Body movements during sleep as a predictor of stage change*

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The number of body movements during the 10-min period of Stage 2 just preceding and following SWS and REM sleep were counted in 10 males for 9 to 11 nights each. There was a significantly greater number of 10-min periods of Stage 2 without movement before SWS than after SWS, before REM sleep, and after REM sleep. The last movements in Stage 2 preceding SWS occurred, in most instances, at least 5 min or more before this transition. These data suggest that body movement in Stage 2 may delay the transition from this stage to SWS.

In their paper, "Body movement artifact as a contaminant in psychophysiological studies of sleep," Altshuler & Brebbia (1967) noted: "Investigators generally have chosen to omit arbitrary lengths of record when body movements occur" and that "others make no mention of the treatment of such artifacts [p. 328]." Perhaps because movements are generally viewed as artifacts, relatively little attention has been given to them by sleep researchers. The studies that have been reported are concerned with the number of movements in each sleep stage. The lowest rate of body movements invariably has been found during Stages 3 and 4, slow-wave sleep (SWS) (Dement & Kleitman, 1957; Kamiya, 1961; Monroe, 1967; Sassin & Johnson, 1968). However, there is a certain discrepancy in these studies: the rate of movements was found to be similar in Stages 2 and REM by Monroe and by Sassin and Johnson, but lower during Stage 2 than during REM by Dement and Kleitman and by Kamiya.

The transition from SWS to Stage 2 is often preceded by a body movement, but we do not know how body movements affect the time course of sleep in its descending transition (from Stages 1, 2, 3, to 4) in NREM sleep and in the transition from NREM sleep to REM sleep. The purpose of this study was to determine if the occurrence of movements during Stage 2 affects the future transition from this stage to SWS or REM sleep.

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SUBJECTS

Ten males, ages 19 to 23, were electrophysiologically and behaviorally monitored 9 to 11 nights over a 2-month period. Ninety-three sleep records were obtained.

SLEEP SCORING

All sleep records were scored automatically by a digital computer program, using the APSS criteria (Rechtschaffen & Kales, 1968). The agreement of this computer scoring with visual scoring of six records was found to be 84%, near the 82% previously reported by Martin, Johnson, Viglione, Naitoh, Joseph, & Moses (1972), using the same computer program on different sleep data. The computer scoring of the crucial stage transition periods used in this study were all checked by visual scoring.

BODY MOVEMENTS

Body movements were detected manually by the occurrence of muscle potential in the EEG. Positions and movements of the head were visually monitored by closed-circuit TV screen. Brazier (1965) observed that muscle artifacts in the EEG were a more sensitive index of movements than were motility recorders placed under the hips and shoulders.

Since the electrodes and other sources of electronic noise could produce sharp muscle potential like artifacts in the EEGs, the records were also checked for simultaneous occurrence of heart rate (HR) increase with EEG muscle potentials. Schieber, Muzet, & Ferriere (1971) found that EEG muscle artifacts and body movements recorded on an actographic bed were always accompanied by an increase in HR and that the duration of the HR increase was a reliable and sensitive index of the duration of the movement. In the present study, the HR increase was used as a supplementary indicator of body movements. Other changes associated with movements, such as decreased finger pulse amplitude, muscle artifact in electrooculograms (EOGs), and skin potential response contaminated by movement artifact, were also used as the check for movement detected by artifact in the EEGs. An example of such changes occurring simultaneously is shown in Fig. 1. This figure illustrates a short movement occurring in Stage REM. Simultaneous observation of the TV

