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History of Sleep Medicine

William C. Dement, MD, PhD

- Professional organizations
- Complications of obstructive sleep apnea
- Discipline identity and discipline overlap
- Minimal penetration of the mainstream educational system
- Final thoughts
- References

There have been a number of accounts of the history of sleep medicine. Perhaps the most notable was developed by a group of sleep specialists for the inaugural issue of the *Journal of Clinical Sleep Medicine* [1]. Insofar as the history of anything is known, it is what it is and cannot be changed, although possibly it can be reinterpreted and expanded. This article may have some novelty from the perspective of the author's participation in the field from 1952 until present, spiced with some information not achieving publication in scientific journals, or even the occasional autobiographic material [2].

It is assumed that the first life forms evolved in equatorial climates rather than the poles. This being the case, early life forms were continuously exposed to the consequences of the earth's rotation. This exposure almost certainly induced some sort of 24-hour rest-activity cycle. With diversity and ecologic specialization, it is likely that some organisms became nocturnal primarily for safety and to avoid daytime predators. Presumably, at the end of eons of evolution primates and human beings arrived whose interaction with the environment was primarily visual. This interaction must have fostered the evolution of the 24-hour sleep-wake cycle.

Interest in sleep almost certainly goes back to the dawn of history. It is in marked contrast that sleep research and particularly the diagnosis and treatment of sleep disorders began so recently. It may be that the major obstacle was the need for investigators and clinicians to stay awake at night. Until the advent of the electric light, working at night had none of the practicality that it currently possesses.

The recognition of the important specific sleep disorders (eg, obstructive sleep apnea) may have some partial roots in antiquity. Although human beings have been concerned about their sleep for centuries, there had not been a specific focus on problems of sleep and particularly the development of specific characterizations of individual sleep disorders. It is difficult to select highlights over the last hundred or so years; however, there is some consensus. A very important early step was the discovery of the electrical activity of the central nervous system by Richard Caton in 1875. The German psychiatrist Hans Berger was the first to describe human brain waves in reports published in the late 1920s. In the 1930s, a group at Harvard described different patterns of sleeping brain waves, and in particular described what are now known as "sleep spindles," "K-complexes," and "high amplitude slow waves." By this time, it had also been found that the resting awake human adult had a very prominent 8 to 12 cycle per second nearly continuous oscillation from the occipital surface of the skull, which disappeared at the onset of sleep. Further advances in understanding the mechanisms of sleep and

Department of Psychiatry and Behavioral Sciences, Sleep Disorder/Sleep Center, 701 Welch Road, #2226, Stanford, CA 94305–5744, USA
E-mail address: dement@stanford.edu

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wakefulness were delayed by the hostilities up to and during World War II, and to some extent, the Korean War and events associated with the Cold War.

Appropriately, the discovery that many say initiated the modern era of sleep research and sleep medicine was made in the laboratory of a man whose focus was on the study of human sleep, University of Chicago Professor of Physiology Nathaniel Kleitman. Slow rolling eye movements during sleep had been described much earlier. Kleitman decided that this slow activity might be an excellent measure of the depth of sleep. He based this hypothesis on the somewhat disproportionately large areas of the brain devoted to the execution of eye movements and the demanding nuances of visual following and focusing. A graduate student in Kleitman's department, Eugene Aserinksy, was put to work studying the aforementioned slow rolling eye movements during sleep. Initially, Aserinsky simply looked at the eyes of sleeping subjects (eg, direct visual observation). He soon came across the fact, however, of the existence of a corneoretinal potential difference with the cornea consistently about 70 mV positive to the retina. Aserinsky then concluded that eye movements could be recorded electrographically and proceeded to do so with the use of an ink-writing oscillograph.

In the course of observing slow eye movements, Aserinsky occasionally saw what appeared to be electrical artifacts. In 1952, I was a sophomore medical student at the University of Chicago. I approached Kleitman and asked if I could work in his laboratory. He immediately gave me the assignment of helping Aserinsky. My somewhat tedious task was to sit by the bed of the sleeping subject (only one subject at a time was studied) and look at the eyes with a flashlight when Aserinsky saw the "electrical artifacts." After a few observations, it became clear that the electrical artifacts were actually the changes in electropolarity as the eyeballs moved rapidly (very different from the previously described slow movements). Because the periods of eye movements were associated with an elevated heart rate, Kleitman wondered if they might represent dreaming.

