CIRCASEMIDIAN AND CIRCASEMISEPTAN GAUGES OF VASCULAR ADJUSTMENT AFTER TRANSMERIDIAN CROSSING OF 3 TIME ZONES

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A temporal microscopy (microchronometry, a term suggested by the senior author, or perhaps microbiochronometry) applied by the cosinor (1-3) to consecutive intervals of a time series is the counterpart of serial sections used in histology; it serves to reveal rhythms as the counterpart of cells, with the anticipation that some rhythm alterations may precede cellular change and could thus provide useful harbingers for preventive action. This approach can be used for analyses revolving around the abundant literature dealing with transmeridian dyschronism (jet lag) and related problems (4-15) by considering mainly the 24-hour component of our time structure, more often than not without parameter estimation after prior hypothesis testing, with only a few exceptions concerned with circaseptans (16-19), circasemiseptans (19, 20) and circannuals (21), and without considering other non-photic (22) components. It seems the more important to include the first harmonic of both the circadian and circaseptan components in each assessment. We here analyze both circasemidians and circasemiseptans with circadians and circaseptans, the former two components considered in their own right and as harmonics accounting for a non-sinusoidal waveform of the circadian and circaseptan rhythm, respectively. With certain interval lengths chosen for analysis by chronobiologic serial sections on data involving flights across only a few (here three) time zones and a return trip by ship rather than air, these first harmonics happen to be sensitive and the only gauges of adaptation.

Systolic and diastolic blood pressure and heart rate were monitored automatically with a TM-2421 instrument (A&D, Tokyo, Japan) at half-hour intervals before, during and after an arctic tour from 20 July to 4 Aug 2005. Serial section analyses on these data and on bracketing ones, extending until 22 Aug 2005 were performed by the separate fit of cosine curves with trial periods (□s) of 168, 84, 24 and 12 hours. Departure from the USA was on July 18 to Anchorage, Alaska, USA, and from there to Anadyr, Russia (64˚44'N, 177˚20'W); return was from Resolute, Nunavut, Canada, 74˚42'N, 95˚10'W, on August 4, 2005.

Consecutive intervals were chosen to cover by their length 4 to 8 □s in the case of circadian and circasemidian analyses, or 2 to 4 □s in the case of circaseptan and circasemiseptan analyses. Intervals were displaced by increments of 12 or 24 hours for the case of circadian/circasemidian and circaseptan/circasemiseptan analyses, respectively. The circadian and circaseptan rhythms remain environmentally synchronized, as apparent from the horizontal time course of their phases with the intervals analyzed, as apparent from Figures 1-3. By contrast, their first harmonics show the major phase adjustments for each of the variables examined, whether we deal with changes in the waveform of the circadian system or with an oscillation with a period of about 12 hours in its own right.

Analyses by sphygmochron (23) of 7-day/24-hour records of blood pressure and heart rate routinely consist of the concomitant fit of cosine curves with □s of 24 and 12 hours to account for the traditional approximation of the usual non-sinusoidal circadian waveform of these variables. Determining the time of maximum of such a composite model (orthophase) with an estimate of uncertainty (95% confidence interval) was achieved in the context of cancer chronotherapy with adriamycin (24; see also 25). The addition of harmonic terms to describe the circadian waveform was illustrated for the case of inter-beat intervals (26). Analyses of such R-R intervals to derive the correlation dimension as a measure of fractal scaling indicated the critical role of the 12-hour component to separate healthy men from patients with coronary artery disease

(27). Harmonic terms indeed may be more sensitive gauges, notably for adjustments after flights over a few time zones: a 3-hour shift as in the case here reported corresponds to a 90˚ change in phase by the 12-hour component, but only to a 45˚ change in phase by the 24-hour component. The 12-hour and 24-hour components could be routinely included in the study by 24-hour and 168-hour cosinors of transmeridian or shiftwork-related adjustments.

Conclusion. Harmonic terms could be routinely used to study adjustments to changes in schedule, provided they contribute with statistical significance to the waveform of the fundamental rhythm(s) of interest and, much more generally, for studies in health and disease.

