

An analysis of escalator-related injuries in an emergency department

急症室有關電梯創傷的分析

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Background: Escalator-related injuries have been considered uncommon and most likely to occur in children. In this study, we described the epidemiology of these injuries with focus on the aged population in order to determine whether escalators are safe for the aged, and to obtain information to help in preventing escalator-related injuries. **Methods:** A prospective survey was taken to identify the number and nature of these injuries from May 2004 to December 2008. We enrolled patients who had sustained escalator-related injuries. A standard list of questions and answers were recorded by the emergency physician. A total of 104 questionnaires were completed during the study period. **Results:** The average patient age was 59.2 ± 24.0 years (range 1-94). There were 64 (61.5%) females. Only 11 (10.6%) were younger than 15 years old, and 59 (56.7%) were aged 65 or above; 35 (59.3%) of the aged people were injured while standing on the escalator. However, out of the 45 patients younger than age 65, 22 (48.9%) were injured from walking on a moving escalator. Head injury was the commonest site of injury overall and all were due to fall or slipping down. **Conclusions:** Escalator-related injuries are not as rare as previously believed and the aged population 65 years old or above is the highest risk group. In particular, walking on a moving escalator was the main cause of injury in people under age 65. Therefore, primary prevention strategies are needed to prevent users from walking on escalators, especially young people, and educate aged people the safe utilization of escalators to prevent slip and fall injuries. (*Hong Kong j.emerg.med.* 2010;17:212-217)

背景：有關電梯的創傷被認為是不常見及最有可能發生在兒童。這研究描述這些創傷的流行病學，焦點在老人，以確定電梯對老人是否安全，及獲取資料幫助防止有關電梯的創傷。**方法：**從2004年5月至2008年12月期間進行一個前瞻性調查以識別這些創傷的數目及性質，登記有關電梯而受傷的病人，由急症醫生記錄一標準問答清單。在研究期間共完成104問卷。**結果：**病人平均年齡為 59.2 ± 24.0 歲（範圍1-94），共64名女性（61.5%）。只有11人是15歲以下（10.6%），59人為65歲或以上（56.7%）。35名老年人（59.3%）是站立在電梯時受傷。然而，在45名65歲以下的病人中，22名於移動的電梯上行走時受傷（48.9%），頭部受傷是整體上最常見的受傷位置，而全部是由於跌倒或滑倒。**結論：**有關電梯的創傷不是過往認為那樣罕見，而65歲或以上的老人為最高危的組別。在移動中的電梯上行走特別是65歲以下人士受傷的主因。因此，需要基本的預防策略防止使用者在電梯上行走，尤其是年青人；及教導老年人安全使用電梯以防止跌倒及滑倒受傷。

Keywords: Accident prevention, aged, elevators and escalators, wounds and injuries

關鍵詞：預防意外，年老，升降機及電梯，傷口與創傷

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Introduction

South Korea has already stepped into the stage of aging. According to the government statistics, people more than 65 years old will account for up to 14.4% of the total population in 2019, which requires a social preparation for the society of aging. Moreover, advanced development in medicine will lengthen life

expectancy, and it is expected that more and more aged people will participate in physical and social activities. Expanding the scope of their social activities will result in their approach to mobile means. In the meantime, the recent urban environment facilitates the set up of large multilateral convenience facilities with the rise in commercialisation and population density. Such facilities may be very spacious. Thus, escalators provide one of the convenient means for movement within these facilities.

Despite the popularity of the use of escalators, there are few studies on the epidemiologic features of escalator injuries. Besides, most of the studies were concerned about paediatric injuries.¹⁻⁴ In 1992, Murphy and Moore conducted the only proactive study, which described the epidemiologic features of escalator injuries.⁵ In 1997, a retrospective study by Platt et al analysed children's escalator injuries that had occurred for five years in the United States.⁶ At that time, the study was the only study in the United States. In 2006, escalator injuries in children were studied in the United States using data collected through the National Electronic Injury Surveillance System (NEISS) for 13 years from 1990 through 2002.⁷

This study aimed to determine the epidemiologic characteristics and types of escalator injuries, mainly concentrating on injury to the elderly, unlike previous studies concerning about children.

Methods

A prospective study was carried out with patients attending our emergency medical centre with escalator-related injuries from May 2004 through December 2008. Information was collected by completing questionnaires while emergency medical doctors were implementing initial treatments after informed consents had been obtained from the patients. This study was approved by the local ethics committee.

