Injury Patterns of Korea Pedestrian Accidents in KIDAS

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Abstract
Recently, EuroNCAP updated the upper legform test protocols for the vehicle has lower bumper reference line is greater than 500mm vertically above the ground. But the majority of pedestrian victim's ages is more than 50 years old which average height is smaller than Europeans. To protect pedestrian from traffic accidents, Korea has been continuously reinforced vehicle safety regulation and KNCAP. Especially, the overall rating system in KNCAP, the weighting factor of safety performance of pedestrian is 25%. But, in the real road, the fatalities involved car-to-pedestrian accidents were 1,843 which is about 40% of all traffic related deaths in 2014. Also, from the police reported data, the pedestrian accidents were 50,315 cases. It was 22.5% of all traffic accidents. However, from the integrated traffic accident data (police reported data and insurance claimed data), severely injured pedestrians were 39,376 and minor or moderately injured pedestrians were 62,764. In this study, the collected 230 cases of pedestrian accidents from KIDAS were investigated to explore the injury severity of body regions as well as age related injury patterns. Not only injury of head and lower leg, injury of all other body regions were examined. Particularly, the injury of abdomen and pelvic areas were closely examined.
The main objective of this study is establish the upper legform test with consideration of domestic pedestrian accident data as well as anthropometric data to protect elderly pedestrians that the average physical status is less weight and shorter than European.

INTRODUCTION

There are many variables in a vulnerable road user traffic accident that will affect the injury severity of the people involved. These include factors related to the casualty (age, gender, biomechanical tolerance, walking positions and directions, etc.), factors related to the vehicle (size, shape, impact speed, effectiveness of absorbing impact energy, etc.), and factors related to the wider environment (characteristics of the object hit, effectiveness of the medical treatment, etc.). All these variables have an important relationship to the likely injury severity of the casualty.

The pedestrian safety testing methodology was initially developed by EEVC (European Enhanced Vehicle-Safety Committee) working groups. It consists of three subsystem tests: headform to bonnet test; upper legform to bonnet leading edge test and lower or upper legform to bumper test.

Since the pedestrian safety test procedures were published in the 1990s, the upper legform test has been frequently criticized as not being representative of the real-world accident scenario or the injury mechanisms in pedestrian-to-vehicle accidents [1–4]. The upper legform test never became mandatory in European regulations but was conducted for monitoring purposes and consumer information tests. In 2013/2014, Euro NCAP discussed modifications to the test procedure. However, the aim of short-term improvement restricted the amount of possible modifications. Essentially, the impact location and speed were changed for the updated test protocol of January 2015.

Various studies analyzing pedestrian accidents were published with or without aid of AEB system on the vehicle recently. Most statistically enhanced analysis is based on the GIDAS (German In-Depth Accident Study) [5, 6] or PCDS (Pedestrian Crash Data Study of the NHTSA) databases [7]. Lower extremities are commonly summarized in one group (according to AIS body regions), without distinction of pelvic, femoral, knee or lower thigh injuries. Several risk factors associated with pelvic and femoral injuries have been reported in literature: age and gender of the pedestrian, vehicle geometry and impact speed,

Demetriades et al. [8] found within a trauma registry study that pelvic fractures were significantly more common for elderly pedestrians (6.8% for pedestrians younger than 14 years compared to 9.8%

for 65+ years). Also, gender and pedestrian body height were found to influence impact kinematics and the risk of sustaining pelvic injuries [9-10].

The main objectives of this study was to find key parameters based on accident analysis that are relevant for pedestrian injury mechanics due to age and height or domestic pedestrian accident environments, especially pelvic and upper femoral injuries, which should be taken into account in future analysis and possible improved pedestrian safety policy in Korea such as regulations and KNCAP test protocols.

