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EVALUATION OF FLIGHT FOODS UNDER HYPOKINETIC CONDITIONS

PART II

Chapters IV and V

pagination for Part II begins with this page

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EVALUATION OF FLIGHT FOODS UNDER HYPOKINETIC CONDITIONS

CHAPTER IV

ANALYSIS OF DATA ON HEART RATE AND DEEP BODY TEMPERATURE

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A variety of changes in biological phenomena appear to be related to bed rest. The chief objective of this portion of the study was to assess the effect of simulated null gravity (hypokinetic condition) for 56 days on the daily wave forms of body temperature (BT) and heart rate (HR) in normal human subjects.

In this report, information was sought concerning methods for best describing in quantitative terms the observed changes in these physiological parameters.

The work of others (Taylor, 1949) indicate a reduction in heart volume, an increase in resting pulse during bed rest and an increase in the work pulse. Metabolic changes in ion excretion (i.e., Ca^{++}) have been reported by the principal investigator. Others have reported no significant changes in lung function, excretion of catecholamines or 17 keto-steroids in the urine (Rodahl et al., 1967). The removal of body weight from the long bones and orthostatic hypotension are considered to be of significance in astronauts even after space travel of relative short duration. Furthermore, the primary "Zeitgeber" for physiologic rhythms is considered to be light. Therefore, the influence of orthostatic hypotension as a circadian phase setter in a defined light environment will be examined in some detail.

EXPERIMENT PROCEDURE AND RESULTS

Eight healthy human males were maintained on a controlled environment of 14L:10D during the study which included a 6-day pre-Bed Rest equilibration period, a 56-day Bed Rest period and a 10-day

post-Bed Rest recovery period. No heart rate data was collected during the pre-Bed Rest period and HR and BT data were collected for two days during the post-Bed Rest period. During the Bed Rest, half of the subjects (1A, 2A, 6A, 7A) exercised for about 20 minutes per day using an Exer-Genie. BT data were obtained using ear probes containing a thermister (Yellow Springs Model 402). HR was measured from the pulse rate. During a portion of the study, HR was measured from both the pulse rate and by Beckman EKG sensors connected to a cardiotachometer (a detailed description of the equipment and methods used are in the first chapter of this Report. The data were analyzed separately by period. Analyses of variance were performed which tested the significance of differences between daily means (i.e., a measure of day-to-day consistency) and between hourly means. A cosine curve (τ = 24 hours) was fitted to the data of each subject for each day for each of the periods. When data were missing for one of the 6 points within the day, they were extimated, but when more than one point was missing, data for that day were not used. Day-to-day evaluation of the sequential information from each subject is described using the Summation Dial method. See Appendix A.

The summation dials for body temperatures of the eight subjects are shown in Figures 1-8. These represent a number of quite different patterns. The results will be presented by subject.

Subject 1A (Figure 1)

Here, two summation dials needed to be constructed. The initial time of peak (days 0-6) was at 1730 hours. During days 6-26, a random walk was observed.

Subject 2A (Figure 2)

The initial time of peak (days 0-6) occurred at 1730. During the next 28 days, the body temperatures of this subject followed a random walk. During days 36-61, a significant rhythm was re-instituted with time of peak at 2400 hours.

Subject 6A (Figure 3)

The pre-Bed Rest time of peak (1630 hours) did not persist under the experimental Bed Rest condition, but shifted immediately to 1930 hours (days 7-22), with a concomittant reduction in amplitude. The time of peak then shifted to 2130 hours (days 23-36). During the next 13 days (37-49) a random walk was seen, in that the amplitude decreased, and only 3.0 per cent of the variation was explained. The time of peak became 1930 hours during the final period, 50-61 days.

Subject 7A (Figure 4)

The initial data were incomplete. In general, this subject did not exhibit significant 24-hour rhythms. During days 1-24 only 5.0 per cent of the variation was explained. For the last period, days 51-61, a random walk was observed.

Subject 3A (Figure 5)

This subject exhibited no initial, pre-Bed Rest 24-hour rhythm. From day 8 to day 15, the time of peak was 1930 hours, with a reversal noted after day 15. The new direction of the vectorial sum was continued in the later data (days 54-61), although no 24-hour rhythms were observed.

Subject 4A (Figure 6)

The data for this subject were incomplete, hence, two separate summation dials had to be constructed. This subject did not exhibit a constant time of peak during the baseline period (1-6 days). During the first 39 days, the time of peak was estimated at 2000 hours, with little of the variation explained, although the harmonic fit was significant. A "loop" was noted during days 29-37. The loop represented either a linear shift in time of peak of approximately 1.2 hours per day or a period of 25 rather than 24 hours. The harmonic fit was not significant. Another loop was noted during days 54-59 representing a linear shift in time of peak of 2.5 hours per day or a period of about 28 hours. Overall, during the final period, the time of peak occurred at 2030 hours.

Subject 8A (Figure 7)

The pre-Bed Rest pattern (time of peak, 1600 hours) persisted during the first two days in bed, then altered during days 9-15 (time of peak, 2300 hours). During the next major period (days 16-26) the peak was estimated at 1830 hours, and was at 1930 hours for days 27-57. As with Subject 9A, the estimated amplitude was lowest for the last period, and, again, good fits were provided by the harmonic equation.

Subject 9A (Figure 8)

A non-random vector sum is noted during the pre-Bed Rest or ambulatory period (days 1-6), with time of peak at 1730 hours. This pattern continued for the first day in bed (day 7) and is then altered (days 8-20) with time of peak 1930 hours. A new code was noted during days 21-29 with the time of peak shifted to 1700 hours and with

the amplitude, R, maximum during this time (Table 1). The final grouping, days 30-57, had a peak at 1930 hours and exhibited reduced amplitude. Overall, for days 1-61, a time of peak of 1800 hours was observed. For this subject, a reasonable proportion of the variation of the data was explained (25-61 per cent), and the K's indicated significance of the harmonic fit.

Heart rate data are shown in Figures 9-16. The summation dials seen here differ remarkably from those of the body temperature, in that all subjects showed rhythms, only one random walk was seen and little variation was noted for overall time of peak. It was not necessary to partition the data into periods as little variation was seen, with the possible exception of 3A (Figure 13) where a change in time of peak occurred in the middle of the experiment. It should be noted that heart rates were not available during the ambulatory, pre-Bed Rest period.

The times of peak using all the data were as follows: Subject 9A, 1700 hours; 8A, 1830 hours; 6A, 1700 hours; 4A, 1700 hours; 2A, 1630 hours; 1A, 1700 hours; 3A, 1500 hours; and 7A, 1600 hours. The last two subjects had exhibited no body temperature rhythms, which were well-defined.

Comaprison with the overall times of peak for body temperature could be made for four subjects. The respective times of peak for body temperatures and heart rates were: Subject 9A, 1800 vs 1700 hours; Subject 8A, 1830 vs 1530 hours; Subject 6A, 1930 vs 1700 hours; and Subject 2A, 2230 vs 1630 hours. Thus, heart rate led body temperature by 1 to 6 hours or an average of about three hours.

The observation of heart rate rhythms with persistent phases differs markedly from that made on body temperature rhythms. A subject such as Subject 7A for whom the body temperature rhythm was not well defined, exhibited an excellent heart rate rhythm. On the other hand, Subject 8A, who had one of the best temperature rhythms, was the only subject to show a random walk for heart rate (days 51-61, Figure 15).

For some subjects, the two parameters were out of phase. This is evident for 3A and 7A where the body temperature rhythms were not well defined while good heart rate rhythms were noted. In other cases, e.g., 6A (compare Figures 3 and 11) exhibited a namifold pattern of phases (times of peak) for body temperature, but was quite consistent for heart rate (see also 2A, Figures 2 and 10). In two subjects, 9A and 8A, the two rhythms appeared to be more or less in phase, except for the last data of 8A. Where overall data could be compared for four subjects, body temperature rhythms lagged those of heart rate by an average of about three hours.

DISCUSSION

The BT data clearly show that the functional state of the body at Bed Rest is subject to a 24-hour rhythmic fluctuation. These results (disregarding phase differences) agree with other data in ambulatory subjects, a general diurnal "high" and a nightly "low". The results confirm earlier work by Jürgensen (1873) who discovered BT rhythms, are independent of activity and state of nutrition in bed rest studies of shorter duration.

Over a hundred oscillating functions have been described in man under various experimental conditions (Sollberger, 1965). There are indications that the daily fluctuations are strongly influenced by the automatic nervous system with predominance of the parasympathetic system at night. The metabolism, the cardiovascular and the pituitary-adrenal activity participate directly or indirectly in the homeostatic rhythmic oscillations (physiologic tonus).

In this study, the phase stability of the BT rhythm was appreciably better in the non-exercised subjects than in the exercised. The diurnal sympathetic phase was labile in all subjects as best exemplified by 2A's data (Figure 2). The exercise schedule results suggest the diurnal phase of BT is influenced by perturbations in the environment. Exercise did not appear to stabilize either the sympathetic or parasympathetic phase of the BT rhythm. There was some indication that the amplitude of the BT data were similar to those reported for certain renal excretion rhythms associated with advancing age and in psychiatric patients (Lobban, 1963).

In contrast to the BT data, the relative bradycardia observed at night was more stable in those subjects on the exercise regime than the non-exercised subjects. This stability of the HR minima suggests a maintenance of parasympathetic integrity. The predominately day sympathetic phase appears to be relatively more stable in the exercised group. This is illustrated by the summation dial random walk or zigzag paths of the non-exercised subjects 3A, 8A, 9A. The "quasi-persistence" of subject 9A indicates only a larger interval between changes in phase and amplitude of the daily HR maxima. The only subject showing random walks in

both BT and HR data is 3A. This inconsistency may be partly attributed to his disposition or age, since he was about 20 years older than the rest of the subjects. The possibility also exists that the period length may have been greater than 24 hours.

There appeared to be no correlation in the rhythms of pairs of roommates.

It must be remembered, in seeking causes for differences in the phase structure of the circadian HR rhythm, that in the hypokinetic environment, there is a reduction in the static physical load and a change in gravitational forces on hemodynamics. In the exercise group, some semblance of physical loading was maintained. These data indicate that the prescribed exercise was sufficient to act as a secondary "Zeitgeber" to the HR rhythm. The results do not indicate cardiovascular adaptation to the prolonged change in the gravitational force.

It is recommended, therefore, than an evaluation of the degree of change in the duration of the various pahses of the cardiac cycle within the circadian rhythm associated with a minimum of 56 days Bed Rest be initiated. Such a study might be most useful in the day- to- day hemodynamic assessmant of the astronaut and permit the early prediction of defects in compensatory cardiovascular mechanisms. These rather complex and subtle phase relationships must be established prior to flight. Once accomplished, the astronaut's cardiovascular integrity can be identified by one or two short sample periods per 24 hours.

SUMMARY

Two aspects of circadian rhythms are of significance for man's efficiency in the space environment: (a) the phase relationships between the various circadian rhythms, and (b) the range of oscillations and position of minima and maxima. The medical problem, desynchronosis, is not a subject of this report.

Analyses of the oscillating ranges for both the group and individual averages reveals the finding that surprising differences existed between the variables. They ranged from 0.4-1.6 per cent in body temperature to approximately 8-30 per cent in heart rate.

In spite of the knowledge of individual differences, the results of early biorhythmic research in man have led to the opinion of a general diurnal "high" and a nightly "low". As we now know, however, the problem certainly is more complicated than expressed in this concept. Nevertheless, our results generally point in the same direction.

EAR PROBE TEMPERATURE - 1A

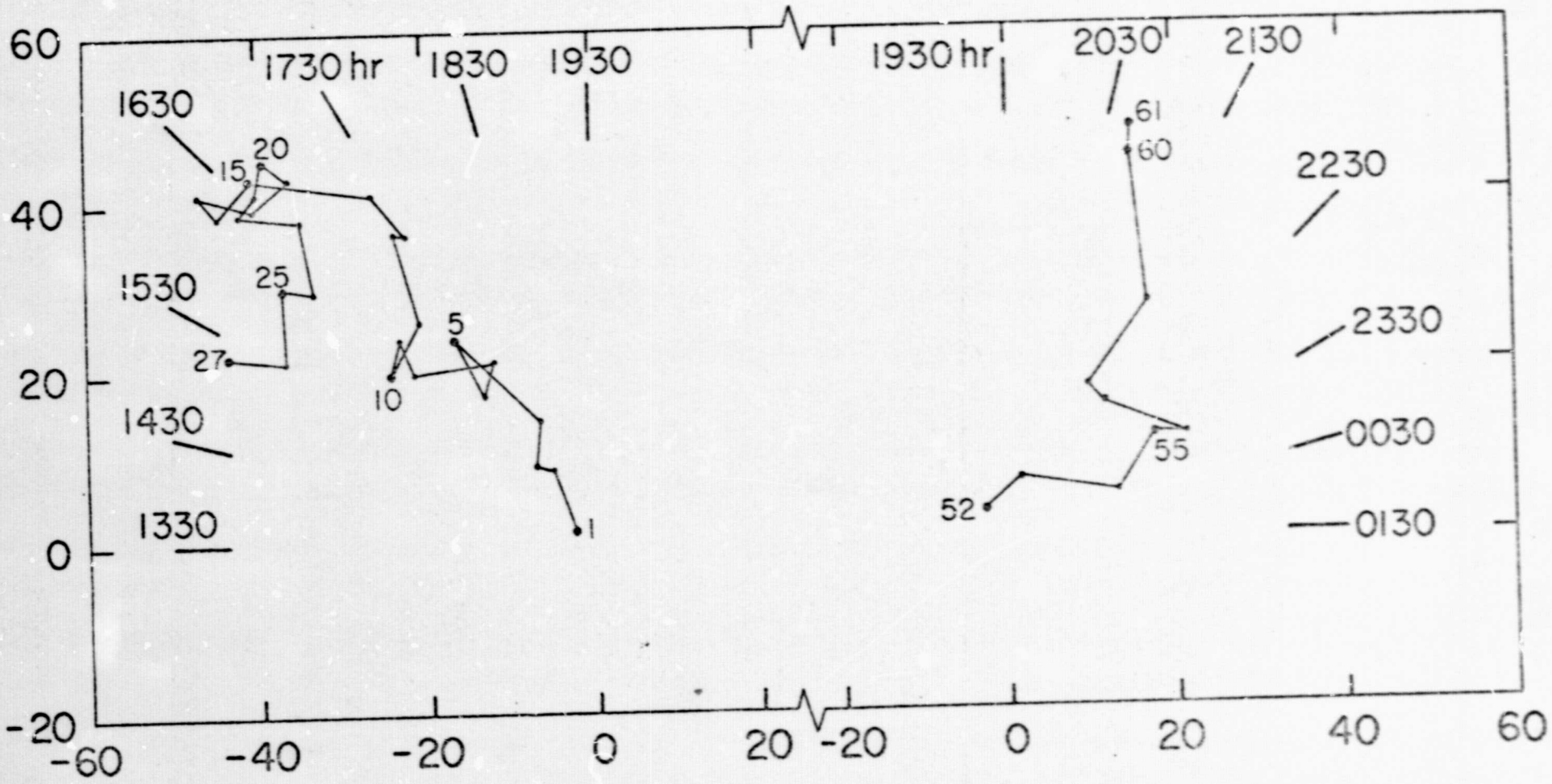

Figure 1. Ear Probe Temperature, Subject 1A

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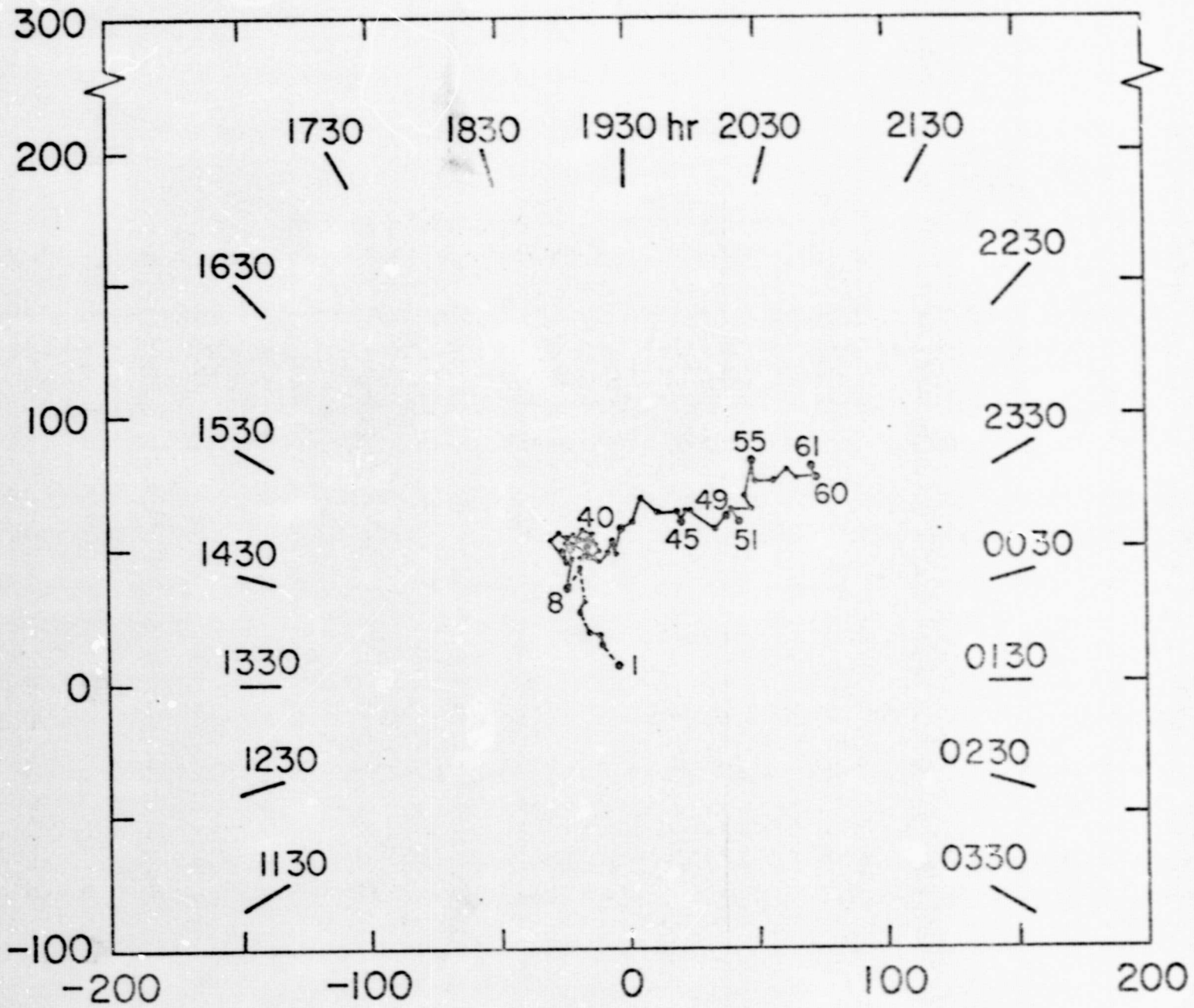

