Report

POSSIBLE INFLUENCE OF THE GEOMAGNETIC FIELD ON SPORTS PERFORMANCE

Dean I. Radin, Ph.D.

ABSTRACT

If human behavior and performance are affected by minute changes in the earth's geomagnetic field, as suggested by a growing body of evidence, then one might also expect to see such influences reflected in skilled physical performance, such as sports. To explore this possibility, scores from a mixed-gender, candlepin competitive bowling league were correlated with daily planetary geomagnetic flux. Results indicated that geomagnetic fluctuations the day before bowling accounted for a significant percentage (40%) of the variance in men's bowling scores. The same relationship was not independently significant for women's scores, but the correlation was opposite to men's scores.

KEYWORDS: Sports, geomagnetic field, performance

INTRODUCTION

A growing number of studies have suggested that the naturally fluctuating magnetic field that surrounds the Earth affects both animal physiology[1-4] and human behavior[5-28] in many ways. In some animals, the geomagnetic field seems to be associated with orientation and navigational abilities.[29] If the human sense of orientation is also sensitive to changes in magnetic fields, perhaps as part of a vestigial navigational ability, or due to magnetic field interactions with ferromagnetic deposits in the brain,[30-31] then we might expect that such influences would be reflected in the performance of tasks requiring keen spatial and motor coordination, such as sports.[32]

To test this possibility, scores from a candlepin bowling league were used as a measure of skilled spatiomotor performance, and these scores were correlated with daily measures of planetary geomagnetic activity. The sport of bowling was selected because skill in this game correlates well with obtained scores, successful performance requires consistently proficient spatiomotor coordination, detailed scoring records are maintained by league statisticians, records are carefully double-checked because competitive rankings and cash prizes depend on accurate data, bowling leagues play weekly for many months, and they are often coeducational, providing the opportunity to examine possible gender differences.

METHOD

Bowling score data was obtained from a competitive bowling league consisting of 30 men and 21 women.[33] These 51 people bowled three games each Monday night, each game consisting of 10 frames, beginning on September 9, 1991 and continuing for the next 29 weeks. Scores from the first three weeks were used to establish individual average scores, and then teams of four people were determined where each team was created on the basis of gender balance and the average of the four individuals' average scores. A few players were maintained in a substitute player pool to fill in when a regular team member was absent. Detailed score data was recorded by the league secretary and double-checked for accuracy to establish the weekly competitive rankings of the teams as well as the season league champions.

To form a measure of weekly skill fluctuations, a difference score $d_{ij} = S_{ij} - A_j$ was calculated where S_{ij} was player j's average score over the three games he or she bowled Monday night on week i, and A_j was player j's cumulative average for all games bowled up to the prior week. From these d_{ij} scores, a mean difference score

$$Di = \sum_{j=1}^{N} d_{ij} / N_i$$

was calculated for each week i, where N_i was the number of players bowling on week i, and d_{ij} were players' difference scores obtained on week i. Mean difference scores were analyzed separately for men and women to test for gender effects. This resulted in a total of 29 mean difference scores, D, for men and for women. While the official league roster listed 30 men and 21 women, the number of people actually playing each week varied. Over the 29 weeks an average of 27 men and 17 women played per week (standard deviations 1.7 and 1.9, respectively).

Figure 1 shows D for men as well as a linear regression between D and week. The regression indicates a slight practice effect in men's scores over the bowling season. To detrend the practice effect, residuals (R) of the linear regression

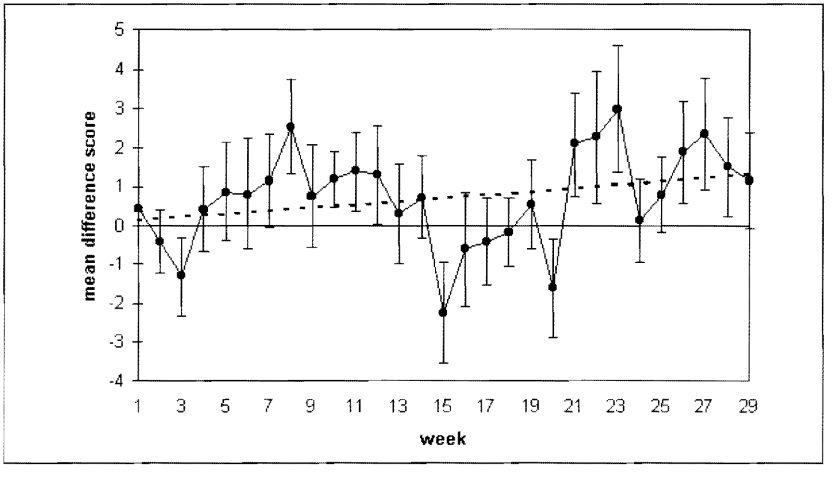

Figure 1. D scores for men.

between *D* and week were determined for both men's and women's *D* scores. The resulting 29 *R* values were used in all subsequent correlations.