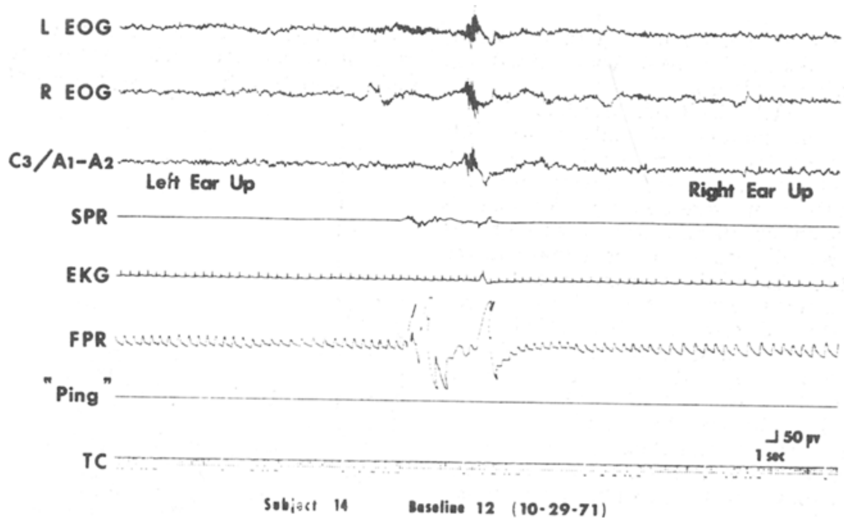

Fig. 1. Polygraphic record showing body movement. To the left of the movement, the S was asleep, the head on its right side (left ear up). After the movement, he was observed to be asleep, the head on its left side (right ear up). LEOG = left electro-oculogram; REOG = right EOG; C_3/A_1-A_2 = central EEG lead referenced to linked mastoids; SPR = skin potential response; EKG = electrocardiogram; FPR = finger pulse response; "Ping" = impulsive noise; TC = time code. Record taken in REM sleep.

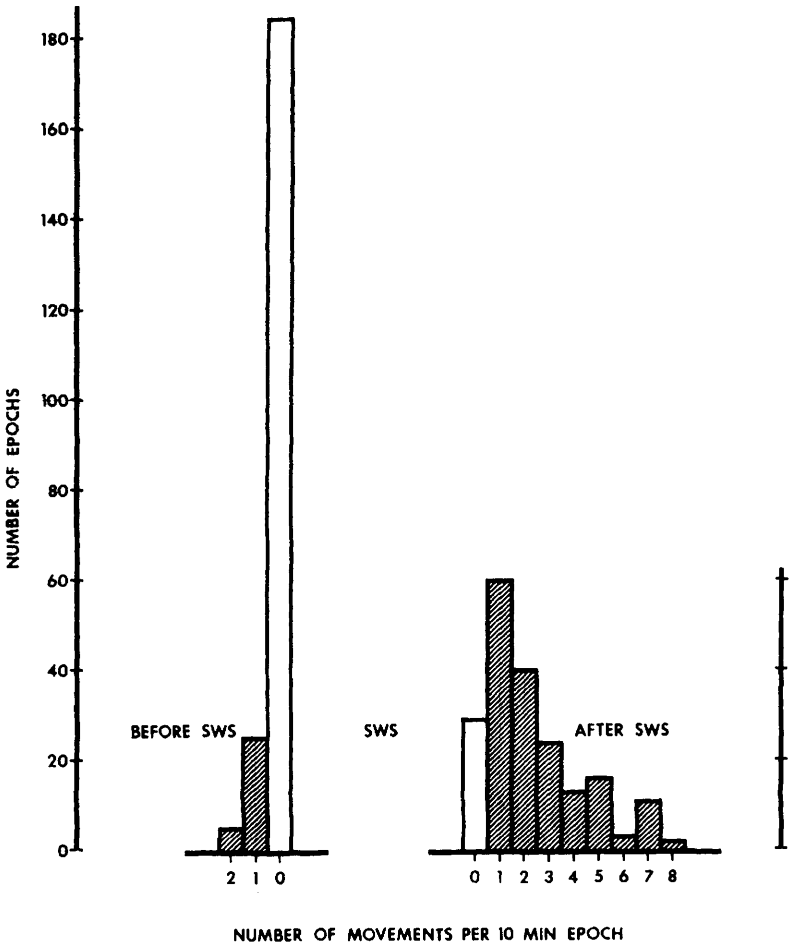

Fig. 2. Number of movements per 10-min epoch during Stage 2 before and after SWS.

screen indicated that in this instance, the S's head moved from left side up to right side up.

STATISTICAL ANALYSIS

The number of body movements during the 10-min period of Stage 2 just preceding and following SWS, and REM sleep were counted. The analysis epoch of 10 min was chosen on the basis of preliminary data that showed that most of the movements in Stage 2 occurred within this 10-min epoch before a transition into REM sleep. Periods of Stage 2 preceding SWS and REM sleep of less than 10-min duration were not included.

In addition to number of body movements, the elapsed time between the last body movement in Stage 2 and the onset of SWS, and between the last body movement in Stage 2 and the onset of Stage REM was also measured. These latency measures could extend beyond the 10-min epoch used above.

RESULTS

Number of Body Movements Before SWS and REM Sleep

Figure 2 shows the number of 10-min epochs of Stage 2 without movement and those with movements before and after SWS for all Ss over all nights. No 10-min epoch with more than two body movements was observed before SWS. One hundred and eighty-five, 86%, of the 215 10-min epochs of Stage 2 just preceding SWS were without movement, 25 epochs contained one movement, and 5 epochs contained two movements. Of the 30 epochs with movements preceding SWS, 15, 50%, occurred before the first SWS period of the night.

