Anti-Slip Devices to prevent pedestrians from slipping and falling during wintertime

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1. Background

According to the Swedish questionnaire-based National Traffic Safety Survey, TSU92, self reported accidents involving pedestrians without involvement of any vehicle (single-pedestrian accidents) accounted for roughly half, or 49 %, (1,141,962) of the total number of all road transport single accidents (2,335,017) in 1998-2000. This survey covered 23,030 people aged 1-84 (Gustafsson and Thulin, 2003). The pedestrian exposure, i.e. total walking distance, was 3,226 million person kilometres per year for 10,660 pedestrians, or 3 km per person per day. The exposure and the proportion of single-pedestrian accidents is different for different age groups. The youngest, aged between 1 and 14, have a greater portion of self-reported single accidents than their proportion of exposure. Between 15 and 24 years it is almost the same and for people between 25 and 84 their proportion of exposure is greater then their proportion of self-reported accidents. Younger people are more at risk than other age groups. Swedish data reveals that the average risk for a single-pedestrian accident is 346 accidents/million person kilometres. This includes all types of single-pedestrian accidents. Approximately 60% involve people in the age group 1-24 years. The probability of being involved in a single-pedestrian accident is therefore, on average, lower for adults. For the period 1999-2002 in Sweden, single-pedestrian accidents accounted for 38% of the total number (3,029,554) of all self-reported traffic accidents, i.e., single and collision accidents added together for all modes of road transport. The average risk of a collision accident for a pedestrian is 24 per million person-kilometres walked. The risk of any kind of single or collision accident among all road transport modes is 20 per million person-kilometres (Gustafsson and Thulin, 2003).

There are many fall accidents on icy surfaces in Sweden. About 25-30 000 people need medical care every year for treating fall injuries. On average, every year there are more than two injuries per 1000 male inhabitants and more than three injuries per 1000 female inhabitants from falls on icy surfaces that are so serious that they need medical care. Females are overrepresented especially for the age group 45 – 74 (Nordin, 2003). The single-pedestrian accidents on snow and ice are estimated to be approximately ten times as frequent as the official police-reported number of pedestrian accidents. (Öberg et al, 1996). In Finland, around 50,000 people visit emergency rooms or other healthcare facilities for injuries caused by slipping and falling during the wintertime (www.kotitapaturma.fi, 2007).

A study of police data and hospital data from five hospitals in southern Sweden showed that those injured in single-pedestrians accidents on slippery, icy or snowy road surfaces are, on average, more seriously injured than those injured on other surfaces (Berntman, 2003). Measures to reduce the accident rate and/or the severity of accidents can be either community-based or based on individual initiatives. Using appropriate shoes and anti-slip devices are examples of individual measures that have been suggested (Björnstig et al, 1997; Lindmark and Lundborg, 1987; McKiernan, 2005; Nilsson, 1986).

There are only a few studies which have focused on the usage of anti-slip devices. A study among women living in Sapporo, Japan, showed a relatively high number of falls requiring medical attention. That study showed that 38% of the people used non-slippery shoes and/or anti-slip devices with studs, knobs or ceramics on the soles including 16.3% (N=1,382) having detachable anti-slip soles (Hara et al, 1997). An intervention study was conducted in the USA during the winter 2003/2004 among 109 fall-prone subjects aged 65 and above. They completed 10,724 diary days. Participants were randomized to wear an anti-slip device or their ordinary winter footwear. Seven falls occurred with people using anti-slip devices. That study concluded that wearing specific anti-slip devices reduces the risk of outdoor winter falls, and of minor falls especially among older people with a history of previous falls (McKiernan, 2005). A pilot study on the use of anti-slip devices was made in Finland in 2005 (Juntunen et al, 2005). Preliminary results shows that the 93 subjects (aged 21–80) studied were exposed to three fall accidents. Anti-slip devices or studded shoes were used in one of those cases. They were also exposed to eight "close calls" or almost fall accidents, where anti-slip devices were used in three of the cases, studded shoes in two cases and ordinary shoes in three of the cases. The users of anti-slip devices and studded shoes reported improved abilities to walk at nearly normal speed independent of weather. Further studies were suggested to more closely assess the benefits of anti-slip devices. (Juntunen and Grönqvist, 2006).

No similar study has earlier been made in Sweden. Therefore an intervention study has been conducted during the period February – April 2008 among healthy subjects in Northern Sweden.