For the geomagnetic measure, the daily Ap-index was used, time-corrected for Eastern Standard Time. This index is a daily measure of global planetary geomagnetic activity, calculated by averaging geomagnetic reports from thirteen magnetic observatories located around the world. The data was downloaded from the National Geophysical Data Center in Boulder, Colorado, USA. Because Ap values can be highly skewed, the natural log of Ap—shown as "ln(Ap)"—was used in all analyses.

Seven planned correlations were determined for men and for women: *R* vs. ln(Ap) recorded on the day of bowling, and *R* vs. ln(Ap) for three days before and three days after the day of bowling. The latter six correlations were used to look for leading and lagging effects.

RESULTS

Figure 2 plots the autocorrelations for 203 successive daily ln(Ap) values (29 weeks x 7 days), starting with the first day of bowling, up to lag 15. The graph indicates that ln(Ap) values on adjacent days tended to be highly correlated, but values recorded two or more days apart were not significantly related. Because the daily geomagnetic values used in the correlations reported here were recorded on days one week apart, the values were effectively independent.

Figure 3 shows the main results of this study: Correlations between fluctuations in the Earth's magnetic field and deviations in bowling scores for the actual day of bowling, and the same correlations for geomagnetic indices recorded three days before and after the day of bowling. The direction of the correlations indicate that in general, increased geomagnetic activity around the time of bowling was associated with an increase in men's bowling scores and a decrease in women's scores.

To determine the statistical significance of the correlations shown in Figure 3, we took an empirical approach. To do this, we extended the correlations shown

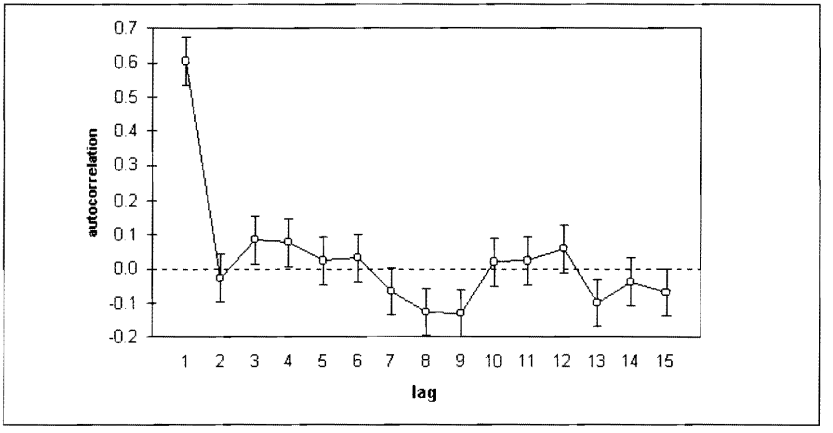

Figure 2. *Autocorrelations in daily ln(Ap) values, up to lag 15, over the course of 29 weeks of bowling.*

in Figure 3 to include the 1,347 days before and 1,652 days after the actual day the bowling league started. Through this process, we effectively asked the question: What if the actual starting date for the bowling league was not September 9, 1991, but one of 3,000 other days about four years before to four years after this date? After determining all of these correlations (29 bowling ***R*** scores vs. 29 daily geomagnetic values recorded one week apart), we sorted them by magnitude and simply counted how many correlations in this list were larger than the correlation obtained on the actual starting day.

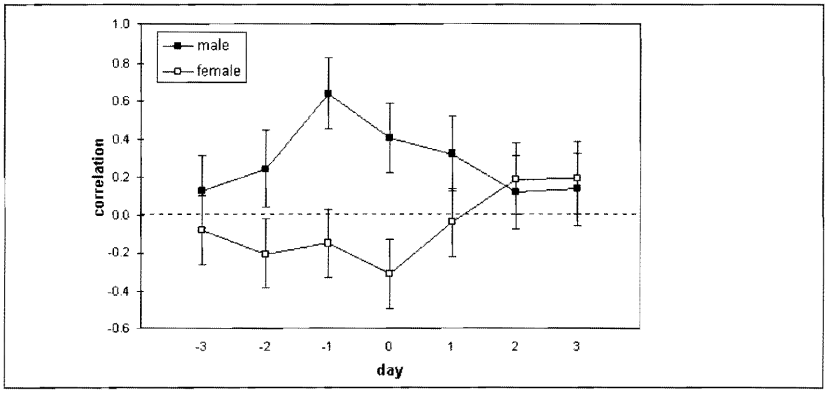

Figure 3. *Correlations for men's and women's* ***R*** *scores vs. ln(Ap), with one standard error bars.*