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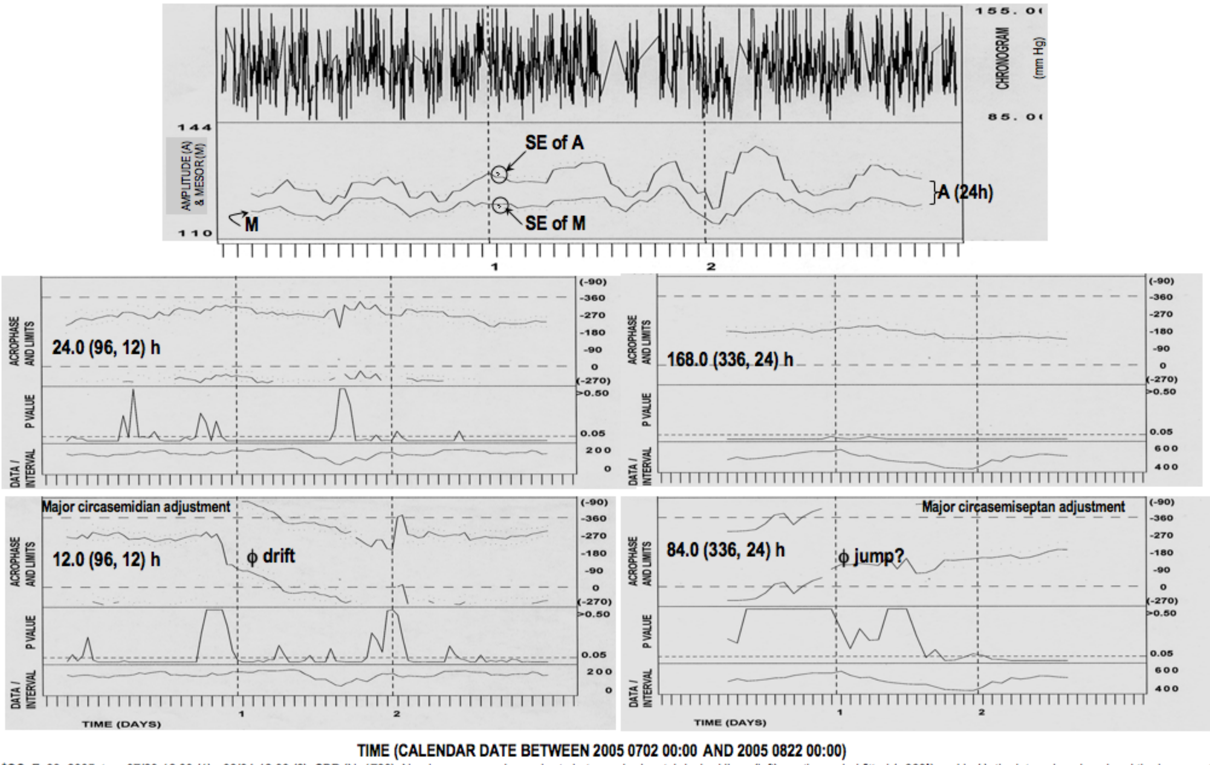
Legends

Figure 1. For systolic blood pressure, with the intervals chosen for analyses, the major adjustment along the 24-hour scale is gauged by the 12-hour cosine fit (bottom left). The 84-hour component suggests, but does not validate, a jump in phase since it is statistically significant too briefly before the return home and thereafter. © Halberg.

Figure 2. For diastolic, as for systolic blood pressure, the 24- and 168-hour components with the intervals chosen for analyses show a steady course of their phases while their harmonics jump in phase, even when inference is limited to the statistically significant sections analyzed. © Halberg.

Figure 3. For heart rate, noise clouds phase behavior and the phases of components that are not statistically significant cannot rigorously distinguish a gradual shift from a sudden jump. © Halberg.

