neck	2,263 (56.8)	2,887 (72.5)	448 (57.1)	558 (71.2)	1,223 (69.6)	1,192 (67.8)	12,004 (74.5)[†,‡,§]
Trunk	78 (2.0)	84 (2.1)	51 (6.5)	15 (2.3)	60 (3.4)	40 (2.3)	144 (0.9)[†,‡,§]
Upper extremity	934 (23.4)	717 (18.0)	81 (10.3)	132 (16.8)	285 (16.2)	358 (20.4)	3,340 (20.7)[†,‡,§]
Lower extremity	708 (17.8)	295 (7.4)	204 (26.0)	76 (9.7)	189 (10.8)	167 (9.5)	633 (3.9)[†,‡,§]

Table 2. Continued

Characteristic	Physical activity (n = 3,983)	Matched control* (n = 3,983)	Extra-vehicular TA (n = 784)	Matched control* (n = 784)	Intra-vehicular TA (n = 1,757)	Matched control* (n = 1,757)	Home injury (unmatched), (n = 16,121)
Injury type	$p < 0.001$[‖]		$p < 0.001$[‖]		$p < 0.001$[‖]		
Open wound	1,339 (33.6)	2,359 (59.2)	150 (19.1)	462 (58.9)	488 (27.8)	1,013 (57.7)	8,884 (55.1)[†,‡,§]
Fracture	1,392 (34.9)	478 (12.0)	296 (37.8)	106 (13.5)	489 (27.8)	244 (13.9)	1,351 (8.4)[†,‡,§]
Dislocation/strain/sprain	587 (14.7)	447 (11.2)	100 (12.8)	83 (10.6)	275 (15.7)	171 (9.7)	2,685 (16.7)
Injury of muscle/tendon	501 (12.6)	474 (11.9)	199 (25.4)	89 (11.4)	442 (25.2)	211 (12.0)	2,552 (15.8)[†,‡,§]
Others	164 (4.1)	225 (5.6)	39 (5.0)	44 (5.6)	63 (3.6)	118 (6.7)	649 (4.0)
Severity	$p < 0.001$[‖]		$p < 0.001$[‖]		$p < 0.001$[‖]		
Mild	2,489 (62.5)	3,425 (86.0)	455 (58.0)	659 (84.1)	1,238 (70.5)	1,464 (83.3)	14,536 (90.2)[‡,§]
Moderate	1,197 (30.1)	408 (10.2)	264 (33.7)	88 (11.2)	429 (24.4)	205 (11.7)	1,141 (7.1)[†,‡,§]
Severe	297 (7.5)	150 (3.8)	65 (8.3)	37 (4.7)	90 (5.1)	88 (5.0)	444 (2.8)[†,‡,§]

Values are presented as number (%) or mean ± standard deviation.
TA: traffic accident.
*Control group among the patients with injuries sustained at home 1:1 matched for patients with injuries by each outdoor activity (physical activity, intra-vehicular TA, and extra-vehicular TA). [†]*p*-value < 0.001 of frequency difference between physical activity. [‡]*p*-value < 0.001 of frequency difference between intra-vehicular TA. [§]*p*-value < 0.001 of frequency difference between extra-vehicular TA. [‖]*p*-values of frequency difference compared with the matched control for each outdoor traumatic situation.