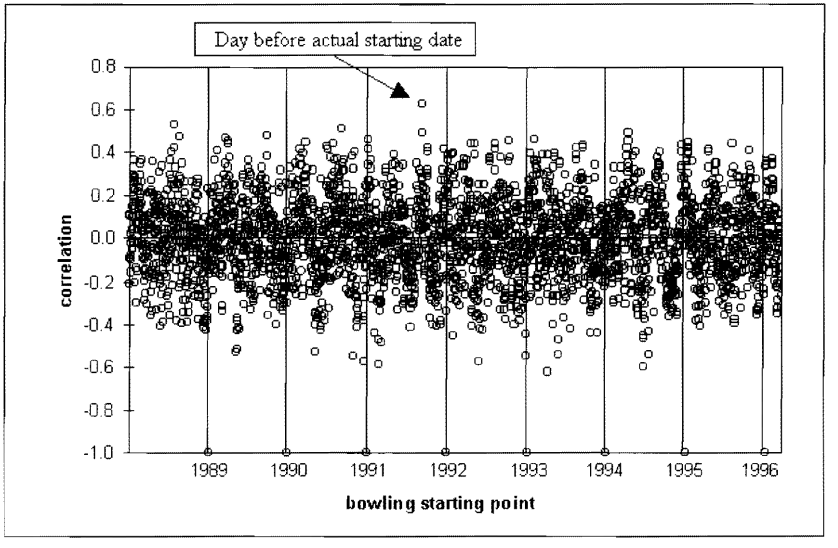

Figure 4. *Correlations for men's bowling score obtained by assuming that the bowling league started on one of 3,000 possible days from 1988 to 1996. The arrow points to the correlation obtained on the actual starting date in September 1991.*

As seen in Figure 4, the single largest correlation, out of 3,000, occurred the day before the actual starting date of September 9, 1991. Therefore, we know that the probability of obtaining a correlation as large or larger than this one is 1 in 3000, or $p = 0.0003$. Because we did not have any prior reason to predict a directional correlation, we employ two-tailed probabilities. Table I lists the results of this statistical significance analysis for the seven correlations shown in Figure 3. Recall that day "-1" in Table I and Figure 3 means that we are correlating ***R*** scores, one for each of the 29 weeks of bowling, against the geomagnetic values on 29 successive Sundays, one day before the day of bowling, starting on September 8, 1991.

CONCLUSION

These results indicate that fluctuations in men's average bowling scores were related to fluctuations in earth-strength geomagnetic fields on the day before bowling ($p = 0.0006$), and the day of bowling ($p = 0.03$). Similar fluctuations

Table I

Correlations for men and women, and associated two-tailed probabilities, for results graphed in Figure 2. For all correlations, N = 29, and significance levels were determined empirically.

Day	*r men*	*p 2 tail*	*r women*	*p 2 tail*
-3	*0.12*	*0.53*	*-0.08*	*0.65*
-2	*0.24*	*0.23*	*-0.20*	*-.27*
-1	*0.64*	*0.0006*	*-0.25*	*0.41*
0	*0.40*	*0.03*	*-0.31*	*0.09*
1	*0.32*	*0.10*	*-0.04*	*0.82*
2	*0.12*	*0.54*	*0.19*	*0.31*
3	*0.14*	*0.48*	*0.20*	*0.30*

in women's scores were not as clear, with only a suggestive relationship observed for the day of bowling (p = 0.09), but with the intriguing twist that correlations for women were generally opposite to those for men.

These findings are surprising because magnetic fields associated with the automatic pin-changing machines in a bowling alley are hundreds to thousands of times stronger than fluctuations in the earth's geomagnetic field. In addition, it is thought that the amount of energy absorbed by the human body by earth-strength magnetic field fluctuations is much too weak to affect biology at the cellular level, to say nothing of the behavioral level.[34]

One way around the energy-absorption problem is the possibility that the human body responds to slow-changing magnetic fields within very specific energetic boundaries or frequencies. But whatever the ultimate cause, the present observation adds to a growing literature suggesting that tiny variations in the earth's geomagnetic field are associated with behavioral and performance changes in human beings, and that there may be gender differences associated with these subtle magnetic influences.[35]

Future studies investigating possible relationships between geomagnetism and sports performance should look beyond gender differences, and study how individuals respond to geomagnetic flux. It seems likely that some people, perhaps those with higher skills, are much more susceptible to changes in geomagnetism, and possibly to other geophysical and astronomical factors.

