Day of the Week and Ischemic Stroke
Is It Monday High or Sunday Low?

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Background and Purpose—The study aim was to examine the incidence of ischemic stroke (IS) by day of the week and its relationship with age, sex, and socioeconomic status (SES).

Methods—A total of 12,801 IS events in men and women aged 25 to 99 years was recorded in a population-based stroke register (FINMONICA), which was functioning in Finland from 1982 to 1992. We analyzed the weekly variation in IS incidence by pooling the data and stratifying by sex and age. Taxable income and level of education were used as indicators of SES.

Results—We observed a significant weekly variation in IS occurrence, but the analysis by age group demonstrated a difference by weekday only in the age group 60 to 74, both in men and women (P<0.001 and P=0.02, respectively). The increase in the number of IS events from Sunday to Monday was pronounced in men (29.2% increase from Sunday to Monday). When stratifying by age, Monday excess in IS incidence was associated with lower SES among persons >59 years of age. No Monday excess was observed in persons with high SES.

Conclusions—Because the incidence of IS is much higher in persons with low SES than in those with high SES, the Monday excess in persons with low SES is of substantial public health interest. This finding may suggest reasons for the higher IS incidence in persons with low socioeconomic positions and open up some possibilities for prevention. (Stroke. 2004;35:2089-2093.)

Key Words: cerebral infarction ■ Finland ■ periodicity ■ socioeconomic factors ■ stroke

Several studies have reported on variability in ischemic stroke (IS) occurrence by the day of week, but the inconsistency of findings has made the conclusions unclear.1-4 Although the underlying mechanisms are speculative and definite conclusions are difficult to draw, it seems likely that a weekly difference in IS onset exists. It has already been shown that low socioeconomic position is associated with risk of IS,5 but the relationship between the weekday variation in IS occurrence and socioeconomic status (SES) is largely unknown.

The aim of the present study was to examine the weekly variation in IS occurrence and incidence in Finland and to investigate whether this variation was dependent on socioeconomic position. Taxable income and level of education were used as proxies for SES.

Materials and Methods
The main data source for this study was the FINMONICA Stroke Register, a population-based register that operated during the 1980s and early 1990s in Finland. The registration methods applied in the FINMONICA Stroke Register have been described previously.6,7 Registration covers all consecutive ISs in the resident population aged 25 to 74 years. The oldest age group (75 to 99 years) was registered during the entire period only in the city of Turku and since 1990 in the province of Kuopio. Strokes of thrombotic and embolic origin were combined (International Classification of Diseases, Ninth Revision [ICD-9] 432 to 436) to form the IS category. Unspecified type of stroke (ICD-9 436) was also included among IS; it was ≈3% of all strokes and occurred mostly among elderly subjects8,9 and thus was most probably IS. In the present report, incidence refers to first-ever strokes (ie, those occurring without any evidence of a clinically recognized previous stroke event in the patient’s history). For IS occurrence, we considered first and recurrent IS events together.

SES information was obtained by record linkage of the stroke register with the files of Statistics Finland on the basis of the personal identification number. Taxable income and level of education for the years 1980, 1985, and 1990 were used as SES indicators as described in detail previously.8 For analysis, income data were adjusted for inflation and classified into 3 broad categories: low, middle, and high. Education was stratified into 2 categories: basic, corresponding to ≤9 years of full-time education; and secondary or higher, corresponding to >9 years of full-time education. Data with SES indicators were analyzed only for subjects with incident IS aged 25 to 74 years because we did not have SES information on subjects >75 years of age.

Statistical Methods
Data for the period from January 1, 1982, until December 31, 1992, was pooled and divided to 7 days of the week. Assuming that the sizes of the monitored populations do not vary by weekday, we used the χ² tests to compare observed IS numbers with those expected if IS events were distributed equally by weekday. These analyses were
stratified by area, sex, and age. Findings were approximately similar in all 3 areas, and therefore the data from all areas were combined. Incidence rates were age standardized with the direct method to the European standard population. The 95% CIs for the incidence rates were calculated assuming Poisson distribution for the number of events. The statistical analyses were performed using SAS statistical software.

Results

Altogether, 12 801 IS events were registered (6246 in men and 6555 in women) in all age groups. Of these, 6903 events were incident (first ever) ISs (3903 in men and 3000 in women) within the age range 25 to 74. Numbers of incident IS events by day of the week, age group, sex, and SES are presented in Table 1.