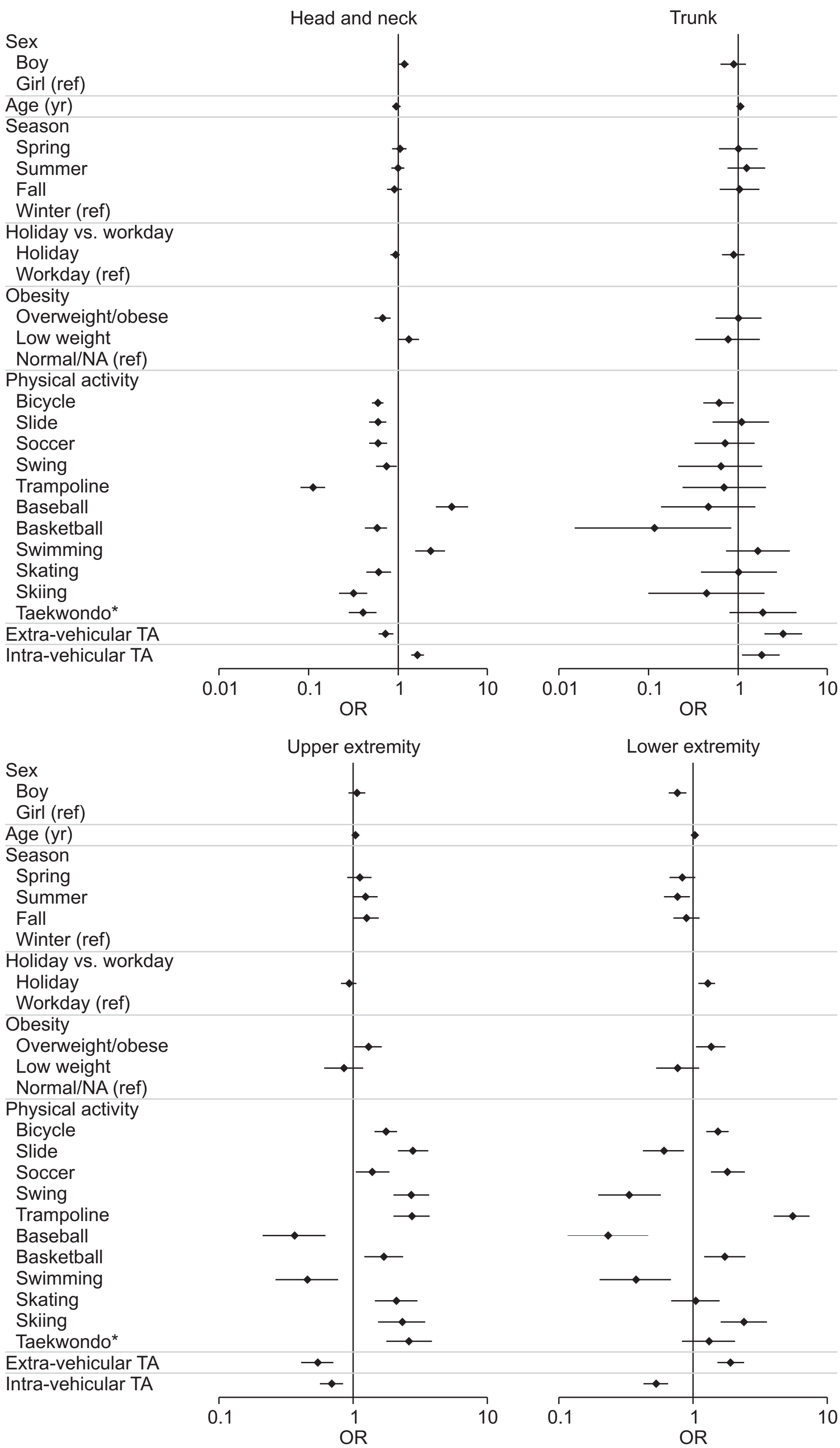

Fig. 1. Forest plot displaying predisposing effects for injured body parts on multivariate analysis. The X-axis represents the odds ratios (ORs; diamond) and 95% confidence intervals (CIs; horizontal line). Details on OR, 95% CI, and *p*-values are provided in the Supplementary Tables 1-4. ref: reference, NA: not available, TA: traffic accident.*Korean martial art.