PEDESTRIAN ACCIDENT DATA

Liers and Hannawald [11] found from their research works on German GIDAS, the age of the pedestrian is ab influence factor on the injury severity outcome. Because of the human physiological properties, elderly people often sustain worse injuries than young adult. It was well known characteristics that children are often hit by different part of vehicle out surfaces than adults, due to their smaller body height. Especially the head impact areas of children differ substantially from the impact zones of adults. According to the research results from GIDAS, the distribution of the age of the pedestrians was compared to the distribution within the German pedestrian accident scenario in year 2006. From results, except child age group young age group who has more frequent outdoor activities, each age group's frequency of pedestrian accidents is similar frequencies. But, relatively less outdoor activities on the elderly age groups, the frequency of pedestrian accidents can't measure as other age groups.

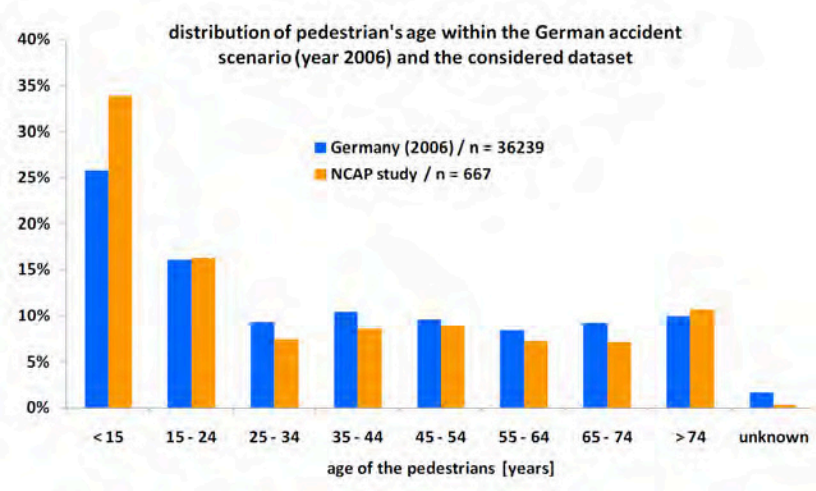


Figure 1. Distribution of age of the involved pedestrians [11]

In other hand, in order to explore of Korea pedestrian accident environment, National Police data and KIDAS (Korean In-depth Accident Study) data were compared. From the integrated police report (police, insurance etc.) which counted all injury involved road traffic accident in 2014, the total numbers of pedestrian accidents were 167,264 cases.

The fatality of pedestrians were 1,843 persons (within 30 days death), and 39,376 persons were severely injured. The minor or moderately injured pedestrians were 62,674 and the numbers of pedestrians who claimed or reported that he or she was injured during the pedestrian-vehicle related accidents were 63,371 as shown in table 1.

In this study, in order to examine adult injury patterns of pedestrian accidents, less than 20 years old pedestrians were excluded from dataset.

Table 1. National integrated police pedestrian accident data (2014)

Age	Injury Severity	Total	Male	Female	Age	Injury Severity	Total	Male	Female
21-30	Fatality	79	55	24	51-60	Fatality	350	245	105
	Sever Injury	3,516	1,903	1,613		Sever Injury	7,667	3,531	4,136
	Minor Injury	8,483	4,278	4,205		Minor Injury	11,907	5,331	6,576
	Injury Report	8,636	4,874	3,762		Injury Report	11,009	6,014	4,995
31-40	Fatality	113	92	21	61-64	Fatality	119	61	58
	Sever Injury	3,489	2,149	1,340		Sever Injury	2,475	960	1,515
	Minor Injury	7,510	4,281	3,229		Minor Injury	3,279	1,369	1,910
	Injury Report	7,586	4,619	2,967		Injury Report	2,931	1,447	1,484
41-50	Fatality	221	181	40	65이상	Fatality	898	332	566
	Sever Injury	5,182	2,959	2,223		Sever Injury	11,032	3,379	7,653
	Minor Injury	9,655	5,074	4,581		Minor Injury	10,058	3,639	6,419
	Injury Report	9,595	5,645	3,950		Injury Report	8,326	3,853	4,473

