Do Ambient Electromagnetic Fields Affect Behaviour? A Demonstration of the Relationship Between Geomagnetic Storm Activity and Suicide

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The relationship between ambient electromagnetic fields and human mood and behaviour is of great public health interest. The relationship between *Ap* indices of geomagnetic storm activity and national suicide statistics for Australia from 1968 to 2002 was studied. *Ap* index data was normalised so as to be globally uniform and gave a measure of storm activity for each day. A geomagnetic storm event was defined as a day in which the *Ap* index was equal to or exceeded 100 nT. Suicide data was a national tally of daily male and female death figures where suicide had been documented as the cause of death. A total of 51 845 males and 16 327 females were included. The average number of suicides was greatest in spring for males and females, and lowest in autumn for males and summer for females. Suicide amongst females increased significantly in autumn during concurrent periods of geomagnetic storm activity ($P = .01$). This pattern was not observed in males ($P = .16$). This suggests that perturbations in ambient electromagnetic field activity impact behaviour in a clinically meaningful manner. The study furthermore raises issues regarding other sources of stray electromagnetic fields and their effect on mental health. Bioelectromagnetics 27, 2006. © 2005 Wiley-Liss, Inc.

Key words: suicide; geomagnetic storms; solar activity; electromagnetic fields; behaviour

INTRODUCTION

An individual's decision to commit suicide is likely to be precipitated by a mosaic of causal factors. The major cause of suicide is unquestionably mental illness [Kirby, 1997]. Also important are major life events resulting in grief, loss, feelings of worthlessness and guilt [Gaynes et al., 2004]. The significance of other factors, such as political and economic variables [Lester and Yang, 1977], culture or ethnicity [Gaynes et al., 2004] etc., remains controversial. Environmental factors, such as ambient electromagnetic field and season [Partonen et al., 2004], may also contribute to suicidality.

The ability of ambient electromagnetic fields to adversely effect health has been a topic of considerable speculation. Elevated magnetic flux densities, caused by the power distribution grid and various electrical devices, are very common, especially in a city environment [Lindgren et al., 2001]. It is highly likely that as society becomes more "wired," these potential sources are likely to increase. Epidemiological studies have shown that residing near a strong source of electromagnetic flux density, such as high-voltage power lines, is associated with an increased risk of leukaemia in children [Feychting and Ahlbom, 1993; Hardell et al., 1995; Ahlbom et al., 2000; Greenland et al., 2000], although earlier studies investigating the physiological and psychological effects of exposure to electromagnetic fields have been negative [Gamberale et al., 1989; Gamberale, 1990].

A hidden danger of stray electromagnetic fields may be in their effect on the mental health of the population. The ability of magnetic fields to alter mood has been established in experiments where patients have been exposed to strong magnetic fields using transcranial magnetic stimulation (TMS) [Fitzgerald et al., 2003] and magnetic resonance imaging (MRI)

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Received for review 11 May 2005; Final revision received 10 August 2005

DOI 10.1002/bem.20190
Published online in Wiley InterScience (www.interscience.wiley.com).

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[Rohan et al., 2004]. Behavioural and cognitive effects have been well documented when electromagnetic exposure is of sufficient intensity to heat tissue [D'Andrea et al., 2003]. Low intensity electromagnetic fields, such as those in geomagnetic storms, do not have sufficient energy to heat tissue and their impact on human mood and behaviour is poorly understood.

Double-blind studies on humans exposed to sham, continuous or intermittent (15 s on–off cycles) magnetic fields (100 μT 50 Hz) have suggested that low level magnetic field exposure may cause event related potential (ERP) latency and reaction time slowing, suggesting that magnetic field can influence neural processing [Crasson et al., 1999]. Bilateral exposure to a 1 μT burst-firing magnetic field, administered along the temporoparietal plane, was found to be a pleasurable experience in a study of 17 men and 18 women. Interruption during exposure to the magnetic stimulation was associated with irritability and pilot data from clinical patients suggested exposure was associated with improved mood and decreased depression [Freeman and Persinger, 1996].