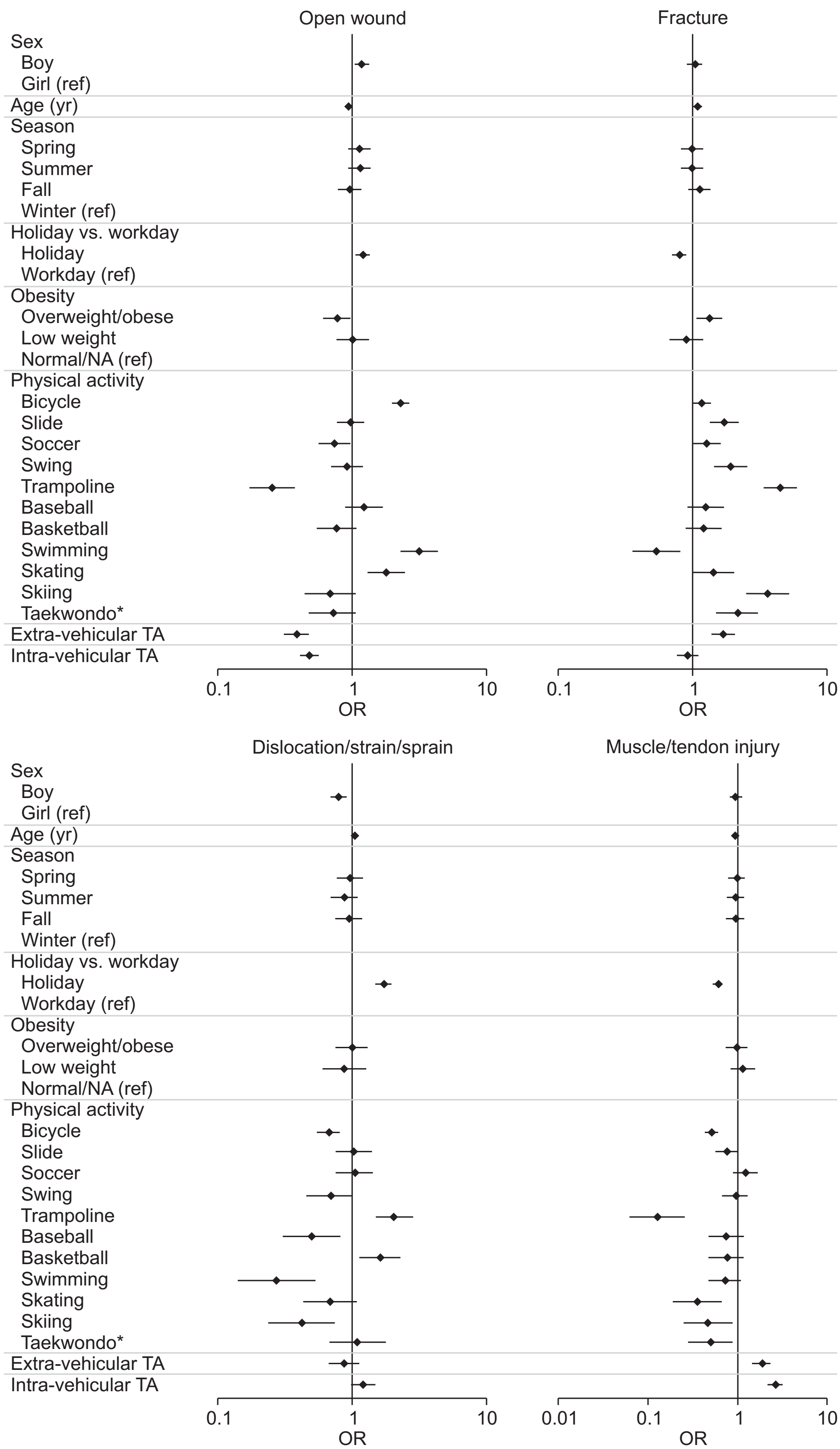

Fig. 2. Forest plot displaying predisposing effects for injury type on multivariate analysis. The X-axis represents the odds ratios (ORs; diamond) and 95% confidence intervals (CIs; horizontal line). Details on OR, 95% CI, and *p*-values are provided in the Supplementary Tables 5-8. ref: reference, NA: not available, TA: traffic accident. *Korean martial art.

traumatic situations presented significant differences in almost all characteristics with data from unmatched patients who suffered home injuries.

Comparison between the Outdoor Traumatic Injuries and Their Respective Matched Controls

For the matched comparisons, injuries that occurred during outdoor physical activity were more frequent in the upper and lower extremities, more fracture-type injury, and more severe injuries; injuries by extravehicular TA showed a higher frequency of lower extremity injury, more fracture and muscle/tendon injuries, and more severe injuries; and injuries by intravehicular TA showed a higher frequency of fracture and muscle/tendon injuries (Table 2).

Predisposing Factor Analyses for Injured Body Parts, Injury Types, and Injury Severity among Outdoor Traumatic Injuries

Multivariate results of predisposing factors for injured body parts, injury types and injury severity are presented in Supplementary Tables 1-9 (Figs. 1-3). The multivariate results of predisposing factor analyses are summarized in Table 3. Only higher risk factors were included because the authors believed that it was statistically possible but actually improbable that a traumatic situation lowers the risk of injury. Most of the outdoor physical activities, except baseball and swimming injuries, were associated with limb injuries, whereas TA presented higher risk for head, neck, and trunk injuries. Especially, trampoline-related injury presented a high risk for lower extremity, fracture, and moderate-to-severe injuries (odds ratio [OR] > 3).