From above table, 49% of pedestrian fatality came from the more than 65 year's old adults. In this age category, total 898 elderly pedestrian were killed by traffic accidents. The female victim of elderly pedestrian was about 63% compared to male victim. However, other age groups, the majority of victim were male pedestrians. The ratio of sever injured elderly pedestrian (65+) was 53.8% and the minor injury ratio was 42%. The total ratio of fatality for the more than 51 year's old pedestrian victim (51+) was 70.3% (1,367 killed). In this age group (51+), 53% of fatal victim was female pedestrians.

Table 2. National police only pedestrian Injury body data (2014)

2014	Total	Head	Face	Neck	Chest	Abdomen	Back	Pevis	Upper Ex.	Lower Ex.	N/C
Fatality	1,843	916	142	35	160	58	3	54	2	159	314
Ratio (%)	**100.0**	**49.7**	**7.7**	**1.9**	**8.7**	**3.1**	**0.2**	**2.9**	**0.1**	**8.6**	**17.0**
Injuried	51,590	3,726	2,030	2,199	1,667	193	149	7,065	3,704	17,963	12,894
Sever	23,657	2,272	1,164	709	1,229	91	55	2,902	856	8,706	5,673
Minor	25,005	1,337	756	1,430	397	81	81	3,880	2,516	8,198	6,329
Injury Report	2,928	117	110	60	41	21	13	283	332	1,059	892
Ratio (%)	100	7.2	3.9	4.3	3.2	0.4	0.3	13.7	7.2	34.8	25.0
Sever Ratio (%)	100	**9.6**	**4.9**	**3.0**	**5.2**	**0.4**	**0.2**	**12.3**	**3.6**	**36.8**	**24.0**

According to the police only statistical data (Table 2), the major cause of fatality is head injury. More than 50% (head, face and neck) of all pedestrian injury is head contact to vehicle or road surface. Second cause of death was chest injury and the followings were lower extremity and abdomen injuries. For the severe injury case, the main injury body parts were lower extremity, pelvis and head.

Anthropometric national data

Average height of adult Korean are vary with ages. According to national statistics which measured on 2010 from 6th SizeKorea project, age from 20 to 60 year's old male adult, average height was 1,715mm (SD 61.4 mm) the average height of female adult (20-60) was 1,586 (SD 56.2 mm). The young male adult (20-29) was 1,736 mm (SD 57.2 mm) and but elderly male adult (60-69) was 1,644 mm (SD 51.7 mm).The young female adult (20-29) 1,602 mm (SD 51.3 mm) and elderly women (60-69) was 1,523 mm (SD 53.2 mm). Compared with European average adult height which applied the current pedestrian test method (GTR and NCAP), the Korean height of adult was about 15 - 20 cm shorter.

PEDESTRIAN ACCIDENT IN KIDAS

The issues of current traffic accident investigation and data collection from polices in Korea were very limited access for an individual accident event. Also, the lacks of automotive related information

which police is not much concerned, are very difficult to analyze the accident involved vehicle's safety problems.
As part of Korea Advanced Safety Vehicle (KASV: 2009-2017) project, the pilot study of KIDAS (Korean In-Depth Accident Study) has been initiated in 2012. Unlike GIDAS, on-site investigation is not allowed by polices, therefore the current KIDAS accident data were collected from in-patient of 3 medical school's hospitals. Once injury involved accidents occurs, the occupants may in-hospitalized through these emergency centers. After medical treatments, the research team can search for police station for more information but, unfortunately not always successful achieving accident data from police due to the privacy protection restrictions. After collecting police's accident report or verbal information related the accident with inspection of crashed vehicle, even though the total amount of collected data is limited, can be constructed the each individual accident database.