After SWS, the number of epochs with movements was significantly[1] higher than before SWS, and several epochs contained more than five body movements.

Figure 3 shows the number of 10-min epochs in Stage 2 without movement and those with movements before and after REM sleep. In contrast with the 86% without movements before SWS, of the 222 epochs before REM sleep, 20% are without movement. Twenty-eight percent contained one movement, 24% two movements, and 28% three or more movements. The number of 10-min epochs without movement was significantly greater before SWS than before and after REM sleep. It was observed also that after REM sleep, the number of 10-min epochs without movement was significantly greater than it was after SWS sleep. No significant difference was found for the number of epochs without movement before and after REM sleep.

Time Since the Last Body Movement

Figure 4 shows the elapsed times between the last movements in Stage 2 preceding the SWS (upper part of the figure) and REM sleep (lower part of the figure). In most instances, the last

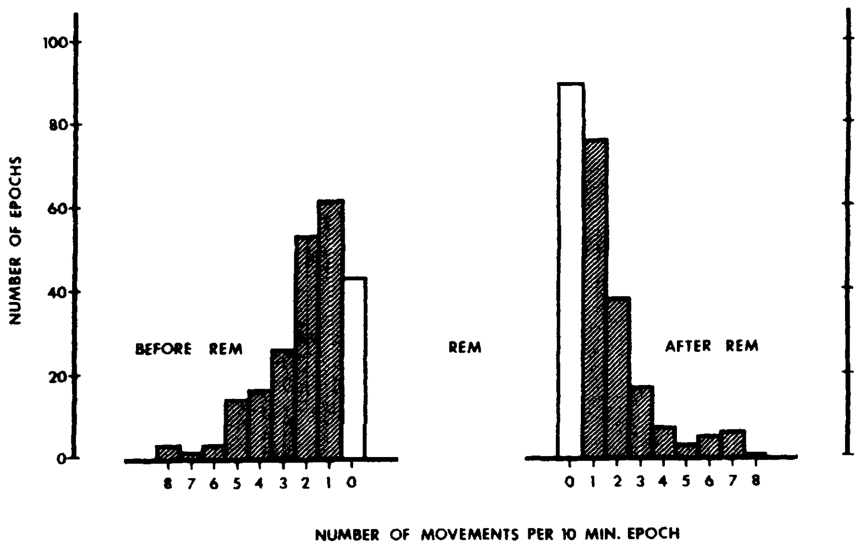

Fig. 3. Number of movements per 10-min epoch during Stage 2 before and after REM sleep.

movements in Stage 2 before the transition to SWS occurred at least 5 min or more before this transition. In contrast, the time between the last movement in Stage 2 and the occurrence of REM sleep was usually less than 5 min and infrequently more than 10 min.

DISCUSSION

These results indicate that the presence or absence of body movements during Stage 2 sleep can be useful as a predictor of the future course of sleep. While one cannot predict that all periods without movement in Stage 2 will be followed by SWS or that a movement in Stage 2 will be followed by REM sleep, one can predict that there is a low probability (i.e., 14% of the time for the first SWS period and only 7% of the time after the first SWS) that Stage 2 will change to SWS within the next 10 min after a body movement. This suggests that a body movement is incompatible with the transition from Stage 2 to SWS. In contrast, movements do not interfere with the transitions from Stage 2 to REM sleep. Perhaps this difference in susceptibility to movements may reflect some fundamental physiological difference in two kinds of sleep: SWS and REM sleep.

Brazier (1966) asked the question of whether there was any justification for using number of movements during sleep as an index of depth of sleep and whether movements made during sleep are always preceded by a rise in level toward the waking state before such activity is possible. Brazier found that alpha potentials tended to return to the sleep record just before a movement was made. Sassin & Johnson (1968) did not find periods of alpha before most movements, nor did we in this study, but brief periods of alpha followed many movments, especially the gross body movements. Similar arousing effects of body movements on the EEG measure were reported by Otto and his colleagues (1970). In five Ss, only once out of 133 body postural changes was there a shift to "deepening sleep," while 92 instances of "sleep-shallowing" were observed following a movement. Our findings support the hypothesis that movements inhibit the entry to SWS because of their arousing effects and are, therefore, contrary to entry to and continuance in the SWS.