• • •

CORRESPONDENCE: Dean I. Radin, Ph.D. • Consciousness Research Division, Harry Reid Center for Environmental Studies • University of Nevada Las Vegas • Box 454009, 4505 Maryland Parkway • Las Vegas, NV 89154-4009

REFERENCES AND NOTES

1. J. Olcese, S. Reuss & P. Semm, Geomagnetic Field Detection in Rodents, *Life Sciences* 42,6 (1988), pp. 605-613.
2. J. Stehle, S. Reuss, H. Schroder, M. Henschel & L. Vollrathm, Magnetic Field Effects on Pineal N-Cetyltransferase Activity and Melatonin Content in the Gerbil—Role of Pigmentation and Sex, *Physiological Behavior* 44,1 (1988), pp. 91-94.
3. J. R. Thomas, J. Schrot & A. R. Liboff, Low-Intensity Magnetic Fields Alter Operant Behavior in Rats, *Bioelectromagnetics* 7,4 (1986), pp. 349-357.
4.. J. Olcese, S. Reuss & L. Vollrath, Evidence for the Involvement of the Visual System in Mediating Magnetic Field Effects on Pineal Melatonin Synthesis in the Rat, *Brain Research* 33 (1985), pp. 382-384.
5. S. J. P. Spottiswoode, Geomagnetic Activity and Anomalous Cognition: A Preliminary Report of New Evidence, *Subtle Energies* 1,1 (1990), pp. 91-102.
6. M. H. Adams, Persistent Temporal Relationships of Ganzfeld Results to Geomagnetic Activity: Appropriateness of Using Standard Geomagnetic Indices. In *Research in Parapsychology 1986* (Scarecrow Press, Metuchen, NJ, 1987), p. 78.
7. M. H. Adams, Variability in Remote-Viewing Performance: Possible Relationship to the Geomagnetic Field, In *Research in Parapsychology 1985* (Scarecrow Press, Metuchen, NJ, 1986), p. 25.
8. M. A. Arango & M. A. Persinger, Geophysical Variables and Behavior: LII. Decreased Geomagnetic Activity and Spontaneous Telepathic Experiences From the Sidgwick Collection, *Perceptual & Motor Skills* 67,3 (1988), pp. 907-910.
9. R. E. Berger & M. A. Persinger, Geophysical Variables and Behavior: LXVII. Quieter Annual Geomagnetic Activity and Larger Effect Size for Experimental Psi (ESP) Studies over Six Decades, *Perceptual & Motor Skills* 73 (1991), pp. 1219-1223.
10. W. G. Braud & S. P. Dennis, Geophysical Variables and Behavior: LVIII. Autonomic Activity, Hemolysis and Biological Psychokinesis: Possible Relationships with Geomagnetic Field Activity, *Perceptual & Motor Skills* **68**,3 Pt 2 (1989), pp. 1243-1254.
11. O. Ganjavi, B. Schell, J. C. Cachon & F. Porporino, Geophysical Variables and Behavior: XXIX. Impact of Atmospheric Conditions on Occurrences of Individual Violence Among Canadian Penitentiary Populations, *Perceptual & Motor Skills* **61**,1 (1985), pp. 259-275.