As the first step, KIDAS research team adopts iGLAD format as KIDAS structure as a Korea standards in-depth accident study. It will be continuously modified to accommodate regional traffic environment effects, but keeps the fundamental structures of iGLAD.

Adult pedestrian patient dataset

The total 230 cases of pedestrian accidents data were collected during the 2014. In this dataset, 5 pedestrian victims (2.2%) were death before or after arrival of emergency room. The severely injured patients who deliver to the intensive care unit after first treatment from emergency room were 56 cases (24.8%). The others were either minor injury (out-patients) or moderate injury (in-patients). In the age distribution, 51 patients were under 20 year's old and the remaining 179 cases were adult pedestrian patients. The average age was 45.43 (SD: 25.24) and mean age was 52 year's old. The minimum age was 1year old and maximum age was 93 year's old patient. The female patients were 121 cases and male cases were 109 cases. The average female patients ages was 49.08 (SD: 26.18) and the male average ages was 41.37 (SD 23.63)

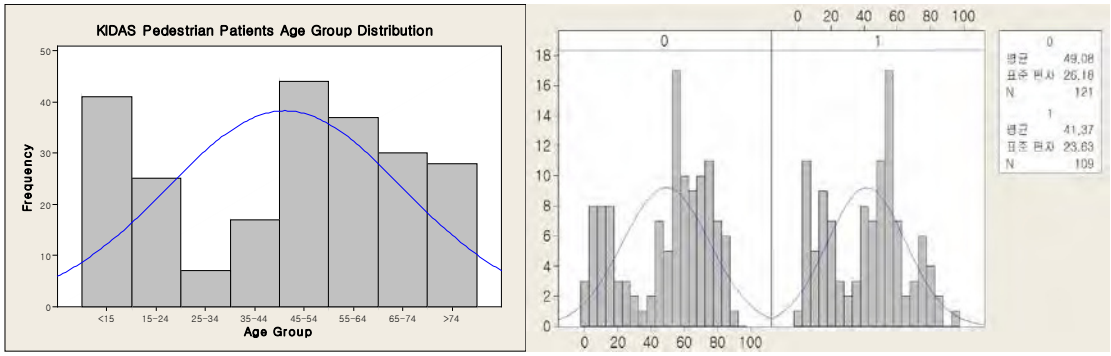


Figure 2. Pedestrian patients age distributions

In this data set, the numbers of missing height or weight information cases (125 cases) were excluded except death before arrival of emergency room (4 cases). Also age under 20 were excluded to consider only adult pedestrians. Therefore, 89 cases of adult pedestrian accident data were examined. The average adult patients was 56.97 with SD 18.37 and mean age was 55 year's old.

36 (41.6%) cases were adult female and 52 (58.4%) cases were adult male pedestrian patients. In the data set 28 cases (31.5%) were elderly pedestrian accidents. Age over 50 (50+) cases were 64 (71.9%), which is similar to national data. From the 50+ patients, the average height and weight was 1,590 mm and 58.7 kg. The other age group's average height and weight were 1,678 mm and 64.8 kg. There is significant difference in height and weight between two age groups. 27 out 89 patients were

treated in the intensive care unit including death before or after arrivals. 18 of 27 intensive care unit patients were over 50 year's old (50+).