Epidemiological characteristics and places of injury

A comparative study was conducted on the difference in occurrence rates between females and males, and

between patients less than 65 years old and those 65 or above. Place of injury was classified according to the features of the building which the escalator belonged to.

Factors relating to escalator injuries

While patients were divided by the age of 65 years, a survey was conducted on injury mechanism, injury time point, escalator direction, physical injury and history of alcohol intake as factors associated with injury. Injury mechanisms were divided into entrapment and fall, and the moving directions of the escalators were divided into upward and downward. The injury time points were divided into stepping onto, standing on, walking on and stepping off the escalator, with consideration of the successive movements at the time of using the escalator. Physical injuries were defined as cases that may impede walking or the use of moving means, and alcohol intake was divided into drunk and not drunk regardless of the amount of drinking.

Injury sites and types

The sites and types of injury were examined during the emergency treatment. The most seriously injury site was selected, with the body divided into head, spine, upper extremity, lower extremity, and others. If there was no obvious lesion, the most uncomfortable body part of the patient would be selected. Injury types were classified into fracture/dislocation, sprain/strain, contusion/abrasion, amputation and laceration according to the results of the emergency management. Subsequently, a comparison was made of the injury sites and types between the two groups divided by the age of 65.

Statistical analysis

The groups were compared using the chi square test or Student's t-test. Data were analysed by SPSS 12.0 for Windows (SPSS Inc., Chicago, Illinois, USA) and $p \leq 0.05$ was considered as statistically significant.

Results

The total number of patients was 104. The epidemiological characteristics, places and mechanisms

of injury are shown in Table 1 and Table 2. The average age was 59.2 ± 24.0 (range 1-94 years), but the majority were 65 years or above. There were more females than males, both below and above 65. Subway stations were the most frequent place of occurrence. Injury when the escalator was moving upward occurred in 76 patients (73.1%), of which 28 were less than 65 years old and 48 were 65 years old or above. Injury when the escalator was moving downward occurred in 17

Table 1. Epidemiology of escalator-related injuries

	Number of patients (%)
Sex	
Male	40 (38.5)
Female	64 (61.5)
Age	
≥ 65	59 (56.7)
≥ 15 , <65	34 (32.7)
<15	11 (10.6)
Place	
Subway station	67 (64.4)
Mall	29 (27.9)
Museum	8 (7.7)

patients (16.3%), of which 8 were less than 65 years old and 9 were 65 years old or above. Notably, 95 patients (91.3%) slipped and fell, while 9 patients (8.7%) were injured by entrapment. Of the patients 65 years or above, all were injured by slip and fall. Of the 9 patients injured by entrapment, the age ranged from 3 years to 18 years. Injury mechanism showed a statistically significant difference between patients below 65 years old and those 65 or above ($p < 0.001$). The difference in injury time points was not statistically significant between the group below 65 years and those 65 or above ($p = 0.127$).

Seven were injured in a drunken state; 1 was over 65 years old and 6 were below. Among these patients, 2 were physically handicapped: one was visually handicapped at age 65 years or above, and the other had leg problem and was less than 65 years old.

Out of the 104 patients, 40 (38.5%) had head injury, 13 (12.5%) had spine injury, 21 (20.2%) had upper extremity injury, and 28 (26.9%) had lower extremity injury (Figure 1). Upper extremity injury was more frequent in the below 65 year age group, while head injury was more frequent in those 65 years or above ($p = 0.020$).

Table 2. Comparison of factors relating to escalator injuries in age groups.

	<65-year-old (%) n = 45	≥ 65 -year-old (%) n = 59	p value
Sex			0.273
Male	20 (44.4)	20 (33.9)	
Female	5 (55.6)	39 (66.1)	
Mechanism			<0.001
Fall/slip	36 (80.0)	59 (100.0)	
Entrapment	9 (20.0)	–	
Injury time point			0.127
Stepping onto escalator	5 (11.1)	8 (13.6)	
Stepping off escalator	–	4 (6.8)	
Standing on escalator	18 (40.0)	35 (59.3)	
Walking on escalator	22 (48.9)	12 (20.3)	
Direction			0.434
Up	28 (62.2)	48 (81.4)	
Down	8 (17.8)	9 (15.3)	
Unknown	9 (20.0)	2 (3.4)	

For type of injury, 41 (39.4%) had contusion/abrasion, 34 (32.7%) had laceration, 15 (14.4%) patients had fracture/dislocation, 13 (12.5%) had sprain/strain, and 1 (1.0%) had amputation. Laceration was more frequent in the below 65 years age group, while contusion/abrasion, fracture/dislocation, and sprain/strain were more common in those 65 years or above (p=0.037, Figure 2).