Geomagnetic storms are disturbances in the earth's magnetic field caused by gusts of solar wind, charged particles emanating from solar flares. During a geomagnetic storm the amount of charged solar material reaching the earth increases and the earth's magnetic field is significantly perturbed. Geomagnetic storms can last several hours and can be of sufficient magnitude to cause fluctuations in and damage to the power distribution grid. Databases maintain records of geomagnetic activity measured using a series of parameters which describe a complex phenomenon [Danilov and Lastovicka, 2001].

In a study of 86 volunteers, physiological and psychological parameters were measured using a standardised questionnaire and compared to geomagnetic activity. Arterial, systolic and diastolic blood pressure was shown to increase significantly for males and females when there was an increase in geomagnetic activity. A positive trend was also measured between geomagnetic activity and subjective psycho-physiological complaints [Dimitrova et al., 2004]. In another study, geomagnetic activity data collected over a 10 year period was highly related to the admission rate of 3449 patients diagnosed as suffering from depression, to a psychiatric hospital in Britain. The significance of the relationship was stronger for males than for females [Kay, 1994]. In a study of individual violence among penitentiary populations in Canada, geomagnetic disturbances significantly related with; minor violence in the psychiatric prison ($P = .01$), minor violence in the women's prison ($P = .01$) and minor violence in one medium security prison ($P = .02$). There was a significant inverse relationship ($P \leq .05$) between geomagnetic disturbances and attempted suicide or self-inflicted injury rates among male prisoners during the summer months [Ganjavi et al., 1985].

Two previous studies have shown a positive relationship between geomagnetic storm activity and an increased incidence of suicide. Partonen et al. [2004] found a relationship between smoothed monthly mean *K* values for geomagnetic activity and relative risk of suicide amongst 27 469 suicides in Finland from 1 January 1979 to 31 December 1999. Gordon and Berk [2003] found a correlation between suicides and average storm activity in South Africa between January 1980 and December 1992. The effect was shown to be stronger in females ($P < .005$) than males ($P < .025$).

MATERIALS AND METHODS

Geomagnetic storms can be described by a series of parameters. The *Ap* index is a measure of the general level of geomagnetic storm activity over the planet over a 24 h period (midnight to midnight Greenwich Mean Time). It is derived from measures taken at 11 magnetometer stations in the northern hemisphere and two in the southern hemisphere and is designed to measure solar particle radiation by its magnetic effects. In this study, daily *Ap* indices from 1 January 1968 to 31 August 2002 were obtained from the World Data Centre for Solar Terrestrial Science, Sydney, Australia.

The date of event and gender of every person in Australia for whom the documented cause of death was suicide, from the same time period, was obtained from the Australian Bureau of Statistics. A total of 51 845 males and 16 327 females committed suicide between these dates.

The number of suicides occurring on the day that the *Ap* index exceeded 100 nT ($Ap > 100$ nT) was compared to the average number of suicides experienced across the rest of the days ($Ap < 100$ nT). Two-way analysis of variance analysed these differences in the mean number of suicides after adjusting for the year. The analysis was split by season due to the strong association previously reported between suicide and season [Partonen et al., 2004]. Interaction was investigated at 0.05 level of significance. The number of events where the index exceeded 100 nT was too small in Summer to analyse ($n = 2$). The analysis was repeated to include the average number of suicides experienced up to 2 and 4 days after the *Ap* index > 100 nT. Where a second geomagnetic storm event occurred within the days studied, days continued