To test this notion, 20 normal men were used in several series of experiments. These observations [3] were subsequently published in 1953 and marked what some have said represents the true beginning of the modern era of sleep research and sleep medicine. Subjects were wakened when eye movement potentials appeared in the electrooculogram. In the original observations, rapid eye movements (REM) were not seen in four of the subjects [3]. Nonetheless, when the occurrence and detail of dream recall reports from REM awakenings were compared with dream recall reports from awakenings when REM were not present, the differences were highly significant.

In 1953, any interest in sleep by health professionals was engendered mainly by the theories of Sigmund Freud, specifically about the meaning of dreams. Accordingly, the interest was only in the phenomenon of dreaming, with sleep as the necessary background state. Freud's work resulted in the creation of a clinical and scientific discipline known as "psychoanalysis," and the technique of dream interpretation was a very important part of its therapeutic and theoretic approach to psychiatric problems. The discovery of an objective measure of dreaming was extremely interesting. Aserinsky's initial observations described previously were performed using a four-channel ink writing oscillograph to record brain waves and eye movements, and because electroencephalogram (EEG) paper at the time was fairly expensive, sample recordings were made about every 10 or 15 minutes. No continuous all-night recordings were performed in the first wave of eye movement observations.

My first independent study was performed at the Illinois Manteno State Hospital, in a special research ward that housed approximately 5000 chronic schizophrenics[1]. No antipsychotic medications were available at the time, but electroconvulsive shock therapy was occasionally used. Because Freud believed that dreams were the safety valve of the mind, it was hypothesized that for some reason this safety valve was not available in schizophrenics and dreaming erupted into the waking state giving rise to the symptomatology of psychosis. During the summer and fall of 1953, I studied 17 schizophrenics and 13 medical students. All had periods of REM during sleep [4].

Because of my intense interest in dreams and dreaming at the time, I decided to carry out a more complete description of all-night sleep by recording brain waves and eye movements continuously all through the night rather than sampling. To do this, a relatively slow paper speed was used but REM potentials were very easy to identify at any paper speed. One purpose was further to expand and quantify the description of these REM periods. During my junior and senior years in medical school, I performed a total of 126 all-night recordings on 33 subjects and, by means of a unique categorization of sleeping EEG patterns, scored the sleep

[1] In 1983, I was driving from Chicago to southern Illinois on a route that took me past the Manteno State Hospital. Permission was given for me to visit the buildings and grounds. They were eerily deserted, but quite familiar, including the building that housed the sleep recordings.

recordings in their entirety. When these 126 all-night records were examined, I found that there was a predictable sequence of patterns over the course of the night that had been hinted at in Aserinsky's study but entirely overlooked in all previous EEG studies of sleep. Furthermore, all subjects without exception showed periods of REM [5].

Although this sequence of regular variations has now been observed thousands of times in hundreds of laboratories, the original description remains essentially unchanged. The following is from my chapter in the 4th edition of *Principles and Practice of Sleep Medicine* [6].

> The usual sequence was that after the onset of sleep, the EEG progressed fairly rapidly to stage 4 (record dominated by high amplitude slow waves) which persisted for varying amounts of time generally about 30 minutes, and then a lightening of sleep indicated by EEG changes took place. Whereas the progression from wakefulness to stage 4 at the beginning of the cycle was almost invariable through a continuum of change, the lightening was usually abrupt and often coincided with a body movement or a series of body movements. After the termination of stage 4, there was generally a short period of stage 2 (low amplitude EEG with sleep spindles) or stage 3 which gave way to stage 1 and rapid eye movements. When the first eye movement period ended, the EEG again progressed through a continuum of change through stage 3 or 4, which persisted for a time and then lightened, often abruptly, with body movement to stage 2 which again gave way to stage 1 and the second rapid eye movement period. This cyclic variation of EEG patterns occurred repeatedly throughout the night at intervals of 90 to 100 minutes from the end of one eye movement period to the end of the next. The regular occurrences of REM periods and dreaming strongly suggested that dreams did not occur in response to chance disturbances.