The overall \( \chi^2 \) tests showed a significant weekly variation in IS occurrence (first and recurrent events together) among men and women (\( \chi^2 = 30.24; df = 6; P = 0.001 \); and \( \chi^2 = 14.76; df = 6; P = 0.02 \), respectively). IS occurred most frequently on Mondays in men (13.6% above weekly average) and on Tuesdays in women (5.3% above weekly average). The lowest numbers of IS events were observed on Sundays in both genders.

Further analysis by age group showed that the difference by weekday was statistically significant only in the age group 60 to 74 years (\( P < 0.001 \) in men and \( P = 0.02 \) women). The increase in the number of IS events from Sunday to Monday was pronounced in men (29.2% increase from Sunday to Monday). The lowest proportion of IS events was observed on Sundays in persons \(<75\) years of age in both sexes (Figure 1).

The age-standardized incidence rates of first IS event among persons aged 25 to 74 years are presented by day of the week in Figure 2. These data show a clear variation by day of the week in men (\( \chi^2 = 19.15; df = 6; P = 0.004 \)) but not in women (\( \chi^2 = 10.30; P = 0.11 \)). The highest numbers of events were observed on Monday (10% in men and 8.3% in women above weekly average) and they were significantly higher compared with Sunday.

Among men aged 60 to 74 years, the average age-standardized IS incidence was highest at 788 (per 100,000 per year) in the middle-income group, almost as high at 742 in the low-income group, and clearly lowest at 489 in the high-income group. In the low-income group, the incidence peaked Monday at 17.9% above the weekly average (Table 2). This was significantly different from Sunday, which was 13.9%

### Table 1. Numbers of Incident Ischemic Stroke Events by Day of the Week, Age Group, Income Group, and Education Level in Men and Women Aged 25 to 74 Years in the FINMONICA Stroke Register

<table>
<thead>
<tr>
<th>Weekday</th>
<th>25–59 Income Group</th>
<th>60–74 Income Group</th>
<th>25–59 Education Level</th>
<th>60–74 Education Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Middle</td>
<td>High</td>
<td>Basic</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td>67</td>
<td>70</td>
<td>42</td>
<td>130</td>
</tr>
<tr>
<td>Monday</td>
<td>63</td>
<td>89</td>
<td>41</td>
<td>130</td>
</tr>
<tr>
<td>Tuesday</td>
<td>66</td>
<td>83</td>
<td>39</td>
<td>136</td>
</tr>
<tr>
<td>Wednesday</td>
<td>47</td>
<td>90</td>
<td>48</td>
<td>119</td>
</tr>
<tr>
<td>Thursday</td>
<td>50</td>
<td>92</td>
<td>47</td>
<td>140</td>
</tr>
<tr>
<td>Friday</td>
<td>61</td>
<td>88</td>
<td>45</td>
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<tr>
<td>Saturday</td>
<td>70</td>
<td>89</td>
<td>45</td>
<td>154</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td>32</td>
<td>20</td>
<td>10</td>
<td>45</td>
</tr>
<tr>
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<td>36</td>
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<tr>
<td>Saturday</td>
<td>44</td>
<td>17</td>
<td>11</td>
<td>48</td>
</tr>
</tbody>
</table>

Figure 1. Proportion (%) of IS events above and below the weekly average by day of the week and age group in men and women aged 25 to 99 years in the FINMONICA Stroke Register.
below the weekly average. Similar significant difference between Monday and Sunday was found also in the middle-income group (14.4% versus -15.5%), but another peak (20.7%) was observed on Thursday. In the high-income group, no Monday peak was observed, but the incidence was clearly lowest (-38.3%) on Sundays. However, Sunday did not differ significantly from any other day of the week in the high-income group.

Among women aged 60 to 74 years, the pattern was similar to men. The age-standardized IS incidence was highest in the middle- and low-income groups (470 and 465, respectively) and lowest in the high-income group (285). In the low-income group, there was a clear incidence peak Monday, which was significantly different from Sunday (12.6% versus -9.1%; Table 2). In the middle- and high-income groups, the event numbers were small among women and CIs became wide.

Among persons with basic education only, IS incidence also peaked on Mondays, which were significantly higher than Sundays in both genders (Table 2). Data also suggested a Monday peak among men with high education. Among women with high education, the highest incidence was observed on Wednesday.

**Discussion**

The present study demonstrated weekday variation in IS occurrence, consistent with findings from other studies.\(^2\),\(^3\),\(^12\) The greater IS incidence on Mondays was pronounced consistently among persons aged 60 to 74 years and with low SES. Because IS incidence is much higher in persons with low SES than in persons with high SES, the Monday excess is of substantial public health interest. The Monday excess may also suggest reasons for the higher IS incidence in persons with low SES and open possibilities for prevention.