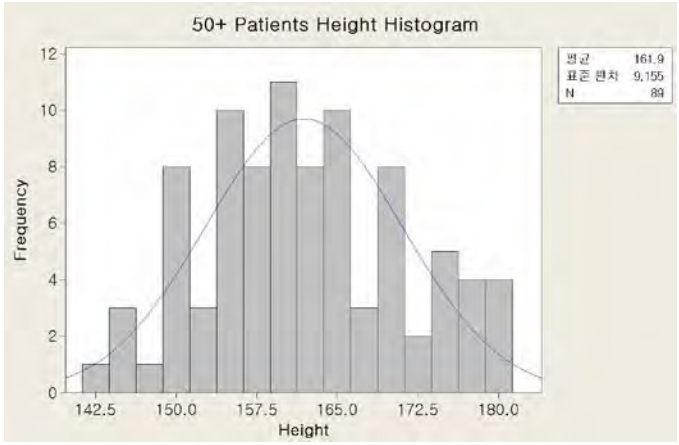
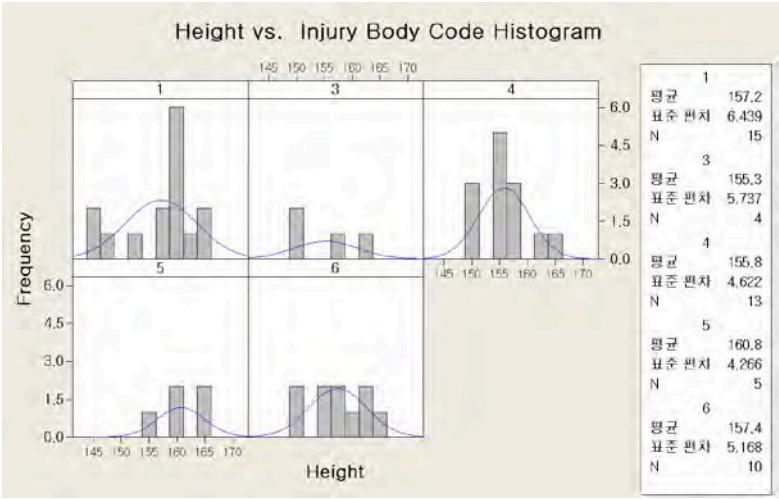


Figure 3. Height distribution of 50+ patients

Body code: 1: head, 2: Neck, 3: Thorax, 4: abdomen+pelvis, 5: Upper extremity, 6: lower extremity, 7: multi-body

Figure 4. Age vs. Body injury code distribution of 50+ patients



Body code: 1: head, 2: Neck, 3: Thorax, 4: abdomen+pelvis, 5: Upper extremity, 6: lower extremity, 7: multi-body

Figure 5. Height vs. Body injury code distribution of 50+ patients (AIS+2)

Table 3. Adult (20-49) pedestrian accidents KIDAS data

Gende	Age	Height	Weight	Severity	AVPU	C0_GCS_E	C0_GCS_	C0_GCS_	RTS	ISS	Body Co
0	20	172.0	73.0	3	V	C3	C5	C6	12		1
0	20	179.0	68.0	1	A	C4	C5	C6	12	2	1
0	20	171.0	56.0	2	A	C4	C5	C6	12	5	3
1	21	159.0	60.0	2	A	C4	C5	C6	12	6	5
1	22	159.0	63.0	1	A	C4	C5	C6	12	1	6
0	22	175.0	78.0	3	V	C4	C5	C6	12	17	4
1	23	165.0	59.0	2	A	C4	C5	C6		4	5
0	24	175.0	69.0	1	A	C4	C5	C6	12	5	1
0	29	177.0	68.0	2	A	C4	C5	C6	12	16	3
0	32	174.0	74.0	1	A	C4	C5	C6	12		6
1	33	166.0	50.0	1	A	C4	C5	C6	8	5	1
0	38	177.0	74.0	3	A	C4	C5	C6	12	12	4
0	38	180.0	92.0	1	A	C4	C5	C6	12	6	5
0	38	174.0	70.0	3	A	C4	C5	C6	12	14	3
0	40	169.0	65.0	1	A	C4	C5	C6	12	1	5
1	41	157.0	46.0	3	P					17	4
1	44	150.0	53.0	2	A	C4	C5	C6			6
1	45	164.0	59.0	1	A	C4	C5	C6	12	2	5
1	46	159.0	54.0	3	P				8	25	1
0	47	165.0	70.0	2	A	C4	C5	C6	12	12	5
1	47	156.0	50.0	2	A	C4	C5	C6	12		4
0	48	179.0	86.0	1	A	C4	C5	C6	12	4	6
1	48	158.0	45.0	2	A	C4	C5	C6	12	14	3
0	48	173.0	73.0	3	P	C2	C3	C5	11	5	1
0	49	163.0	66.0	3	A	C4	C5	C6	12		1