Despite these observations, sleep was still considered to be a single organismic state of being. In our 1957 paper, Kleitman and I characterized the EEG during REM periods "as emergent stage 1 in contrast to descending stage 1 at the onset of sleep" [5]. The percentage of total sleep time occupied by REM periods was between 20% and 25%. The periods of REM tended to be shorter in the early cycles of the night. This typical pattern of all-night sleep has been seen over and over in normal humans of both genders in widely varying environments and cultures and across the lifespan.

By the time I graduated from medical school, the data allowed me to assume that all male adults in the human population had a characteristic sleep architecture that consisted of alternating periods of REM sleep and non-REM sleep. The latter name was consistent with the much greater interest in REM periods. Although it seemed unlikely, in the absence of data it remained a possibility that these REM periods did not occur in females. Accordingly, it was necessary to study at least one woman. Kleitman was somewhat reluctant to have a woman sleeping all night in his laboratory and insisted on having a chaperone. I recruited a chaperone, who came to Kleitman's sleep laboratory on the same evening as the first female subject and promptly went to sleep on a cot in Kleitman's office. The first female subject did indeed have periods of REM during sleep that were essentially the same as the male subjects. In 1955, Kleitman temporarily left the University of Chicago to spend a sabbatical leave in Europe. Alone in the sleep laboratory, I recorded several more females without a chaperone and satisfied myself that the characteristic sleep architecture was present in all human adults regardless of gender.

Because of the corneal bulge, it is very easy to see the eyeballs rotate under the closed lids. It had been assumed that dreaming might not occur until several years after birth. It was also assumed that the ability of the human brain to experience the subjective world of dreaming was not necessarily a requirement for the occurrence of the REM. In 1956, I went to the newborn nursery at the University of Chicago Hospital and observed sleeping 1-day old infants. I saw the characteristic binocularly synchronous REMs enough times to assume that newborn sleep includes REM periods. In subsequent studies, Howard Roffwarg and I found that nearly 50% of the sleep time in newborns consisted of REM periods [7]. These observations have been subsequently confirmed by many others. Assuming that all human sleep contained REM periods, the next question was what about animals? In the Department of Physiology at the University of Chicago, research was being performed on cats. Although cats were somewhat unwilling to sleep under laboratory circumstances, enough observations were eventually accumulated to be certain that a state of sleep analogous to REM sleep in humans did occur with regularity in cats [8].

The technique of electrodes implanted directly into the brain of animals had been developed in 1956; my studies of sleep in cats used pins inserted into the scalp. When cats were awake, the recordings were dominated entirely by the electromyographic activity of the cats' prominent temporal muscles. During periods of REM sleep, this electromyographic activity completely disappeared and the brain wave patterns were easy to observe. In addition, it was noteworthy that in these observations, the brain wave patterns during eye movement periods in the cat were essentially identical with EEG patterns recorded during wakefulness. These patterns were of low amplitude with higher

frequencies. The assertion by me, however, that an "activated" EEG could be associated with unambiguous sleep was considered to be absurd.

I must admit that I did not fully appreciate the significance of the absence of muscle potentials during the REM periods. It remained for the French scientist, Michel Jouvet, who began working in Lyon, France, in 1959 to insist on the importance of electromyographic suppression in his early studies [9], the first of which was published in 1959. I left Chicago in 1957 to take a post at the Mt. Sinai Medical Center in New York City. There I collaborated with others to study muscle activity during sleep. We monitored the electrically induced H reflex during sleep and found it to be completely suppressed in REM periods [10].

As the decade of the 1960s began, the concept of sleep as a single organismic state with different levels was giving way to the concept of the duality of sleep. In all other mammals that were studied in addition to humans, it was found that overall sleep consisted of two entirely different alternating organismic states: REM sleep and non-REM sleep. An enormous amount of data was accumulated supporting the duality concept; microelectrode studies of single neurons in the brain during sleep, more complex studies of motor atonia, and finally the seminal work of Jouvet and Mounier [11] showing that electrolytic lesions in the pontine reticular formation of the cat brain eliminated REM sleep, but left non-REM sleep intact.

