ORIGINAL ARTICLE

# Seasonality of type 1 diabetes mellitus in children and its modification by weekends and holidays: retrospective observational study

**J A Mooney, P J Helms, I T Jolliffe, P Smail, on behalf of the Scottish Study Group for the Care of Diabetes in the Young**

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**Background:** Diagnoses of type 1 insulin dependent diabetes mellitus are generally more common in winter, although this seasonal pattern has not been observed in children of preschool age (0–4 years) or in all countries.
**Aims:** To confirm the persistence of seasonality and the influence of age, holidays, and weekends.
**Methods:** We extracted data on date of birth, date of presentation, age, and sex of children diagnosed with diabetes and registered with the Scottish Study Group for the Care of Diabetes in the Young. Cosinor analysis was applied to monthly and mid-monthly data. Two sample Z tests were used to compare the epochs 1984–1992 and 1993–2001.
**Results:** Some 4517 children between 0 and 14 years of age (2407 male and 2110 female) presented with IDDM between 1 January 1984 and 31 December 2001. Seasonality was evident in children above 4 years of age with amplitudes of 19.5–25.7% and peaks between mid December and mid January. Presentation was strongly influenced by weekends and holiday periods, with reduced presentations in December compared with November and January, and with the lowest presentations in July (the main Scottish holiday month). Using mid-month to mid-month data did not change the overall seasonality but did improve the fits for cosinor analysis. Mondays and Fridays were the most common days for presentation.
**Conclusion:** Initial presentation of IDDM in Scotland follows a stable seasonal pattern in all but the youngest children with lower rates of presentation in holiday periods and at weekends for all age groups.

Seasonal patterns in the onset of type 1 insulin dependent diabetes mellitus (IDDM) in children have previously been noted, although not in all studies. In a study of Scottish data over the period 1984–1993, a marked seasonal pattern in the onset of IDDM was found in children aged between 5 and 9 years.[1] Using cosinor analysis it was noted that the peak incidence for this group occurred in December and the lowest in July, with an amplitude of 28%. Significant seasonality was observed in children aged 10–14 years, although this was less obvious than in those aged 5–9 years. No significant seasonal pattern was found in children aged 0–4 years. However such seasonality is not universal as no seasonal pattern was found in Japanese children aged between 0 and 14 years over the period 1986–1990[2] nor in the Baltic states for the years 1983–1992.[3] In view of this lack of agreement and the possible distortion of the data by delayed presentation during holiday periods and at weekends, we sought to clarify these issues using the Scottish Study Group for the Care of Diabetes in the Young dataset.

## METHODS

Data on date of birth, date of onset, age, and sex of children diagnosed with IDDM between 1984 and 2001 were obtained from the Scottish Study Group for the Care of Diabetes in the Young, a comprehensive prospective dataset into which data on all affected children presenting to paediatric units in Scotland are entered. Data were analysed using the same methods and age groups as previously reported[1]: namely 0–4 years, 5–9 years, and 10–14 years. Cosinor analysis was applied to monthly data.[4 5] To eliminate any variation due to differing month length, the data were month corrected to 31 days by multiplying the February figure by 1.097 and the 30 day months by 1.033. The results from cosinor analysis give the amplitude (the distance of the peak above the mean level, expressed as a percentage), the acrophase (the position in the year of the peak), and a p value indicating the significance of the seasonal pattern. In order to take into account any distortion of month by month seasonality due to the winter and summer holiday seasons mid-month to mid-month data were also used, again month corrected to 31 days. In order to assess whether any observed patterns were consistent over time, two sample Z tests were used to compare the epochs 1984–1992 and 1993–2001.

## RESULTS

Over the 18 year period, 4517 children aged between 0 and 14 years presented with IDDM. The initial presentations made in each calendar month over the whole period failed to demonstrate any evidence of seasonality for children aged 0–4 years in contrast to those aged 5–9 years and 10–14 years (fig 1). Cosinor analysis confirmed these impressions with non-significant seasonality in the youngest age group but with evidence of seasonality in the two older age groups although this was not consistent across all gender/age groups (table 1). However, as can be seen from fig 1, the number of presentations in December tended to be lower than in the adjacent months of November and January. It was also apparent that in three of the gender/age groups July, the main holiday month in Scotland, exhibited the lowest number of presentations (fig 1). When mid-month to mid-month data