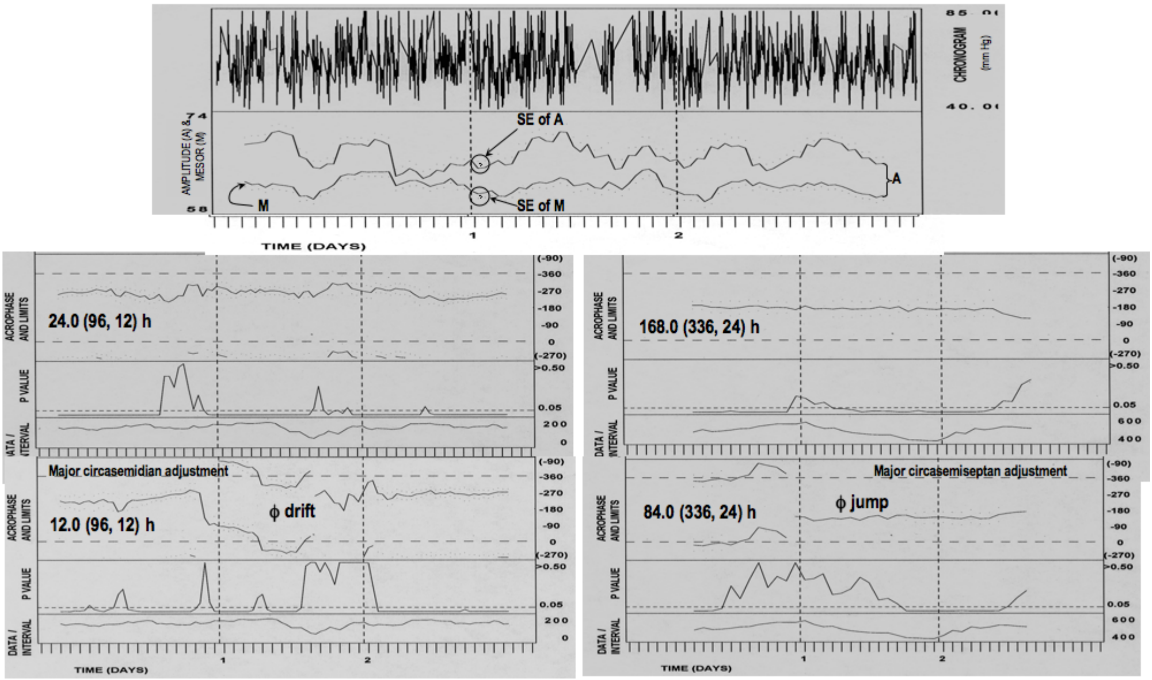
Gradual return by icebreaker vessel (reverse Northwest Passage) after abrupt transmeridian east-to-west displacement over 3 time zones best reflected in adjustment of one-half of each the daily and weekly change in systolic blood pressure*



*OS, F, 83, 2005, tour 07/20-12:00 (1) - 08/04-12:00 (2), SBP (N=1780). Numbers on acrophase charts between horizontal dashed lines (left) are the period fitted (=360˚) and in ( ), the interval analyzed and the increment by which this interval was displaced for consecutive analyses, all in hours (h); vertical dashed lines are 1, departure from Minnesota for a flight to Anadir, Russia, followed by a Northwest Passage cruise from west to east and 2. return flight from Resolute, Nunavut, Canada. Phases are doubly plotted when near 0˚ or 360˚. SEs in row 2 (top) are distances from the dot, shown by a tiny circled bracket.,to the lower (M) or upper (M+A) curves.