Figure 2. Ear Probe Temperature, Subject 2A

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EAR PROBE TEMPERATURE - 6A

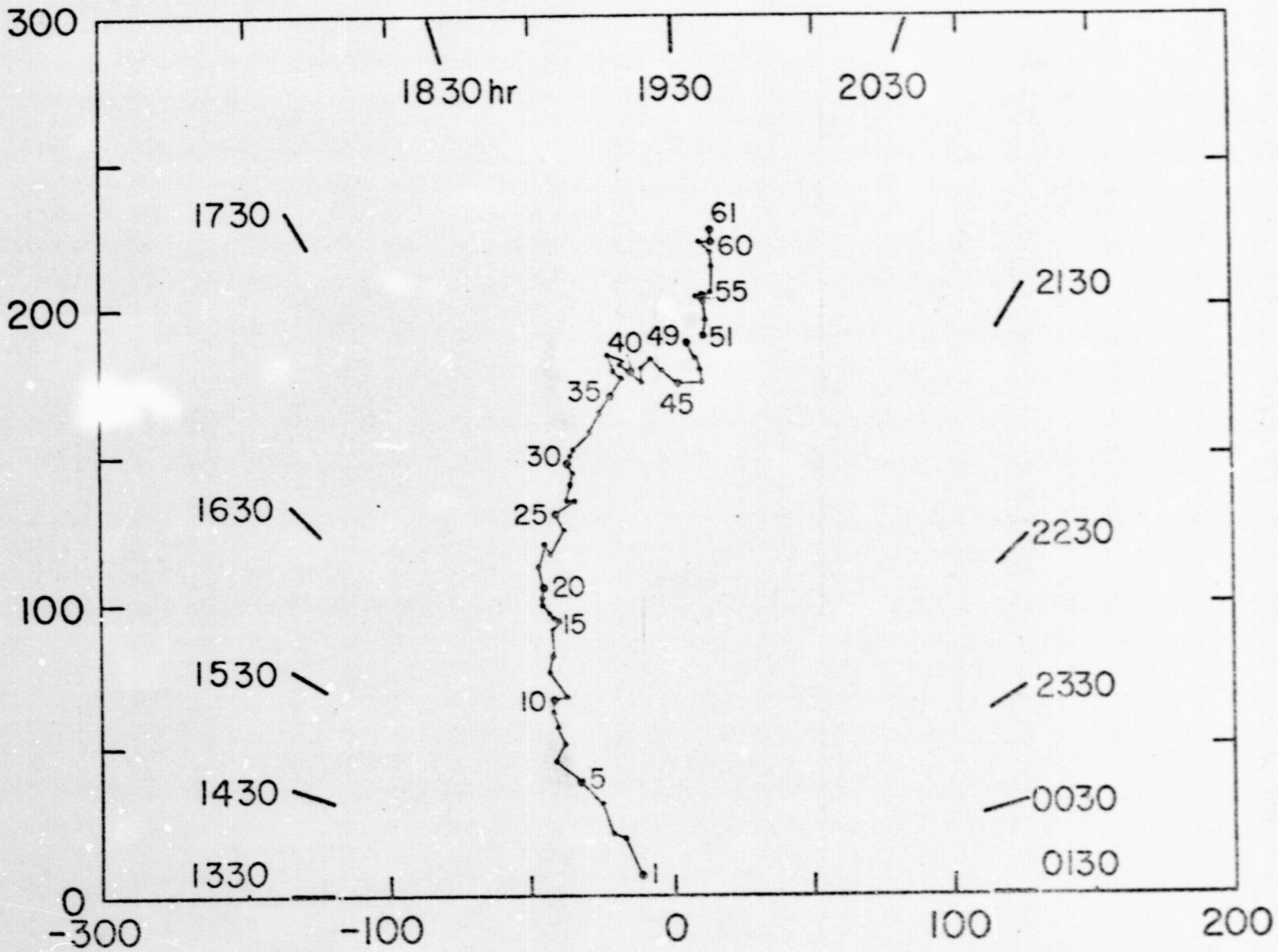

Figure 3. Ear Probe Temperature, Subject 6A

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EAR PROBE TEMPERATURE–7A

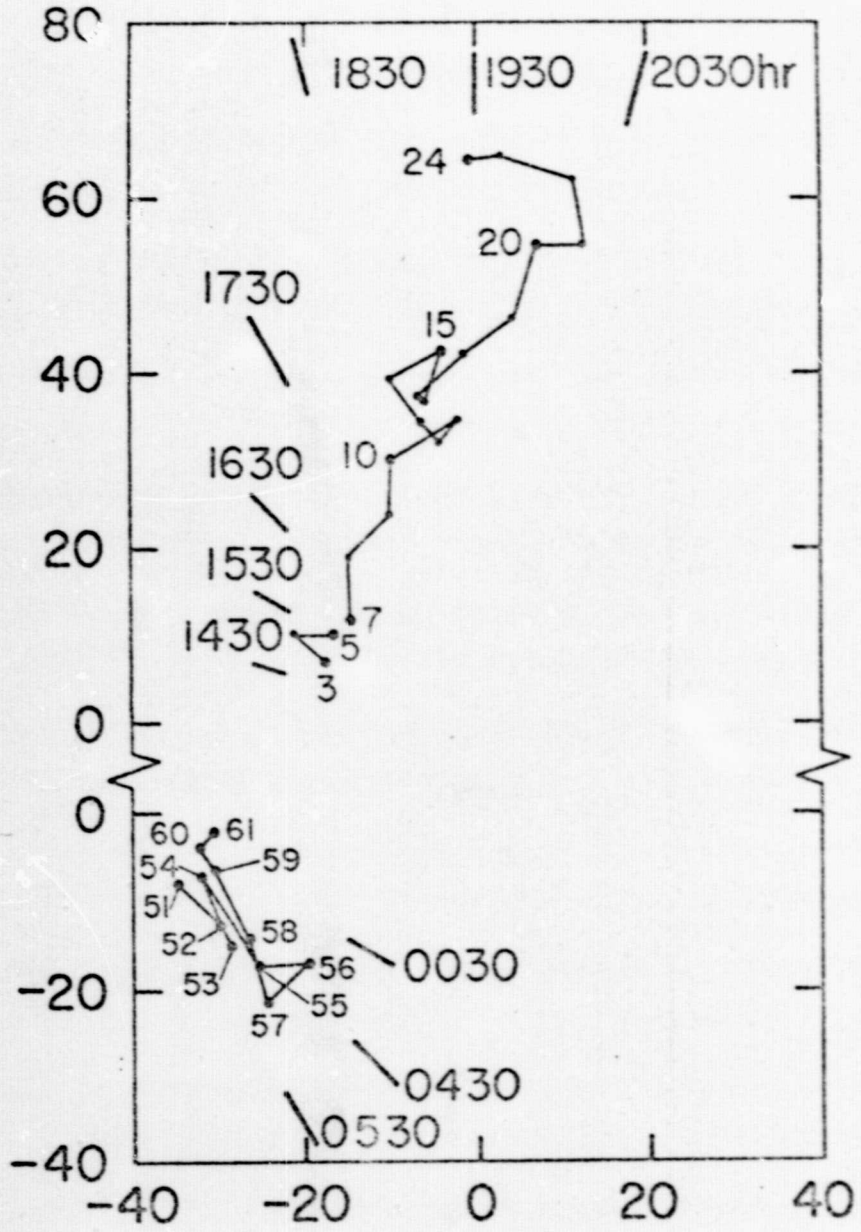

Figure 4. Ear Probe Temperature, Subject 7A

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EAR PROBE TEMPERATURE-3A

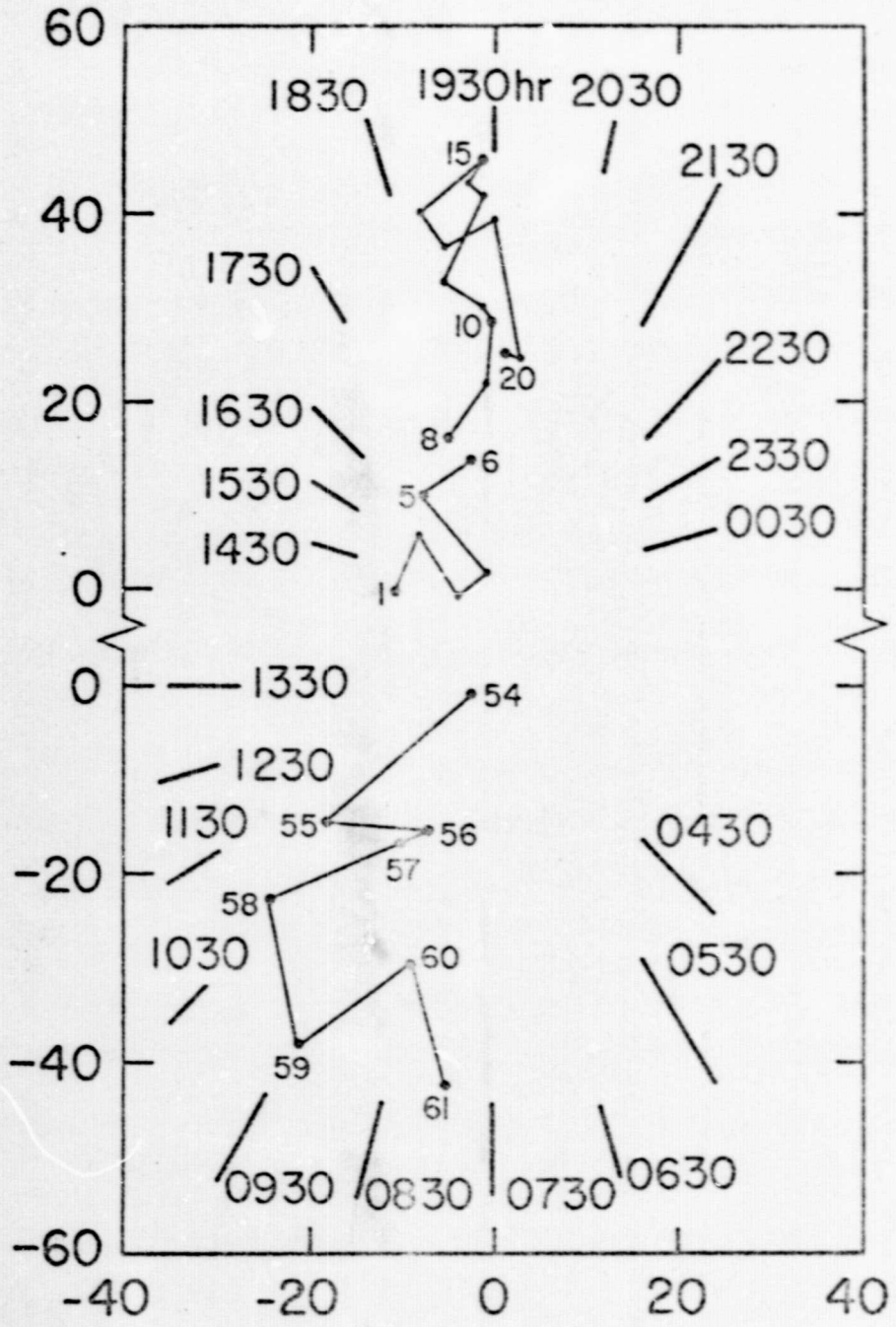

Figure 5. Ear Probe Temperature, Subject 3A

EAR PROBE TEMPERATURE-4A

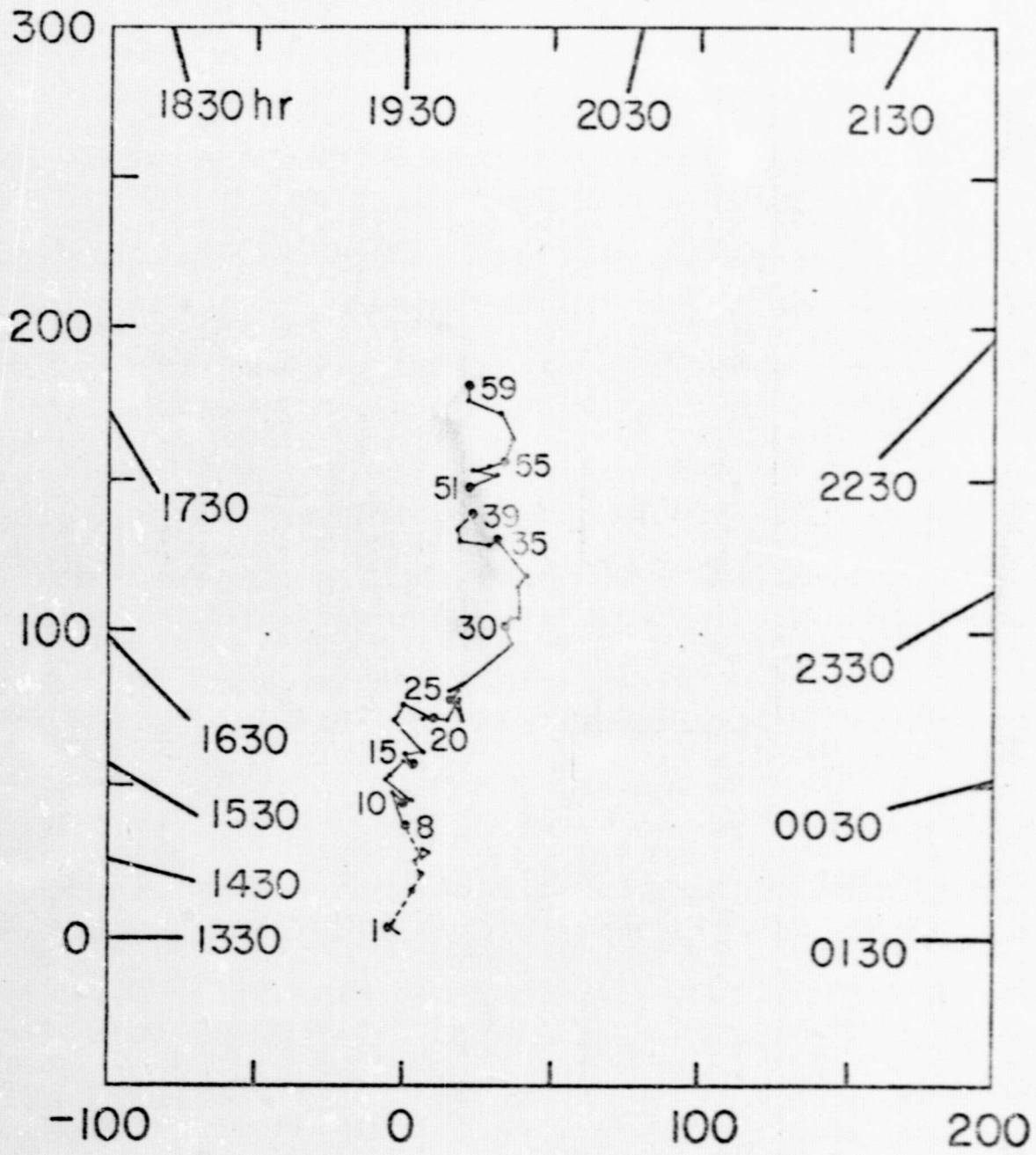

Figure 6. Ear Probe Temperature, Subject 4A

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EAR PROBE TEMPERATURE-8A

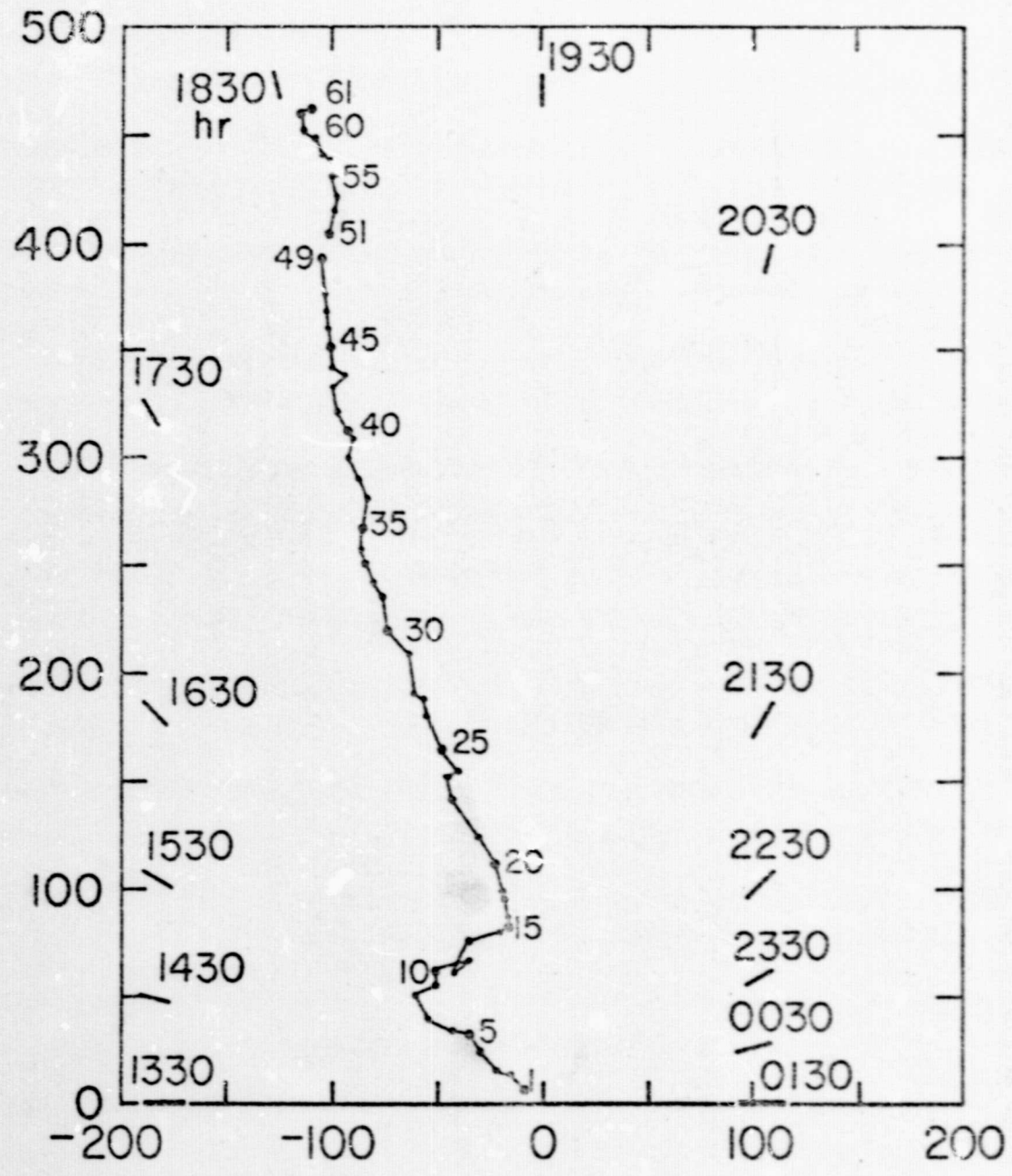

Figure 7. Ear Probe Temperature, Subject 8A

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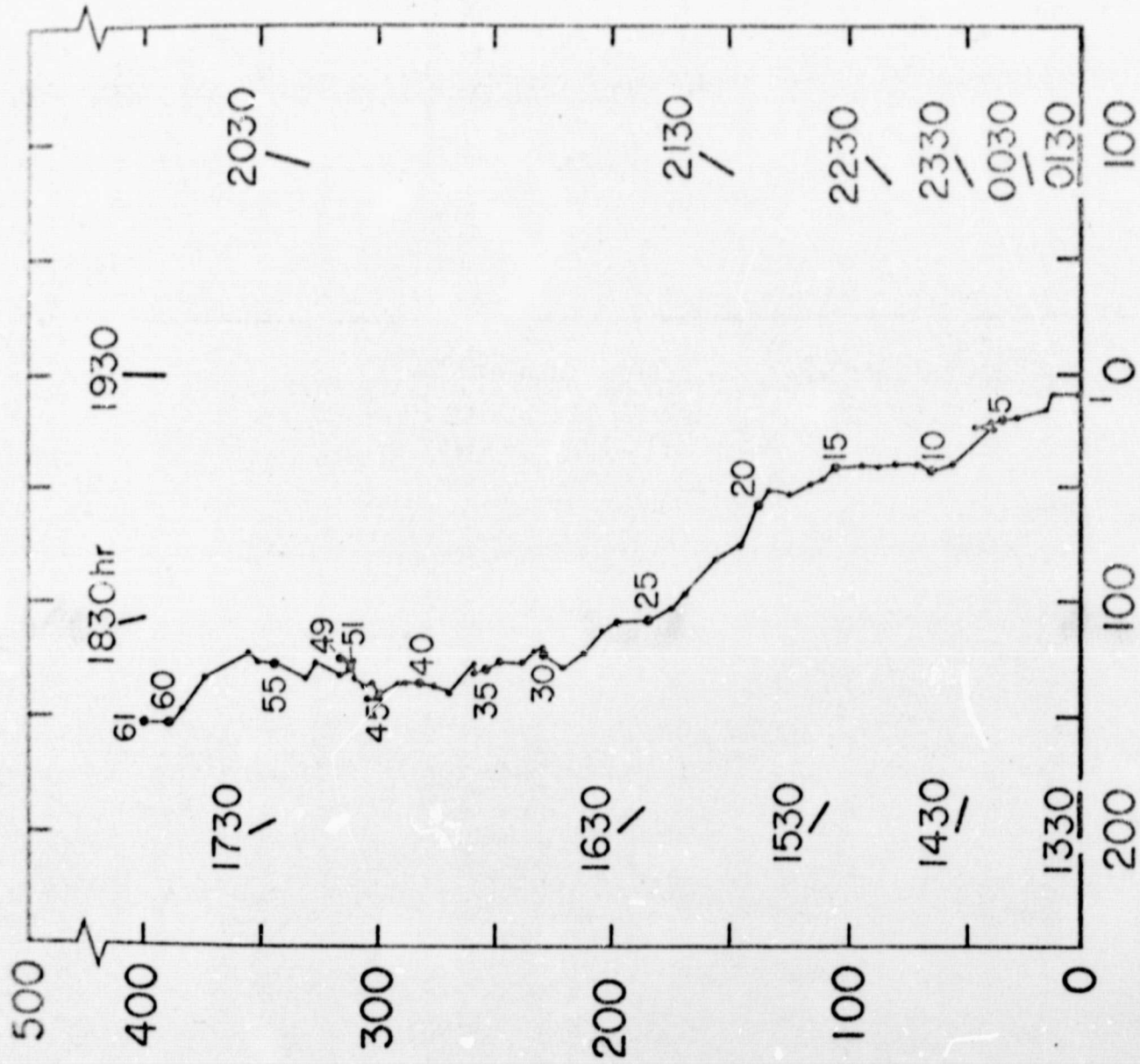

Figure 8. Ear Probe Temperature, Subject 9A

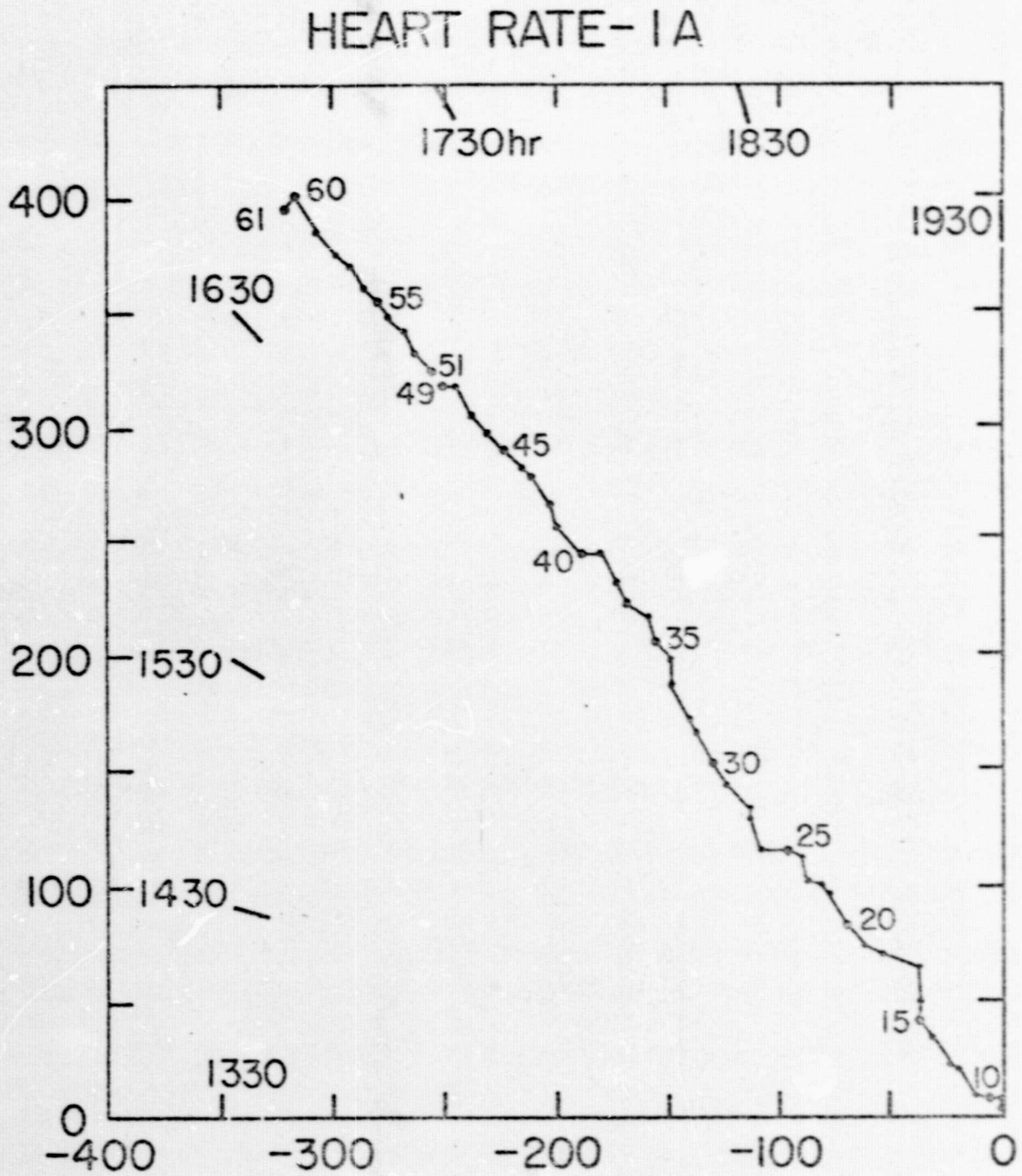

Figure 9. Heart Rate, Subject 1A

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HEART RATE–2A

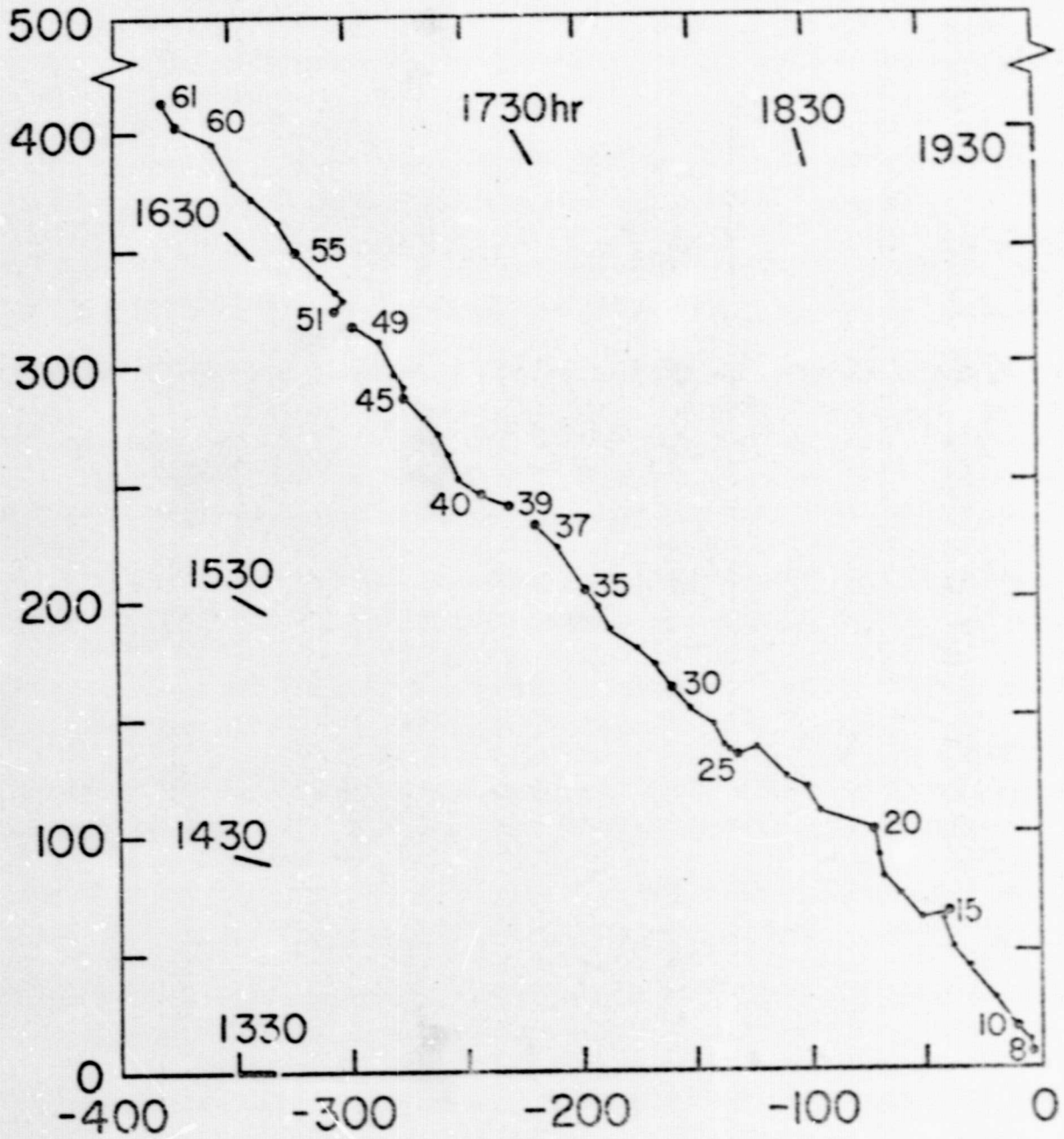

Figure 10. Heart Rate, Subject 2A

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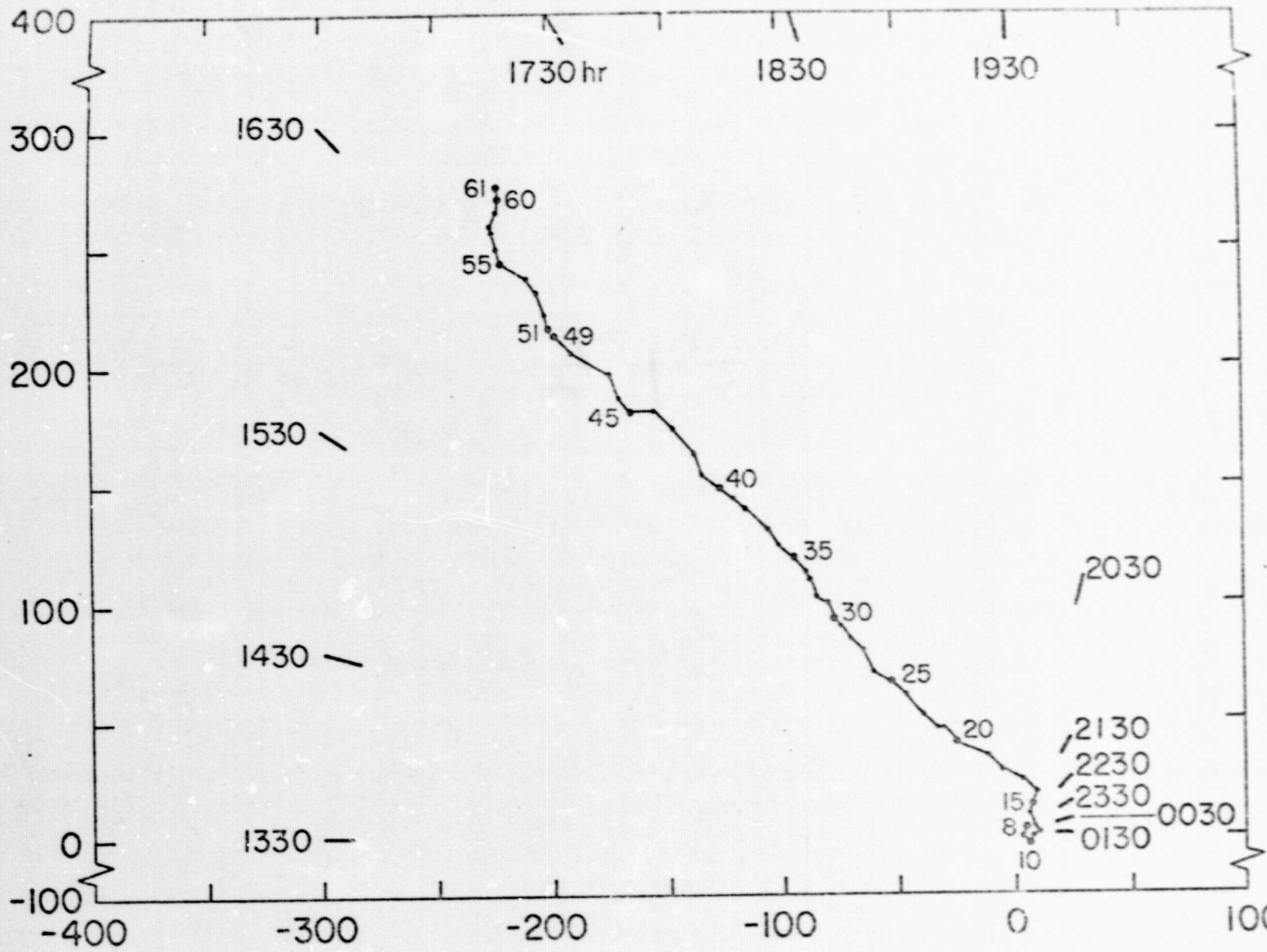