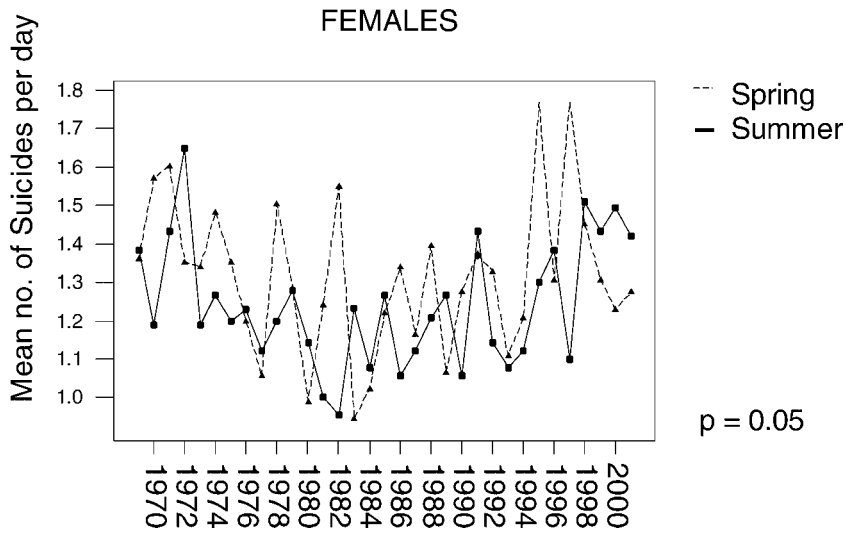

Fig. 1. Mean suicides per day for females for Spring and Summer adjusted for year.

to be included until there was no storm event within the 2 or 4 day period. Where no day occurred that the *Ap* index exceeded 100 nT, the data for this year was included with the closest year prior that had an event. The analysis was repeated on the ranks of the data and the results were consistent with the parametric tests.

RESULTS

The average number of suicides each day from 1 January 1968 to 31 August 2002 was 1.28 ± 0.01 (mean $\pm$ SE) for females and 4.08 ± 0.02 for males, and was 1.39 ± 0.06 for females and 2.82 ± 0.09 for males in 1968 and 1.29 ± 0.07 for females and 5.01 ± 0.15 for males in 2002. The Australian population grew from 5 965 400 females and 6 043 235 males in 1968 to 9 908 963 females and 9 753 818 males in 2002.

The largest average number of suicides per day for females occurred in Spring (1.32 ± 0.02) and the smallest average occurred in Summer (1.24 ± 0.02) ($P = .05$), with the other seasons intermediate, across the entire range of years studied (Fig. 1). The average suicide numbers for males in Spring (4.07 ± 0.04) was increased for the years 1968–1997 and lowest in Autumn (3.67 ± 0.04) ($P = .00$) (Fig. 2), but after 1997 there was no significant difference across the seasons.

Within the study period there were 21 (20 and 17) days during Autumn (Winter and Spring) when the *Ap* index exceeded 100 nT; however some of these events occurred within 2 or 4 days of each other. During

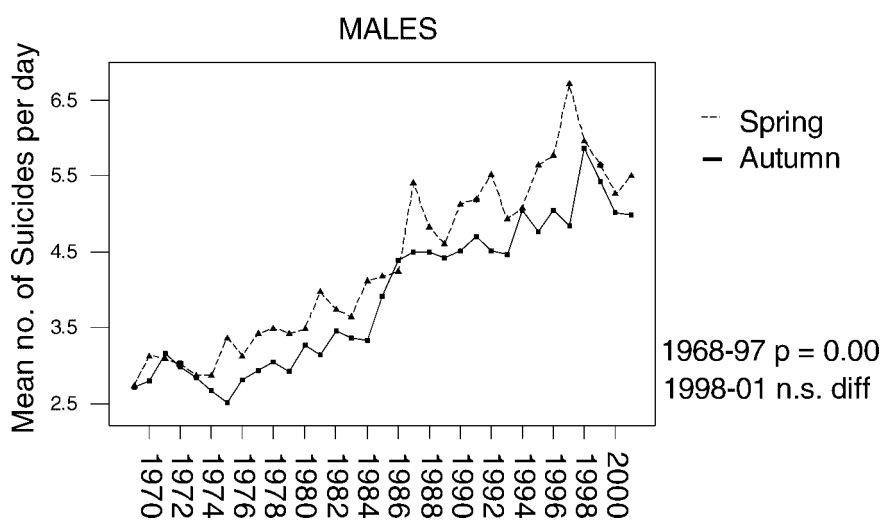

Fig. 2. Mean suicides per day for males for Spring and Autumn adjusted for year.