2. Aim

The aim of the study was to register and study the:

- Pedestrian exposure during wintertime
- Occurence of slips/falls
- Preventive gains of anti-slip devices

3. Method

The subjects have been divided into three groups: an Intervention Group (N=25) and a Control Group 1 (N=25) with similar distribution of gender and age and an extra Control Group 2 (N=17). 60% were female. The Intervention Group were equipped with anti-slip devices. The Intervention Group and Control Group 1 were informed about slip and fall accidents during wintertime. Control Group 2 was just informed about their participation in a travel survey.

Four questionnaires were used and collected during different phases of the trial period:

- I, Background, health, attitudes and previous experiences of fall during the winter 2007/2007 collected in the beginning of the trial period
- II, Daily diary of walked distance, walking conditions, walking aids and occurrence of incidences/falls collected weekly
- III, Detailed incident/fall report collected after each occurrence of incidents/fall.
- IV, Experiences of the use of anti-slip devices to those who used anti-slip devices during the trial period collected after the trial period.

All forms were available on paper, in digital format for printing out or for submitting by e-mail, both in Word and PDF-format.

4. Results

The different Groups showed similar age and gender distribution (See Table 1). The subjects hade experienced 24 actual falls previously during the winter 2007/2008 without any injury.

Table 1: Previously experiences of falls during the winter.

Characteristics	Group			
	Intervention	Control 1	Control 2	Total
Ages, yr	30-67 (N=25)	27-64 (N=25)	30-63 (N=17)	27-67 (N=67)
Female, %	60	60	60	60
Falls previous during the winter	10	8	6	24
% falls by female	50	63	17	46

There was no significant difference in daily average walking distance and walking time among the different groups (See table 2). The intervention group walked 38% of the total walking distance, the Control Group 1 walked 44% and the Control Group 2 walked 18% of the total walking distance.

Table 2: Total walking distance and walking time.

Characteristics	Groups			
	Intervention	Control 1	Control 2	Total
Mean daily total walking distance, km	2.95 (N=919)	2.85 (N=1,093)	2.77 (N=451)	2.87 (N=2,463)
Mean daily total walking time, minutes	32 (N=919)	33 (N=1,094)	37 (N=446)	33 (N=2,459)
Total walking distance, km	2,714	3,099	1,247	7,061

Most of the walking trips were made in daylight. Walk trips in darkness were only performed during 27% of the diary days (See table 3). Reflexes were used during 9% of all the diary days. Walking sticks were used during 40 (<2%) of the diary days and anti-slip devices were used during 356 (14%) of the diary days.

Table 3: Walking conditions.

Characteristics	Intervention	Control 1	Control 2	Total
Mean daily walking distance in darkness, km (N=2463)	1.76 (N=255)	0.92 (N=314)	1.83 (N=105)	1.38 (N=674)
Mean daily walking distance with reflex, km	2.28 (N=132)	2.02 (N=59)	2.93 (N=33)	2.31 (N=224)
Mean daily walking distance in street lightning, km	1.75 (N=266)	1.22 (N=238)	1.77 (N=113)	1.55 (N=617)
Mean daily walking distance with walking sticks, km	5.00 (N=4)	5.00 (N=16)	4.69 (N=20)	4.85 (N=40)
Mean daily walking distance with anti-slip devices, km	3.36 (N=284)	5.88 (N=52)	3.15 (N=20)	3.71 (N=356)

Anti-slip devices were used in 356 dairy days (See table 4). The average total walking distance among the younger subjects (-44 years of age) (N=1,075) were significantly (df=1, F=43.277, p=0.000 < 0.05) shorter, 2.48 km, compared to among the older subjects, 3.21 km (N=1,357). The average walking distance with anti-slip devices among the younger subjects were 1.73 km (N=69) and significantly (df=1, 49.818, p=0.000 <0.05) longer among the older subjects, 4.19 km (N=287).

72% of the total walking distance, when using anti-slip devices, was performed in the Intervention group, 23% in Control Group 1 and 5% in control Group 2. 80% of the diary days when using anti-slip devices were in the Intervention Group, 15% in Control Group 1 and 5% in Control Group 2. For subjects not using anti-slip devices the mean daily total walking distance is significantly (df=1, F=86.1139, p<0.05) shorter, 2.66 km, compared to subjects using anti-slip devices, 4.08 km (See table 4).