Figure 11. Heart Rate, Subject 6A

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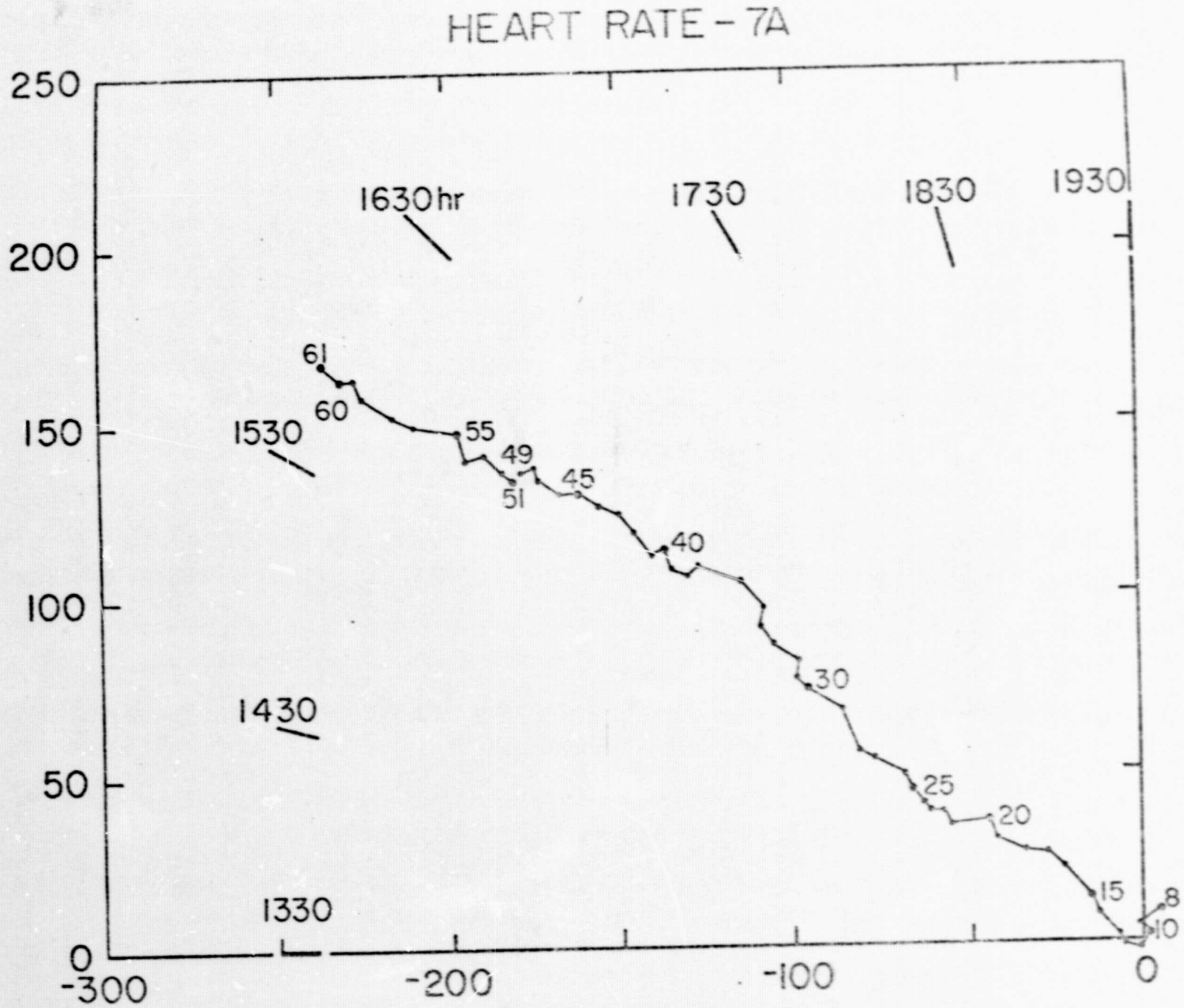

Figure 12. Heart Rate, Subject 7A

HEART RATE — 3A

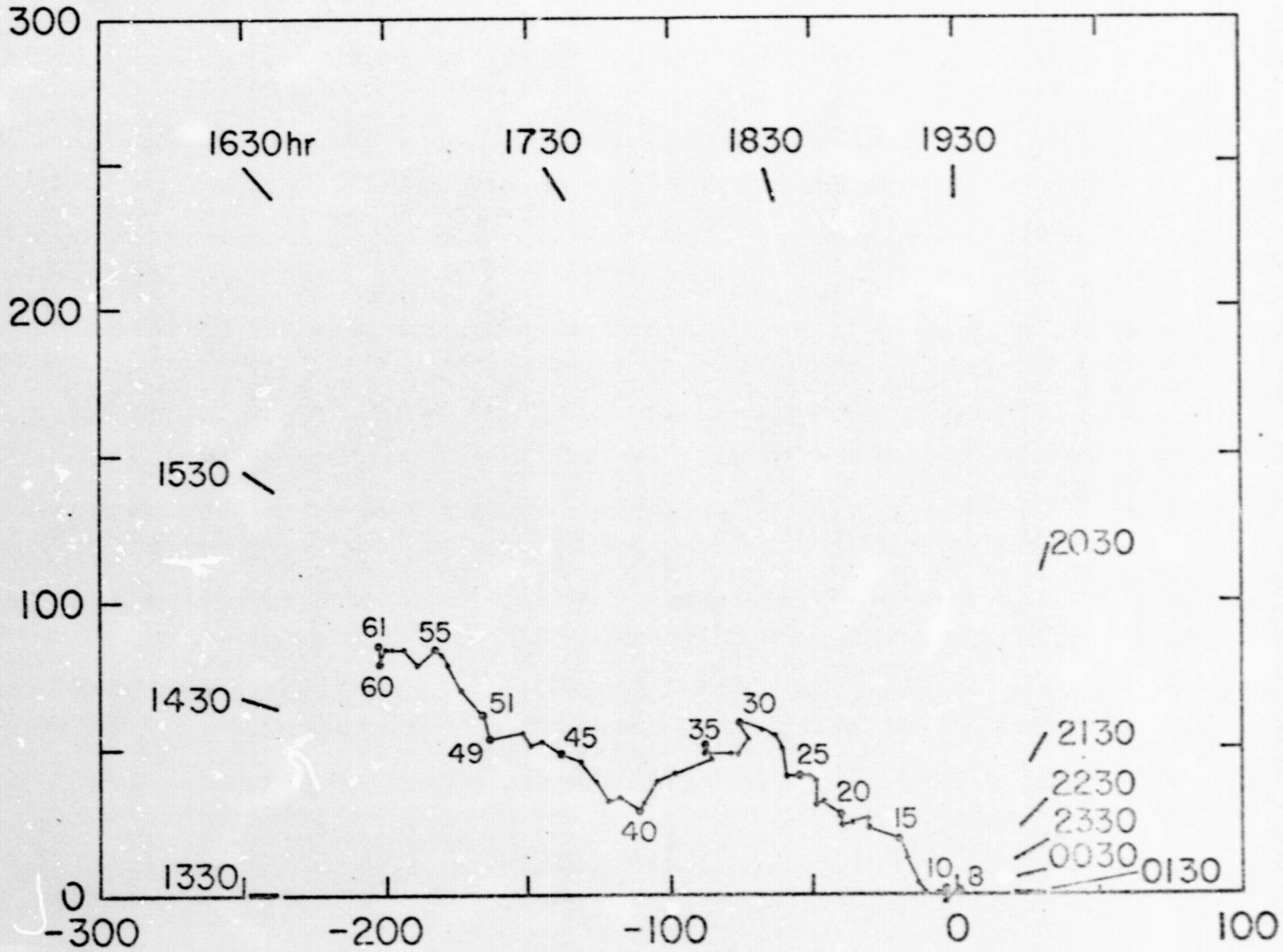

Figure 13. Heart Rate, Subject 3A

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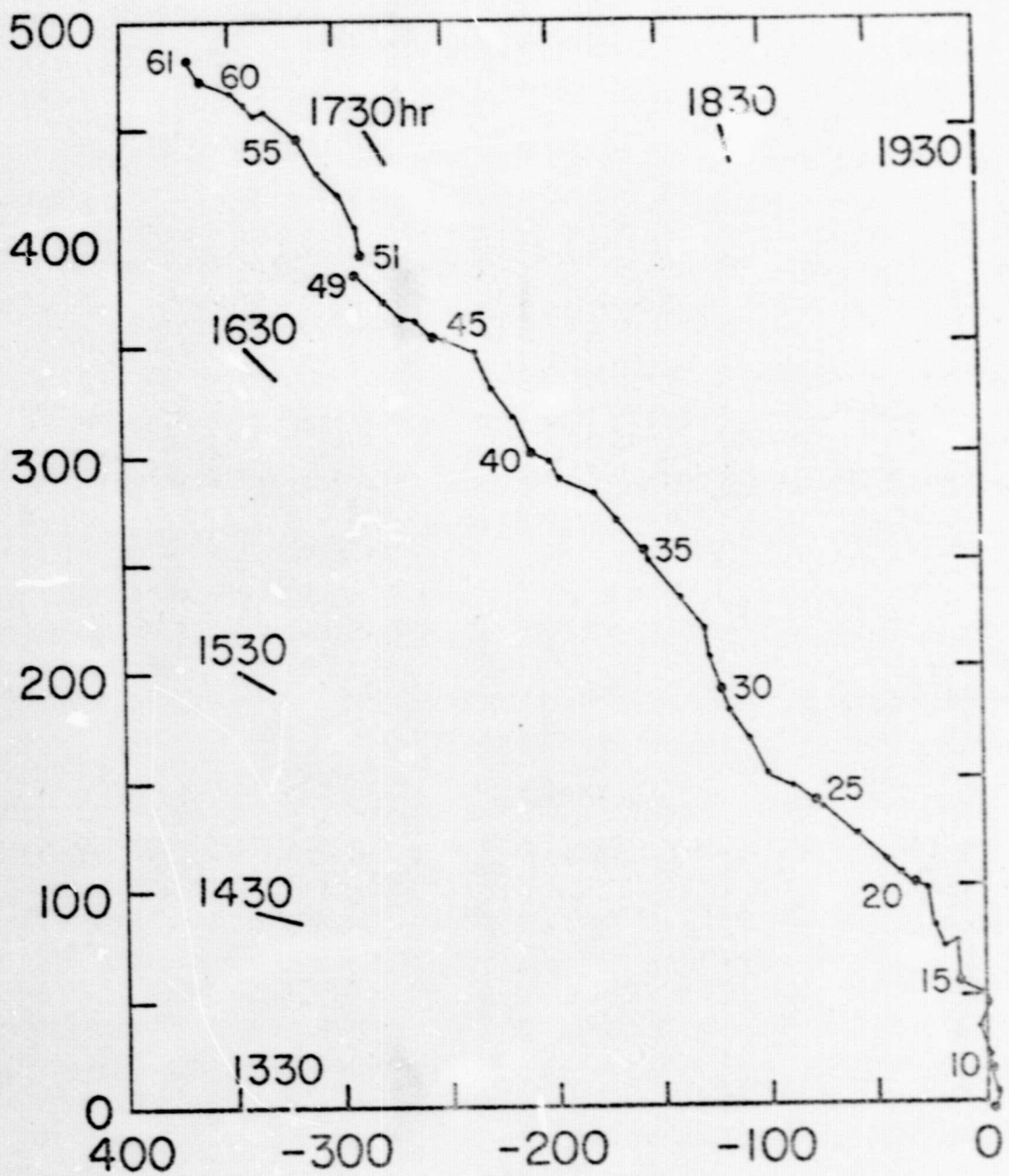

Figure 14. Heart Rate, Subject 4A

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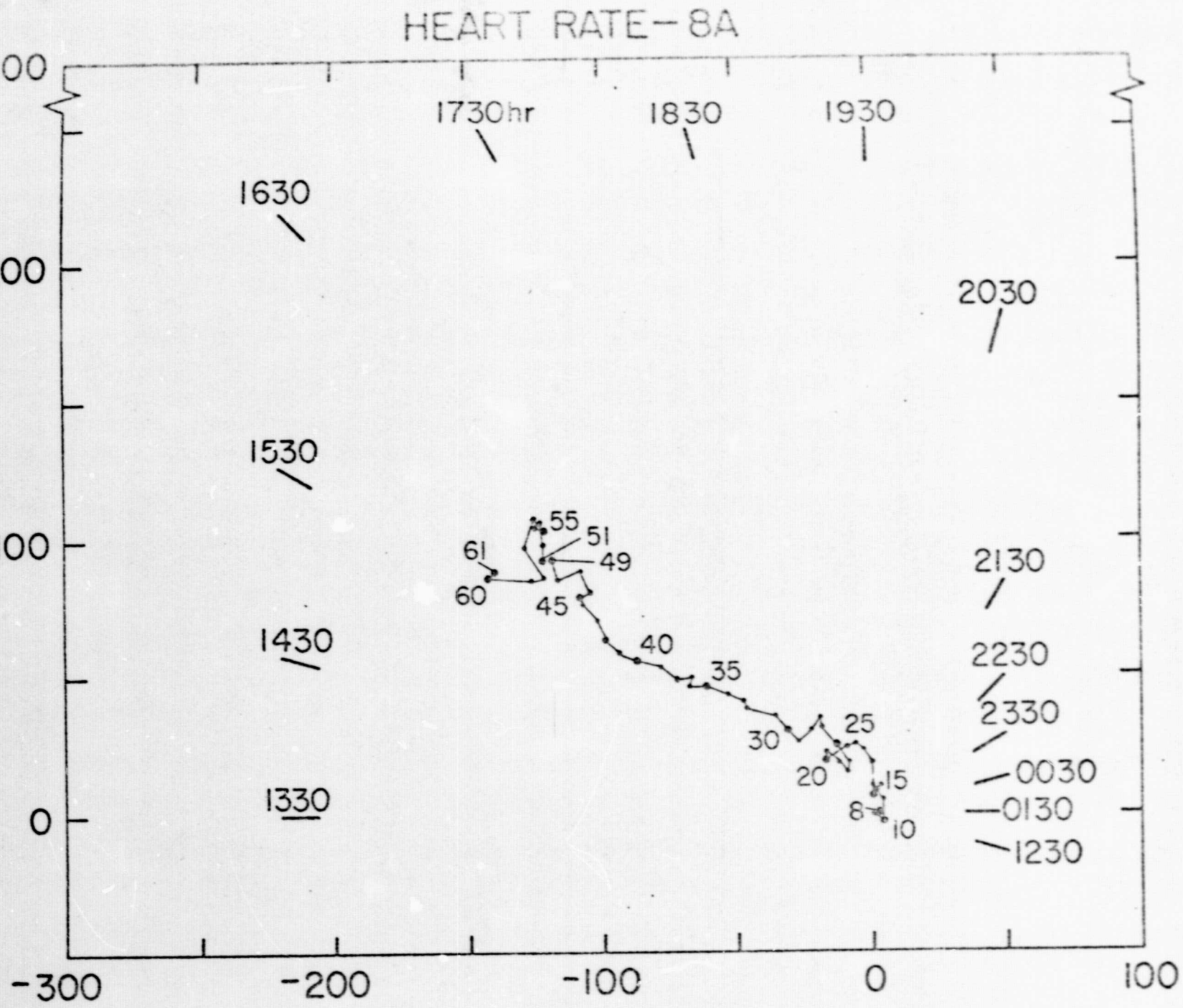

Figure 15. Heart Rate, Subject 8A

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HEART RATE-9A

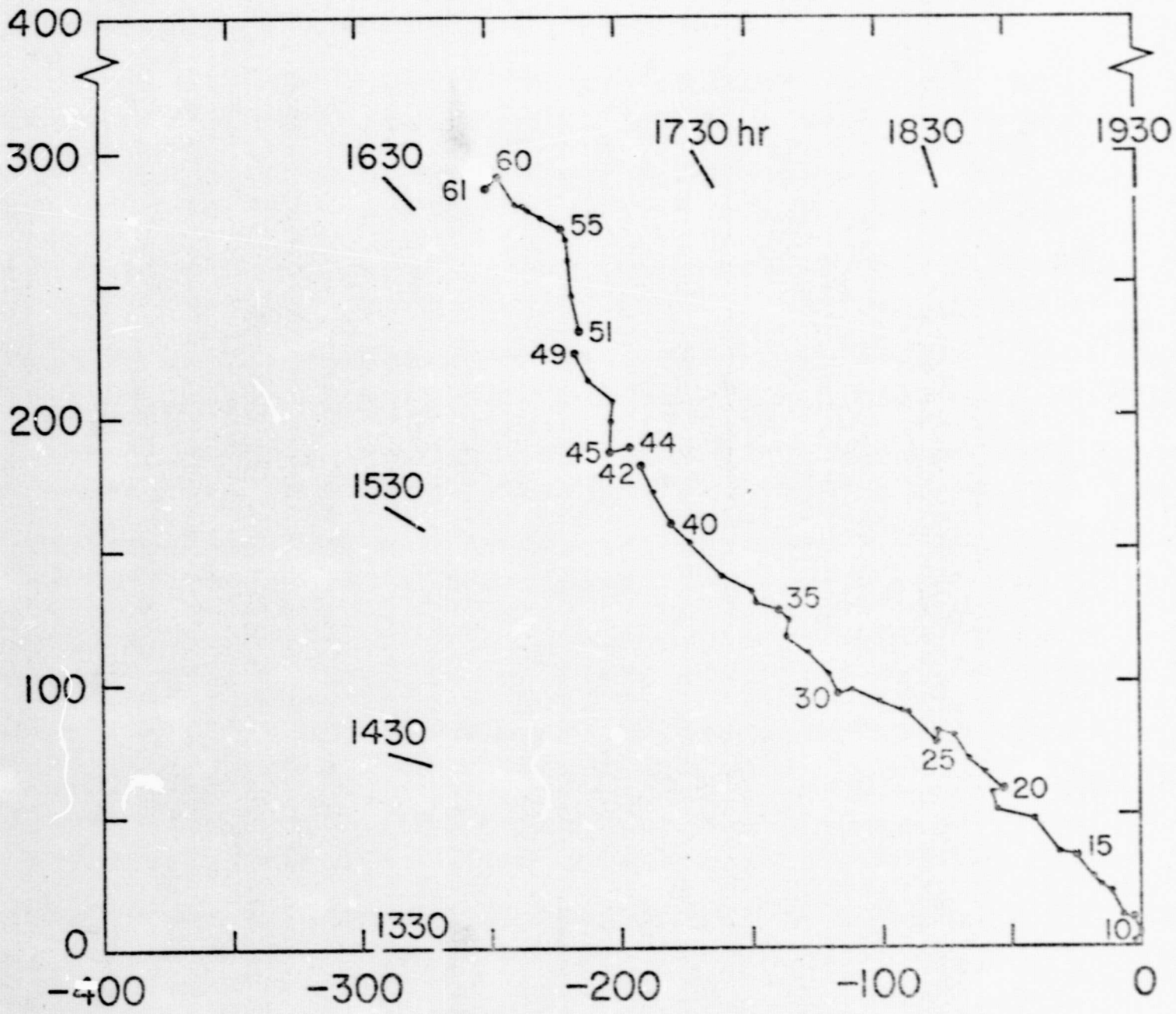

Figure 16. Heart Rate, Subject 9A

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EXPLANATION OF THE SUMMATION DIAL TECHNIQUE WITH PARTICULAR APPLICATION TO A HYPOKINETIC STUDY

In the hypokinetic study (56 days Bed Rest) data on heart rate (HR) and body temperature (BT) were available as 6 points per 24-hour day. It was necessary to fit a simple harmonic equation to the data of each day; but in order to do so, as assumption was required, namely—— that there was a 24-hour period (τ = 24 hours) through the data.

The harmonic equation utilized was:

$$\hat{y} = m + \hat{a} \cos wt + \hat{b} \sin wt$$

$$y = R \cos (wt - \emptyset)$$

where $w = 60^{\circ}$, We define:

$$\emptyset = \text{Tan}^{-1} = \frac{\hat{b}}{\hat{a}} \qquad \text{and} \qquad \hat{R} = \sqrt{\hat{a}^2 + \hat{b}^2}$$

where $\hat{a}$ and $\hat{b}$ are the parameters estimated from the fit to the daily data of the harmonic equation above. The value, $\hat{R}$, can be further defined as a vector (a line having both a direction and a length) and $\hat{R}$ is shown graphically in Figure 1. It should be noted that $\hat{R}$ is always a positive quantity since it is a sum of squares. The quantities $\hat{a}$ and $\hat{b}$ may each be positive or negative, their signs determining the quadrant into which the vector $\hat{R}$ will lie.

If n days of data are available, it is possible to fit n harmonic equations to derive n $\hat{a}$'s, n $\hat{b}$'s, and n $\hat{R}$'s, and n $\hat{\emptyset}$'s, or more formally

to estimate $\hat{a}_i$, $\hat{b}_i$, and from these, $\hat{R}_i$ and $\hat{\emptyset}_i$; i = 1, 2, ..., n. It would then be possible to plot for the data of each day the point $(\hat{a}_i, \hat{b}_i)$, producing a "cloud of points", or the harmonic dial (S. Chapman and J. Bartels, Geomagnetism Vol. II, Oxford University Press, 1940, Chapter XIX, 669-683). Figures 2 and 3 show two examples of harmonic dials, to which have been fit ellipsoids. The hypothetical data in Figure 2 show greater variation of amplitudes than phase angles, whereas those in Figure 3 show the reverse.