Discussion

According to the Korea Elevator Safety Institute, 6843 escalators were installed by the end of 1999. They rose sharply to 16,343 in 2006. As buildings and facilities are getting larger and larger with the progress of urbanisation, it is expected that escalators as mobile means within buildings will increase in the future. However, it is true that we still regarded escalator injuries as rare till the early 1990s.⁶ Advanced countries have recently started to show interest in prevention, and studies have been conducted on the scopes of escalator injuries and their epidemiological characteristics.

In this study, 104 escalator injury patients were brought to one regional emergency medical centre from May 2004 to December 2008. There are three subway stations, one large shopping mall and one national museum around the emergency centre. According to Murphy and Moore, 50 patients were injured in 55 months at five hospitals in London, where there were 69 subway stations with escalators.⁵ However, South Korea has 884 escalators at subway stations in the Seoul metropolitan area and more than 450 subway stations

all over the country. Considering the number of escalators in department stores and large buildings, the real injury scope in South Korea will exceed the findings of Murphy and Moore. In the United States, escalator injuries are not rare any more, as about 33,000 escalators were installed as of 2006 and 221 persons per 1000 escalators were reported injured every year.⁷

In our study, 59 patients (56.7%) were 65 years old or above, exceeding those less than 65 years old; and 11 patients (10.6%) were less than 15 years old (Table 1). In the 1980s, Wells et al reported that patients less than 16 years old and 60 years or above accounted for 40% and 35% respectively.⁸ However in the 1990s, Murphy and Moore reported that children and those older than 65 years accounted for about 6% and 18% respectively, showing that most patients were vigorous adults less than 65 years old.^{5,8} Accordingly, children did not account for high percentages in escalator injuries. In particular, with the recent increase in the elderly population, there is a trend that more elderly people are involved in escalator injuries. In our study, more than half of the patients were 65 years old or above.

Injuries mostly occurred at subway stations (Table 1). This can be explained as escalators are intensively used at subway stations, unlike shopping malls or museums where escalators are used at regular rates, as noted by Platt et al.⁶ Their users amounted to 5 million persons daily on the average, and subway stations should be placed on top priority when establishing strategies to prevent escalator injuries.

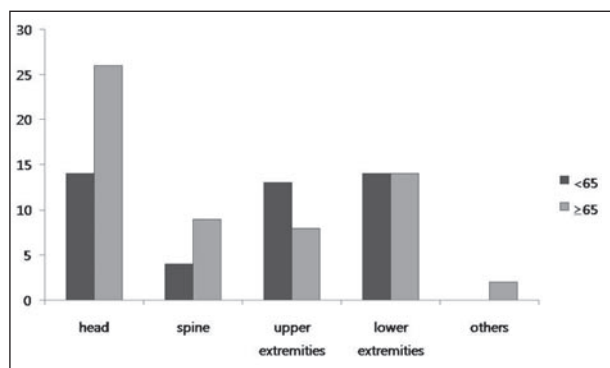


Figure 1. Comparison of injury site.

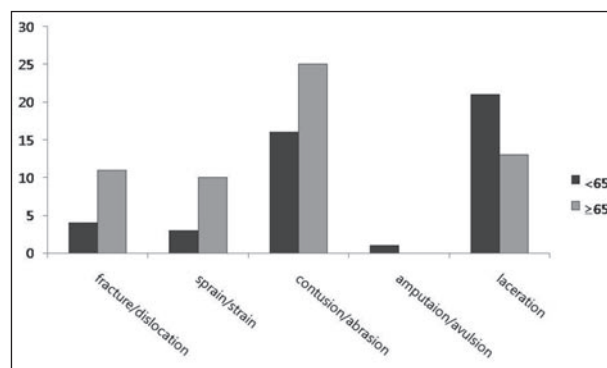


Figure 2. Comparison of injury type.

At both age groups, more injuries occurred when the escalator was moving upward (Table 2). This concurs with Platt et al.⁶ One of the reasons might be that the number of escalators moving in the upward direction usually exceeded the number moving downward in a number of subway stations, shopping malls and museums.