The increase in movements before Stage REM sleep may serve to produce the aroused central nervous system (CNS) state necessary for REM sleep and for staying in REM sleep. Computer studies of sleep (Larsen & Walter, 1970; Johnson, Naitoh, Lubin, & Moses, 1972) have shown that the electrographic activity during REM is more like awake activity than other stages of sleep.

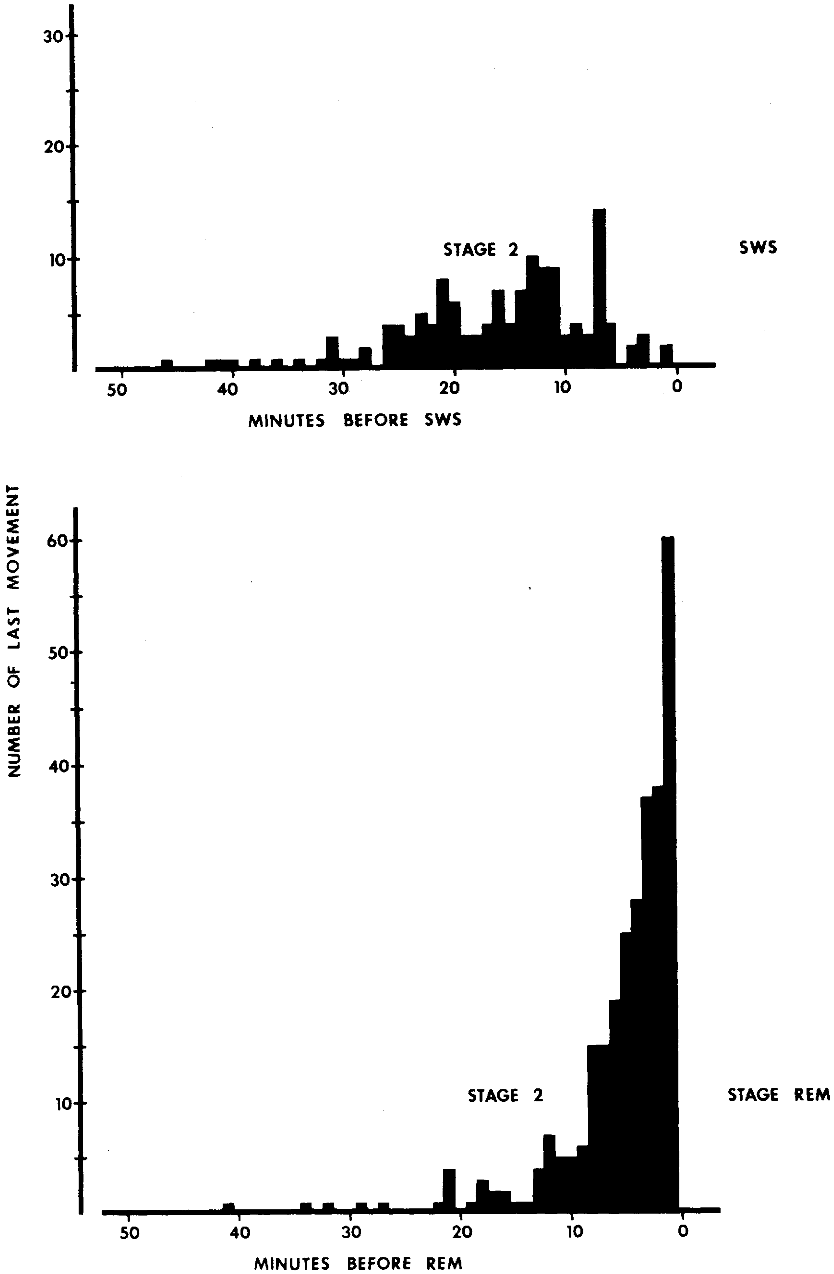

Fig. 4. Elapsed time since the last movement in Stage 2 preceding SWS and REM sleep.

The role and reason for body movements during sleep are still unknown. The common assumption that they reflect muscular discomfort or some internal pressure or discomfort is difficult to maintain in light of the consistency of body movements from night to night and the fact that movements appear to be related to specific periods of sleep stages and cycles (Sassin & Johnson, 1968). Therefore, body movements should not be viewed as an artifact to be omitted, but rather, they should be viewed as a possible indicator of the internal state preceding stage change and as another phasic event during sleep that can profitably be related to other sleep parameters as well as to waking behavior.

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NOTE

1. Unless otherwise indicated, all tests of significance were zero-mu t tests. Significance means .05 level or better.