12. L. Gearhart & M. A. Persinger, Geophysical Variables and Behavior: XXXIII. Onsets of Historical and Contemporary Poltergeist Episodes Occurred with Sudden Increases in Geomagnetic Activity, *Perceptual & Motor Skills* **62**,2 (1986), pp. 463-466.
13. L. R. Gissurarson, The Psychokinesis Effect: Geomagnetic Influence, Age and Sex Differences, *Journal of Scientific Exploration* **6**,2 (1992), 157-166.
14. E. Haraldsson & L. R. Gissurarson, Does Geomagnetic Activity Affect Extrasensory Perception? *Personality and Individual Differences* **8** (1987), pp. 745-747.
15. D. R. Lewicki, G. H. Schaut & M. A. Persinger, Geophysical Variables and Behavior: XLIV. Days of Subjective Precognitive Experiences and the Days Before the Actual Events Display Correlated Geomagnetic Activity, *Perceptual & Motor Skills* **65**,1 (1987), pp. 173-174.
16. K. Makarec & M. A. Persinger, Geophysical Variables and Behavior: XLIII. Negative correlation Between Accuracy of Card-guessing and Geomagnetic Activity: A Case Study. *Perceptual & Motor Skills* **65**,1 (1987), pp. 105-106.
17. M. A. Persinger, Geophysical Variables and Behavior: XXX. Intense Paranormal Experiences Occur During Days of Quiet, Global, Geomagnetic Activity, *Perceptual & Motor Skills* **61** (1985), pp. 320-322.
18. M. A. Persinger, Spontaneous Telepathic Experiences from Phantasms of the Living and low Global Geomagnetic Activity, *Journal of the American Society for Psychical Research* **81** (1987a), pp. 23-36.
19. M. A. Persinger, Geopsychology and Geopsychopathology: Mental Processes and Disorders Associated with Geochemical and Geophysical Factors, *Experientia* 43,1 (1987b), pp. 92-104.
20. M. A. Persinger, Geophysical Variables and Behavior: LXVI. Geomagnetic Storm Sudden Commencements and Commercial Aircrashes, *Perceptual & Motor Skills* 72 (1991), pp. 476-478.
21. M. A. Persinger & Krippner, S. Dream ESP experiences and geomagnetic activity. *Journal of the American Society for Psychical Research* 83 (1989), pp. 101-116.
22. M. A. Persinger & B. F. Levesque, Geophysical Variables and Behavior: XII. The Weather Matrix Accommodates Large Portions of Variance of Measured Daily Mood, *Perceptual & Motor Skills* 57,3 Pt 1 (1983), pp. 868-870.
23. M. A. Persinger & M. Nolan, Geophysical Variables and Behavior: XX. Weekly Numbers of Mining Accidents and the Weather Matrix: The Importance of Geomagnetic Variation and Barometric Pressure, *Perceptual & Motor Skills* **59,3** (1984), pp. 719-722.
24. M. A. Persinger & G. B. Schaut, Geomagnetic Factors in Subjective Telepathic, Precognitive and postmortem experiences, *Journal of the American Society for Psychical Research* **82** (1988), pp. 217-235.
25. S. M. Roney-Dougal & G. Vogl, Some Speculations on the Effect of Geomagnetism on the Pineal Gland, *Journal of the Society for Psychical Research* **59**,830 (1993), pp. 1-15.
26. G. B. Schaut & M. A. Persinger, Geophysical Variables and Behavior: XXXI. Global Geomagnetic Activity During Spontaneous Paranormal Experiences: A Replication, *Perceptual & Motor Skills* **61**,2 (1985), pp. 412-414.
27. H. P. Wilkinson, & A. Gauld, Geomagnetism and Anomalous Experiences, 1868-1980. *Proceedings of the Society for Psychical Research* 57,217 (1993), pp. 275-310.
28. M. A. Persinger, Geophysical Variables and Human Behavior: VIII. Specific Prediction of UFO Reports Within the New Madrid States by Solar-Geomagnetic and Seismic Measures, *Perceptual & Motor Skills* 56,1 (1983), pp. 243-249.
29. J. G. Mather & R. R. Baker, A Demonstration of Navigation by Rodents Using an Orientation Cage, *Nature* **284** (1980), pp. 259-262.

30. M. Barinaga, Giving Personal Magnetism a Whole New Meaning, *Science* **256** (1992), p. 967.
31. ___ Presti & J. D. Pettigrew, Ferromagnetic Coupling to Muscle as a Basic of Geomagnetic Sense Direction in Animals, *Nature* **285** (1980), pp. 99-101.
32. H. Lukacova & I. Tunyi, Urazovost Vrcholovych a Vykonnostnych Sportovcov a Geomagneticka Aktivita [Injuries in Elite and Recreational Athletes and Geomagnetic Activity] *Teorie a Praxe Telesne Vychovy* (Czechoslovakian) **36,3** (1988), pp. 138-141.
33. Courtesy of GTE Laboratories, Inc., Candlepin Bowling League [1991-92 season] Waltham, MA, USA.
34. R. K. Adair, Constraints on Biological Effects of Weak Extremely-Low-Frequency Electro Magnetic Fields, *Physical Review* A, 43 (1991), pp. 1039-1048.
35. E. Green, P. Parks, A. Green, P, Guyer, S. Fahrion & L. Coyne, Gender Differences in a Magnetic Field, *Subtle Energies* **3**,2 (1992), pp. 65-104.

∞ ∞ ∞