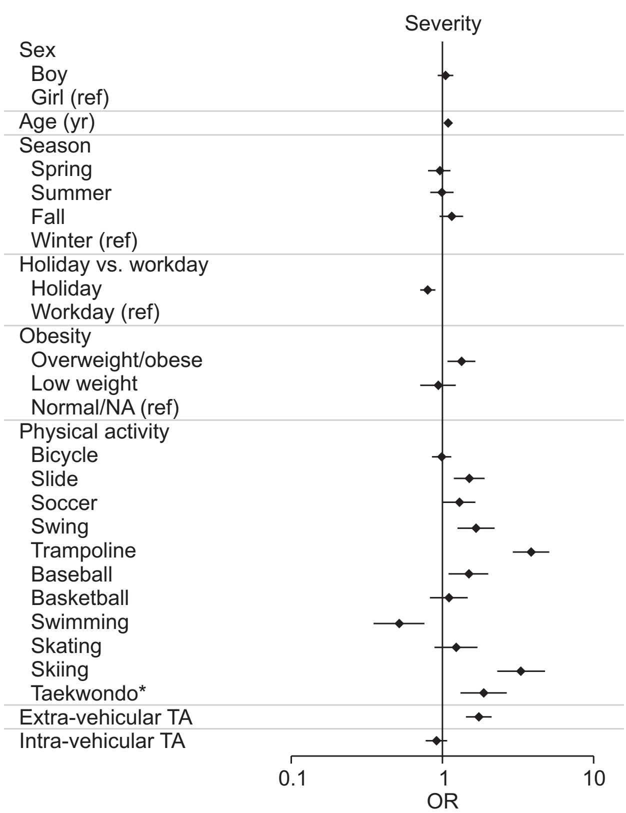

Fig. 3. Forest plot displaying predisposing effects for injury severity on multivariate analysis. The X-axis represents the odds ratios (ORs; diamond) and 95% confidence intervals (CIs; horizontal line). Details on OR, CI, and *p*-values are provided in the Supplementary Table 9. ref: reference, NA: not available, TA: traffic accident. *Korean martial art.

Frequent Outdoor Physical Activities Causing Traumatic Injuries According to Age Groups

The ranking of frequent outdoor physical activities according to age groups are presented in Table 4. Bicycle injury was the commonest traumatic situation among outdoor physical activities, and its frequency remained constantly high at all age groups. Trampoline-related injury (Table 4) was relatively common until age 6, but it suddenly became out of the ranks after age 7. Prior to age 9, injuries during play, such as from swings and slides, were the main causes; whereas sports injuries, such as from baseball, basketball, and soccer, became the main causes thereafter (playing injuries and sports injuries in Table 4).

DISCUSSION

The outdoor activities of children and adolescents are divided into physical activity and transportation related, including extravehicular TA and intravehicular TA. To reduce bias when comparing with indoor trauma, 1:1 matching analysis was undertaken using propensity scoring for sex, age, obesity, and injury timing among children and adolescents with home injury. Multivariate binary logistic regression analysis was used to evaluate the predisposing effects on injury characteristics of various outdoor traumatic situations.

The three classes of outdoor traumatic situations in the present study showed typical characteristics on comparison with the home-injury control group. Injury characteristics of children and adolescents with home injury showed that head and neck injuries constituted the majority of injured body parts whereas open wound was the commonest injury type, similar to the findings from previous studies.[10-12] Intravehicular TA showed a similar pattern of injury as home injury, but fracture incidence was relatively high and moderate, and severe injury was more frequent than in the home-injury cohort. Physical activity-related injury and injury from extravehicular TA showed different characteristics from those of home injury; fracture injury was more frequent, and the frequency of moderate to severe injury was more than three times higher. Even after matching for sex, age, obesity, and visit timing, there was a marked difference from that of home injury with regard to injured body part, injury type, and severity.

We analyzed the risks of each outdoor traumatic injury, which revealed different characteristics compared to home injury. In case of physical activity-related injury, the risk of extremity injury was high, especially for upper extremity injury; slide, swing, trampoline, and taekwondo showed OR higher than 2.5. For lower extremity injury, trampoline had very high OR (5.454). Taekwondo is a movement that mainly attacks the lower extremities; however, in actuality, the risk of upper extremity injury was high. The lower extremity or torso is covered by protective gear, whereas the upper extremity sustained more severe injuries because it can be injured while defending or falling.[13] In injuries due to TA, injury patterns in intravehicular and extravehicular TA showed diverse results (Table 3, Figs. 1-3).