**Abbreviations:** IDDM, insulin dependent diabetes mellitus



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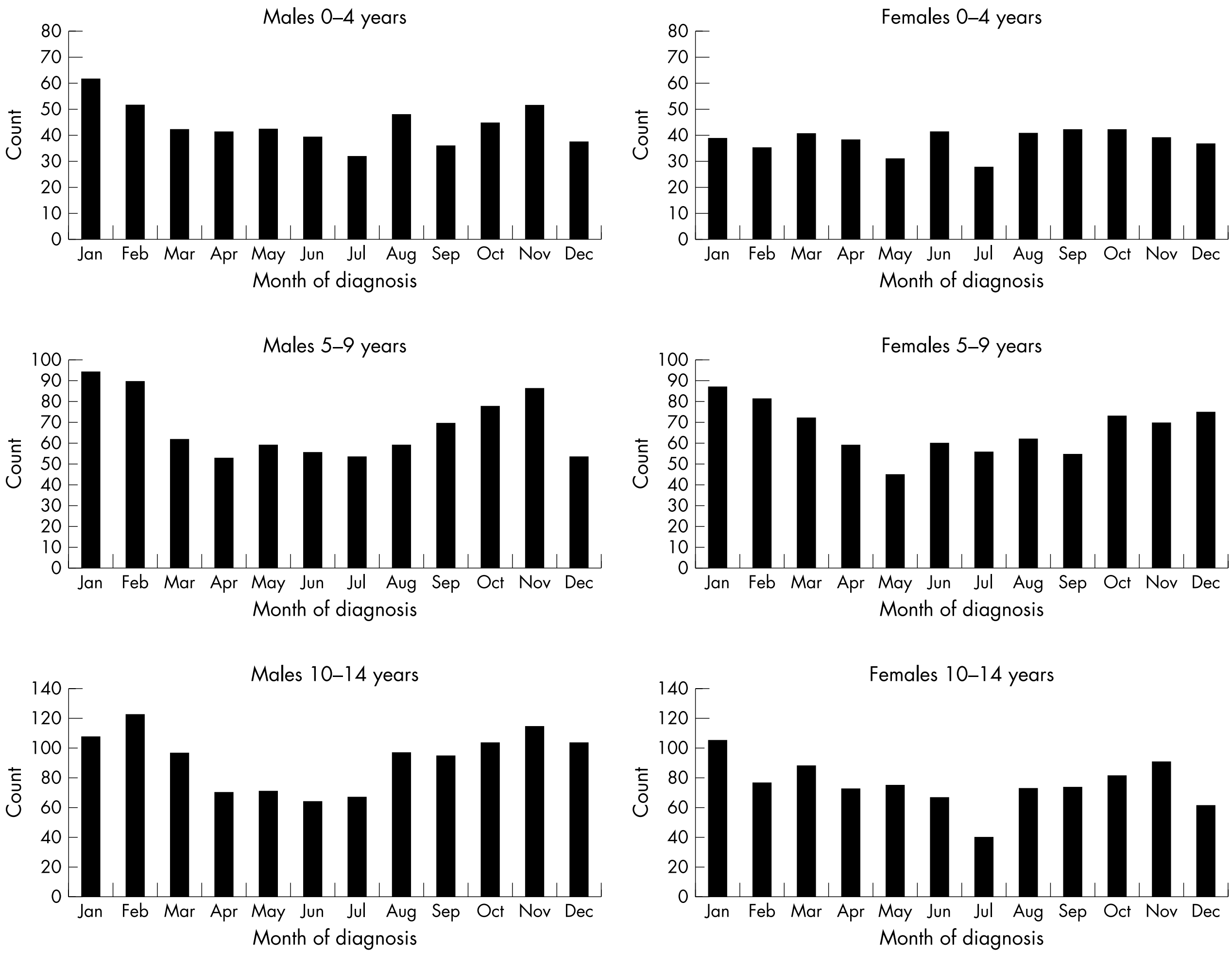


