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CIRCANNUAL VARIATION IN HUMAN DIASTOLIC BLOOD PRESSURE DURING CONSECUTIVE SOLAR CYCLES

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A b s t r a c t

Putative circadecadal modulations of a circannual variation in diastolic blood pressure are explored in a still accumulating 35–year record of self-measurements by a clinically healthy man. Analyses of monthly means by gliding spectra, one-way analysis of variance (ANOVA), and cosinor were carried out after removing data collected during travel across time zones or during illness. An about yearly change in diastolic blood pressure may or may not be detected with statistical significance by cosinor or ANOVA, apparently as a function of solar cycle number and/or stage. It appears to be, however, 1–year synchronized in the entire span analysed as a whole. A given variable such as diastolic blood pressure may be characterized by multifrequency rhythms that may intermodulate, so that findings in different stages of cycles with the lowest (e.g., circadecadal) frequency mapped may determine different outcomes in cycles with higher frequencies, such as circannuals.

K e y w o r d s

Blood pressure, Circannual rhythm, Solar cycle

INTRODUCTION

The importance of solar cycle stage on physiology has been noted by the senior author earlier, as has been its importance also for vascular pathology (*1–3*). Watanabe et al. (4) have reported numerical counterparts to sunspot cycles for human blood pressure and heart rate variability. The broader problem of invisible "sunburns" in terms of an increased risk of myocardial infarctions and strokes has been reviewed (*5*). *Cornélissen et al.* (*3, 6*) demonstrated the dangers associated with correlation analyses assessing any association with solar cycle stage of human blood pressure and heart rate and have advocated the need for an approach by subtraction and replacement (*7*).

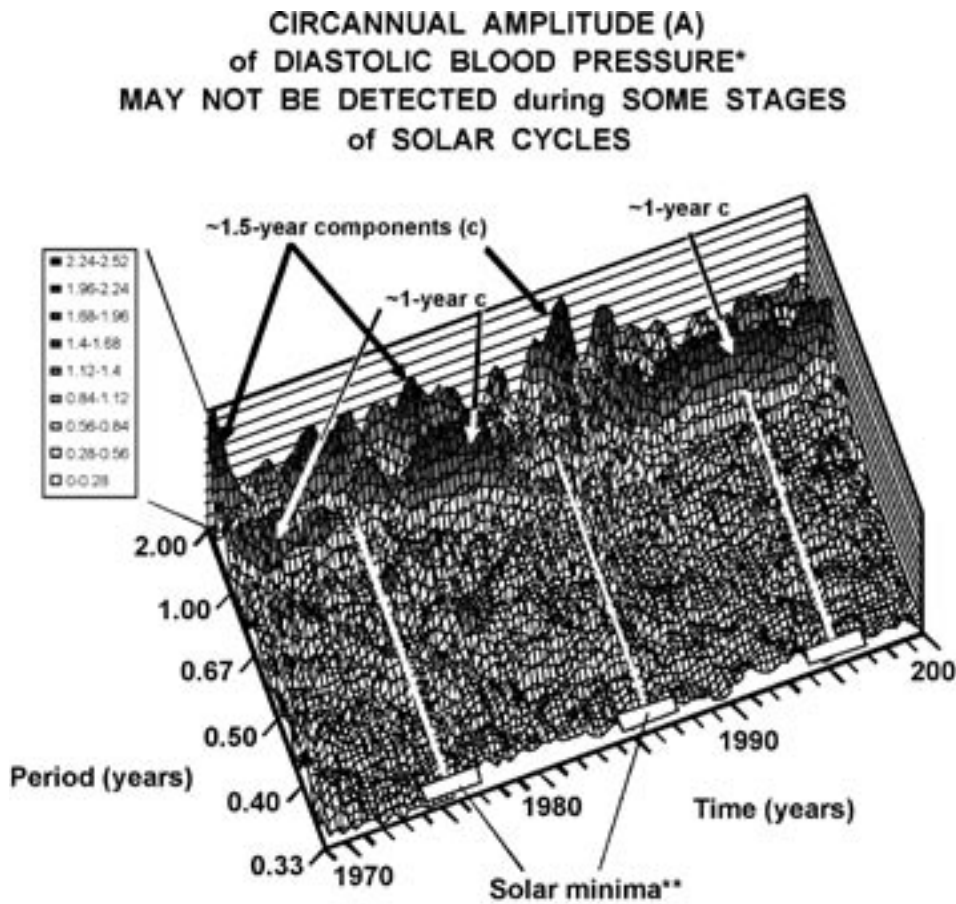

Fig. 1
3D chart of changes as a function of time (or age) in the spectral structure of diastolic blood pressure of a clinically healthy man. A possible modulation by the about 10.5–year cycle in solar activity is suggested.