Fitting of the confidence or error ellipsoid is not without certain difficulties, but has some merit in describing the variability of the population of days as to amplitudes and phase angles. The harmonic dial, however, represents a somewhat static way of representing the data, i.e., the relationship of any two points, vis-a-vis time, is not known. Bartels (Random fluctuations, persistence and quasi-persistence in geophysical and cosmical periodicities. Terrestrial Magnetism 40:1-6b, 1935) has described the summation dial which is a more dynamic way of looking at rhythmic data. The construction of the summation dial and some examples of its more prominent features are shown in Figures 4-7.

Mathematically, the summation dial is constructed as follows: Given n days of data, we derive n values of $\hat{a}$ and $\hat{b}$, or the $\hat{a}_i$ and $\hat{b}_i$; i = 1, 2, ..., n, as well as $\hat{R}_i$ and $\hat{\emptyset}_i$. We then compute $\sum_{i=1}^{k} \hat{a}_i$ and $\sum_{i=1}^{k} \hat{b}_i$, $k \leq n$, that is, the cumulative of the $\hat{a}$ and of the $\hat{b}$ for each successive day. We may plot $\sum \hat{a}_i$ against $\sum \hat{b}_i$ for each successive day, deriving the summation dial.

The summation dial is, in reality, a sum of vectors or a vectorial sum. Figure 4a shows three vectors derived from some hypothetical data. We may simply place each vector at the end of the preceding one to produce by plotting ($\sum \hat{a}_i$, $\sum \hat{b}_i$) $i = 1, 2, 3$. The length of the vector is the estimated amplitude of the rhythm of the data while the angle made by the vector with the $\hat{a}$-axis is the phase angle, which will be shown later to correspond with the time (hour of day) of peak or of maximum amplitude, $\hat{R}$.

It may be reasonably assumed that a series of data are stationary in time (i.e., both amplitude and phase angle are constant aside from experimental or random error) the data may be represented quite well by the harmonic dial. If, on the other hand, because of experimental or other conditions, it cannot readily be assumed that the data are stationary in time, the harmonic dial will not present a true picture of the data, and may, in fact, be misleading, since either the amplitude or phase angle, or both, may be changing with time.

In this hypokinetic study it reasonably could be expected that the enforced Bed Rest would act as a forcing function on the daily oscillating physiologic system and could induce non-stationary time series. In such case, the summation dial would be not only more descriptive of the true situation, but less prone to error than would the harmonic dial. It is assumed that, if the data were non-stationary with a 24-hour cycle, the estimation of the vector would be unaffected. There may, however, be a non-stationary condition between 24-hour cycles.

If the data are stationary in time, the summation dial would be as shown in Figure 5a, where both amplitude and phase angle are constant (the vectors are of equal length with no change in direction). Figure 5b, shows the result of a damping amplitude together with a constant phase angle. If the amplitude vary in height and the phase angle is altered once, there would be a summation dial as shown in Figure 5c. Were the vector sum to come back on itself, it would represent a 180° change in phase angle (Figure 5d). Were the summation dial seen to form a loop as shown in Figure 5e, it would represent either a linear phase shift (the phase angle changing by a more or less constant amount each day) or a 26-hour period instead of the assumed 24-hour period.

If, as successive days are plotted, the direction of the summation dial changes randomly (i.e., if the latest direction is randomly chosen from the infinite population of directions) and the length of the latest vector also changes randomly, the summation dial shows a random walk (Figure 6). A random walk indicates that the data possess no rhythmicity over time.

Were the direction only to change, i.e., the length of the vectors constant, there could still be a random walk. This may be simulated mathematically by normalizing the vectors to a constant length, by dividing each $\hat{a}_i$ by its $\hat{R}_i$ and each $\hat{b}_i$ by its $\hat{R}_i$.

If the data had a true period τ_t, and a wrong period τ_w, was assumed, and if, further, the data were stationary in time, the summation dail would form a loop (Figure 5e). A random walk would not be seen.

If there was a linear phase shift in the data and the amplitude continuously decreased a spiral would be seen, and not a random walk. A random walk, therefore, is observed only when both direction and amplitude change in a random fashion. A random walk suggests that the harmonic model is not appropriate in explaining the data.

The summation dial, as its name implies, represents a 360° circle, and if a 24-hour period is assumed, this dial is composed of 24 equal segments, which must be related to the data. The time of the first data point lies on the $\hat{a}$-axis, with the hours succeeding it going around the dial counterclockwise. To show the dial as the customary clock (clockwise) the $\hat{a}$ and $\hat{b}$ axes must be reversed. Such a dial is shown in Figure 7, where it has been assumed that the first data point was taken at 2400 hours. It is not necessary so to plot the dial; and in fact, the vertical axis may be plotted as a matter of choice.

In Figure 7, times of peak are shown. In the first section of the data, the initial time of peak occurs at 0200 hours for 6 days, then at 1200 hours for 6 days, at 2100 hours for 1 day, etc. The direction of the data (i.e., times of peak) is given quite simply by the dial.

The summation dial may thus be viewed as a graphical and mathematical representation of a dynamic system. The rhythm studied may persist for some time and may change direction (time of peak) one or more times when perturbed, and may eventually return to its initial time of peak. An example of this is seen in Figure 7, and may represent the "resetting of the clock" as postulated by Aschoff.

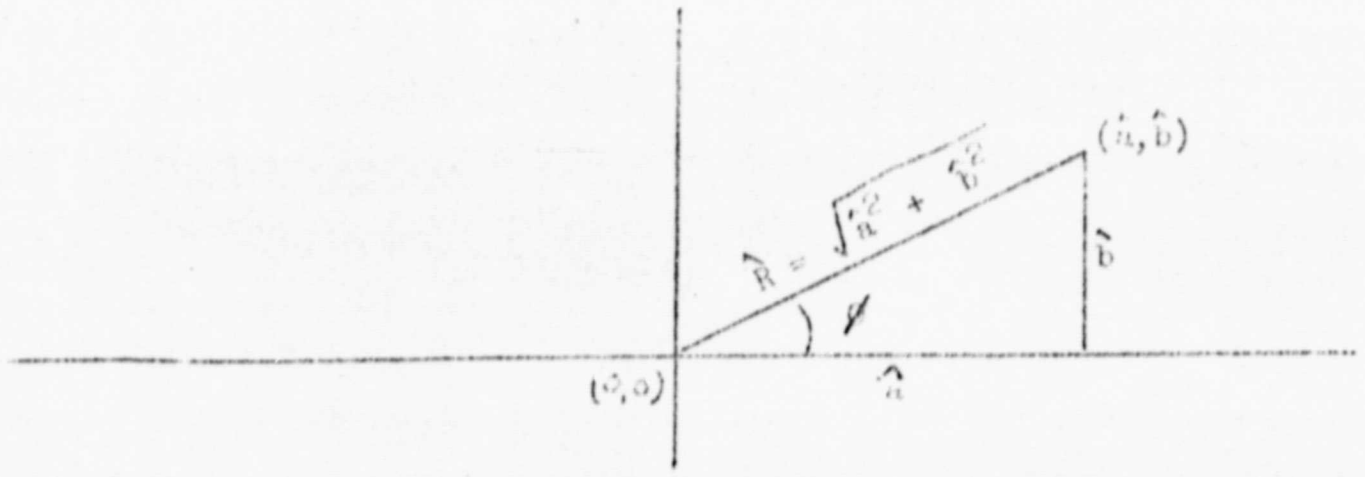


Figure 1. The vector, R

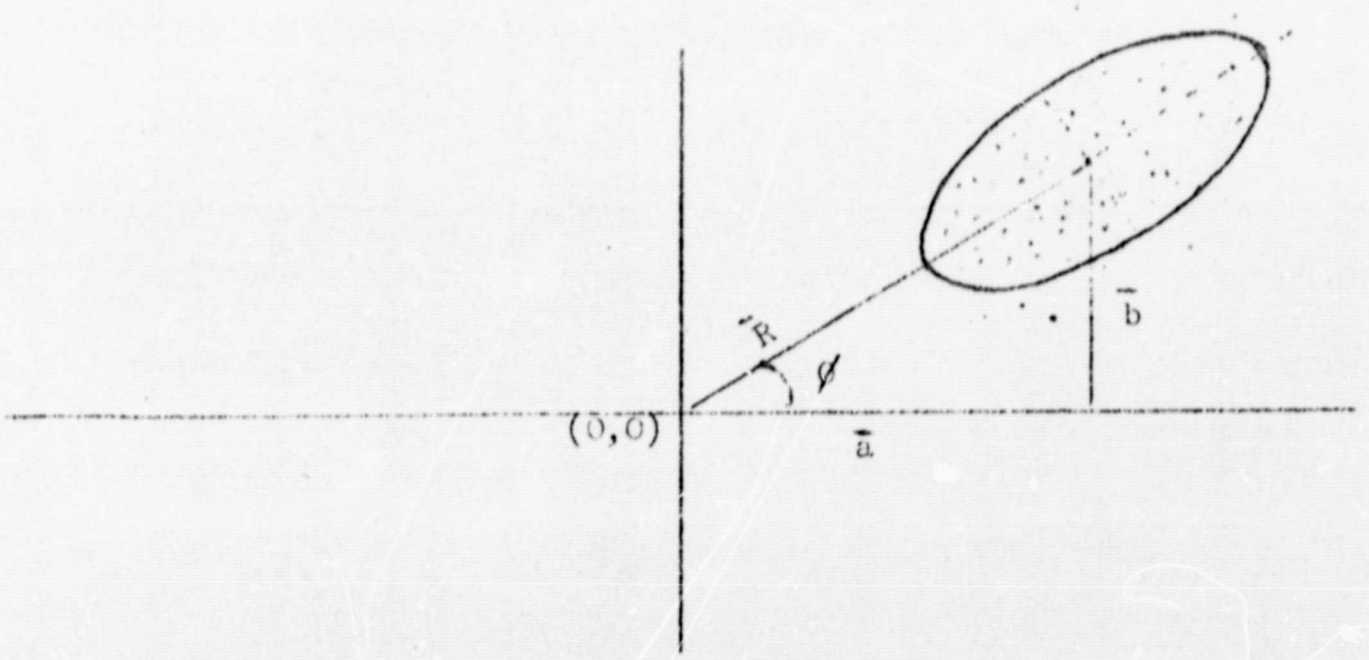


Figure 2. Harmonic Dial, with confidence ellipse centered at$(\bar{a},\bar{b})$, the data varying more as to amplitude than phase angle.

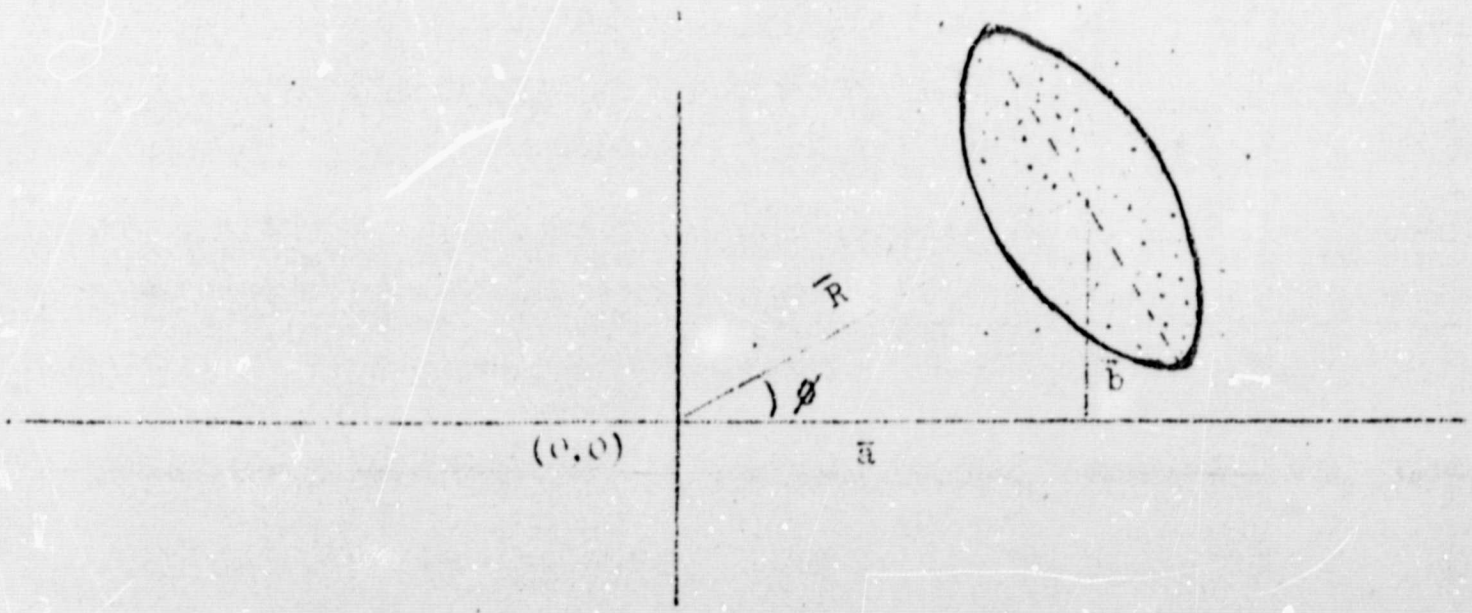
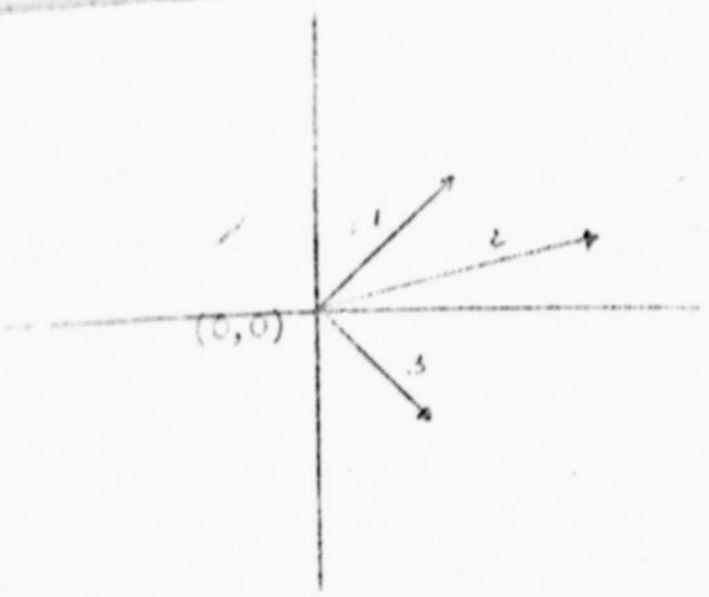
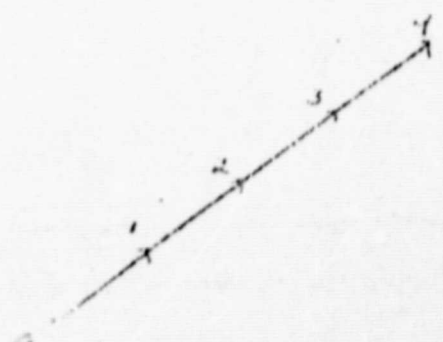


Figure 3. Harmonic Dial, with confidence ellipse centered at $(\bar{a},\bar{b})$, the data varying more as to phase angle than amplitude.

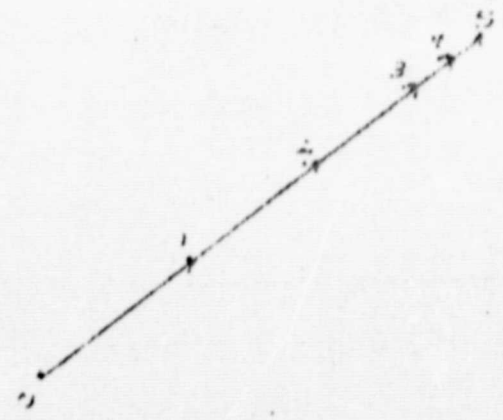


(b)

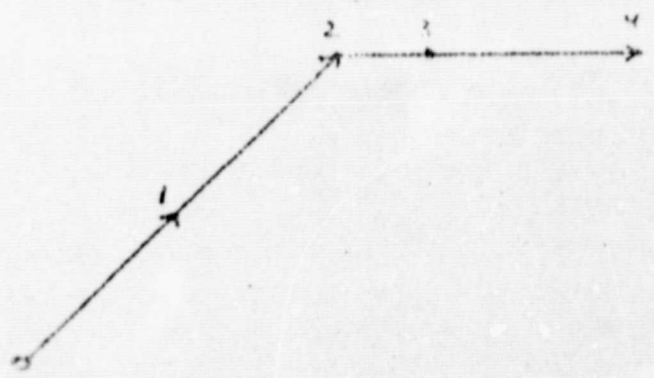
Figure 4. Construction of the summation dial.



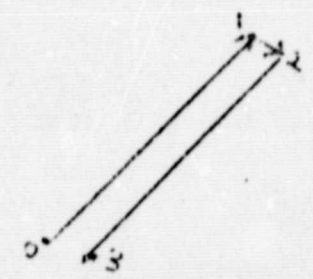
Data stationary in time



(b) Amplitude damping with constant phase angle



Change in phase angle.



(d) Complete (180°) phase reversal

A loop, indicating either a linear phase drift or a 26 hour, rather than a 24 hour period.

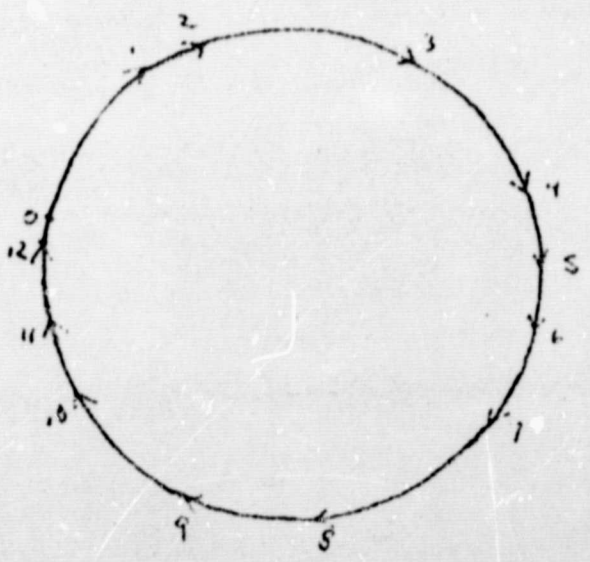


Figure 5. Examples of features encountered in summation dials.

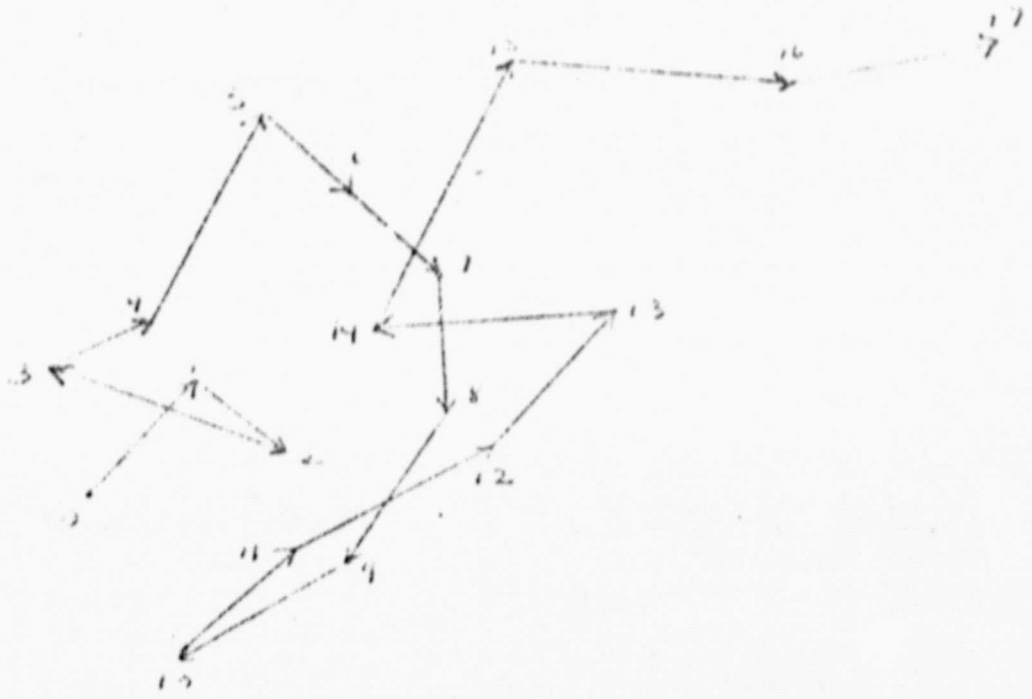


Figure 6. A random walk.

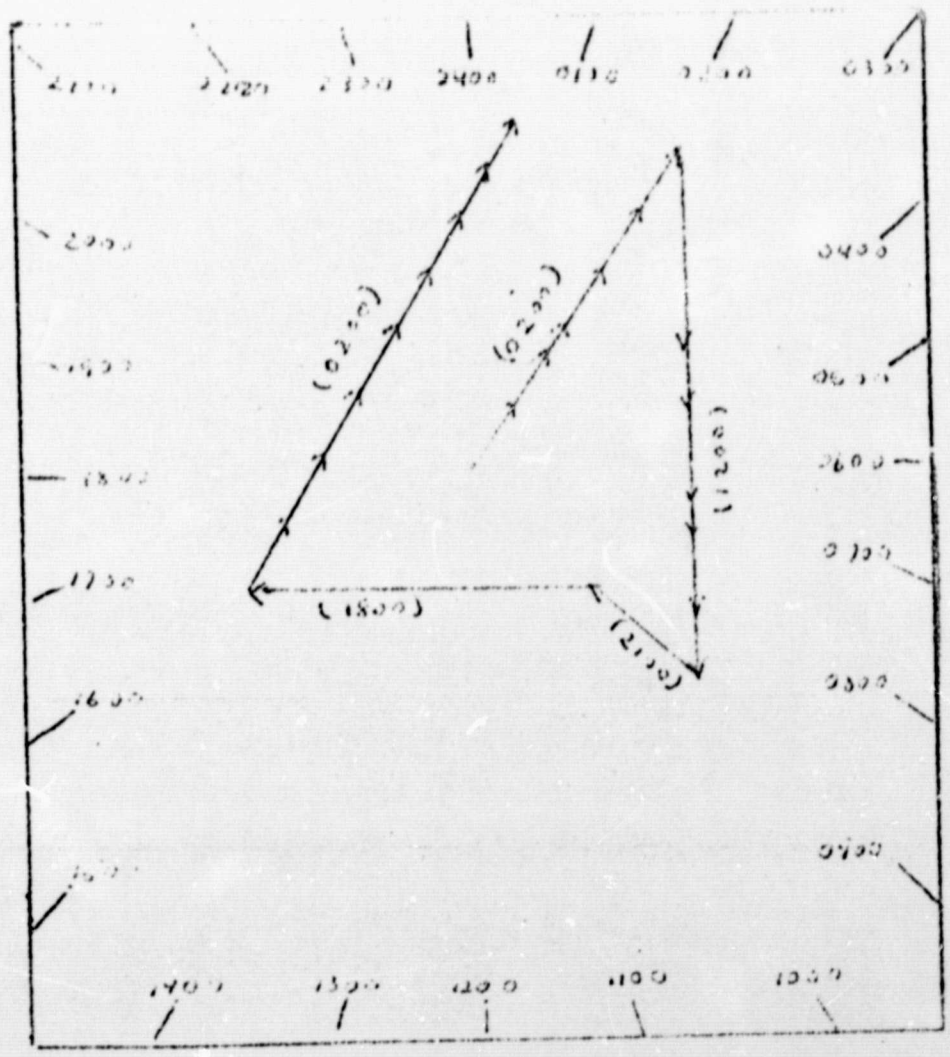


Figure 7. The summation dial and its relation to time of day.

EVALUATION OF FLIGHT FOODS UNDER HYPOKINETIC CONDITIONS

CHAPTER V

URINARY EXCRETION OF CREATININE AND CREATINE DURING RECUMBENCY AND AMBULATION

Contract NAS 9-9755

Texas Woman's University
Denton, Texas

URINARY EXCRETION OF CREATININE

Since physical activity is known to influence body metabolism, it has been of interest to scientists in this laboratory to ascertain the effect of programmed exercise on the physical status of subjects who are participating in immobilization studies.

For many years creatinine values have been used clinically as an index for assessing nutritional status. Controversy over the accuracy of employing the creatinine ratio for this purpose has stimulated many investigators to probe further into this phenomenon. The research presented in this report deals in particular with the aspects of circadian rhythm and programmed exercise relative to urinary creatinine excretion.

The specific objectives of this part of the study were the following:

a). To analyze the urinary creatinine excretion values of eight men in a recumbency study;

b). To compare statistically the daily creatinine excretion values of the three different periods of the study which included the Equilibration Period, a Bed Rest Period, and a Recovery Period; and

c). To investigate the effect of exercise on the excretory levels of urinary creatinine.