Figure 1

Gradual return by icebreaker vessel (reverse Northwest Passage) after abrupt transmeridian east-to-west displacement over 3 time zones best reflected in adjustment of one-half of each the daily and weekly change in diastolic blood pressure*

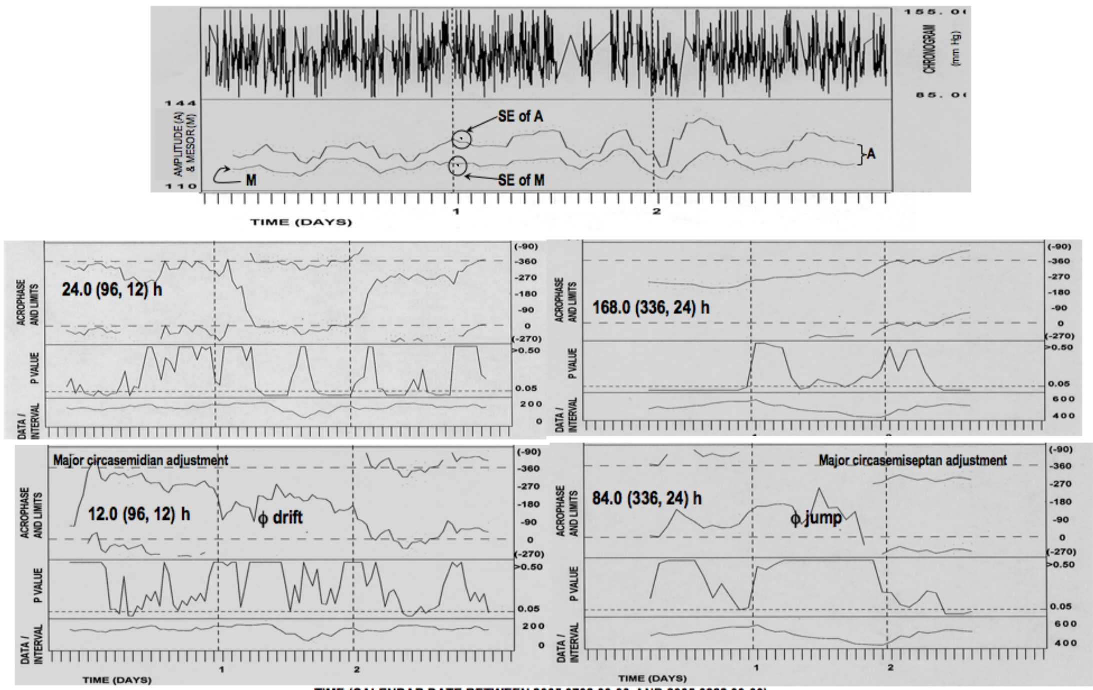


TIME (CALENDAR DATE BETWEEN 2005 0702 00:00 AND 2005 0822 00:00)

*OS, F, 83, 2005, tour 07/20-12:00 (1) - 08/04-12:00 (2), DBP (N=1780). Numbers on acrophase charts between horizontal dashed lines (left) are the period fitted (=360°) and in ( ), the interval analyzed and the increment by which this interval was displaced for consecutive analyses, all in hours (h); vertical dashed lines are 1, departure from Minnesota for a flight to Anadir, Russia, followed by a Northwest Passage cruise from west to east; and 2. return flight from Resolute, Nunavut, Canada. Phases are doubly plotted when near 0° or 360°. SEs in row 2 (top) are distances from the dot, shown by a tiny circled bracket, to the lower (M) or upper (M+A) curves.

Figure 2

Gradual return by icebreaker vessel (reverse Northwest Passage) after abrupt transmeridian east-to-west displacement over 3 time zones best reflected in adjustment of one-half of each the daily and weekly change in heart rate*



TIME (CALENDAR DATE BETWEEN 2005 0702 00:00 AND 2005 0822 00:00)

** OS, F, 83, 2005, tour 07/20-12:00 (1) - 08/04-12:00 (2), HR (N=1780). Numbers on acrophase charts between horizontal dashed lines (left) are the period fitted (=360°) and in ( ), the interval analyzed and the increment by which this interval was displaced for consecutive analyses, all in hours (h); vertical dashed lines are 1, departure from Minnesota for a flight to Anadir, Russia, followed by a Northwest Passage cruise from west to east; and 2. return flight from Resolute, Nunavut, Canada. Phases are doubly plotted when near 0° or 360°. SEs in row 2 (top) are distances from the dot, shown by a tiny circled bracket, to the lower (M) or upper (M+A) curves.

Figure 3