Genger: 0: Male, 1: female
Severity: 1: out-patient, 2; in-patients(general), 3: in-patients(intensive), 4; fatality
Body code: 1: head, 2: Neck, 3: Thorax, 4: abdomen+pelvis, 5: Upper extremity, 6: lower extremity, 7: multi-body

Table 4. Adult (50-65) pedestrian accidents KIDAS data

Gende	Age	Height	Weight	Severity	AVPU	C0_GCS_E	C0_GCS_	C0_GCS_	RTS	ISS	Body Co
1	50	162.0	47.0	3	U	C1	C1	C1	5		3
0	52	167.0	70.0	3	A	C4	C5	C6	12	17	3
1	52	163.0	57.0	3	A	C4	C5	C6	12	21	4
0	53	163.0	62.0	1	A	C4	C5	C6	12	1	3
1	53	158.0	55.0	2	A	C4	C5	C6	12		6
0	53	179.0	83.0	1	A	C4	C5	C6	12		1
1	53	160.0	65.0	3	U	C1	C1	C1	8	35	1
0	53	175.0	70.0	3	U	C1	C1	C1	8	14	4
0	53	170.0	77.0	2	A	C4	C5	C6	12	9	1
1	53	157.0	48.0	2	A	C4	C5	C6			4
1	54	155.0	68.0	3	V				8	4	4
0	54	170.0	60.0	4	U	C1	C1	C1	0	17	3
0	54	177.0	70.0	3	V	C3	C4	C5	11	27	4
0	54	168.0	72.0	2	A	C4	C5	C6	12		4
1	54	162.0	70.0	2	A	C4	C5	C6	12	2	6
1	54	155.0	57.0	2	A	C4	C5	C6	12	1	6
1	54	157.0	51.0	2	A	C4	C5	C6	12	9	6
1	54	160.0	51.0	2	A	C4	C5	C6	12	12	1
1	55	161.0	60.0	2	A	C4	C5	C6	12	6	6
0	55	165.0	57.0	3	V	C4	C4	C6	12	22	1
0	55	160.0	57.0	3	A	C4	C5	C6	12	22	1
1	55	152.0	65.0	1	A	C4	C5	C6	12	2	2
1	56	166.0	61.0	1	A	C4	C5	C6	12	1	5
0	56	170.0	60.0	2	V	C3	C4	C6	12		6
1	57	154.0	68.0	2	A	C4	C5	C6	12	14	6
1	57	156.0	50.0	1	A	C4	C5	C6	12	1	6
0	57	158.0	60.0	3	A	C4	C5	C6	12	21	1
1	59	148.0	43.0	2	A	C4	C5	C6	12		1
0	59	165.0	69.0	2	A	C4	C5	C6	12		6
1	59	160.0	63.0	2	A	C4	C5	C6		2	5
0	60	168.0	63.0	3	U	C1	C1	C1	7		1
0	60	170.0	78.0	3	V	C4	C4	C5	12		1
1	61	170.0	65.0	2	A	C4	C5	C6	12	17	6
1	62	156.0	52.0	2	A	C4	C5	C6	12	21	4
1	62	157.0	55.0	2	A	C4	C5	C6	12		4
1	63	146.0	45.0	2	V	C4	C5	C6	12	10	1