Effects of Stress and Immobilization

Many Bed Rest studies have been conducted to determine the physiological changes occurring as a result of the conditions of prolonged weightlessness and partial immobilization which are associated with physical confinement in a spacecraft. Hoffman, Mack et al[1] conducted a study using primates in which one group was restrained in couches while another group was caged and free of restraint. The restrained animals showed an increase in creatine excretion with levels of creatinine excretion in the urine remaining irregular. These investigators concluded that, due to restraint, there was a decrease in muscle mass, loss of body weight, and a weakening of skeletal muscle.

Scrimshaw et al[2] determined the urinary composition of university students during, before, and after examinations. They observed that, during examination periods, increased excretions of 17,21-dihydroxycorticosteroids, creatinine, nitrogen and sulfates were detected in the urine of freshmen while the average excretion of these substances by upperclassmen remained cirtually unchanged.

Whedon, Deitrick and Shorr[3] studied the effects of immobilization on the metabolic and physiologic functions of normal men. Creatinine excretion was observed to remain quite constant for all subjects participating in this study.

Hale, Ellis, and Williams[4] have reported that the urinary creatinine values of 48 men determined both before and after 12 hours of simulated flight showed no significant changes.

Effect of Exercise

The effect of muscular exercise on creatinine excretion currently is an object of extensive investigation. Cathcart, Kennaway, and Leathes[5] have noted that the excretion of creatinine is not changed by severe exercise. Mitchell and Kruger[6] made an extensive study in which eight rats were subjected to a four-day rest period after a five-day work period, and reported that no change was noted in the excretion either of total endogenous nitrogen or creatinine in the urine as a result of activity or inactivity. These investigators concluded that increased catabolism of muscle tissue could not be attributed to any increase in muscle activity.

Garry[7] determined the creatinine excretion in experimental animals over a six-day period. On the third day some of the animals were allowed to have voluntary activity while other animals were made to participate in various planned activities. The results of this study showed that voluntary activity did not change creatinine excretion significantly, but that involuntary activity induced a slight increase in creatinine excretion both during and following the exercise.

Hobson[8] studied the relationship between creatinine excretion and exercise on 97 physical education students. These subjects participated in a strenous exercise regime every day except Saturday and Sunday. On these two days they participated in limited physical exercise. The severity of the exercise regime appeared to cause no significant change in the amount of creatinine excreted in the urine.

Haldi and Bachmann[9] reported that the addition of glucose or fructose or a mixture of both hexoses to the diets of subjects engaged in exercise prompted an increase in the creatinine excretion in the urine. These investigators suggest that exercise stimulates carbohydrate oxidation which is essential for creatine to creatinine metabolism, with a rise in urinary creatinine levels consequently being noted.

Norris and Weiser[10] studied the correlation between strenous muscular exercise and creatinine excretion in two young men, and found a significant decrease in creatinine excretion to occur both during and after muscular exercise. In this same study, the other urinary constituents observed, such as total nitrogen, uric acid, chlorides and inorganic phosphates also exhibited a decrease in escretion. It was hypothesized by these investigators that following exercise there is a decrease in urinary volume and consequently there occurs a decrease in urinary metabolites.

Ahlborg and Brohult[11] studied the effect of exercise on the levels of serum creatinine and creatinekinase in 12 healthy men and concluded that the levels both of creatinine and creatinekinase are elevated slightly after exercise, with serum creatinine showing a faster return to normal values.

Srivastava et al[12] conducted a series of four experiments to study the effect of muscular exercise on the excretion of creatinine and creatine in the urine. The army personnel employed as subjects in these studies were required to march three hours daily. The results of all four investigations showed that the 24-hour urinary creatinine excretion

was elevated during the days of exercise as compared to normal values, and that the hourly excretion rate during the exercise period was higher than during the pre-exercise and recovery periods.

Umapathy[13] reported on a study using six primates as subjects during the experimental days. Two primates were forced to exercise for one hour each day, two served as controls, and two were placed in restraint. The results showed that the creatinine excretion of the experimental animals remained virtually unchanged during the pre-restraint and restraint periods with a decrease noted in the recovery stage. No markedly different levels were recorded for the control animals.

Montgomery[14] measured the urinary creatinine and creatine excretion of six male university students during a study containing two Bed Rest periods. During the first period, no exercise was taken by the subjects. During the second Bed Rest, one group of subjects engaged in regular programmed exercise, while the other group exercised at will. The results of this study showed that the creatinine excretion of all subjects during both bed rest periods was significantly higher than during the pre-Bed Rest period. The creatinine excretion during the exercise period was higher for the group exercising ad libitum than for the group exercising regularly.

In the study covered by this Report, eight healthy adult male subjects participated in an immobilization study, as described in previous chapters, as consisting of three different periods: pre-Bed Rest; Bed Rest; and post-Bed Rest. This study was designed to investigate

changes in various metabolic reactions throughout all periods of the investigation as well as to determine circadian periodicities existing in the physiological functions of these subjects while they were engaged in a 56-day period of bed rest immobilization.

The daily urinary excretion data on creatinine, which constituted a major part of this chapter are recorded in the Appendix in Table I. Urinary creatinine excretion during four daily periods throughout Bed Rest are reported in Table II. The statistical comparisons of excretion between pairs of different periods are presented in Table III. The statistical comparisons of different periods of the 24-hour day are recorded in Table IV. The statistical data relating to exercise are shown in Table V, VI, VII, and VIII.

Comparison of Urinary Creatinine Excretion During the Bed Rest, Pre- and Post-Bed Rest Periods

The statistical analyses of the urinary creatinine excretion data are shown in Table III (Appendix).

Creatinine Urinary Excretion by Subjects which Exercised during Bed Rest

SUBJECT 2A

The average daily urinary excretion of creatinine by this subject with pre-Bed Rest and Bed Rest compared statistically are presented in Table III, Part A. The amount of urinary creatinine excreted by this subject during Bed Rest was greater in quantity than during pre-Bed Rest

and post-Bed Rest by a difference which was highly significant ($P<0.001$) in both comparisons.

SUBJECT 6A

When the amount of urinary creatinine excreted by this subject during the pre-Bed Rest period was compared with that excreted during Bed Rest, a higher amount of urinary creatinine was recorded during Bed Rest than during pre-Bed Rest, with a difference which was distinctly significant ($P<0.02$).

The urinary excretion by Subject 6A differed little between pre-Bed Rest and post-Bed Rest, with no statistically significant difference between that excreted between Bed Rest and post-Bed Rest.

SUBJECT 7A

During Bed Rest, the urinary creatinine excretion by this subject was greater than that during the pre-Bed Rest period and the post-Bed Rest. This difference was highly significant in both instances ($P<0.001$), as shown in Table III, Part A.

SUBJECTS 2A, 6A, 7A

As shown in Table III, Part B, when the data for all subjects who exercised throughout the Bed Rest period were pooled together for purposes of statistical comparison, the amount of creatinine excreted in the urine during the Bed Rest period was higher than that during the pre-Bed Rest period by a difference which was highly significant ($P<0.001$).

Creatinine Urinary Excretion by Subjects Who Did Not Exercise Routinely during Bed Rest

SUBJECT 4A

A higher level of daily urinary creatinine was excreted by Subject 4A during Bed Rest than during pre-Bed Rest. The difference was highly significant ($P<0.001$), as shown in Table III, Part C. The same was true when the Bed Rest and the post-Bed Rest periods were compared. The excretion during the pre-Bed Rest and the post-Bed Rest periods did not differ significantly.

SUBJECT 8A

The excretion of urinary creatinine by this subject was significantly higher ($P<0.001$) during the Bed Rest period than during the pre-Bed Rest or the post-Bed Rest periods, with the pre- and post-Bed Rest periods not differing significantly from each other. Table III, Part C.

SUBJECT 9A

As shown in Table III, Part C, Subject 9A excreted an appreciably greater quantity of creatinine in the urine during the Bed Rest than during the pre- or post-Bed Rest. The difference was highly significant in both cases ($P<0.001$). The pre- and post-Bed Rest periods were not statistically different from each other in this respect.

SUBJECTS 4A, 8A, 9A (No Exercise)

Table III, Part D gives a resume of the statistical findings when the urinary creatinine data were pooled together for the three subjects who did not exercise. The total excretion during the Bed Rest

period surpassed that of the pre-Bed Rest and of the post-Bed Rest periods by differences which were highly significant in both cases ($P<0.001$). There was no significant difference in creatinine excretion between the two ambulatory periods of this group.

Creatinine Urinary Excretion by Subjects Who Exercised Only One-Half of the Bed Rest Period

Table III, Part E gives the urinary creatinine statistical data for Subject 3A, who exercised during the first 28 days of the 56-day Bed Rest period, and for Subject 1A, who exercised during the last 28 days.

It is shown in the table which was cited that Subject 3A, who exercised during the first half of the Bed Rest period surpassed both the pre- and post-Bed Rest Periods during the part of the Bed Rest period when he exercised, by a highly significant amount of urinary creatinine excreatinine ($P<0.001$), with no significant difference between the amounts excreted during the pre- and post periods when the subjects were ambulatory.

The same was found for Subject 1A during the part of the Bed Rest period when he exercised.

ALL SUBJECTS

When the data for all eight subjects were combined for the purpose of comparing the urinary creatinine excretion during Bed Rest with that of pre-Bed Rest and post-Bed Rest, Table III, Part F, shows that the amount excreted during the Bed Rest period was appreciably greater than that of either of the two ambulatory periods in both instances.

The results of this study support previous reports by Umapathy[13] and Montgomery[14] which indicated that the element of stress induced by long periods of immobilization might serve to enhance the excretion of creatinine in the urine.

Summary and Conclusions on Creatinine Findings

Eight male university students participated in an immobilization study which consisted of a 16-day pre-Bed Rest period, a 56-day Bed Rest period, and a 14-day post-Bed Rest period. This study was conducted during the summer of 1969 at the Nelda Childers Stark Laboratory for Human Nutrition Research at the Texas Woman's University Research Institute and was sponsored by the National Aeronautics and Space Administration to find changes in metabolic functions in human subjects experiencing prolonged immobilization under carefully controlled environmental conditions.

This report deals with the metabolite, creatinine. The analytical method of Biggs and Cooper[15] was employed to determine the creatinine content of all urinary samples collected throughout this study.

Total 24-hour urinary creatinine excretion was found to be significantly higher ($P<0.001$) for all subjects during the Bed Rest period of the study as compared to the pre- and post-Bed Rest periods. Immobilization appears to increase the excretion levels of creatinine, possibly because of stress. Creatinine excretions rapidly returned to normal levels in the post-Bed Rest Ambulatory period.

The circadian variation of creatinine also was studied during the 56-day Bed Rest period. Throughout this period of the study, a

strict regimen of 14 hours daytime and 10 hours nighttime was maintained, and urinary samples were collected four times daily. Most subjects excreted the lowest amount of urinary creatinine during the overnight period. Five of the subjects attained a peak in creatinine excretion between 8 P.M. and 12 Midnight while three of the subjects exhibited the highest excretion of this metabolite between 8 A.M. and 12 Noon.

The subjects were divided into groups which did and did not participate in programmed exercise which was introduced as a variable during the immobilization period. It was observed that the group which exercised a significantly greater amount of creatinine in the urine than did the group which did not exercise ($P<0.001$). Two individuals exercised for 28 days each, one the first half of the bed rest and the other the latter part. Both of these individuals excreted a greater amount of creatinine during the second half of the bed rest. This finding could have been related to the influence of the element of stress which is involved in prolonged immobilization.

Pattern of Urinary Creatinine Excretion during the Bed Rest Period

In order to dtudy the periodicity pattern of creatinine at different periods of the 24-hour day and night during Bed Rest, the urine excreted at different times during the following periods were collected into four aliquots which ended respectively at 8 A.M., 12 Noon, 8 P.M., and 12 Midnight. The statistical data regarding the excretion patterns are given in Table IV and in Figure 1. This denotes that the highest excretion of this metabolite occurred during 8 P.M. until 12 Midnight,

and from 8 A.M. until 12 Noon. The differences between these two periods for the respective experimental subjects were slight. See also Tables V - VIII.

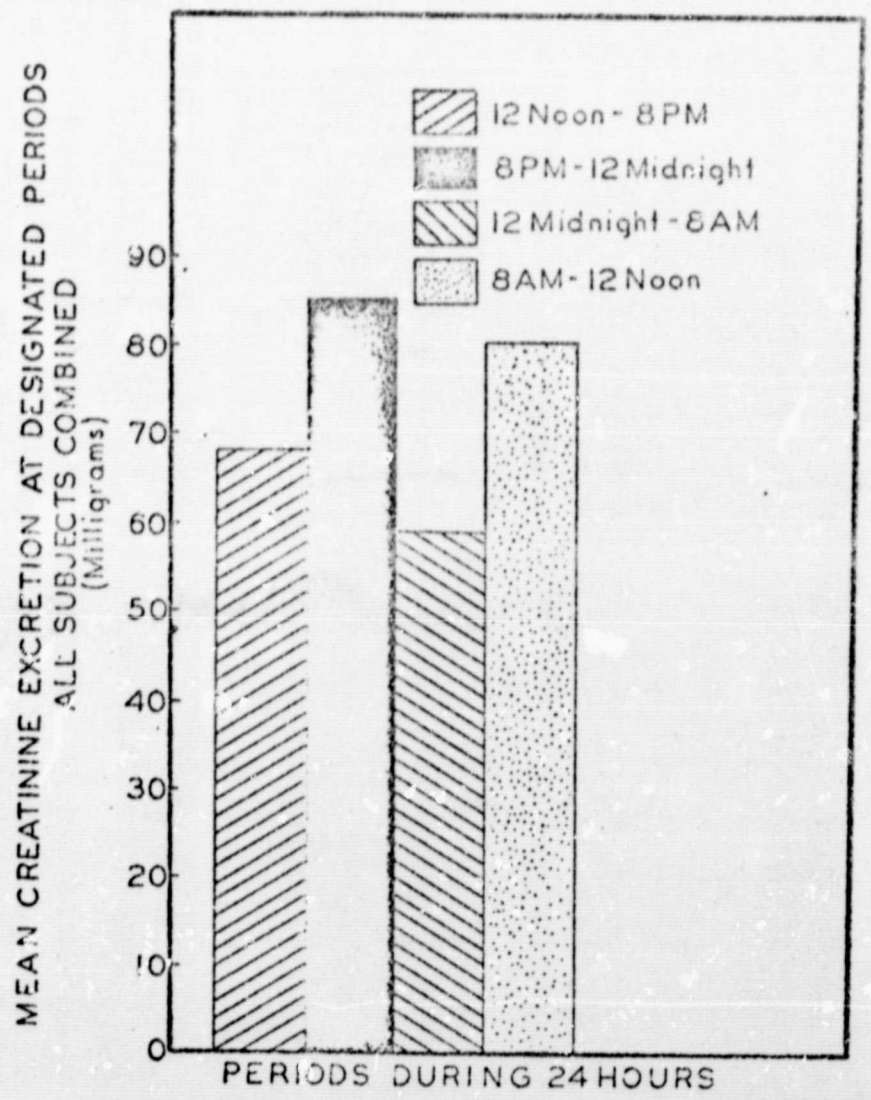


Figure 1. Mean Creatinine Excretion at Designated Periods, All Subjects Combined

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A P P E N D I X

TABLE I

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART A. SUBJECT 1A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	1202	(1)	830	(29)	1980	(1)	756
(2)	X	(2)	1267	(30)	1823	(2)	752
(3)	656	(3)	1621	(31)	1601	(3)	652
(4)	919	(4)	1221	(32)	2022	(4)	843
(5)	1969	(5)	1445	(33)	1708	(5)	649
(6)	1004	(6)	1389	(34)	1922	(6)	X
(7)	1441	(7)	1424	(35)	1908	(7)	614
(8)	704	(8)	1117	(36)	1681	(8)	520
(9)	1210	(9)	1529	(37)	2159	(9)	2825
(10)	466	(10)	1404	(38)	2101	(10)	849
(11)	2127	(11)	1431	(39)	1906	(11)	X
(12)	1086	(12)	1577	(40)	1946	(12)	863
(13)	1216	(13)	1644	(41)	1923	(13)	X
(14)	956	(14)	1583	(42)	1705	Mean	942
(15)	1490	(15)	1805	(43)	1736		
(16)	1542	(16)	1598	(44)	1823		
Mean	1199	(17)	1718	(45)	1606		
		(18)	1798	(46)	1959		
		(19)	1958	(47)	1878		
		(20)	1370	(48)	1968		
		(21)	1844	(49)	1670		
		(22)	1983	(50)	1651		
		(23)	1819	(51)	1982		
		(24)	1780	(52)	1691		
		(25)	1683	(53)	1763		
		(26)	1655	(54)	1724		
		(27)	1999	(55)	1879		
		(28)	2014	(56)	1493		
				Mean	1702		

TABLE I, CONTINUED

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART B. SUBJECT 2A

Pre-Bed Rest		Bed Rest		Bed Rest		Post-Bed Rest	
(1)	1291	(1)	834	(29)	1700	(1)	1269
(2)	1017	(2)	814	(30)	1675	(2)	1012
(3)	1188	(3)	1506	(31)	1708	(3)	1357
(4)	607	(4)	1362	(32)	1754	(4)	984
(5)	1062	(5)	1892	(33)	1629	(5)	510
(6)	996	(6)	1669	(34)	1719	(6)	500
(7)	760	(7)	1188	(35)	1543	(7)	1192
(8)	896	(8)	1716	(36)	1593	(8)	574
(9)	740	(9)	1382	(37)	2014	(9)	1266
(10)	1156	(10)	1599	(38)	1412	(10)	1229
(11)	1081	(11)	1506	(39)	1716	(11)	656
(12)	1303	(12)	1432	(40)	1719	(12)	273
(13)	1371	(13)	1514	(41)	1739	(13)	638
(14)	1028	(14)	1307	(42)	1665	Mean	882
(15)	1200	(15)	1530	(43)	1598		
(16)	1064	(16)	1441	(44)	1620		
Mean	1048	(17)	1747	(45)	1514		
		(18)	1592	(46)	1517		
		(19)	1504	(47)	1821		
		(20)	1475	(48)	1596		
		(21)	1656	(49)	1786		
		(22)	1754	(50)	1270		
		(23)	1951	(51)	1759		
		(24)	1044	(52)	1723		
		(25)	1768	(53)	2038		
		(26)	1774	(54)	1599		
		(27)	1658	(55)	1990		
		(28)	1736	(56)	1088		
				Mean	1587		

TABLE I, CONTINUED

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART C. SUBJECT 3A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	680	(1)	689	(29)	1495	(1)	942
(2)	523	(2)	919	(30)	1415	(2)	1355
(3)	1140	(3)	1190	(31)	1194	(3)	630
(4)	935	(4)	1168	(32)	1403	(4)	1696
(5)	1148	(5)	1256	(33)	1523	(5)	1236
(6)	628	(6)	1454	(34)	1601	(6)	1323
(7)	958	(7)	1120	(35)	1227	(7)	695
(8)	761	(8)	1286	(36)	1738	(8)	1570
(9)	938	(9)	1851	(37)	1838	(9)	912
(10)	550	(10)	1238	(38)	1383	(10)	1421
(11)	668	(11)	843	(39)	1741	(11)	816
(12)	2033	(12)	1234	(40)	1507	(12)	620
(13)	1056	(13)	1724	(41)	1651	(13)	1134
(14)	469	(14)	1238	(42)	1687	Mean	1104
(15)	1734	(15)	1072	(43)	1297		
(16)	870	(16)	1313	(44)	1486		
Mean	943	(17)	1555	(45)	2042		
		(18)	1450	(56)	1777		
		(19)	1402	(47)	1537		
		(20)	736	(48)	1381		
		(21)	1515	(49)	1332		
		(22)	1513	(50)	1415		
		(23)	1504	(51)	1878		
		(24)	1062	(52)	1360		
		(25)	2059	(53)	1639		
		(26)	1061	(54)	1456		
		(27)	1609	(55)	1573		
		(28)	1604	(56)	1464		
				Mean	1423		

TABLE I, CONTINUED

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART D. SUBJECT 4A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	1349	(1)	921	(29)	2230	(1)	1426
(2)	1125	(2)	1413	(30)	1808	(2)	951
(3)	1360	(3)	1142	(31)	1789	(3)	684
(4)	1348	(4)	1556	(32)	1944	(4)	1727
(5)	1188	(5)	1012	(33)	1838	(5)	1305
(6)	1800	(6)	1555	(34)	1988	(6)	1400
(7)	1662	(7)	1786	(35)	1743	(7)	1473
(8)	1166	(8)	1598	(36)	2002	(8)	1120
(9)	1121	(9)	1712	(37)	2063	(9)	2288
(10)	891	(10)	1300	(38)	1591	(10)	1185
(11)	984	(11)	1597	(39)	1802	(11)	1114
(12)	627	(12)	1293	(40)	2192	(12)	2154
(13)	1085	(13)	1751	(41)	2516	(13)	901
(14)	887	(14)	2308	(42)	1701	Mean	1364
(15)	1223	(15)	1833	(43)	2192		
(16)	1073	(16)	1465	(44)	1787		
Mean	1181	(17)	1560	(45)	1795		
		(18)	1782	(46)	1795		
		(19)	1834	(47)	1952		
		(20)	1257	(48)	1705		
		(21)	1899	(49)	1675		
		(22)	1925	(50)	1891		
		(23)	1995	(51)	1926		
		(24)	1305	(52)	1824		
		(25)	2214	(53)	2868		
		(26)	1704	(54)	1826		
		(27)	1987	(55)	1940		
		(28)	2123	(56)	1655		
				Mean	1785		

TABLE I, CONTINUED

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART E. SUBJECT 6A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	1223	(1)	1283	(29)	2072	(1)	1221
(2)	1667	(2)	1507	(30)	2392	(2)	1465
(3)	1243	(3)	1303	(31)	1888	(3)	1844
(4)	1678	(4)	1462	(32)	1678	(4)	2196
(5)	1502	(5)	1360	(33)	2047	(5)	1675
(6)	1642	(6)	1668	(34)	2156	(6)	1802
(7)	2016	(7)	1539	(35)	1961	(7)	2013
(8)	1551	(8)	1568	(36)	2010	(8)	2233
(9)	1276	(9)	1764	(37)	2276	(9)	1919
(10)	1682	(10)	1535	(38)	1838	(10)	1837
(11)	1846	(11)	1512	(39)	2144	(11)	1524
(12)	1155	(12)	1505	(40)	2159	(12)	2025
(13)	1544	(13)	1640	(41)	2186	(13)	2190
(14)	1627	(14)	1801	(42)	2140	Mean	1842
(15)	2111	(15)	1514	(43)	1728		
(16)	2103	(16)	2034	(44)	2392		
Mean	1617	(17)	2187	(45)	2040		
		(18)	2006	(46)	2316		
		(19)	1481	(47)	1962		
		(20)	930	(48)	1770		
		(21)	1652	(49)	2149		
		(22)	2160	(50)	1843		
		(23)	1960	(51)	1631		
		(24)	1256	(52)	1783		
		(25)	1811	(53)	2090		
		(26)	1866	(54)	1825		
		(27)	2114	(55)	2111		
		(28)	2202	(56)	1794		
				Mean	1839		

TABLE I, CONTINUED.