Table 4: The exposure for users and *non users* of anti-slip devices.

Characteristics	Group			
	Intervention	Control 1	Control 2	Total
Mean daily total walking distance for subjects when using anti-slip devices, km	3.68	6.51	3.55	4.08
Diary days with walk trips for subjects with anti-slip devices	284	52	20	356
Mean daily walking distance when using anti-slip devices, km	3.36	5.88	3.15	3.71
Total walking distance during days using anti-slip devices, km	953	305	63	1,321
Mean daily walking distance for subjects NOT using anti-slip devices, km	*2.63*	*2.65*	*2.73*	*2.66*
Diary days with walk trips for subjects NOT using anti-slip	*635*	*1,041*	*431*	*2,107*
Total walking distance during days when NOT using anti-slip devices, km	*1,670*	*2,761*	*1,177*	*5,608*

86% of the subjects in the Intervention group reported walking with an anti-slip device. Only 35% of the subjects in Control Group 1 and 31% of the subjects in Control group 2 reported walking with an anti-slip device. 41% of the subjects in the Intervention Group, 57% in Control Group 1 and 38% on Control Group 2 reported an incident/fall (See table 5).

Table 5: Incidents/falls.

Characteristics	Group			
	Intervention	Control 1	Control 2	Total
Subjects using walking diaries	22	23	16	61
Total no of reported walking days	1,028	1,138	492	2,658
Subjects reporting incidents/falls	9	13	6	28
% subjects reporting incidents/falls	41	57	38	46
Subjects using anti-slip devices	19	8	5	32
% subjects anti-slip users	86	35	31	52
Number of incidents/falls	29	23	12	64
Incidents/falls per day	0.0282	0.0202	0.0244	0.0241
Incidents/falls per subject	1.3182	1.0000	0.7500	1.0491
Incidents/falls per km	0.0106	0.0074	0.0096	0.0091

30% of the days when not using anti-slip devices were performed in the Intervention Group, 49% in Control Group 1 and 21% in Control Group 2.

In the Intervention group anti-slip devices were used in 30.9% of the days, in Control Group 1 in 4.8% of the days and in Control Group 2 4.4% of the days. In average anti-slip devices were used in 14% of the registered days.

Table 6: Incident/falls and actual falls.

Characteristics	Group			
	Intervention	Control 1	Control 2	Total
Number of incidents/falls when walking with anti-slip devices	8	1	0	9
Number of actual falls without anti-slip devices	1	5	0	6
Number of incidents/falls when walking without anti-slip devices	21	22	12	55
Number of actual falls with anti-slip devices	1	0	0	1
Stated prevented no. of falls by using anti-slip devices (* and walking sticks)	5	1*	0	6

Mean daily total walking distance compared with experiences of incidences/falls is similar among the subjects and the groups. The subject stated that the use of an anti-slip device prevented from falling in six cases. A heel device was used in the actual fall when using anti-slip devices.

Table 7: Mean daily walking distance with anti-slip devices compared with experiences of incidences/falls.

Variable	Group			
	Intervention	Control 1	Control 2	Total
Mean daily walking distance on anti-slip devices with incidence/fall, km	1.78 (N=8)	4.80 (N=1)	- (N=0)	2.12 (N=9)
Mean daily walking distance on anti-slip devices without incidence/fall, km	3.40 (N=276)	5.90 (N=51)	3.15 (N=20)	3.75 (N=347)

The subjects reduced their mean daily total walking distance significantly on days experiencing an incident/fall.