In terms of injury mechanism, all patients 65 years or above were injured by fall, and the 9 entrapment cases belonged to the age group less than 65 years old. According to McGeehan et al, injuries by fall and entrapment were similar in number in children less than 5 years old, but with increasing age, there were more fall and less entrapment.⁷ Platt et al also referred to entrapment as a major injury mechanism.⁶ The present study did not separate the age group of children, but the 9 patients involved in entrapment were between 3 to 18 years old, corresponding to the existing data that entrapment occurred mostly in children. On the contrary, all patients 65 years or above were injured by fall (Table 2). The results of this and previous studies showed that the mechanism of escalator injury varied with age: entrapment is the main mechanism of injury in children while fall is the usual mechanism in the elderly.

Entrapment in children was often caused by wearing skirts, shoe laces etc. According to the user cautions recommended by the US Consumer Product Safety Commission, children should be warned against shoe laces or skirts and always be accompanied by guardians.⁹ In addition, the Commission puts emphasis on warnings on matters that may cause children to be trapped and preventive measures, such as the prohibition of wheeling a baby in a baby carriage and the installation of emergency stop buttons.⁹ On the other hand, efforts have also been made to prevent injury by entrapment on the basis of mechanical engineering. A new escalator was manufactured to apply such new concept in 2003.¹⁰

Unlike children, the elderly were mostly injured by fall. Accordingly, the key for injury prevention is to determine the factors associated with fall. The answer could be postulated by the injury time point. Of the 45 persons less than 65 years old, 22 (48.9%) were

injured while walking on the escalator; of the 59 persons 65 years or above, 12 (20.3%) were injured while walking on the escalator and 35 (59.3%) persons were injured while standing on the escalator (Table 2). This indicates that there were differences in the causes of fall between the two groups. Younger persons most likely fell as a result of losing their balance while walking on the moving escalator. This implies that injuries were caused by the behaviour on the escalator rather than mechanical reasons. However, most elderly persons fell while standing on the escalator. This makes it inappropriate to attribute such injuries to behaviour such as walking. Accordingly, walking guidance may help persons less than 65 years old to prevent injury, but walking guidance alone has limitations in preventing persons 65 years or above from being injured. In fact, only 12 of the patients 65 years or above were injured while walking on the escalator, and the remaining did not violate any user rule and most of them said they had difficulty in keeping their balance by moving onto the stepping plate of a moving escalator. Fall is known to be one of the mechanisms that often cause external injuries to the elderly, who lose their sense of balance and do not keep their posture stable according to changes in the environment. It should not be overlooked that changes in the position and velocity of the escalator may cause trouble to elderly persons who are physiologically not sensitive to changes.

In terms of injury site, head injury was the commonest one regardless of age (Figure 1). For injury type, laceration was more common in the age group less than 65 years and contusion/abrasion were more common in those 65 years or above (Figure 2). Amputation occurred in one person less than 65 years, while fracture occurred more often in persons 65 years or above. Amputation and fracture, relatively serious injuries, were major injuries of children and the elderly respectively.

This study has some limitations. Study subjects were patients of one regional emergency medical centre only, and could not represent an overall picture of escalator-related injuries and patients who did not seek medical attention or who visited other hospitals would not be recruited. Some patients could not remember how they got injured, and hence the relationship between their

injuries and behaviours could not be made. Besides, Murphy and Moore reported that 28% of the injuries were caused by alcohol drinking.⁵ However, this study found only seven patients drank alcohol, which could not represent as a major injury factor. In addition, this study found only two patients had physical handicap, which might have little to do with the escalator-related injuries. Thus, more studies are required to find out the relationships between escalator-related injuries and alcohol or physical handicap.

Nevertheless, the epidemiological study of escalator-related injuries enabled us to determine the characteristics of occurrence by age groups. Unlike previous studies, this study showed that the elderly were more vulnerable to escalator-related injuries than younger people and that head injury was the commonest. Therefore, it is necessary to make social efforts, e.g. to educate how to use the escalator and for a person nearby to grasp an elderly person's arm when he or she uses the escalator or to install elevators instead of escalators.

Conclusions

Escalator-related injuries are not as rare as previously studied, showing a sharp increase in recent years. For patients 65 years or above, injuries might be triggered

by physiological factors such as lessened sense of balance and for patients less than 65 years old, most injuries resulted from walking on the escalator. Therefore, age and walking are factors that should be taken into consideration in order to establish strategies to prevent escalator-related injuries.

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