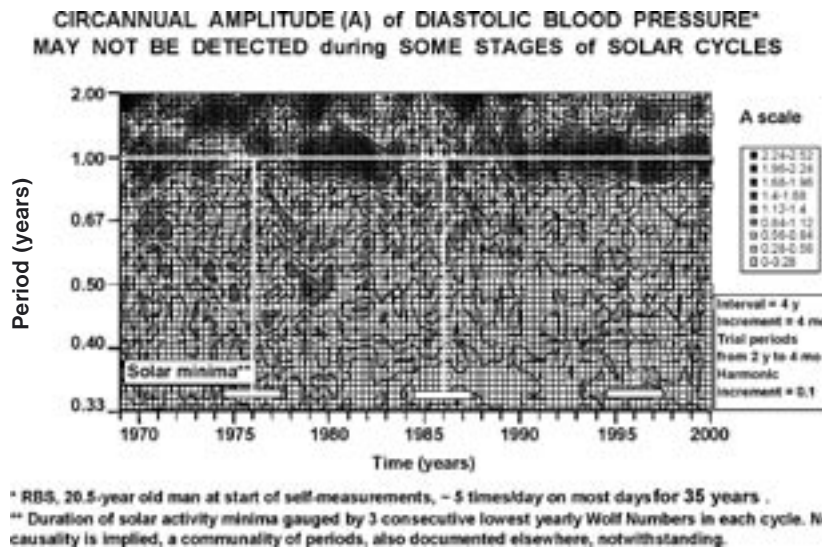

Fig 2

Results in Fig 1 shown as a surface chart. The intermittent detection of a circannual rhythm in diastolic blood pressure is clearly apparent, lack of statistical significance coincident with the first 2 of 3 minima in solar activity.

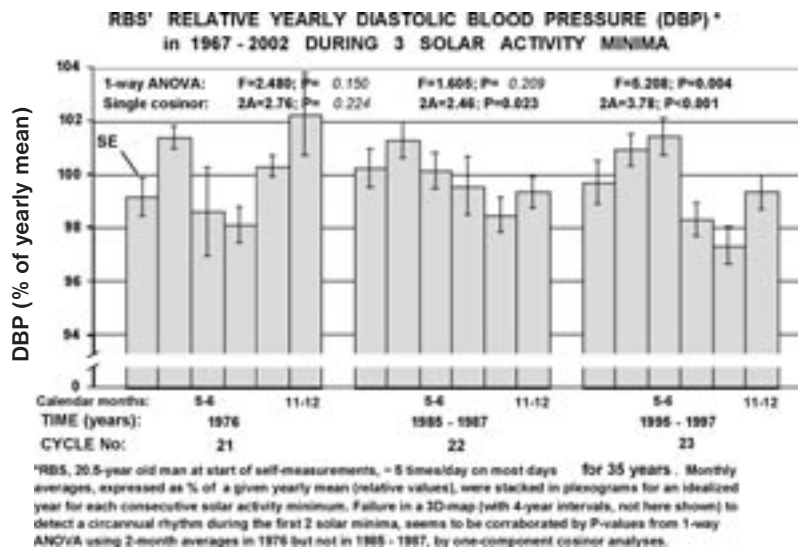

Fig 3

Changing circannual patterns in diastolic blood pressure during spans of minimal solar activity during three consecutive solar activity cycles

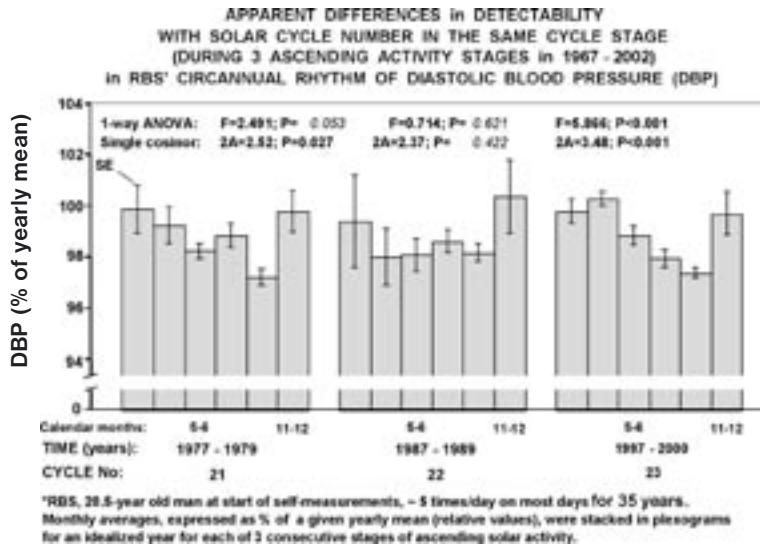

Fig 4
Changing circannual pattern of diastolic blood pressure during the ascending stage of solar activity during consecutive solar activity cycles