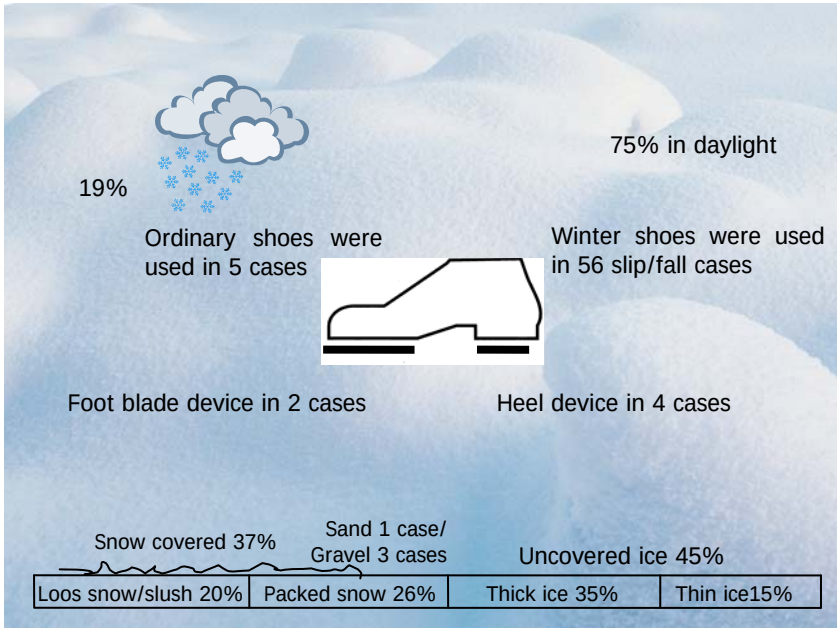
Table 8: Relative incidence/falls and actual fall rate for anti-slip users and non users.

	Anti-slip		
	Users	Non users	Total
Number of days	356	2,107	2,463
Mean daily walking distance, km	4.08	2.66	2.87
Total walking distance, km	1,453	5,607	7,061
Number of incidences/falls	9	55	64
Incidence/fall per km	6.2 *10-3	9.2 *10-3	9.0 *10-3
Actual falls	1	6	7
Actual falls per km	0.69 *10-3	1.07 *10-3	0.99 *10-3

The difference in mean daily total walking distance is significantly ($df=1$, 86.139, $p<0.05$) between non-users, 2.66 km, and users, 4.08 km, of anti-slip devices.

The relation between users and non-users of anti-slip devices is 0.67 incidence/falls per km and 0.64 for actual falls per km. This indicates both a reduction in the incident/fall risk and actual fall risk by using anti-slip devices.

Figure 1: Experiences from reported incidents/falls (The empty box is incidences/falls from Control Group 2).



Most of the incidences/falls occurred in daylight, 75% (See figure 1). 50% were on ice. Most of it were uncovered thick or thin ice. Only 19% occurred during snowfall. Winter shoes were used in most of the cases. Foot blade anti-slip devices were used in to incidents/falls and heel devices in 4 cases. The type of device in the other three cases was not registered. None of the incidents/falls or actual falls caused any injury.

Most of the incidences/falls occurred during March and April. In figure 2 and figure 3 the incidences/falls are plotted against the dates together with the temperature in Luleå were most of the subjects made their walking trips. 80 % of the incidences/falls occurred between -6 °C and 0 °C.

The questionnaire among actual users of anti-slip devices shows that they found them useful and will both continue to use them and will also recommend others to do so.

Figure 2: Incident/fall occurrence and temperature during March 2008.