Outdoor traumatic situations with a high risk of moderate-to-severe injury included the slide, soccer, swing, trampoline, baseball, skiing, taekwondo, and extravehicular TA. Among them, trampoline and skiing damage were particularly high (OR > 3). In the case of trampoline-related injury, the risk of severe injury is increased by the repulsive force caused by elastic recoil.[14] In skiing, high kinetic energy due to rapid downhill movement increases the risk of severe injury.[15] In the case of an

Table 3. Summary of Multivariate Binary Logistic Regression Results for Predisposing Effects on Injury Characteristics

Characteristic	Increased risk in injured body part	Increased risk in injury type	Increased risk for severe/moderate injury
Sex			
Boy		Open wound (1.177)	
Girl	Head and neck (1.162) Lower extremity (1.307)	Dislocation/strain/sprain (1.267)	
Age			
Older	Trunk (1.072) Upper extremity (1.044) Lower extremity (1.025)	Fracture (1.086) Dislocation/strain/sprain (1.032)	Yes (1.092)
Younger	Head and neck (1.054)	Open wound (1.067) Muscle/tendon injury (1.067)	
Season			
Spring			
Summer			
Fall			
Winter			
Holiday vs. workday			
Holiday	Lower extremity (1.267)	Open wound (1.217) Dislocation/strain/sprain (1.710)	
Workday		Fracture (1.258) Muscle/tendon injury (1.653)	Yes (1.250)
Obesity			
Overweight/obese		Fracture (1.336)	Yes (1.343)
Low weight	Head and neck (1.329)		
Normal/undetermined			

Table 3. Continued

Characteristic	Increased risk in injured body part	Increased risk in injury type	Increased risk for severe/moderate injury
Physical activity			
Bicycle	Upper extremity (1.748) Lower extremity (1.522)	Open wound (2.316)	
Slide	Upper extremity (2.795)	Fracture (1.743)	Yes (1.511)
Soccer	Upper extremity (1.392) Lower extremity (1.815)		Yes (1.301)
Swing	Upper extremity (2.700)	Fracture (1.939)	Yes (1.682)
Trampoline	Upper extremity (2.733) Lower extremity (5.454)*	Fracture (4.493)* Dislocation/strain/sprain (2.038)	Yes (3.882)*
Baseball	Head and neck (4.097)*		Yes (1.497)
Basketball	Upper extremity (1.690) Lower extremity (1.724)	Dislocation/strain/sprain (1.597)	
Swimming	Head and neck (2.330)	Open wound (3.171)*	
Skating	Upper extremity (2.091)	Open wound (1.787) Fracture (1.437)	
Skiing	Upper extremity (2.300) Lower extremity (2.401)	Fracture (3.608)*	Yes (3.345)*
Taekwondo†	Upper extremity (2.621)	Fracture (2.162)	Yes (1.885)
Extra-vehicular traffic accident	Trunk (3.188)* Lower extremity (1.912)	Fracture (1.692) Muscle/tendon injury (1.876)	Yes (1.752)
Intra-vehicular traffic accident	Head and neck (1.676) Trunk (1.818)	Muscle/tendon injury (2.661)	

Odds ratios are presented as values within parentheses.
*Odds ratios > 3. †Korean martial art.

Table 4. Frequency-Based Ranking of Common Physical Activity-Related Injuries According to Age Groups