In a community-based stroke register from Japan, Wang et al\(^12\) found among persons >60 years of age a considerable weekly variation in cerebral infarction incidence, with a peak of 26% on Monday compared with the weekend in men, whereas in women, most events occurred on Thursday and Friday. In the Framingham Study,\(^3\) a significantly higher number of strokes occurred on Monday (17.2%) than on any other day. Johansson et al\(^13\) found that cerebral ischemic events resulting from thrombosis of large vessels had their highest peak of frequency between Tuesday and Thursday and lacunar infarctions on weekends. Pasqualetti et al\(^14\) reported a zenith of ischemic and hemorrhagic events on Saturday, Sunday, and Monday and a nadir on Wednesday and Thursday. On the other hand, in the community-based study, Brackenridge\(^4\) found that the highest frequency of events (35%) occurred on Wednesday and the lowest (14%) during the weekend, without stratifying data by gender and subtypes of stroke.

In our study, Sunday was the day of the week with lowest IS occurrence. This result was confirmed in overall analyses, low SES, and low education in both genders and all age groups studied. The Sunday “low” IS incidence finding was actually more consistent than Monday “high” IS incidence (we also found “high” incidence on Tuesdays among women). The weekly differences in IS occurrence were most prominent among persons aged 60 to 74 years, with the younger men and women showing smaller and nonsignificant differences. Previous literature has reported that the weekly variation in cerebral infarction onset is greater in younger\(^15\) and working populations\(^2\) than in the older age groups. We also observed an excess of IS events on Friday among younger women with higher SES, but this may be a chance finding caused by the relatively small number of events in the highest-income group. Overall, taxable income results were consistent with those on education, suggesting that observed differences in the excess of IS by SES may be attributable to differences in modifiable rather than nonmodifiable risk factors.\(^16\) Unfortunately, we did not have lifestyle information, which would be helpful in assessing the possible relationship of Monday excess with drinking and smoking habits during the weekend, which have been related to the increased incidence of myocardial infarction\(^17\) and IS.\(^15\),\(^18\)

Etiology for observed weekly periodicity with the higher IS occurrence on Mondays is not clear. Gneccchi-Ruscone et al\(^19\) found that the onset of acute myocardial infarction is unevenly distributed over the week, with increased incidence of events on Monday, which might be a result of the shift from a period of nonscheduled to scheduled activity. On the other hand, cardiological studies have found no evidence of weekly variation of life-threatening ventricular arrhythmias,\(^20\) and sudden deaths on Mondays have been considered to be mainly a result of ischemic heart disease. The novel finding of the present study was that patients with lower SES had the least ISs on Sundays and tended to have IS events more often on Mondays compared with their wealthier and better-educated counterparts, for whom we did not find a significant weekly difference. This only partially confirms the findings of a previous Finnish study, which suggested that weekday variation in IS occurrence may be attributable to the short-term lifestyle changes during the weekend.\(^18\) Our main findings were among older persons, whose lifestyles during the weekend are likely to be more stable and may not be a proper explanation for the observed variation by day of the week. Unfortunately, we did not have data on IS subtypes,
which might have been helpful in understanding the relationships between weekly IS variation and age, sex, and SES.

The strengths of the study include its population-based design and the large number of IS events collected according to a standardized protocol and under rigorous quality control of the WHO MONICA Project. A recent analysis of the MONICA myocardial infarction registry data suggested that the Monday excess in coronary heart disease might simply be an artifact of registration. However, the FINMONICA stroke register team put considerable effort into registering the date of stroke event onset according to the first presentation of symptoms and not according to hospital admission. For this reason, we do not believe that our findings are classified erroneously regarding day of onset. Another major strength of our study was the possibility of linking our records with the files of Statistics Finland, which provided us with accurate information on taxable income and education for each stroke patient before the stroke occurred.

In conclusion, we noted a significant weekly variation in IS incidence, which was lowest on Sundays and highest on Mondays. The Monday excess was particularly prominent in elderly men and women with a low SES.

**Appendix**

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**Acknowledgments**

This work was supported by the Finnish Foundation for Cardiovascular Research. We are grateful to hospitals, primary health centers,
and health personnel of the registration areas for supporting the local data collection.

References
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Stroke. 2004;35:2089-2093; originally published online July 22, 2004;
doi: 10.1161/01.STR.0000137763.88044.28
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://stroke.ahajournals.org/content/35/9/2089