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART F. SUBJECT 7A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	X	(1)	1773	(29)	2094	(1)	1590
(2)	1297	(2)	1989	(30)	2330	(2)	2322
(3)	775	(3)	1484	(31)	1942	(3)	1838
(4)	674	(4)	1479	(32)	2180	(4)	1492
(5)	1275	(5)	1301	(33)	2014	(5)	1507
(6)	2708	(6)	1887	(34)	2551	(6)	992
(7)	1008	(7)	1963	(35)	2288	(7)	1639
(8)	1485	(8)	2164	(36)	2089	(8)	784
(9)	399	(9)	1928	(37)	2554	(9)	1344
(10)	1238	(10)	1937	(38)	1555	(10)	558
(11)	1601	(11)	1817	(39)	2195	(11)	1354
(12)	1688	(12)	2061	(40)	1876	(12)	1092
(13)	1622	(13)	1698	(41)	2080	(13)	1896
(14)	1242	(14)	1683	(42)	1792	Mean	1416
(15)	1407	(15)	2082	(43)	1649		
(16)	1451	(16)	1929	(44)	2005		
Mean	1325	(17)	2551	(45)	2062		
		(18)	1845	(46)	2057		
		(19)	2192	(47)	2290		
		(20)	1107	(48)	1987		
		(21)	1596	(49)	2222		
		(22)	2068	(50)	1768		
		(23)	1707	(51)	1957		
		(24)	1479	(52)	2067		
		(25)	1873	(53)	2114		
		(26)	2016	(54)	2002		
		(27)	2303	(55)	2273		
		(28)	2107	(56)	1687		
				Mean	1959		

TABLE I, CONTINUED

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART G. SUBJECT 8A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	1046	(1)	1420	(29)	1900	(1)	2023
(2)	1077	(2)	1577	(30)	1695	(2)	1090
(3)	1520	(3)	1356	(31)	1795	(3)	1038
(4)	1473	(4)	1240	(32)	1707	(4)	1523
(5)	1724	(5)	892	(32)	1929	(5)	1418
(6)	1892	(6)	2656	(34)	1687	(6)	1305
(7)	1101	(7)	1045	(35)	1485	(7)	1397
(8)	1646	(8)	1546	(36)	1810	(8)	1332
(9)	930	(9)	1764	(37)	2044	(9)	1734
(10)	1394	(10)	1605	(38)	1838	(10)	1247
(11)	1837	(11)	1374	(39)	1938	(11)	825
(12)	1340	(12)	1432	(40)	1798	(12)	864
(13)	1409	(13)	1584	(41)	1890	(13)	1413
(14)	1390	(14)	1304	(42)	1735	Mean	1324
(15)	1357	(15)	1542	(43)	1024		
(16)	2026	(16)	1967	(44)	1720		
Mean	1448	(17)	1849	(45)	1508		
		(18)	1771	(46)	1736		
		(19)	1664	(47)	1744		
		(20)	1414	(48)	1465		
		(21)	1720	(49)	2142		
		(22)	1914	(50)	1844		
		(23)	2343	(51)	1694		
		(24)	1075	(52)	1566		
		(25)	1864	(53)	1594		
		(26)	1556	(54)	1434		
		(27)	2080	(55)	1506		
		(28)	2108	(56)	1546		
				Mean	1685		

TABLE I, CONTINUED

URINARY CREATININE EXCRETION

(milligrams per 24 hours)

PART H. SUBJECT 9A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	1079	(1)	1078	(29)	1571	(1)	951
(2)	1290	(2)	1803	(30)	1623	(2)	1219
(3)	587	(3)	1471	(31)	1380	(3)	X
(4)	621	(4)	1092	(32)	1602	(4)	1300
(5)	1032	(5)	1069	(33)	1610	(5)	1245
(6)	1051	(6)	1158	(34)	1685	(6)	650
(7)	1219	(7)	2560	(35)	1634	(7)	1333
(8)	1176	(8)	1234	(36)	1534	(8)	1087
(9)	808	(9)	1495	(37)	1742	(9)	1391
(10)	873	(10)	1089	(38)	1562	(10)	1104
(11)	1126	(11)	1415	(39)	1261	(11)	1357
(12)	996	(12)	1482	(40)	1627	(12)	719
(13)	1180	(13)	1333	(41)	1787	(13)	977
(14)	748	(14)	1097	(42)	1451	Mean	1111
(15)	1302	(15)	1290	(43)	1625		
(16)	955	(16)	1592	(44)	1583		
Mean	1003	(17)	1676	(45)	1518		
		(18)	1408	(46)	1512		
		(19)	2017	(47)	1466		
		(20)	938	(48)	1333		
		(21)	1465	(49)	1610		
		(22)	1543	(50)	1479		
		(23)	1614	(51)	1772		
		(24)	924	(52)	1563		
		(25)	1261	(53)	1353		
		(26)	1538	(54)	1445		
		(27)	1800	(55)	1517		
		(28)	1604	(56)	960		
				Mean	1479		

TABLE II

URINARY CREATININE EXCRETION DURING FOUR DAILY PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART A. SUBJECT 1A

Days	12 Ncon-8 P.M. (mgs/hr.)	8 P.M. 12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	28	28	28	68	(30)	87	86	66	66
(2)	67	68	19	77	(31)	65	33	26	186
(3)	84	33	79	70	(32)	57	118	86	100
(4)	53	57	44	54	(33)	86	78	59	59
(5)	61	75	42	81	(34)	106	75	65	65
(6)	48	39	62	90	(35)	100	91	62	62
(7)	75	56	59	33	(36)	62	110	71	45
(8)	42	59	24	88	(37)	90	84	92	92
(9)	78	43	61	58	(38)	75	112	88	88
(10)	42	42	49	128	(39)	101	48	91	44

(8)	42	59	24	[illegible]	[illegible]				
(9)	78	48	61	58	(38)	75	112	88	88
(10)	42	42	49	128	(39)	101	48	91	44
(11)	49	97	62	40	(40)	94	46	28	196
(12)	66	55	80	47	(41)	85	63	20	209
(13)	73	66	61	79	(42)	62	91	19	174
(14)	88	50	39	93	(43)	99	64	18	156
(15)	57	142	75	45	(44)	63	136	77	42
(16)	29	179	59	44	(45)	42	108	80	49
(17)	63	76	67	96	(46)	77	111	13	199
(18)	87	38	63	114	(47)	81	78	26	178
(19)	77	139	67	67	(48)	59	175	14	171
(20)	42	67	53	85	(49)	77	55	19	170
(21)	94	100	63	48	(50)	93	75	13	128
(22)	108	63	77	64	(51)	125	31	25	165
(23)	86	86	33	131	(52)	23	167	75	59
(24)	59	63	6	102	(53)	108	72	51	51
(25)	59	112	73	46	(54)	63	109	70	56
(26)	80	89	78	60	(55)	33	168	25	197
(27)	01	105	78	36	(56)	84	X	X	X
(28)	74	140	72	72	Mean	72	85	53	92
(29)	86	130	73	47					

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART B. SUBJECT 2A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	21	33	33	68	(30)	68	73	67	75
(2)	24	55	36	29	(31)	72	82	34	132
(3)	82	13	71	59	(32)	56	87	78	85
(4)	72	49	38	72	(33)	60	75	64	88
(5)	105	94	55	60	(34)	90	71	54	72
(6)	65	108	60	50	(35)	61	53	77	58
(7)	63	65	25	57	(36)	58	100	72	40
(8)	70	108	52	77	(37)	98	96	62	87
(9)	71	81	31	62	(38)	60	43	59	73
(10)	65	98	46	81	(39)	73	67	79	60
(11)	76	79	81	65	(40)	63	104	62	76
(12)	28	131	57	57	(41)	70	62	77	79

(8)	70	108	52	77	(37)	98	96	62	87
(9)	71	81	31	62	(38)	60	43	59	73
(10)	65	98	46	81	(39)	73	67	79	60
(11)	76	79	81	65	(40)	63	104	62	76
(12)	28	131	57	57	(41)	70	62	77	79
(13)	67	82	51	62	(42)	76	72	65	63
(14)	46	46	56	79	(43)	63	108	53	60
(15)	38	73	76	82	(44)	79	78	49	73
(16)	43	39	71	94	(45)	45	92	63	70
(17)	79	89	85	22	(46)	85	73	30	76
(18)	52	91	45	113	(47)	91	59	80	55
(19)	56	97	53	62	(48)	63	99	52	71
(20)	57	77	64	49	(49)	76	91	71	61
(21)	63	64	72	73	(50)	31	58	65	68
(22)	97	29	71	73	(51)	84	61	71	70
(23)	81	86	69	102	(52)	49	129	62	79
(24)	27	36	46	79	(53)	122	87	54	71
(25)	66	107	59	86	(54)	66	82	57	72
(26)	45	184	55	61	(55)	117	26	87	64
(27)	77	31	85	60	(56)	33	X	X	X
(28)	56	83	53	130	Mean	66	77	60	71
(29)	70	104	59	62					

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART C. SUBJECT 3A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	28	28	28	40	(30)	25	78	27	171
(2)	33	44	51	19	(31)	47	53	53	47
(3)	61	63	40	28	(32)	30	84	76	56
(4)	28	37	42	107	(33)	56	110	51	56
(5)	53	52	55	46	(34)	84	37	20	155
(6)	84	78	34	49	(35)	35	83	32	90
(7)	57	32	45	45	(36)	90	70	63	59
(8)	51	103	33	53	(37)	59	80	34	138
(9)	68	88	58	124	(38)	66	42	24	124
(10)	56	45	25	101	(39)	79	94	26	131
(11)	47	35	31	22	(40)	33	117	63	69

(8)	51	103	33	53	(37)	59	80	34	138
(9)	68	88	58	124	(38)	66		24	124
(10)	56	45	25	101	(39)	79	94	26	131
(11)	47	35	31	22	(40)	33	117	63	69
(12)	65	67	37	37	(41)	69	87	31	127
(13)	83	68	73	51	(42)	43	106	71	89
(14)	55	36	36	91	(43)	57	93	39	39
(15)	43	32	44	61	(44)	37	139	32	94
(16)	41	61	46	92	(45)	94	61	86	90
(17)	65	77	31	120	(46)	90	78	21	145
(18)	57	98	39	74	(47)	60	67	28	142
(19)	74	90	30	53	(48)	32	113	20	128
(20)	23	44	10	75	(49)	70	65	22	95
(21)	59	78	43	96	(50)	59	83	26	101
(22)	51	94	35	112	(51)	109	41	43	125
(23)	78	65	36	83	(52)	53	68	50	67
(24)	29	86	49	49	(53)	67	93	61	61
(25)	48	52	8	351	(54)	48	86	58	66
(26)	22	44	48	77	(55)	66	88	25	124
(27)	76	55	50	96	(56)	77	X	X	X
(28)	71	70	63	63	Mean	57	71	41	88
(29)	60	69	68	46					

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART D. SUBJECT 4A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M. 12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	8	46	46	56	(30)	54	124	65	90
(2)	69	62	42	71	(31)	73	98	74	57
(3)	30	54	41	80	(32)	56	117	65	126
(4)	76	68	56	81	(33)	91	70	63	82
(5)	43	25	37	69	(34)	117	201	82	97
(6)	73	88	49	57	(35)	100	82	63	27
(7)	79	134	72	12	(36)	27	149	74	96
(8)	12	121	83	90	(37)	99	69	70	110
(9)	89	131	40	40	(38)	65	71	57	83
(10)	68	67	41	40	(39)	97	82	69	38

(8)	12	121	83	90	(37)	99	[illegible]	74	96
(9)	89	131	40	40	(38)	65	71	70	110
(10)	68	67	41	40	(39)	97	82	57	83
(11)	33	33	33	151	(40)	99	52	69	38
(12)	47	120	36	36	(41)	72	116	107	84
(13)	84	72	34	128	(42)	50	128	80	208
(14)	128	72	76	98	(43)	69	130	65	69
(15)	44	156	72	70	(44)	72	136	114	53
(16)	25	116	59	83	(45)	78	74	62	43
(17)	47	163	20	95	(46)	74	85	75	64
(18)	73	77	77	69	(47)	60	60	63	89
(19)	69	126	64	68	(48)	74	90	117	75
(20)	49	67	35	79	(49)	80	128	56	76
(21)	79	119	63	72	(50)	71	102	38	67
(22)	33	214	61	80	(51)	75	77	76	76
(23)	89	78	78	87	(52)	33	184	90	70
(24)	32	112	56	37	(53)	151	151	64	78
(25)	101	126	66	96	(54)	56	56	89	86
(26)	68	81	66	79	(55)	100	71	109	70
(27)	88	112	73	63	(56)	87	X	72	72
(28)	80	158	65	83	Mean	67	102	X	X
(29)	41	131	118	99				66	77

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART E. SUBJECT 6A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M. 12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	66	51	51	38	(30)	39	256	71	122
(2)	82	70	40	63	(31)	75	118	74	56
(3)	81	41	51	23	(32)	77	31	70	95
(4)	38	80	72	49	(33)	91	91	75	89
(5)	46	79	52	68	(34)	95	90	78	104
(6)	86	102	57	29	(35)	97	92	69	66
(7)	96	31	29	104	(36)	66	113	78	104
(8)	57	43	41	153	(37)	79	146	83	100
(9)	78	54	87	56	(38)	82	86	55	100
(10)	80	69	40	75	(39)	98	109	72	88
(11)	80	83	48	39	(40)	60	91	115	100
(12)	48	47	80	74	(41)	58	140	98	90

(8)	57	43	41	153	(37)	79	146	83	100
(9)	78	54	87	56	(38)	82	[illegible]	55	100
(10)	80	69	40	75	(39)	98	109	72	88
(11)	80	83	48	39	(40)	60	91	115	100
(12)	48	47	80	74	(41)	58	140	98	98
(13)	92	86	46	46	(42)	15	179	107	113
(14)	77	39	82	94	(43)	113	14	7	28
(15)	42	47	33	82	(44)	82	97	89	160
(16)	50	151	76	106	(45)	56	164	76	83
(17)	73	129	83	105	(46)	112	100	84	86
(18)	28	148	95	108	(47)	76	109	74	82
(19)	31	71	84	68	(48)	74	74	78	64
(20)	35	79	28	29	(49)	67	105	92	74
(21)	64	94	78	36	(50)	60	132	83	45
(22)	102	110	70	85	(51)	52	79	72	82
(23)	173	134	89	33	(52)	39	127	77	88
(24)	28	44	73	68	(53)	97	73	72	112
(25)	62	107	77	69	(54)	51	177	72	44
(26)	72	107	69	78	(55)	85	126	75	82
(27)	90	84	105	54	(56)	86	X	X	X
(28)	51	191	79	98	Mean	69	99	71	78
(29)	49	127	73	71					

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART F. SUBJECT 7A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	52	83	83	90	(30)	103	120	95	68
(2)	71	58	74	64	(31)	100	102	65	53
(3)	43	98	54	78	(32)	83	117	79	104
(4)	62	63	72	41	(33)	93	94	74	76
(5)	27	93	61	56	(34)	105	71	121	114
(6)	72	94	71	91	(35)	95	134	82	68
(7)	75	76	91	83	(36)	68	129	89	80
(8)	95	92	95	70	(37)	93	88	13	339
(9)	75	133	53	93	(38)	29	82	34	181
(10)	67	108	70	103	(39)	91	109	53	152
(11)	118	50	70	28	(40)	74	69	32	188

(8)	95	92	95	70	(37)	93	88	13	339
(9)	75	133	53	93	(38)	29	82	34	181
(10)	67	108	70	103	(39)	91	109	53	152
(11)	118	50	70	28	(40)	74	69	32	188
(12)	93	39	104	82	(41)	62	92	103	97
(13)	86	81	44	83	(42)	72	46	84	45
(14)	74	46	79	71	(43)	61	79	16	179
(15)	119	89	83	27	(44)	95	74	63	113
(16)	90	79	76	72	(45)	108	63	27	183
(17)	95	141	107	94	(46)	114	60	29	169
(18)	32	164	21	191	(47)	115	140	33	138
(19)	69	143	83	101	(48)	60	158	78	61
(20)	30	59	60	38	(49)	98	62	112	74
(21)	103	101	94	60	(50)	73	72	41	143
(22)	75	69	65	169	(51)	91	77	53	123
(23)	95	86	63	26	(52)	113	82	75	59
(24)	35	87	84	46	(53)	43	73	104	161
(25)	70	93	18	199	(54)	66	166	85	34
(26)	60	149	82	72	(55)	95	99	26	228
(27)	118	60	101	79	(56)	85	X	X	X
(28)	68	84	107	94	Mean	79	93	69	103
(29)	89	113	58	116					

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART G. SUBJECT 8A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	38	55	55	61	(30)	57	107	67	70
(2)	76	54	60	69	(31)	96	65	28	137
(3)	107	37	15	58	(32)	63	92	65	80
(4)	65	47	53	27	(33)	95	81	71	69
(5)	38	86	18	25	(34)	83	28	63	103
(6)	75	47	68	109	(35)	99	70	20	64
(7)	102	63	66	38	(36)	64	128	59	79
(8)	69	50	54	91	(37)	86	126	62	91
(9)	63	79	79	78	(38)	79	78	65	94

(8)	69	50	54	91	(37)	86	126	62	91
(9)	63	79	79	78	(38)	79	78	65	94
(10)	74	63	51	90	(39)	113	76	54	75
(11)	85	49	50	25	(40)	82	23	99	66
(12)	55	66	68	48	(41)	85	58	79	89
(13)	74	71	54	70	(42)	81	66	55	97
(14)	43	51	58	51	(43)	38	52	31	68
(15)	64	62	58	80	(44)	79	57	66	86
(16)	63	65	95	111	(45)	47	87	62	73
(17)	65	143	65	64	(46)	85	73	56	78
(18)	73	96	69	60	(47)	77	105	59	61
(19)	60	64	84	64	(48)	57	74	59	64
(20)	44	114	62	28	(49)	85	125	85	70
(21)	57	87	69	92	(50)	74	122	58	75
(22)	93	71	67	86	(51)	71	41	88	66
(23)	107	69	111	83	(52)	67	76	45	88
(24)	32	46	59	42	(53)	54	117	52	70
(25)	81	104	57	85	(54)	44	81	55	81
(26)	66	96	46	69	(55)	26	97	79	63
(27)	107	56	91	68	(56)	77	X	X	X
(28)	85	121	74	88	Mean	71	77	62	74
(29)	73	94	75	88					

TABLE II, CONTINUED

URINARY CREATININE EXCRETION DURING FOUR DAILY PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART H. SUBJECT 9A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	32	45	45	67	(30)	65	94	52	77
(2)	133	46	48	44	(31)	81	63	25	70
(3)	79	80	48	35	(32)	58	120	51	61
(4)	35	113	24	41	(33)	74	48	72	63
(5)	42	27	57	44	(34)	72	72	72	59
(6)	48	60	61	14	(35)	88	51	61	60
(7)	61	112	38	41	(36)	60	102	50	58
(8)	43	68	45	66	(37)	73	53	76	84
(9)	67	90	7	137	(38)	65	87	52	68
(10)	45	51	46	44	(39)	43	59	58	55
(11)	64	72	51	52	(40)	70	59	76	58

(9)	67	90	7	137	(38)	65	87	52	68
(10)	45	51	46	44	(39)	43	59	58	55
(11)	64	72	51	52	(40)	70	59	76	58
(12)	68	83	56	41	(41)	74	55	77	86
(13)	83	51	34	48	(42)	57	34	73	58
(14)	42	71	26	68	(43)	73	85	66	44
(15)	33	40	81	55	(44)	66	82	59	64
(16)	55	55	75	84	(45)	76	68	48	64
(17)	80	81	76	25	(46)	64	89	25	112
(18)	44	85	49	81	(47)	72	78	47	66
(19)	56	240	47	59	(48)	57	58	50	62
(20)	34	59	25	60	(49)	71	79	62	60
(21)	60	110	53	29	(50)	69	77	68	46
(22)	76	57	55	67	(51)	76	79	80	52
(23)	79	98	57	33	(52)	58	86	58	73
(24)	41	29	40	42	(53)	27	109	41	95
(25)	38	59	54	72	(54)	65	63	58	53
(26)	67	116	38	59	(55)	67	46	68	64
(27)	102	37	75	60	(56)	46	x	x	x
(28)	58	64	71	79	Mean	63	74	54	60
(29)	82	64	58	45					

TABLE III

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION BETWEEN PAIRS OF THE DIFFERENT PERIODS OF THE STUDY

PART A. SUBJECTS 2A, 6A, 7A (Exercised Throughout the Study, Individual Data)

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Subject 2A				
Pre-Bed Rest	1048	207	7.6736	P < 0.001
Bed Rest	1587	250		
Pre-Bed Rest	1048	207	1.4629	N.S.
Post-Bed Rest	882	354		
Bed Rest	1587	250	8.1174	P < 0.001
Post-Bed Rest	882	354		
Subject 6A				
Pre-Bed Rest	1617	291	2.4525	P < 0.02
Bed Rest	1839	317		
Pre-Bed Rest	1617	291	1.9213	P < 0.10
Post-Bed Rest	1842	294		
Bed Rest	1839	317	0.0256	N.S.
Post-Bed Rest	1842	294		
Subject 7A				
Pre-Bed Rest	1325	514	6.0156	P < 0.001
Bed Rest	1959	291		
Pre-Bed Rest	1325	514	0.4573	N.S.
Post-Bed Rest	1416	460		
Bed Rest	1959	291	5.1635	P < 0.001
Post-Bed Rest	1416	460		

TABLE III, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION BETWEEN PAIRS OF THE DIFFERENT PERIODS OF THE STUDY

PART B. SUBJECTS 2A, 6A, 7A (Exercised Throughout the Study, Combined Data)

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Pre-Bed Rest	1330	427	7.9467	$P < 0.001$
Bed Rest	1795	327		
Pre-Bed Rest	1330	427	0.4670	N.S.
Post-Bed Rest	1380	544		
Bed Rest	1795	327	6.1189	$P < 0.001$
Post-Bed Rest	1380	544		

TABLE III, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION BETWEEN PAIRS OF THE DIFFERENT PERIODS OF THE STUDY

PART C. SUBJECTS 4A, 8A, 9A (Did not exercise, Individual Data)

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Subject 4A				
Pre-Bed Rest	1181	279	6.3337	P<0.001
Bed Rest	1785	340		
Pre-Bed Rest	1181	279	1.2461	N.S.
Post-Bed Rest	1364	450		
Bed Rest	1785	340	3.6433	P<0.001
Post-Bed Rest	1364	450		
Subject 8A				
Pre-Bed Rest	1448	308	2.6676	P<0.01
Bed Rest	1685	304		
Pre-Bed Rest	1448	308	0.9851	N.S.
Post-Bed Rest	1324	319		
Bed Rest	1685	304	3.7078	P<0.001
Post Bed Rest	1324	319		
Subject 9A				
Pre-Bed Rest	1003	216	6.2182	P<0.001
Bed Rest	1479	275		
Pre-Bed Rest	1003	216	1.1744	N.S.
Post-Bed Rest	1111	235		
Bed Rest	1479	275	4.1862	P<0.001
Post-Bed Rest	1111	235		

TABLE III, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION BETWEEN PAIRS OF THE DIFFERENT PERIODS OF THE STUDY

PART D. SUBJECTS 4A, 8A, 9A (Did NOT Exercise, Combined Data)

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Pre-Bed Rest	1210	327	8.0252	P<0.001
Bed Rest	1650	333		
Pre-Bed Rest	1210	327	0.7847	N.S.
Post-Bed Rest	1270	365		
Bed Rest	1650	333	6.1660	P<0.001
Post-Bed Rest	1270	365		

TABLE III, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION BETWEEN PAIRS OF THE DIFFERENT PERIODS OF THE STUDY FOR SUBJECTS WHO EXERCISED 28 DAYS EACH

(Subject 3A - First 28 Days,
Subject 1A - Second Half
of Study)

PART E. SUBJECTS 1A, 3A

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Subject 1A				
Pre-Bed Rest	1199	446	5.3426	P<0.001
Bed Rest	1702	266		
Pre-Bed Rest	1199	446	1.0259	N.S.
Post-Bed Rest	942	674		
Bed Rest	1702	266	5.7179	P<0.001
Post-Bed Rest	942	674		
Subject 3A				
Pre-Bed Rest	943	414	5.1296	P<0.001
Bed Rest	1423	287		
Pre-Bed Rest	943	414	1.0394	N.S.
Post-Bed Rest	1104	347		
Bed Rest	1423	287	3.3564	P<0.001
Post-Bed Rest	1104	347		

TABLE III, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION BETWEEN PAIRS OF THE DIFFERENT PERIODS OF THE STUDY

PART F. ALL SUBJECTS

POPULATIONS COMPARED	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Pre-Bed Rest	1220	411	12.8712	P<0.001
Bed Rest	1682	338		
Pre-Bed Rest	1220	411	0.6932	N.S.
Post-Bed Rest	1262	493		
Bed Rest	1682	338	10.1697	P<0.001
Post-Bed Rest	1262	493		

TABLE IV

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

(Data for Individual Subjects)

PART A. SUBJECT 2A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.	66	21	2.3988	P<0.020
8 P.M. - 12 Midnight	77	29		
12 Noon - 8 P.M.	66	21	1.5693	N.S.
12 Midnight - 8 A.M.	60	15		
12 Noon - 8 P.M.	66	21	1.4384	N.S.
8 A.M. - 12 Noon	71	19		
8 P.M. - 12 Midnight	77	29	3.8533	P<0.001
12 Midnight - 8 A.M.	60	15		
8 P.M. - 12 Midnight	77	29	1.3057	N.S.
8 A.M. - 12 Noon	71	19		
12 Midnight - 8 A.M.	60	15	3.3735	P<0.001
8 A.M. - 12 Noon	71	19		

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART B. SUBJECT 6A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	69 99	23 46	4.3581	P<0.001
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	69 71	23 21	0.4097	N.S.
12 Noon - 8 P.M. 8 A.M. - 12 Noon	69 78	23 30	1.7025	P<0.101
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	99 71	46 21	4.1507	P<0.001
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	99 78	46 30	2.8911	P<0.01
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	71 78	21 30	1.4022	N.S.