**Figure 1** Monthly diabetes diagnoses by age groups and sex, 1984–2001.

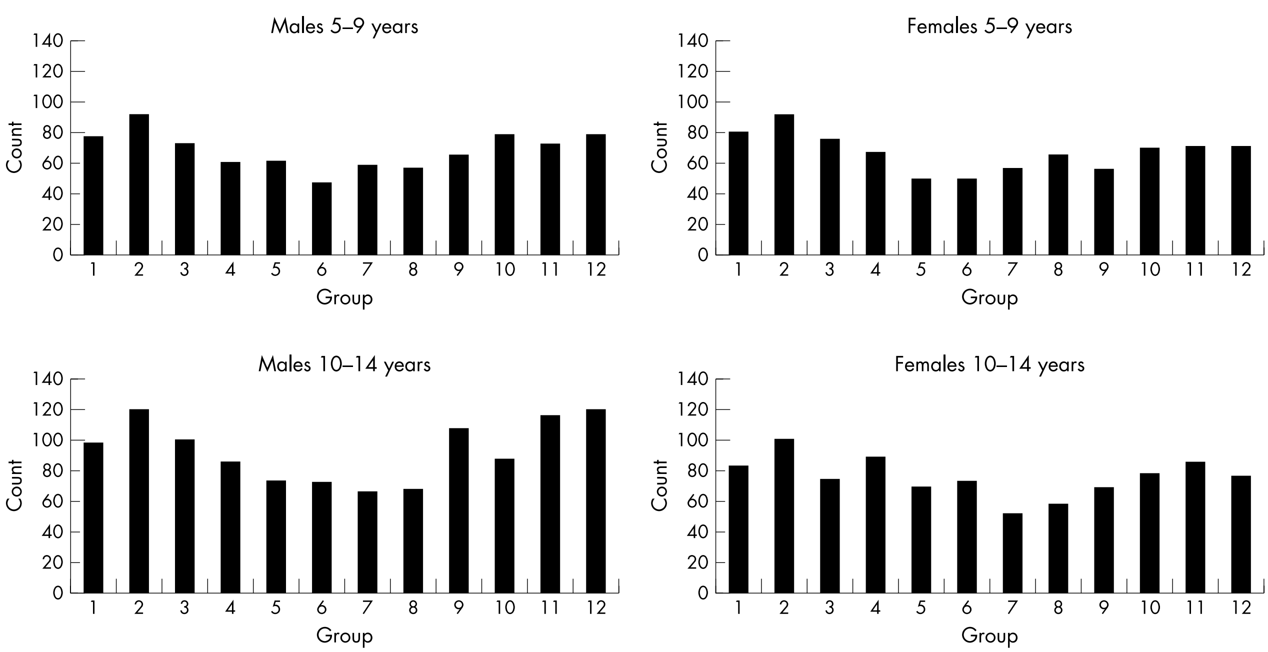


**Figure 2** Diabetes diagnoses using the groups from table 1.



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were used in place of calendar month, the lack of seasonality remained in the youngest age group (data not shown), although a more consistent and significant pattern emerged in the older two age groups (fig 2 and table 2). Dividing the data into two time periods, 1984–1992 and 1993–2001, the amplitude of seasonal variability was almost identical in the two periods (22.1%, 21.9%). However, the peak occurrence (acrophase) was later in the second period (6th January) than in the first (7th December). As cosinor analysis is a form of regression analysis, an approximate Z test can be constructed to test the significance (or otherwise) of this difference in the acrophase. The p value for this test between the two time epochs was approximately 0.02.

As a depression of presentations similar to that in holiday periods could also be operating at weekends, we compared actual presentations to those expected if occurrence was uniform throughout the week. For such an even distribution, 28.57% of all presentations would be expected over weekends. This was clearly not the case as can be seen from fig 3 where actual weekend presentations for 1984–1992 and 1993–2001 were 12.35% and 11.38%, respectively. These values were significantly lower than the 28.57% expected ($p<0.0001$, one sample Z test using a normal approximation to the binomial distribution), and with no significant difference between the percentage of weekend presentations in each period ($p = 0.07$, two sample Z test). Mondays and Fridays were the most common days for presentation in both periods with approximately 40% of all presentations falling on these 2 days. Unlike the lack of seasonality observed in the youngest age group (0–4 years), age did not appear to influence the weekday/weekend pattern of presentation (data not shown).

## DISCUSSION

Presentation of IDDM in Scottish children exhibits a seasonal pattern, except in children aged less than 4 years. More diagnoses are made in the winter months, although the number of presentations in December is lower than in adjacent months. The lower rates in December could be explained by the reduction in specialist and non-emergency services over the holiday period with a subsequent "catch up" in January, or by a reluctance of parents to seek medical help and invite disruption to their family routine during holiday periods. The dip in July presentations, which corresponds to the Scottish school holidays, would favour the latter rather than the former explanation although some of the reduction in July could be accounted for by families taking their holidays outside Scotland. Taking these possible distortions of the true seasonal pattern into account by grouping from mid-month to mid-month resulted in an even clearer seasonal pattern which was easier to model using cosinor analysis (fig 2).

In the whole data set there was no evidence of seasonality for date of birth ($p = 0.121$). Furthermore, the amplitude of 4% and the peak in mid May were very similar to the non-significant seasonality of all live births in Scotland for the period 1983–2000 which had an amplitude of 4% and which showed annual peaks between mid May and August (data not shown but available on request).