Table 5. Adult (65+) pedestrian accidents KIDAS data

Gender	Age	Height	Weight	Severity	AVPU	C0_GCS_E	C0_GCS_	C0_GCS_	RTS	ISS	Body Co
1	50	162.0	47.0	3	U	C1	C1	C1	5		3
0	52	167.0	70.0	3	A	C4	C5	C6	12	17	3
1	52	163.0	57.0	3	A	C4	C5	C6	12	21	4
0	53	163.0	62.0	1	A	C4	C5	C6	12	1	3
1	53	158.0	55.0	2	A	C4	C5	C6	12		6
0	53	179.0	83.0	1	A	C4	C5	C6	12		1
1	53	160.0	65.0	3	U	C1	C1	C1	8	35	1
0	53	175.0	70.0	3	U	C1	C1	C1	8	14	4
0	53	170.0	77.0	2	A	C4	C5	C6	12	9	1
1	53	157.0	48.0	2	A	C4	C5	C6			4
1	66	150.0	66.0	3	A	C4	C5	C6	12	13	3
1	67	143.0	38.0	1	A	C4	C5	C6	12		1
1	67	159.0	65.0	2	A	C4	C5	C6	8	5	1
1	67	158.0	55.0	2	A	C4	C5	C6			1
1	68	155.0	44.0	2	A	C4	C5	C6	12	9	4
0	69	170.0	74.0	2	A	C4	C5	C6	12		5
1	70	159.0	75.0	1	A	C4	C5	C6		4	6
1	70	162.0	73.0	2	A	C4	C5	C6	12	4	6
1	72	150.0	55.0	1	A	C4	C5	C6	12	4	1
1	73	155.0	56.0	3	P	C1	C1	C5	10	22	5
1	74	155.0	56.0	3	P	C1	C1	C4	9	34	4
1	74	152.0	38.0	3	V				8	34	1
1	74	152.0	55.0	1	A	C4	C5	C6		5	5
0	75	165.0	62.0	2	A	C4	C5	C6		9	4
0	76	160.0	59.0	2	A	C4	C5	C6	12	11	1
1	76	145.0	45.0	2	A	C4	C5	C6	12		1
1	77	151.0	57.0	2	V	C4	C5	C6	12		3
0	78	177.0	60.0	2	A	C4	C5	C6		4	6
0	78	165.0	57.0	1	A	C4	C5	C6	12	5	1
0	80	163.0	61.0	1	A	C4	C5	C6	12		7
0	80	162.0	64.0	1	A	C4	C5	C6	12		4
1	81	145.0	52.0	1	A	C4	C5	C6	8	5	1
1	81	150.0	50.0	2	A	C4	C5	C6	12	8	6
1	82	149.0	42.0	3	V	C3	C4	C6	12	24	4
1	86	150.0	50.0	3	A	C4	C5	C6	8	26	4
1	87	165.0	45.0	2	A	C4	C5	C6	12	13	1
1	87	150.0	40.0	2	A	C4	C5	C6	12		4

DISCUSSION AND FUTURE WORKS

In this study, the frequency of pedestrian accidents was examined in both National integrated police data and KIDAS data in 2014 accident reports.
The analysis of accident data underlies a variety of limitations, as follows:

1. This KIDAS data analysis includes only 3 local hospitals data that collected from Emergency Care Center cannot represent national pedestrian accident trends.
2. There was no raw data available of raw data of the integrated police data.
3. The KIDAS dataset is relatively small and all data may not completed form
4. Limitation of access of accident scene or crashed vehicles, vehicle impact speeds and impact location of vehicle body cannot be classified.

In Korea, the pedestrian accidents are major cause of traffic fatality. The characteristics of domestic pedestrian accidents are more elderly people involved accidents which show similar patterns between police and KIDAS data. Among elderly accidents, the female pedestrian is more frequently involved pedestrian-car accidents compared with other age groups.

Since average height and weight of Korean elderly people is much smaller and lighter than other age groups especially comparison with Europeans. Not only shorter status but posture of walking with

bended back bone, the elderly height may much shorter than expected. Even passenger vehicle can hit the pelvis or abdomen area of elderly female pedestrians.

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