Age (yr)	No.	Rank by frequency (%)				
		First	Second	Third	Fourth	Others (%)*
1–2	405	Slide (36.8)†	Swing (20.5)†	Bicycle (14.6)	Trampoline (11.9)	16.5
3–4	491	Slide (27.7)†	Bicycle (19.3)	Swing (14.1)†	Trampoline (13.0)	25.8
5–6	557	Slide (19.4)†	Bicycle (16.5)	Trampoline (11.8)	Swing (11.7)†	40.6
7–8	628	Bicycle (14.3)	Slide (13.1)†	Swimming (9.6)‡	Swing (8.3)†	54.8
9–10	465	Bicycle (16.3)	Baseball (10.3)‡	Skating (10.1)‡	Slide (8.8)†	54.4
11–12	439	Soccer (17.1)‡	Bicycle (14.4)	Baseball (10.7)‡	Basketball (8.0)‡	50.6
13–14	429	Soccer (27.0)‡	Basketball (18.6)‡	Bicycle (13.8)	Baseball (8.4)‡	32.2
15–16	325	Soccer (29.8)‡	Basketball (21.2)‡	Bicycle (10.2)	Baseball (7.1)‡	31.7
17–18	230	Soccer (24.8)‡	Basketball (20.4)‡	Bicycle (11.3)	Baseball (8.7)‡	34.8
Total	3,969	Bicycle (14.9)	Slide (13.7)	Soccer (11.4)	Swing (8.0)	52.0

Children < 1 year were excluded because of the small sample size (n = 14).
*The combined percentages, which were not included within the fourth rank. †Playing injuries. ‡Sports injuries.

extravehicular TA, there are many direct collisions, which apparently results in many severe injuries.[16,17)]

Age was considered to have a significant influence on the pattern of physical activity, which in turn affected physical activity-related injury. In case of bicycle-related injuries, children and adolescents showed high frequency of injuries regardless of age, although there were many physical activities that showed different characteristics by age. Slide and swing injuries were common at ages less than 8, and sports injury was common from age 9 onward, similar to the findings from previous studies.[18,19)]

The characteristics of slide and swing injuries showed a high frequency in young children, as well as a high risk of upper extremity and fracture injuries.[20)] Therefore, preventive measures for upper extremity fracture are necessary when children younger than 8 years use playground equipment. There are several reports on the prevention of sports-related injury. In most sports, the use of protective equipment, warming up, preventive training, and stretching are well-known injury-preventive methods.[21-23)] Additionally, the recent focus on improving safety in organized youth sports has led to rule changes that have reduced specific acute injuries.[24)] Moreover, there have been reports that a lower extremity injury can be significantly reduced through a neuromuscular training program.[25)] Thus, a multifaceted approach is needed to prevent sport-related injury in children and adolescents.

Trampoline-related injury was associated with a higher risk of upper and lower extremity injury, fracture injury, as well as a higher risk of moderate-to-severe injury (Table 3). There have been reports of a rapid increase in the incidence of trampoline-related injuries in young children.[14,26)] In the present study, trampoline-related injuries predominantly occurred also in children younger than 6 years (Table 4). Therefore, it is considered that a special guideline is required for trampoline use in children younger than age 6.

This study was limited by its retrospective data collection, and does not present a population-based descriptive analysis. The cases included in this study were identified using keyword searches, which may have not identified some cases and could have led to missing data. Also, since this study used data from one hospital emergency department, there is a possibility of selection bias during data collection. When classifying the severity of injury, the already authorized score could not be measured and was not used. However, the authors thought that even if a procedure under general anesthesia was necessary, severe injury could be sufficiently expressed. Care must be exercised when interpreting and accepting the meaning of high predisposing risks. For example, even if the risk of injuries to the upper and lower extremities is high in injuries sustained during physical activities, head and neck injuries still account for more than half of all injuries. Therefore, we should not only acknowledge the types of injuries with high predisposing risks, but also other types of injuries as well. It is recommended to consider predisposing risks when undertaking the basic preventive measures against injury.

We determined outdoor traumatic situations to investigate the characteristics of injuries in children and adolescents and (1) compared the characteristics of each outdoor trauma with 1:1 matched indoor trauma (home injuries); (2) analyzed each predisposing risk of the outdoor traumatic situation for the injured body part, injury type, and injury severity; and (3) investigated the changes of frequency ranking among physical activity-related injuries by age groups. Outdoor trauma showed higher risks for limb injuries, fracture and muscle/tendon injuries, and severe injuries than the indoor trauma (Table 2). Various outdoor traumatic situations presented different predisposing effects with regard to injury characteristics (Table 3). Among the physical activity-related injuries, bicycle-related injury was commonest across all age groups, and playing activities were common causes for injuries for patients younger than 9 years; however, sports activities dominated as the common causes of injuries beyond age 9 (Table 4). The findings of the present study would help establish more effective injury-prevention measures in various outdoor potentially traumatic situations.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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SUPPLEMENTARY MATERIAL

Supplementary material is available in the electronic version of this paper at the CiOS website, www.ecios.org.

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