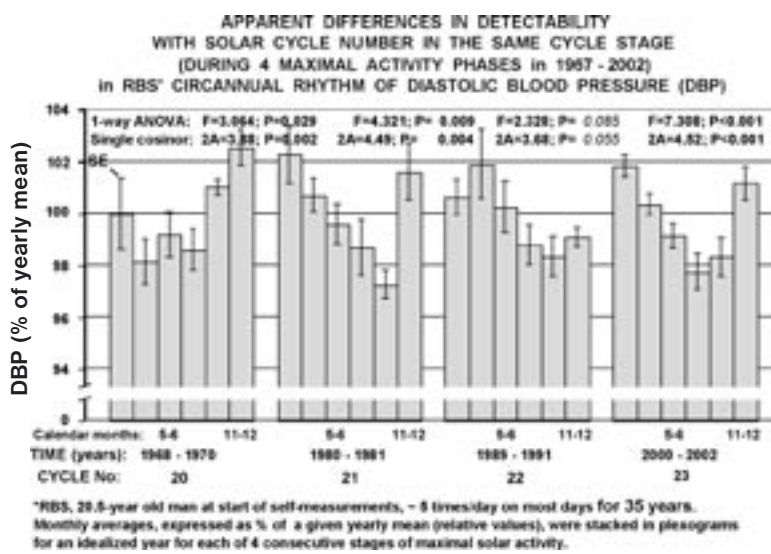

Fig 5
Changing circannual pattern of diastolic blood pressure during spans of maximal solar activity during consecutive solar activity cycles

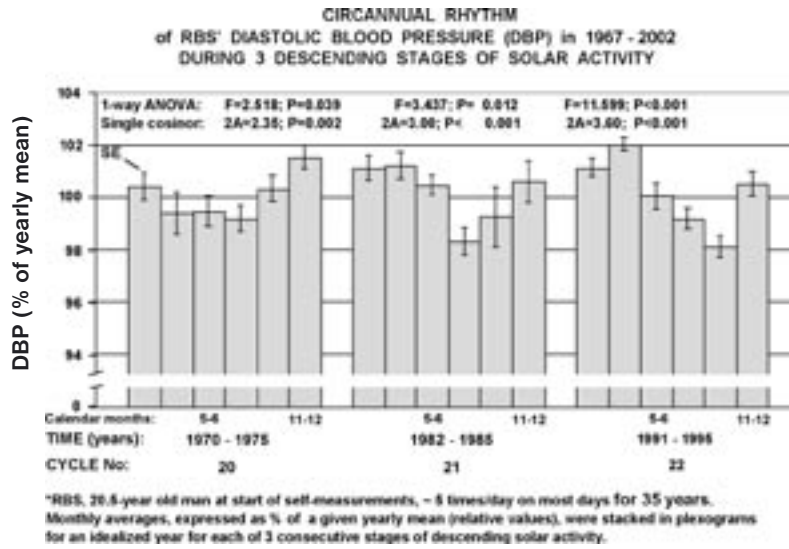

Fig 6
Changing circannual pattern of diastolic blood pressure during the descending stage of solar activity during consecutive solar activity cycles

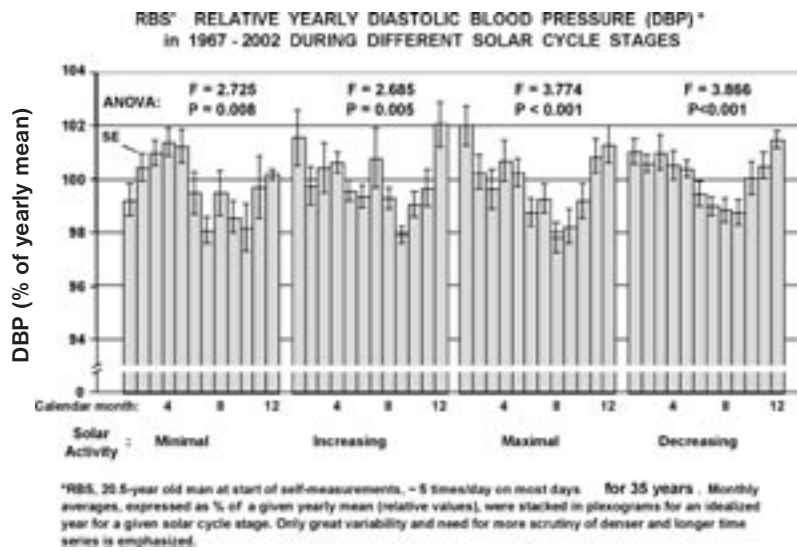

Fig 7
Illustration of differences in the yearly pattern of diastolic blood pressure as a function of solar activity stage as well as of the overall consistency of higher values in the winter and lower values in the summer