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART C. SUBJECT 7A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.	79	24	2.4663	P<0.02
8 P.M. - 12 Midnight	93	31		
12 Noon - 8 P.M.	79	24	2.1226	P<0.05
12 Midnight - 8 A.M.	69	27		
12 Noon - 8 P.M.	79	24	2.6849	P<0.01
8 A.M. - 12 Noon	103	59		
8 P.M. - 12 Midnight	93	31	4.1990	P<0.001
12 Midnight - 8 A.M.	69	27		
8 P.M. - 12 Midnight	93	31	1.1075	N.S.
8 A.M. - 12 Noon	103	59		
12 Midnight - 8 A.M.	69	27	3.7892	P<0.001
8 A.M. - 12 Noon	103	59		

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART D. SUBJECTS 2A, 6A, 7A (Exercised Throughout the Study, Combined Data)

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.	71	23	5.3928	P<0.001
8 P.M. - 12 Midnight	90	37		
12 Noon - 8 P.M.	71	23	1.9130	P<0.10
12 Midnight - 8 A.M.	66	22		
12 Noon - 8 P.M.	71	23	3.3534	P<0.001
8 A.M. - 12 Noon	84	42		
8 P.M. 12 Midnight	90	37	6.8660	P<0.001
12 Midnight - 8 A.M.	66	22		
8 P.M. - 12 Midnight	90	37	1.3492	N.S.
8 A.M. - 12 Noon	84	42		
12 Midnight - 8 A.M.	66	22	4.6687	P<0.001
8 A.M. - 12 Noon	84	42		

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART E. SUBJECT 4A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	67 102	28 41		
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	67 66	28 21	0.1982	N.S.
12 Noon - 8 P.M. 8 A.M. - 12 Noon	67 77	28 30	1.8979	P<0.10
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	102 66	41 21	5.8056	P<0.001
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	102 77	41 30	3.6035	P<0.001
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	66 77	21 30	2.2768	P<0.05

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART F. SUBJECT 8A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	71 77	20 27	1.1044	N.S.
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	71 62	20 18	2.5212	P<0.02
12 Noon - 8 P.M. 8 A.M. - 12 Noon	71 74	20 21	0.6368	N.S.
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	77 62	27 18	3.1880	P<0.01
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	77 74	27 21	0.5495	N.S.
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	62 74	18 21	3.1055	P<0.01

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART G. SUBJECT 9A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	63 74	19 32	2.1097	$P < 0.05$
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	63 54	19 16	2.6937	$P < 0.01$
12 Noon - 8 P.M. 8 A.M. - 12 Noon	63 60	19 20	0.8036	N.S.
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	74 54	32 16	4.0279	$P < 0.001$
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	74 60	32 20	2.6402	$P < 0.01$
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	54 60	16 20	1.7244	$P < 0.10$

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART H. SUBJECTS 4A, 8A, 9A (Did NOT Exercise, Combined Data)

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	67 84	23 36	5.1668	P<0.001
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	67 61	23 19	2.7778	P<0.01
12 Noon - 8 P.M. 8 A.M. - 12 Noon	67 70	23 25	1.2698	N.S.
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	84 61	36 19	7.3580	P<0.001
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	84 70	36 25	3.9959	P<0.001
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	61 70	19 25	3.9426	P<0.001

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART I. SUBJECT 3A (Exercised First 28 Days of Study)

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	57 71	20 25	3.2392	$P < 0.01$
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	57 41	20 17	4.4808	$P < 0.001$
12 Noon - 8 P.M. 8 A.M. - 12 Noon	57 88	20 51	4.1680	$P < 0.001$
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	71 41	25 17	7.2932	$P < 0.001$
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	71 88	25 51	2.1978	$P < 0.05$
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	41 88	17 51	6.3680	$P < 0.001$

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART J. SUBJECT 1A (Exercised Second Half of Study)

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.	72	22	2.1176	$P < 0.05$
8 P.M. - 12 Midnight	85	38		
12 Noon - 8 P.M.	72	22	4.2526	$P < 0.001$
12 Midnight - 8 A.M.	53	24		
12 Noon - 8 P.M.	72	22	2.6146	$P < 0.01$
8 A.M. - 12 Noon	92	50		
8 P.M. - 12 Midnight	85	38	5.1296	$P < 0.001$
12 Midnight - 8 A.M.	53	24		
8 P.M. - 12 Midnight	85	38	0.7837	N.S.
8 A.M. - 12 Noon	92	50		
12 Midnight - 8 A.M.	53	24	5.0525	$P < 0.001$
8 A.M. - 12 Noon	92	50		

TABLE IV, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY

PART K. ALL 8 SUBJECTS

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M. 8 P.M. - 12 Midnight	68 85	23 36	8.2179	P<0.001
12 Noon - 8 P.M. 12 Midnight - 8 A.M.	68 59	23 22	5.6467	P<0.001
12 Noon - 8 P.M. 8 A.M. - 12 Noon	68 80	23 40	5.5998	P<0.001
8 P.M. - 12 Midnight 12 Midnight - 8 A.M.	85 59	36 22	12.4914	P<0.001
8 P.M. - 12 Midnight 8 A.M. - 12 Noon	85 80	36 40	1.7175	P<0.10
12 Midnight - 8 A.M. 8 A.M. - 12 Noon	59 80	22 40	9.5390	P<0.001

TABLE V

STATISTICAL COMPARISON OF URINARY CREATININE

EXCRETION DURING BED REST BY SUBJECTS

WHO EXERCISED 28 DAYS EACH

(Subject 3A - First 28 Days,

Subject 1A - Second Half of Study)

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Proba-bility
Subject 1A				
No Exercise	1589	294	3.5324	$P < 0.001$
Exercise	1823	160		
Subject 3A				
No Exercise	1539	202	3.0334	$P < 0.010$
Exercise	1316	312		

TABLE VI

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY DURING BED REST BY SUBJECTS WHO EXERCISED 28 DAYS EACH

(Subject 3A - First 28 Days,
Subject 1A - Second Half of Study)

PART A. SUBJECT 3A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.				
No Exercise	62	21	1.6635	$P < 0.100$
Exercise	53	18		
8 P.M. - 12 Midnight				
No Exercise	82	24	2.9936	$P < 0.010$
Exercise	62	21		
12 Midnight - 8 A.M.				
No Exercise	42	19	0.3602	N.S.
Exercise	40	14		
8 A.M. - 12 Noon				
No Exercise	97	34	1.1075	N.S.
Exercise	81	61		

TABLE VI, CONTINUED

STATISTICAL COMPARISON OF URINARY CREATININE EXCRETION AT DIFFERENT TIMES OF THE DAY DURING BED REST BY SUBJECTS WHO EXERCISED 28 DAYS EACH

(Subject 3A - First 28 Days,
Subject 1A - Second Half of Study)

PART B. SUBJECT 1A

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.				
No Exercise	68	20	1.5164	N.S.
Exercise	77	24		
8 P.M. - 12 Midnight				
No Exercise	80	37	1.1570	N.S.
Exercise	92	39		
12 Midnight - 8 A.M.				
No Exercise	57	20	1.1223	N.S.
Exercise	49	28		
8 A.M. - 12 Noon				
No Exercise	71	25	3.6655	$P < 0.001$
Exercise	117	60		

TABLE VII

STATISTICAL COMPARISON BETWEEN URINARY CREATININE EXCRETION OF GROUPS OF SUBJECTS WHO EXERCISED (2A, 6A, 7A) AND WHO DID NOT EXERCISE (4A, 8A, 9A) THROUGHOUT BED REST

Populations Compared	Means (mg/24 hrs.)	Standard Deviation	"t" Value	Probability
Exercisers	1795	327	4.0115	$P < 0.001$
Non-Exercisers	1650	333		

TABLE VIII

STATISTICAL COMPARISON BETWEEN URINARY CREATININE EXCRETION OF GROUPS OF SUBJECTS WHO EXERCISED (2A, 6A, 7A) AND WHO DID NOT EXERCISE (4A, 8A, 9A) THROUGHOUT BED REST

Populations Compared	Means (mg/hr.)	Standard Deviation	"t" Value	Probability
12 Noon - 8 P.M.				
Exercisers	71	23	1.6548	$P<0.1$
Non-Exercisers	67	23		
8 P.M. - 12 Midnight				
Exercisers	90	37	1.3325	N.S.
Non-Exercisers	84	36		
12 Midnight - 8 A.M.				
Exercisers	66	22	2.5809	$P<0.01$
Non-Exercisers	60	19		
8 A.M. - 12 Noon				
Exercisers	84	42	3.4765	$P<0.001$
Non-Exercisers	70	25		

URINARY EXCRETION OF CREATINE

Since creatinine has been found to be higher during Bed Rest than during the ambulatory periods of pre- and post-Bed Rest, similar analyses have been made on creatine.

The mean urinary creatine excretion values in terms of milligrams per 24 hours are given in Table I, Parts A through H for each man, for the pre-Bed Rest, the Bed Rest, and the post-Bed Rest. An overall series of the means is given in Summary A. The mean values for the three periods show clearly that a higher amount of urinary creatine is excreted during the Bed Rest than during either of the ambulatory periods.

SUMMARY A - MEAN URINARY CREATINE EXCRETION

(Milligrams per 24 Hours)

Subject	Pre-Bed Rest	Bed Rest	Post-Bed Rest
1A	148	173	155
2A	124	325	177
3A	85	463	174
4A	141	338	257
6A	174	345	303
7A	178	717	345
8A	147	342	228
9A	101	432	206
Overall Mean	137.3	392	231

As in the case of creatinine, the mean urinary creatine excretion was analyzed for four periods during the 24 hours of the day and night, while Bed Rest was in progress. Also, like creatinine, the highest amount of urinary creatine was excreted from 8 P.M. until Midnight, while the smallest amount was found from 12 Midnight until 8 A.M. while Bed Rest recumbency was in progress.

The Rank Order of the quantity of creatine excretion during Bed Rest, with all of the values of the eight experimental subjects pooled was the following:

Rank 1. 8 P.M. until Midnight;

Rank 2 and 3. 12 Noon until 3 A.M. and 8 A.M. until Noon (tied); and

Rank 4. 12 Midnight until 8 A.M.

See Summary B.

Table I, Parts A - H, Appendix, gives the full data on urinary excretion during pre-Bed Rest, Bed Rest, and post-Bed Rest for individual subjects participating in this investigation.

Table II, Parts A - H, Appendix, outlines the data on urinary creatine excretion during four daily periods throughout the 56 days of Bed Rest covered in the investigation covered by this Report.

SUMMARY B - MEAN URINARY CREATINE EXCRETION DURING FOUR DAILY PERIODS THROUGHOUT THE BED REST

(Milligrams per Hour during Each Period)

Subject	Periods of Day throughout the Bed Rest Period			
	12 Noon - 8 P.M.	8 P.M. - 12 Midnight	12 Midnight - 8 A.M.	8 A.M. - 12 Noon
1A	14.5	15.6	9.1	14.6
2A	13.7	15.7	11.9	14.8
3A	22.0	27.1	10.1	25.1
4A	13.4	19.5	12.1	14.6
6A	13.0	18.9	14.2	13.3
7A	33.9	38.7	21.4	31.4
8A	14.8	15.1	12.7	15.2
9A	22.1	23.1	12.0	17.7
Total Mean	18.4	21.7	12.9	18.3

APPENDIX

TABLE I

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART A. SUBJECT JA

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	144	(1)	125	(29)	530	(1)	240
(2)	X	(2)	244	(30)	283	(2)	130
(3)	96	(3)	162	(31)	304	(3)	123
(4)	111	(4)	112	(32)	380	(4)	83
(5)	231	(5)	118	(33)	338	(5)	125
(6)	64	(6)	138	(34)	374	(6)	X
(7)	165	(7)	179	(35)	473	(7)	151
(8)	56	(8)	140	(36)	360	(8)	47
(9)	183	(9)	221	(37)	400	(9)	102
(10)	29	(10)	344	(38)	306	(10)	403
(11)	307	(11)	261	(39)	572	(11)	X
(12)	136	(12)	303	(40)	363	(12)	143
(13)	155	(13)	271	(41)	361	(13)	X
(14)	302	(14)	356	(42)	373	Mean	155
(15)	145	(15)	220	(43)	397		
(16)	238	(16)	248	(44)	342		
Mean	148	(17)	268	(45)	399		
		(18)	381	(46)	301		
		(19)	388	(47)	352		
		(20)	338	(48)	287		
		(21)	349	(49)	217		
		(22)	350	(50)	327		
		(23)	308	(51)	415		
		(24)	217	(52)	321		
		(25)	239	(53)	304		
		(26)	303	(54)	274		
		(27)	388	(55)	395		
		(28)	314	(56)	240		
				Mean	173		

TABLE I. CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART B. SUBJECT 2A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	190	(1)	74	(29)	391	(1)	114
(2)	153	(2)	120	(30)	399	(2)	235
(3)	141	(3)	123	(31)	371	(3)	268
(4)	56	(4)	125	(32)	359	(4)	339
(5)	97	(5)	135	(33)	431	(5)	100
(6)	146	(6)	186	(34)	395	(6)	91
(7)	56	(7)	177	(35)	564	(7)	298
(8)	102	(8)	168	(36)	575	(8)	66
(9)	50	(9)	202	(37)	549	(9)	266
(10)	130	(10)	400	(38)	250	(10)	252
(11)	146	(11)	211	(39)	349	(11)	136
(12)	136	(12)	334	(40)	419	(12)	51
(13)	152	(13)	256	(41)	316	(13)	89
(14)	127	(14)	249	(42)	340	Mean	177
(15)	150	(15)	358	(43)	405		
(16)	152	(16)	293	(44)	330		
Mean	124	(17)	523	(45)	323		
		(18)	311	(46)	314		
		(19)	313	(47)	398		
		(20)	267	(48)	282		
		(21)	308	(49)	369		
		(22)	311	(50)	350		
		(23)	360	(51)	421		
		(24)	299	(52)	329		
		(25)	394	(53)	380		
		(26)	371	(54)	308		
		(27)	509	(55)	342		
		(28)	439	(56)	128		
				Mean	325		

TABLE 1. CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART C. SUBJECT 3A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	59	(1)	139	(29)	598	(1)	147
(2)	42	(2)	154	(30)	475	(2)	184
(3)	130	(3)	167	(31)	607	(3)	113
(4)	89	(4)	149	(32)	550	(4)	229
(5)	127	(5)	171	(33)	584	(5)	117
(6)	33	(6)	173	(34)	435	(6)	215
(7)	65	(7)	177	(35)	561	(7)	95
(8)	72	(8)	250	(36)	505	(8)	238
(9)	86	(9)	469	(37)	621	(9)	229
(10)	11	(10)	328	(38)	603	(10)	248
(11)	78	(11)	525	(39)	869	(11)	151
(12)	223	(12)	377	(40)	597	(12)	119
(13)	89	(13)	678	(41)	694	(13)	176
(14)	67	(14)	478	(42)	567	Mean	174
(15)	112	(15)	555	(43)	438		
(16)	84	(16)	424	(44)	491		
Mean	85	(17)	517	(45)	525		
		(18)	522	(46)	541		
		(19)	431	(47)	639		
		(20)	464	(48)	469		
		(21)	473	(49)	238		
		(22)	801	(50)	497		
		(23)	575	(51)	565		
		(24)	349	(52)	414		
		(25)	472	(53)	570		
		(26)	351	(54)	438		
		(27)	552	(55)	417		
		(28)	370	(56)	344		
				Mean	463		

TABLE 1. CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART D. SUBJECT 4A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	89	(1)	136	(29)	284	(1)	226
(2)	179	(2)	211	(30)	320	(2)	196
(3)	180	(3)	187	(31)	407	(3)	135
(4)	133	(4)	158	(32)	240	(4)	307
(5)	80	(5)	131	(33)	393	(5)	135
(6)	231	(6)	215	(34)	416	(6)	322
(7)	253	(7)	211	(35)	374	(7)	344
(8)	119	(8)	230	(36)	417	(8)	227
(9)	92	(9)	341	(37)	430	(9)	394
(10)	98	(10)	358	(38)	302	(10)	220
(11)	104	(11)	444	(39)	467	(11)	212
(12)	117	(12)	212	(40)	371	(12)	437
(13)	141	(13)	230	(41)	430	(13)	182
(14)	92	(14)	301	(42)	352	Mean	257
(15)	142	(15)	315	(43)	497		
(16)	201	(16)	306	(44)	342		
Mean	141	(17)	339	(45)	474		
		(18)	357	(46)	457		
		(19)	332	(47)	536		
		(20)	213	(48)	455		
		(21)	368	(49)	419		
		(22)	314	(50)	419		
		(23)	335	(51)	492		
		(24)	157	(52)	469		
		(25)	453	(53)	429		
		(26)	231	(54)	349		
		(27)	407	(55)	335		
		(28)	284	(56)	283		
				Mean	338		

TABLE 1. CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART E. SUBJECT 6A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	37	(1)	160	(29)	469	(1)	250
(2)	186	(2)	177	(30)	518	(2)	301
(3)	133	(3)	117	(31)	292	(3)	331
(4)	198	(4)	158	(32)	479	(4)	281
(5)	105	(5)	127	(33)	300	(5)	251
(6)	159	(6)	169	(34)	949	(6)	392
(7)	176	(7)	131	(35)	363	(7)	232
(8)	189	(8)	220	(36)	372	(8)	373
(9)	220	(9)	211	(37)	335	(9)	324
(10)	135	(10)	253	(38)	401	(10)	285
(11)	107	(11)	378	(39)	360	(11)	302
(12)	141	(12)	499	(40)	370	(12)	301
(13)	171	(13)	204	(41)	343	(13)	316
(14)	203	(14)	436	(42)	348	Mean	303
(15)	247	(15)	351	(43)	373		
(16)	377	(16)	275	(44)	458		
Mean	174	(17)	344	(45)	335		
		(18)	473	(46)	487		
		(19)	286	(47)	340		
		(20)	321	(48)	375		
		(21)	189	(49)	307		
		(22)	379	(50)	425		
		(23)	464	(51)	404		
		(24)	258	(52)	341		
		(25)	428	(53)	333		
		(26)	355	(54)	380		
		(27)	570	(55)	294		
		(28)	333	(56)	309		
				Mean	345		

TABLE 1, CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART E. SUBJECT 7A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	X	(1)	233	(29)	937	(1)	508
(2)	194	(2)	248	(30)	1384	(2)	588
(3)	110	(3)	253	(31)	930	(3)	554
(4)	72	(4)	212	(32)	923	(4)	464
(5)	200	(5)	305	(33)	940	(5)	220
(6)	273	(6)	432	(34)	1221	(6)	387
(7)	91	(7)	571	(35)	986	(7)	410
(8)	258	(8)	650	(36)	778	(8)	158
(9)	150	(9)	683	(37)	793	(9)	272
(10)	188	(10)	697	(38)	710	(10)	113
(11)	112	(11)	849	(39)	976	(11)	287
(12)	230	(12)	383	(40)	721	(12)	198
(13)	161	(13)	472	(41)	698	(13)	329
(14)	166	(14)	43	(42)	574	Mean	345
(15)	206	(15)	747	(43)	599		
(16)	263	(16)	836	(44)	783		
Mean	178	(17)	978	(45)	911		
		(18)	834	(46)	746		
		(19)	850	(47)	820		
		(20)	726	(48)	681		
		(21)	898	(49)	665		
		(22)	1142	(50)	636		
		(23)	879	(51)	595		
		(24)	540	(52)	565		
		(25)	677	(53)	486		
		(26)	787	(54)	748		
		(27)	991	(55)	758		
		(28)	962	(56)	345		
				Mean	717		

TABLE I. CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART G. SUBJECT 8A

Pre-Bed Rest		Bed Rest		Bed Rest		Post-Bed Rest	
(1)	73	(1)	191	(29)	619	(1)	313
(2)	202	(2)	212	(30)	307	(2)	216
(3)	215	(3)	195	(31)	409	(3)	152
(4)	145	(4)	208	(32)	373	(4)	190
(5)	92	(5)	136	(33)	332	(5)	266
(6)	121	(6)	178	(34)	355	(6)	246
(7)	108	(7)	214	(35)	403	(7)	139
(8)	161	(8)	195	(36)	484	(8)	292
(9)	89	(9)	367	(37)	445	(9)	333
(10)	122	(10)	206	(38)	404	(10)	271
(11)	135	(11)	254	(39)	459	(11)	131
(12)	147	(12)	281	(40)	348	(12)	266
(13)	181	(13)	442	(41)	344	(13)	152
(14)	67	(14)	371	(42)	284	Mean	228
(15)	147	(15)	394	(43)	339		
(16)	352	(16)	371	(44)	385		
Mean	147	(17)	303	(45)	328		
		(18)	434	(46)	353		
		(19)	409	(47)	359		
		(20)	284	(48)	319		
		(21)	290	(49)	324		
		(22)	314	(50)	343		
		(23)	396	(51)	339		
		(24)	293	(52)	322		
		(25)	477	(53)	281		
		(26)	570	(54)	239		
		(27)	501	(55)	270		
		(28)	515	(56)	263		
				Mean	342		

TABLE 1, CONTINUED

URINARY CREATINE EXCRETION

(milligrams per 24 hours)

PART H. SUBJECT 9A

Pre-Bed Rest		Bed Rest				Post-Bed Rest	
(1)	74	(1)	52	(29)	900	(1)	239
(2)	28	(2)	263	(30)	758	(2)	284
(3)	65	(3)	107	(31)	734	(3)	230
(4)	59	(4)	187	(32)	470	(4)	197
(5)	90	(5)	189	(33)	629	(5)	205
(6)	130	(6)	195	(34)	520	(6)	74
(7)	202	(7)	166	(35)	624	(7)	190
(8)	122	(8)	132	(36)	467	(8)	149
(9)	76	(9)	284	(37)	700	(9)	288
(10)	66	(10)	194	(38)	523	(10)	238
(11)	109	(11)	368	(39)	361	(11)	243
(12)	89	(12)	341	(40)	317	(12)	156
(13)	126	(13)	446	(41)	550	(13)	180
(14)	96	(14)	291	(42)	450	Mean	206
(15)	125	(15)	478	(43)	372		
(16)	155	(16)	442	(44)	358		
Mean	101	(17)	529	(45)	357		
		(18)	362	(46)	372		
		(19)	755	(47)	393		
		(20)	552	(48)	245		
		(21)	560	(49)	429		
		(22)	682	(50)	464		
		(23)	646	(51)	511		
		(24)	289	(52)	381		
		(25)	484	(53)	533		
		(26)	539	(54)	563		
		(27)	635	(55)	351		
		(28)	473	(56)	215		
				Mean	432		

TABLE 11

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART A. SUBJECT 1A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M. 12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night 8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	3.6	3.6	3.6	13.8	(30)	14.2	12.0	10.1	10.1
(2)	10.2	14.2	9.8	6.8	(31)	12.2	7.0	5.2	34.0
(3)	5.2	3.2	9.4	8.0	(32)	8.9	30.2	18.2	10.5
(4)	3.0	7.2	4.9	5.0	(33)	19.6	10.0	11.7	11.7
(5)	1.8	6.8	7.1	5.0	(34)	13.0	11.8	18.6	18.6
(6)	4.4	7.8	5.9	6.2	(35)	17.2	31.8	17.4	17.4
(7)	5.1	11.0	11.1	1.2	(36)	17.4	10.8	19.0	6.5
(8)	3.8	7.5	5.5	9.0	(37)	13.4	29.2	14.7	14.7
(9)	8.5	18.0	6.0	8.2	(38)	16.2	16.0	9.3	9.3
(10)	10.0	6.2	22.1	15.5	(39)	45.2	13.0	16.0	7.5
(11)	8.8	17.0	14.6	1.5	(40)	19.0	13.2	5.2	29.0
(12)	22.1	6.8	8.9	7.0	(41)	15.6	10.5	2.8	43.0
(13)	13.4	13.8	9.5	8.2	(42)	22.9	15.0	2.0	27.0

(7)	5.1	11.0	11.1	1.2	(36)	17.4	10.0		
(8)	3.8	7.5	5.5	9.0	(37)	13.4	2	14.7	14.7
(9)	8.5	18.0	6.0	8.2	(38)	16.2	16.0	9.3	9.3
(10)	10.0	6.2	22.1	15.5	(39)	45.2	13.0	16.0	7.5
(11)	8.8	17.0	14.6	1.5	(40)	19.0	13.2	5.2	29.0
(12)	22.1	6.8	8.9	7.0	(41)	15.6	10.5	2.8	43.0
(13)	13.4	13.8	9.5	8.2	(42)	22.9	15.0	2.8	27.0
(14)	19.5	17.5	10.1	12.2	(43)	28.2	14.8	2.2	23.5
(15)	7.8	12.5	8.8	9.5	(44)	10.8	34.2	9.2	11.2
(16)	9.1	16.5	6.8	13.8	(45)	11.2	19.0	21.5	15.2
(17)	9.9	11.8	11.8	12.0	(46)	14.1	12.0	1.9	31.2
(18)	22.9	11.5	9.1	19.8	(47)	18.1	13.5	3.5	31.2
(19)	14.8	34.8	10.9	10.9	(48)	9.1	27.0	2.2	22.0
(20)	20.2	22.8	6.8	7.8	(49)	10.5	7.5	2.4	21.0
(21)	24.2	11.0	9.6	8.5	(50)	19.9	12.8	2.0	25.2
(22)	20.1	7.0	12.6	15.0	(51)	28.4	7.0	4.1	31.8
(23)	19.5	9.0	4.0	2..0	(52)	5.6	35.8	12.8	7.8
(24)	11.0	9.5	1.2	20.2	(53)	16.1	13.0	10.2	10.2
(25)	9.0	16.5	7.8	9.8	(54)	14.6	11.2	9.9	8.2
(26)	19.0	7.8	10.2	9.5	(55)	7.9	46.0	4.0	29.0
(27)	23.0	16.5	13.1	8.2	(56)	13.1	X	X	X
(28)	8.1	35.8	8.8	8.8	Mean	14.5	15.6	9.1	14.6
(29)	29.8	32.5	12.2	16.0					