Fewer presentations of diabetes at weekends compared to during weekdays might be expected for the same reasons outlined above. Despite the changes in access to medical services at weekends that have occurred over the period of assessment, the observation that the pattern of weekend presentations has not changed suggests that the explanation may lie in the use of health services rather than their availability. Presentation of IDDM is a process in which noticeable symptoms of IDDM can vary in their timing and their severity. Some symptoms of intermittent hyperglycaemia may occur for up to a year,[6] whereas thirst and polyuria caused by sustained hyperglycaemia may take more than 1–3 weeks before progressing to diabetic ketoacidosis.[7] However there was no suggestion in our data, in contrast to a previous report,[7] that the pattern of weekday presentation was influenced by season. The biphasic pattern of presentation intensity with peaks on Mondays and Fridays would be consistent with parents either trying to get their children seen before the weekend or, if the child became ill over the weekend, waiting until Monday before seeking medical help. This pattern of referral is likely to be followed for many other subacute conditions and could potentially adversely affect outcome. Distortions such as this and the effects of holiday periods need to be accounted for when studying the seasonality of subacute diseases.

**Table 1** Results of cosinor analysis on original data

| Group | Sample size | Amplitude (%) | Acrophase | p Value |
|---|---|---|---|---|
| 0–4 Male | 519 | 15.1 | 7 January | 0.137 |
| 0–4 Female | 447 | 6.3 | 8 November | 0.482 |
| 5–9 Male | 798 | 20.9 | 17 December | 0.063 |
| 5–9 Female | 779 | 21.2 | 1 January | 0.003 |
| 10–14 Male | 1090 | 25.7 | 12 December | 0.001 |
| 10–14 Female | 1663 | 19.5 | 9 January | 0.117 |

**Table 2** Cosinor analysis using mid-month data

| Group | Sample size | Amplitude (%) | Acrophase | p Value |
|---|---|---|---|---|
| 5–9 Male | 798 | 21.5 | 16 December | 0.002 |
| 5–9 Female | 779 | 21.6 | 27 December | 0.005 |
| 10–14 Male | 1090 | 25.6 | 11 December | 0.002 |
| 10–14 Female | 1663 | 18.8 | 11 January | 0.012 |

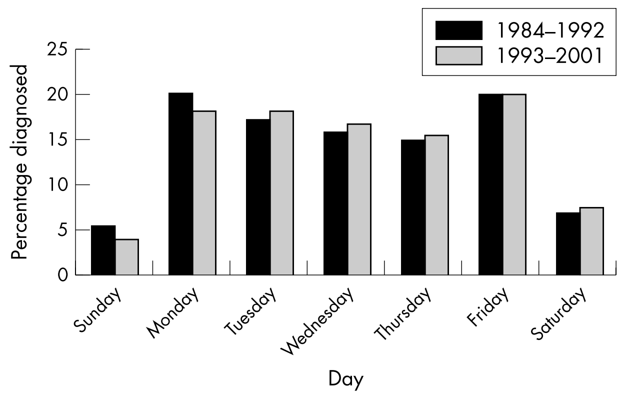


**Figure 3** Weekend effect by period.

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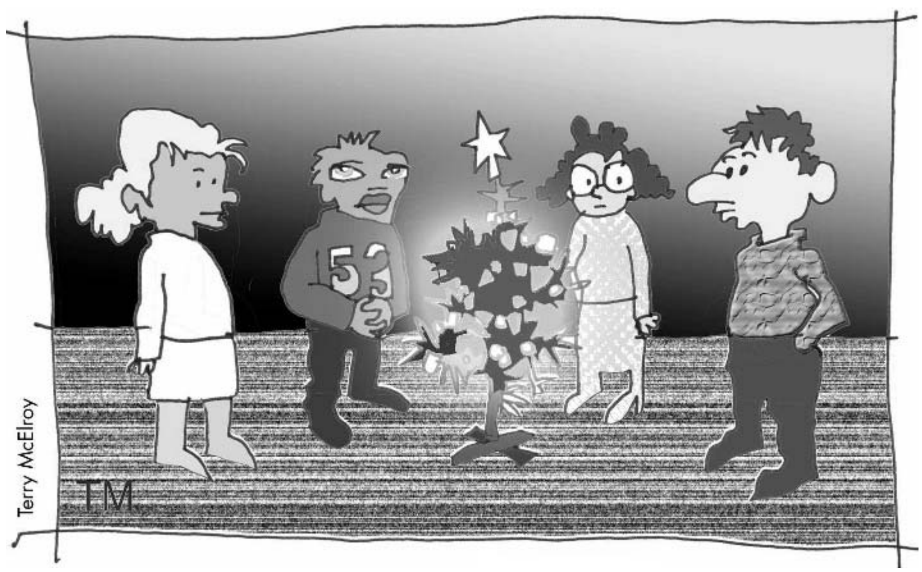


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