MATERIALS AND METHODS

RBS started about 5 self-measurements per day (about 58,000 sessions in triplicate for a total of 174,000 values) at 20.5 years of age, covering the span from 1967 to 2002, with but few interruptions. Analyses on monthly means were carried out after removing data during travel across time zones or during illness, by gliding spectra (*8*), with results examined in 3D, by a 1-way analysis of variance (ANOVA), and by single cosinor (*9, 10*).

RESULTS

As seen in 3D (*Fig. 1*) and in a surface chart (*Fig. 2*), an apparent modulation by non-photic solar activity, gauged by Wolf's relative sunspot numbers was seen in 3D during the first minimum in solar activity. At this time, an about-yearly rhythm failed to be detected with statistical significance by ANOVA and cosinor. The same applies to years covering a second minimum in solar activity, when a yearly variation was not demonstrated by ANOVA, albeit it was statistically significant by cosinor, the zero-amplitude assumption being rejected at the 5% level of statistical significance. During a third minimum in solar activity, the circannual rhythm was statistically significant ($P<0.01$) by both methods, an indication of solar cycle number associated differences in rhythm detection with the resolutions used. The changing yearly patterns in diastolic blood pressure during spans of minimal solar activity are visualized in *Fig. 3*. Parameter tests (*11*) revealed differences among circannual acrophases in certain solar cycle stages.

Circannual patterns in diastolic blood pressure also differ in relative prominence during other solar activity stages. *Figs. 4-6* illustrate the changing yearly waveforms during the ascending stage, during spans of maximal solar activity, and during the descending stage of the solar activity cycle, respectively. Yearly patterns for each solar activity stage, pooling data across the entire 35-year record, further visualize the modulation of the circannual variation by the about 10.5-year solar activity cycle, while also revealing an overall consistency of higher values during the winter and lower values during the summer, *Fig 7*.

DISCUSSION AND CONCLUSION

It has become clear during the past half century that in one and the same biological as well as physical variable, multifrequency rhythms can be encountered that span with their periods many orders of magnitude. These rhythms intermodulate, so that findings in different stages of cycles with the lowest frequency mapped may determine different outcomes in cycles with higher frequencies. Herein, gliding spectra revealed a fading circannual rhythm in stages of minimal solar activity during 2 of 3 consecutive solar cycles. Two other methods validated the failure to detect a circannual rhythm during the first solar minimum.

Thirty-five years of systematic measurements show with a circadecadal change the extent of reproducibility of circannual variation in diastolic blood pressure with

differences but as yet without any consistent associations with solar cycle number or stage. Much longer and denser series are needed before physiological time structures, chronomes, can be assessed in the circadecadal range of variation. These long cycles, e.g., in the occurrence of stroke and myocardial infarctions (*5*), of murder and of international battles (*12*) are of critical importance for clarifying any long postulated invisible effects from the sun and/or galactic cosmic rays. Lifetime monitoring in physiology as continuous recordings in physics will be indispensable for mapping a combined spectrum of photic and non-photic, possibly magnetic, cycles in us and around us.

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ROČNÍ VARIACE V DIASTOLICKÉM KREVNÍM TLAKU V PRŮBĚHU NÁSLEDNÝCH SOLÁRNÍCH CYKLŮ

Souhrn

Přibližně desetiletá modulace ročních rytmů v diastolickém krevním tlaku byla studována v záznamu krevního tlaku 35 let dlouhém, získaného měřením na sobě několikrát denně klinicky zdravou osobou. Analýza měsíčních průměrů klouzavými spektry a analýza variace (ANOVA) a kosinorová analýza byla provedena poté, co byla vyřazena data získaná v průběhu transkontinentálních letů nebo onemocnění. Roční rytmy v diastolickém krevním tlaku byly nebo nebyly statisticky signifikantní metodou kosinorové analýzy nebo ANOVA, v závislosti na počtu a/nebo stupni solárního cyklu.

Ukazuje se však, že 1 rok je synchronizován, pokud je celé období analyzováno jako celek. Určitá proměnná jako diastolický krevní tlak může být charakterizována multifrekvenčními rytmy, které jsou vzájemně intermodulovány, takže nálezy určitých stupňů cyklů s nejnižší mapovanou frekvencí (tj. přibližně desetiletých) mohou určovat různé výsledky u cyklů s vyššími frekvencemi, jako jsou roční rytmy.

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