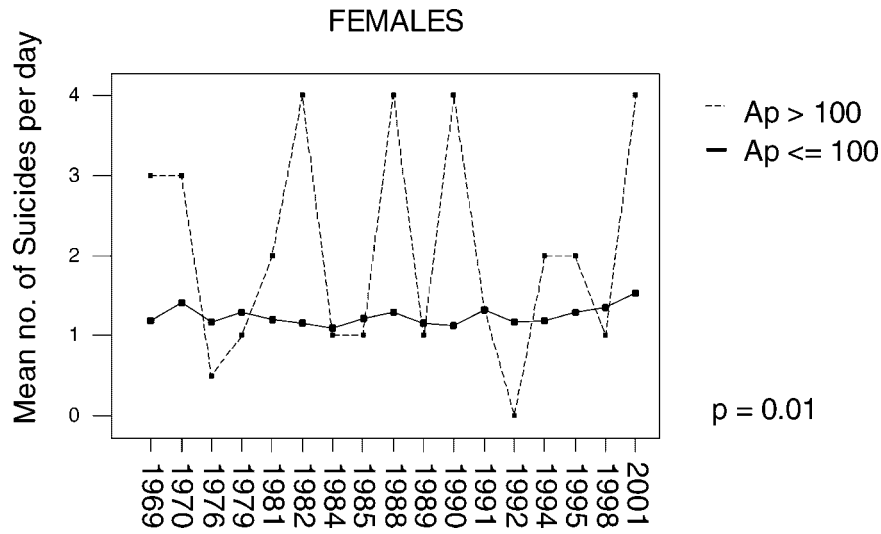

Fig. 3. Average number of suicides for females in Autumn was increased on days where the $Ap > 100$ compared to the average number of suicides for the rest of the season. (Two way analysis of variance, $P = .01$.)

Autumn there were 57 days (93 days), which included or were within 2 days (4 days) of an Ap index > 100 nT event.

The average number of suicides in Autumn were increased for females on the days where $Ap > 100$ (1.86 ± 0.29 vs. 1.27 ± 0.02, mean $\pm$ SE, $P = .01$) (Fig. 3) but no significant difference was observed in the average number of male suicides ($P = .16$). The increase in the number of suicides for females persisted including 2 days past the $Ap > 100$ (1.61 ± 0.16 vs. 1.27 ± 0.02, $P = .01$) and there was no significant difference in the average number of suicides comparing up to 4 days past the event with the rest of the days during Autumn ($P = .15$).

In Winter and Spring, there was no significant difference in the mean number of suicides for females ($P = .88$ and $P = .66$) or males ($P = .90$ and $P = .23$) on the days where $Ap > 100$ compared to the number during the rest of the season.

CONCLUSIONS

This study displays findings similar to previous studies that geomagnetic activity has a subtle but measurable impact on the incidence of suicide in women. These findings support the hypothesis that mood, and indeed suicidality, can be influenced by disturbances in the electromagnetic field in our environment and may have an adverse impact on mental health.

The modulation of mood and behaviour is probably attributable to a direct effect of perturbations in the ambient electromagnetic field on the neurobiology, perhaps disrupting sleep regulation, pineal function or cell membrane permeability. The nature of the perturbations of the low intensity electromagnetic fields in terms of intensity, duration and other descriptors, required to influence mood and behaviour are at this stage unknown, as are interindividual susceptibilities.

These findings suggest that it may be possible for human mood and behaviour to be impacted by other, man-made, perturbations in the ambient electromagnetic field such as those caused by the power distribution grid and electrical devises. Further research is needed to determine if these perturbations adversely impact human mental health.

ACKNOWLEDGMENTS

We thank Richard Marshall from the World Data Center for Solar Terrestrial Science, Sydney, Australia, and the National Geophysical Data Center, Boulder, USA, for supplying the geomagnetic activity data and Peter Burke and Geoff Bell of the Australian Bureau of Statistics for supplying the suicide data.

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