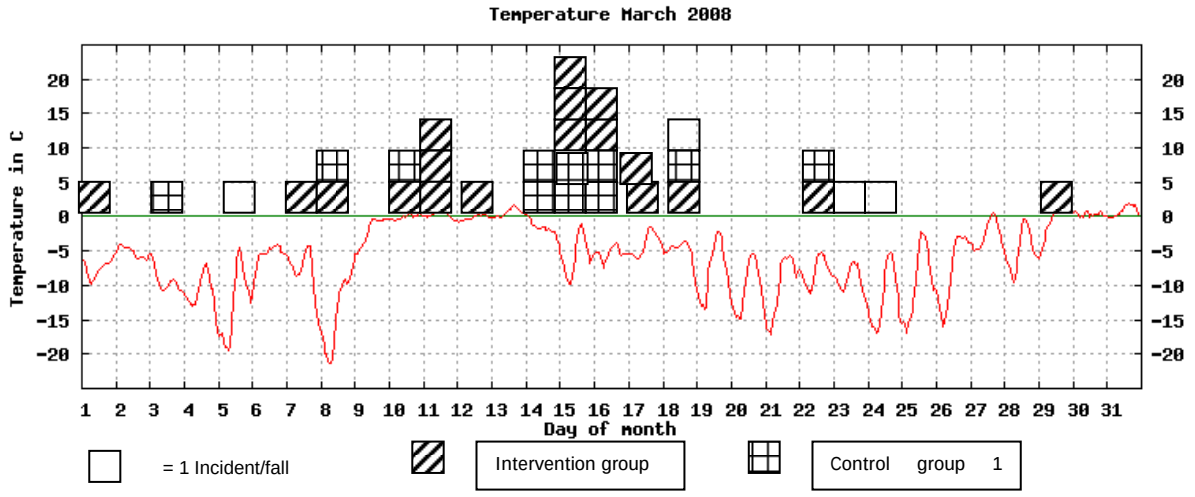
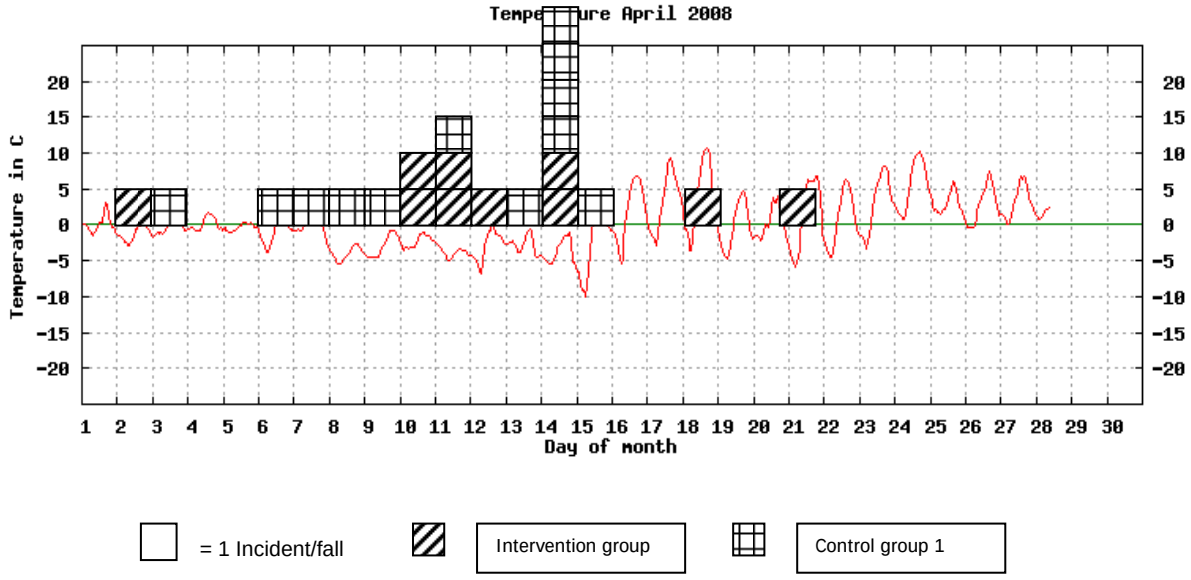


Figure 3: Incident/fall occurrence and temperature during April 2008.



5. Discussion

The average daily total walking distance in this study is similar to the walking distance found in the national travel survey data. There was no significant difference in total walking distance, or total walking time, between the Intervention Group and any of the Control Groups. The differences found were among younger (<45 years of age) and the older subjects and between users and non-users of anti-slip devices. A majority of the subjects, 52%, used an anti-slip device at least during one dairy day. Those using anti-slip devices increased their daily total walking distance. When a subject experienced an incident/fall wearing anti-slip devices they reduced the walking distance that day. The risk of an incident/fall and actual fall is reduced by using anti-slip devices, 0.67 and 0.64 respectively. Similar experiences have been found in studies among fall-prone elderly (McKiernan, 2005). The slip per trip rate was 0.063/trip (N=3,634) for anti-slip users and 0.113/trip (N=4,274) for ordinary winter shoe user. The relationship for falls and slips was 0.56 for anti-slip users and 0.89 for winter shoe users. The subjects reported an anti-slip device to prevent from falling in six incident/fall cases.

6. Conclusions

The anti-slip users walked longer compared to non users of anti-slip devices. The anti-slip users increased the exposure. The use of anti-slip devise reduced the incidence/fall rate compared to non user. Anti-slip devices prevents from falling. The use of anti-slip devise can therefore be used to increase the exposure without increasing the risk for incident/falls and actual falls. The users of anti-slip devices will continue to do so and they will also recommend others to do so. By reducing slip and fall accidents during wintertime the single-pedestrian accidents can be reduced thus improving the safety in the traffic environment for pedestrians.

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