TABLE 11, CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART B. SUBJECT 2A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hrs.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	2.6	2.4	2.4	6.0	(30)	21.0	26.2	10.5	10.5
(2)	3.9	6.0	3.4	9.5	(31)	19.1	23.5	5.5	20.0
(3)	5.9	6.8	3.6	5.0	(32)	9.9	22.5	13.8	30.5
(4)	5.2	3.2	7.8	2.0	(33)	20.9	17.8	8.9	13.0
(5)	1.0	5.0	9.8	7.2	(34)	26.9	21.8	11.1	21.5
(6)	3.9	12.0	7.0	12.8	(35)	22.8	10.5	28.2	28.6
(7)	7.1	8.0	8.9	4.2	(36)	28.6	34.5	23.1	5.8
(8)	2.5	8.0	5.9	17.2	(37)	35.1	23.0	10.8	22.5
(9)	8.1	15.0	5.6	8.0	(38)	10.9	5.2	10.2	15.0
(10)	16.9	7.2	17.9	23.2	(39)	15.4	19.5	12.0	13.0
(11)	6.6	11.5	9.4	9.2	(40)	13.2	29.8	15.8	17.0
(12)	14.2	31.5	8.4	6.8	(41)	14.9	14.2	10.8	13.5
(13)	5.8	9.0	15.8	12.0	(42)	14.9	11.2	12.1	17.8
(14)	6.6	11.5	9.2	19.0	(43)	17.8	28.2	10.6	16.0
(15)	24.8	10.2	9.6	10.5	(44)	15.6	20.2	8.2	14.5

(8)	2.5	8.0	5.9	17.2	(37)	35.1	23.0	10.8	22.5
(9)	8.1	15.0	5.6	8.0	(38)	10.9	5.2	10.2	15.0
(10)	16.9	7.2	17.9	23.2	(39)	15.4	19.5	12.0	13.0
(11)	6.6	11.5	9.4	9.2	(40)	13.2	29.8	15.8	17.0
(12)	14.2	31.5	8.4	6.8	(41)	14.9	14.2	10.8	13.5
(13)	5.8	9.0	15.8	12.0	(42)	14.9	11.2	12.1	17.8
(14)	6.6	11.5	9.2	19.0	(43)	17.8	28.2	10.6	16.0
(15)	24.8	10.2	9.6	10.5	(44)	15.6	20.2	8.2	14.5
(15)	3.4	12.8	19.9	14.0	(45)	10.4	21.5	11.0	16.5
(17)	10.0	25.5	38.4	8.5	(46)	20.8	10.8	3.4	19.5
(18)	11.2	24.8	5.9	18.8	(47)	21.6	15.0	15.9	9.5
(19)	7.6	16.2	16.2	14.2	(48)	10.6	17.8	9.9	11.8
(20)	11.4	13.0	8.8	13.5	(49)	22.8	7.2	12.4	14.8
(21)	8.5	11.2	13.4	22.0	(50)	15.6	14.2	13.4	15.2
(22)	18.9	4.5	12.1	11.2	(51)	22.0	18.5	15.1	12.5
(23)	14.9	15.2	15.2	14.5	(52)	8.6	24.0	13.4	14.2
(24)	7.9	9.5	15.0	19.5	(53)	17.6	20.5	11.2	16.8
(25)	13.9	27.1	7.0	29.5	(54)	12.2	12.8	12.2	15.2
(26)	13.4	37.0	8.9	11.2	(55)	17.5	5.0	16.6	12.2
(27)	39.6	10.0	13.0	12.0	(56)	0.5	X	X	X
(28)	18.1	19.0	7.5	39.5	Mean	13.7	15.7	11.9	14.8
(29)	12.0	17.0	21.8	13.2					

TABLE II, CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART C. SUBJECT 3A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	6.4	6.5	6.4	2.5	(30)	15.5	35.5	8.2	35.8
(2)	7.6	11.0	4.2	3.8	(31)	41.4	13.8	14.6	26.0
(3)	9.9	4.0	7.8	2.6	(32)	21.5	31.5	17.1	28.7
(4)	2.6	8.8	7.1	9.0	(33)	28.7	37.0	11.8	28.2
(5)	4.4	7.8	9.1	8.0	(34)	33.6	8.8	2.8	27.2
(6)	6.8	8.0	8.1	5.5	(35)	15.4	59.0	10.2	30.0
(7)	8.2	10.2	7.8	2.0	(36)	30.0	22.2	14.8	14.4
(8)	6.5	13.2	9.2	17.8	(37)	14.4	58.5	9.6	48.8
(9)	20.8	12.0	7.1	49.0	(38)	28.9	12.2	9.1	62.5
(10)	25.0	5.8	3.9	18.5	(39)	52.5	52.8	6.8	46.0
(11)	15.0	16.2	33.1	18.8	(40)	9.5	62.0	18.2	31.8
(12)	20.1	36.5	8.3	8.3	(41)	31.8	44.2	8.0	40.5
								13.5	20.2

(8)	6.5	13.2	9.2	17.8	(37)	14.4	58.5	9.6	48.8
(9)	20.8	12.[illegible]	7.1	49.0	(38)	28.9	[illegible].2	9.1	62.5
(10)	25.0	5.8	3.9	18.5	(39)	52.5	52.8	6.8	46.0
(11)	15.0	16.2	33.1	18.8	(40)	9.5	62.0	18.2	31.8
(12)	20.1	36.5	8.3	8.3	(41)	31.8	4[illegible].2	8.0	49.5
(13)	34.0	27.8	29.0	15.8	(42)	24.0	46.5	13.5	20.2
(14)	29.5	18.5	5.0	32.0	(43)	28.1	22.8	10.2	10.2
(15)	32.4	19.5	18.0	18.5	(44)	12.5	58.5	3.5	32.2
(16)	11.6	23.8	8.0	43.0	(45)	32.2	24.5	5.9	30.5
(17)	26.6	30.5	7.0	31.5	(46)	30.5	23.5	5.1	40.5
(18)	30.0	30.5	6.8	26.4	(47)	35.5	34.2	7.0	40.5
(19)	26.4	26.0	9.1	10.8	(48)	10.8	45.5	8.6	33.0
(20)	21.4	26.5	5.8	35.2	(49)	3.9	28.5	4.1	15.0
(21)	17.1	19.8	16.2	31.8	(50)	27.4	32.0	7.2	23.0
(22)	49.1	49.1	6.9	39.2	(51)	31.1	15.0	17.1	29.8
(23)	45.6	22.0	6.0	18.5	(52)	15.5	28.5	8.5	30.9
(24)	13.2	28.5	10.7	10.7	(53)	30.9	34.2	15.5	15.5
(25)	18.1	21.5	2.0	55.8	(54)	19.4	27.8	10.2	22.6
(26)	4.1	18.4	18.4	24.2	(55)	22.6	25.8	3.8	25.8
(27)	29.2	11.5	24.0	20.0	(56)	20.5	X	X	X
(28)	19.6	30.8	7.5	7.5	Mean	22.0	27.1	10.1	25.1
(29)	24.8	59.8	11.4	17.5					

TABLE 11, CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART D. SUBJECT 4A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hrs.)	8 P.M.-12 Midnight (mgs/hr.)	12 Midnight-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	1.2	7.4	7.4	9.5	(30)	7.4	16.2	13.4	22.2
(2)	7.5	16.2	4.9	11.8	(31)	22.1	21.8	9.2	17.2
(3)	5.6	8.8	6.8	13.2	(32)	8.6	16.0	7.8	11.2
(4)	7.5	8.8	3.8	8.2	(33)	22.9	12.2	11.4	17.5
(5)	4.9	2.0	6.1	8.8	(34)	2.9	55.2	14.4	14.2
(6)	9.1	10.0	7.4	10.8	(35)	24.9	4.0	21.8	10.1
(7)	12.4	17.8	4.4	1.5	(36)	10.1	49.0	11.9	11.2
(8)	1.5	20.0	12.6	9.2	(37)	17.0	10.5	16.1	30.8
(9)	10.4	28.5	12.0	12.0	(38)	13.5	7.2	13.2	14.8
(10)	20.6	7.5	7.4	26.0	(39)	31.0	[illegible]0	14.6	18.5
(11)	21.2	21.2	6.[illegible]	34.2	(40)	11.8	10.0	20.6	18.0

(6)	9.1	10.0	7.4	10.8	(35)	24.9	4.0	21.8	10.1
(7)	12.4	17.8	4.4	1.5	(36)	10.1	49.0	11.9	11.2
(8)	1.5	20.0	12.6	9.2	(37)	17.0	10.5	16.1	30.8
(9)	10.4	28.5	12.0	12.0	(38)	13.5	7.2	13.2	14.8
(10)	20.6	7.5	7.4	26.0	(39)	31.0	12.0	14.6	18.5
(11)	21.2	21.2	6.5	34.2	(40)	11.8	10.0	20.6	18.0
(12)	7.4	23.8	4.8	4.8	(41)	16.0	27.2	12.9	22.5
(13)	7.6	20.5	4.4	13.0	(42)	11.9	21.2	14.0	15.1
(14)	13.0	20.8	7.6	13.2	(43)	15.1	23.0	28.8	13.5
(15)	6.6	38.5	8.5	10.0	(44)	12.5	18.0	10.5	21.5
(16)	12.2	19.8	11.1	10.0	(45)	17.5	24.0	23.4	12.8
(17)	13.1	38.5	0.9	18.2	(46)	22.9	20.2	14.8	18.8
(18)	25.6	9.1	9.1	10.7	(47)	14.9	14.9	34.2	20.8
(19)	10.7	19.5	12.9	16.2	(48)	11.8	19.0	26.5	18.2
(20)	3.2	9.0	12.1	13.4	(49)	21.2	24.2	10.2	17.5
(21)	13.4	22.5	13.6	15.5	(50)	15.4	23.2	16.9	16.9
(22)	5.1	33.5	9.8	15.2	(51)	21.5	21.5	23.4	11.8
(23)	13.9	20.5	12.0	11.5	(52)	8.0	55.0	16.5	13.2
(24)	5.1	9.5	6.9	5.8	(53)	17.2	17.2	19.9	16.0
(25)	21.4	39.0	8.1	15.2	(54)	12.2	12.2	16.4	18.0
(26)	9.8	14.0	8.5	7.2	(55)	26.6	13.8	5.6	5.6
(27)	28.8	6.5	12.9	12.0	(56)	16.0	X	X	X
(28)	12.5	16.5	8.0	13.5	Mean	13.4	19.5	12.1	14.6
(29)	8.0	16.8	7.6	23.0					

TABLE II, CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART E. SUBJECT 6A

Days	8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night 8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	10.9	5.4	5.4	2.0	(30)	9.8	52.2	17.0	23.8
(2)	3.2	8.2	7.6	14.2	(31)	15.0	15.5	11.0	5.5
(3)	5.2	3.2	5.8	4.0	(32)	11.4	36.5	16.6	27.2
(4)	2.0	8.5	10.0	7.0	(33)	13.9	9.2	14.6	8.8
(5)	5.6	4.5	5.0	6.0	(34)	74.6	18.0	26.4	17.2
(6)	9.9	8.0	6.5	1.5	(35)	23.0	16.5	8.8	10.7
(7)	6.8	3.8	2.2	11.0	(36)	10.7	19.8	15.9	20.2
(8)	2.5	24.2	5.0	15.8	(37)	9.2	12.0	16.4	20.5
(9)	7.5	7.0	12.0	6.8	(38)	22.6	23.8	9.9	11.5
(10)	12.5	7.2	10.2	10.5	(39)	14.8	15.0	16.6	12.2
(11)	11.8	34.8	12.8	10.8	(40)	10.6	15.2	21.0	14.0
(12)	28.6	16.0	22.6	6.2	(41)	9.1	[illegible]	13.7	13.7

(7)	6.8	3.8	2.2	11.0	(36)	10.7	19.8	15.9	20.2
(8)	2.5	24.2	5.0	15.8	(37)	9.2	12.0	16.4	20.5
(9)	7.5	7.0	12.0	6.8	(38)	22.6	23.8	9.9	11.5
(10)	12.5	7.2	10.2	10.5	(39)	14.8	15.0	16.6	12.2
(11)	11.8	34.8	12.8	10.8	(40)	10.6	15.2	21.0	14.1
(12)	28.6	16.0	22.6	6.2	(41)	9.1	26.5	13.7	13.1
(13)	11.6	8.2	6.5	6.5	(42)	2.6	35.8	16.8	12.5
(14)	10.2	10.8	23.2	31.2	(43)	17.5	24.0	16.2	1.8
(15)	7.2	25.2	18.1	11.8	(44)	18.5	24.5	17.9	17.2
(16)	11.8	20.0	6.6	12.0	(45)	6.5	23.5	15.8	15.8
(17)	10.1	22.1	12.1	19.2	(46)	21.8	17.8	14.1	32.2
(18)	7.4	24.5	31.9	15.2	(47)	13.8	12.5	16.6	11.8
(19)	4.0	7.0	20.4	15.8	(48)	13.9	13.9	18.5	15.0
(20)	14.5	12.5	13.9	11.0	(49)	12.2	17.5	11.6	11.5
(21)	4.0	11.0	11.0	6.2	(50)	13.0	25.0	20.4	14.5
(22)	16.2	14.5	17.1	13.5	(51)	23.1	14.5	13.9	12.5
(23)	9.1	59.8	15.1	7.8	(52)	6.2	23.5	16.4	16.5
(24)	9.4	7.8	14.2	9.5	(53)	17.2	11.0	9.4	19.0
(25)	23.2	34.8	9.0	7.8	(54)	10.9	20.5	20.0	12.8
(26)	20.6	13.5	9.9	14.2	(55)	7.2	21.8	13.1	11.0
(27)	15.9	32.5	32.9	12.5	(56)	15.0	X	X	X
(28)	6.5	23.0	10.1	27.0	Mean	13.0	18.9	14.2	13.3
(29)	16.1	33.8	14.1	23.0					

TABLE II, CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART E. SUBJECT 7A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night 8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	9.2	11.8	11.8	4.2	(30)	104.8	43.0	31.0	31.5
(2)	8.0	13.8	11.8	8.8	(31)	49.9	59.8	25.0	23.0
(3)	8.4	8.5	15.2	7.5	(32)	45.2	67.0	19.2	34.8
(4)	6.9	8.0	14.0	3.2	(33)	55.5	43.5	20.0	40.5
(5)	4.6	21.2	17.0	11.8	(34)	73.0	28.0	34.2	62.8
(6)	18.6	13.2	23.0	11.5	(35)	45.9	69.5	31.1	23.1
(7)	25.9	25.8	23.6	18.0	(36)	23.1	47.2	32.2	36.5
(8)	31.8	25.8	25.1	23.0	(37)	35.6	46.0	3.4	74.2
(9)	25.4	46.0	21.0	32.0	(38)	14.8	50.5	16.5	64.5
(10)	34.0	37.5	19.1	30.5	(39)	46.0	66.0	16.8	52.5
(11)	48.9	24.8	35.2	19.2	(40)	31.2	30.5	12.4	62.5
(12)	2.9	38.8	17.8	15.8	(41)	27.4	30.0	25.5	38.8
(13)	22.2	21.5	16.1	19.8	(42)	28.4	36.8	20.8	8.0
(14)	23.9	23.0	12.0	13.0	(43)	25.6	[illegible]5	4.8	51.5
(15)	44.4	44.0	23.4	7.2	(44)	38.9	35.0	23.4	36.2

(9)	25.4	46.0	21.0	32.0	(38)	[illegible]	[illegible]	[illegible]	[illegible]
(10)	34.0	37.5	19.1	30.5	(39)	46.0	66.0	16.8	52.5
(11)	48.9	24.8	35.2	19.2	(40)	31.2	30.5	12.4	62.5
(12)	2.9	38.8	17.8	15.8	(41)	27.4	30.0	25.5	38.8
(13)	22.2	21.5	16.1	19.8	(42)	28.4	36.8	20.8	8.0
(14)	23.9	23.0	12.0	13.0	(43)	25.6	37.5	4.8	51.5
(15)	44.4	44.0	23.4	7.2	(44)	38.9	35.0	23.4	36.2
(16)	52.4	30.2	24.1	25.8	(45)	64.1	25.0	12.1	50.?
(17)	35.8	56.8	39.9	36.5	(46)	47.1	25.5	8.2	50.2
(18)	20.5	76.2	4.8	81.8	(47)	42.6	69.5	9.4	31.5
(19)	31.9	61.8	27.2	32.5	(48)	23.0	62.8	20.4	20.8
(20)	30.1	39.0	30.6	21.0	(49)	28.5	26.2	28.2	26.5
(21)	36.5	49.5	38.2	28.0	(50)	40.9	22.8	11.2	32.0
(22)	50.1	44.8	34.8	71.0	(51)	21.8	39.0	20.5	25.2
(23)	53.9	50.5	21.1	19.2	(52)	30.9	29.2	18.2	13.8
(24)	11.9	25.5	32.1	21.5	(53)	9.0	23.2	26.2	27.8
(25)	28.5	30.5	7.1	67.5	(54)	36.4	58.5	22.5	10.8
(26)	40.6	54.8	28.6	3.5	(55)	39.8	46.2	9.0	45.8
(27)	60.0	20.5	36.0	35.2	(56)	22.5	X	X	X
(28)	28.4	41.2	48.6	45.2	Mean	33.9	38.7	21.4	31.4
(29)	49.4	66.2	17.0	35.2					

TABLE 11. CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART G. SUBJECT 8A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M. 12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	5.9	11.1	11.1	2.7	(30)	11.9	24.7	7.3	13.7
(2)	10.3	6.2	9.6	7.0	(31)	22.9	18.5	4.0	30.0
(3)	11.1	4.2	5.3	11.7	(32)	16.1	24.7	12.0	12.2
(4)	4.4	5.7	16.5	4.5	(33)	18.5	15.5	10.3	10.0
(5)	7.9	5.5	5.0	2.7	(34)	16.1	7.7	13.4	22.0
(6)	7.4	3.0	11.1	4.5	(35)	20.2	11.7	14.8	19.0
(7)	9.3	10.0	5.3	14.5	(36)	19.0	29.0	20.0	14.0
(8)	6.9	4.2	9.6	11.5	(37)	12.7	25.2	19.0	22.5
(9)	9.1	14.5	20.8	17.5	(38)	12.9	14.5	17.9	25.0
(10)	6.8	12.7	5.0	15.2	(39)	28.5	24.5	11.0	11.2
(11)	10.6	13.7	8.8	10.7	(40)	17.0	4.7	16.5	15.2
(12)	17.0	10.2	9.3	7.5	(41)	14.9	8.7	15.1	17.2
(13)	18.3	22.0	20.3	11.5	(42)	15.6	6.5	8.4	17.0

(8)	6.9	4.2	9.6	11.5	(37)	12.7	25.2	19.0	22.5
(9)	9.1	14.5	20.8	17.5	(38)	12.9	14.5	17.9	25.0
(10)	6.8	12.7	5.0	15.2	(39)	28.5	24.5	11.0	11.2
(11)	10.6	13.7	8.8	10.7	(40)	17.0	4.7	16.5	15.2
(12)	17.0	10.2	9.3	7.5	(41)	14.9	8.7	15.1	17.2
(13)	18.3	22.0	20.3	11.5	(42)	15.6	6.0	8.4	17.0
(14)	15.8	15.5	9.6	26.5	(43)	11.0	15.7	16.5	14.0
(15)	25.6	10.7	12.8	11.0	(44)	19.9	10.7	14.8	6.2
(16)	10.4	10.5	17.5	26.5	(45)	9.5	17.2	13.9	18.0
(17)	13.3	22.8	5.3	16.0	(46)	17.3	14.2	11.4	16.7
(18)	28.6	11.7	10.5	18.5	(47)	17.4	16.7	12.1	14.0
(19)	18.5	15.0	17.9	14.5	(48)	11.4	14.7	14.0	14.2
(20)	14.6	9.2	12.5	7.5	(49)	15.5	10.2	12.6	14.5
(21)	11.5	8.0	9.6	22.2	(50)	13.0	22.8	11.5	14.0
(22)	15.8	11.7	10.6	14.0	(51)	11.8	8.2	18.9	15.2
(23)	16.4	13.8	16.6	19.2	(52)	11.2	19.0	11.5	16.0
(24)	7.3	19.7	14.3	10.5	(53)	9.1	15.2	10.4	16.0
(25)	18.5	15.7	23.7	19.0	(54)	8.6	12.5	8.5	13.0
(26)	37.0	15.5	5.8	41.5	(55)	4.6	19.2	11.5	16.0
(27)	29.8	15.2	13.5	23.2	(56)	14.8	X	X	X
(28)	27.0	63.3	9.0	18.5	Mean	14.8	15.1	12.7	15.2
(29)	14.2	39.0	35.3	16.5					

TABLE II, CONTINUED

URINARY CREATINE EXCRETION DURING FOUR DAILY

PERIODS THROUGHOUT THE BED REST

(milligrams per hour during each period)

PART H. SUBJECT 9A

Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night 8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)	Days	12 Noon-8 P.M. (mgs/hr.)	8 P.M.-12 Mid-night (mgs/hr.)	12 Mid-night-8 A.M. (mgs/hr.)	8 A.M.-12 Noon (mgs/hr.)
(1)	2.1	0.9	0.9	6.0	(30)	26.9	67.5	21.0	26.2
(2)	16.1	6.0	10.6	6.2	(31)	58.1	21.2	5.4	35.2
(3)	5.2	4.2	3.6	4.8	(32)	20.1	35.8	16.5	8.5
(4)	3.5	17.2	7.8	7.0	(33)	29.6	17.2	19.6	41.5
(5)	5.1	3.8	12.1	9.0	(34)	29.9	19.2	12.4	26.2
(6)	4.6	6.5	10.6	11.8	(35)	51.6	17.8	11.0	12.9
(7)	8.5	14.8	4.2	1.2	(36)	12.9	43.5	16.4	14.8
(8)	5.6	3.0	5.8	7.2	(37)	38.6	13.8	26.9	30.2
(9)	11.5	9.8	7.9	22.5	(38)	21.9	25.5	17.2	27.0
(10)	6.9	8.8	6.1	13.8	(39)	17.0	22.2	11.2	11.5
(11)	16.8	36.5	7.1	7.8	(40)	9.5	?	14.0	12.0

(8)	5.8								
(9)	11.5	9.8	7.9	22.5	(38)	21.9	25.5	17.2	27.0
(10)	6.9	8.8	6.1	13.8	(39)	17.0	22.2	11.2	11.5
(11)	16.8	36.5	7.1	7.8	(40)	9.5	20.2	14.0	12.0
(12)	7.5	32.5	10.8	16.2	(41)	26.9	17.2	16.6	33.2
(13)	16.5	17.2	12.2	38.8	(42)	26.5	4.0	19.5	16.5
(14)	15.5	8.2	7.0	19.5	(43)	20.0	19.8	12.5	11.0
(15)	17.1	29.8	15.4	24.8	(44)	11.6	16.2	16.9	16.2
(16)	25.0	18.8	11.0	19.8	(45)	22.4	15.0	5.6	18.2
(17)	23.8	32.8	20.9	10.2	(46)	17.4	14.5	4.8	34.2
(18)	20.9	22.0	6.2	14.2	(47)	20.9	20.8	9.1	17.5
(19)	20.6	89.5	16.1	26.0	(48)	10.8	11.0	6.9	15.0
(20)	27.8	40.5	14.5	13.0	(49)	25.1	17.0	11.8	16.5
(21)	23.5	58.8	10.6	13.0	(50)	24.8	16.5	19.1	11.3
(22)	53.8	15.5	15.1	17.2	(51)	28.6	27.5	11.9	19.2
(23)	45.9	29.8	16.5	7.0	(52)	16.9	26.8	10.2	14.2
(24)	12.2	15.0	9.4	14.0	(53)	18.8	43.2	10.1	32.2
(25)	17.2	26.8	13.2	33.2	(54)	40.4	22.0	11.6	14.8
(26)	34.2	60.8	6.8	17.0	(55)	18.6	3.0	13.2	16.0
(27)	40.6	25.5	12.5	27.0	(56)	7.6	X	X	X
(28)	17.5	31.2	17.4	17.0	Mean	22.1	23.1	12.0	17.7
(29)	78.1	24.2	13.8	16.5					