Sleep research, emphasizing all-night sleep recordings, burgeoned in the 1960s. This research was the legitimate precursor of sleep medicine and particularly of its core clinical test, polysomnography. Other than the early studies in schizophrenic patients at the Manteno State Hospital, very little interest in other clinical applications had been manifested until investigators noted a significantly shortened REM latency in association with endogenous depression. In the ensuing years, this phenomenon has been well investigated. Other important harbingers of sleep medicine were the following: (1) the observation of sleep-onset REM periods in individuals afflicted with narcolepsy, (2) an interest in epileptic seizures during sleep, and (3) sleep studies to evaluate benzodiazepine medications for the treatment of insomnia. The latter application represents the first time the sleep laboratory and all-night polysomnography were used as part of efficacy protocols to evaluate sedative hypnotics.

In 1959, my colleague at the Mt. Sinai Hospital, Dr. Charles Fisher, saw a patient who was referred with the diagnosis of narcolepsy. At Fisher's suggestion, I arranged to record all-night sleep in this patient. Within several seconds after the patient fell asleep, he was showing the dramatically characteristic REM sleep and electromyographic suppression. Simultaneously, observations were performed on a single patient by Vogel [12] at the University of Chicago, the results of which were published in 1960. In a subsequent collaborative study between the University of Chicago and the Mt. Sinai Hospital, nine patients underwent all-night sleep recordings and the important sleep-onset REM periods were described and reported in a 1963 publication [13]. It is noteworthy that patients were diagnosed with narcolepsy when they showed a characteristic set of symptoms reported in 1880 by Gelineau (sleep attacks, hypnagogic hallucinations, sleep paralysis, and cataplexy). The latter term was applied to sudden attacks of muscular atonia experienced by the narcoleptic patients usually precipitated by strong emotion. Subsequent studies showed that sleepy patients who did not report having attacks of cataplexy also did not show sleep-onset REM periods. Conversely, sleepy individuals who reported the occurrence of attacks of cataplexy always had sleep-onset REM periods. It was clear that the best explanation for the strange attacks of muscle atonia was the normal motor inhibitory mechanism of REM sleep occurring in a precocious or abnormal manner [14].

Most of the aforementioned research was performed after I moved to Stanford University in January 1963. My plans to carry out this research were initially hampered by the fact that not a single narcoleptic patient could be identified at the Stanford University Medical Center. Finally, in desperation, I placed an advertisement in the local daily newspaper. More than 100 people responded! About 50 of these respondents were bona fide narcoleptics having daytime sleepiness and cataplexy and hypnagogic hallucinations and sleep paralysis. The response to this advertisement was a seminal event in the future development of sleep disorders medicine. None of the narcoleptics had been previously diagnosed and I was forced to assume responsibility for their clinical management for them to participate in the research project. As the months passed, I and a research colleague became responsible for managing and taking care of over 100 individuals with narcolepsy. Mostly this involved visiting with the patients at regular intervals and adjusting their medications, which consisted mainly of methylphenidate or dextroamphetamine. Providing this patient care was the harbinger of the modern sleep disorders clinic. I was managing sleep disorders patients and in addition performing diagnostic recordings to demonstrate the pathognomonic sleep-onset REM periods. In 1964, I formally launched the Stanford University Narcolepsy Clinic. It was set up as a true fee-for-service

enterprise. Most of the patients were unable to pay their bills, however, and insurance companies denied payment because the diagnostic recordings of narcolepsy patients were deemed "experimental." Accordingly, this unique clinic was closed because of financial bankruptcy.

One of the most important landmarks in the history of sleep disorders medicine occurred in Europe around this time. Obstructive sleep apnea was discovered independently by Gastaut, Tassinari, and Duron in France and by Jung and Kuhlo in Germany. Both groups reported their findings in 1965. Scholars have found hints in earlier works, even biblical, that suggest obstructive sleep apnea was being described. The aforementioned European reports, however, were the first clear-cut recognition and description that had a direct continuity to sleep disorders medicine as it is known today. There is no evidence that the pulmonary medicine community in the United States understood the importance of these European reports. What should have been an almost inevitable discovery by the pulmonary medicine community or perhaps by the ear-nose-throat surgery community did not occur because there was no interest in either specialty for meticulously observing respiration during sleep. The well-known and frequently cited study of Burwell and colleagues [15], although impressive in a literary sense in its evoking of the somnolent boy Joe from the *Papers of the Pickwick Club* by Charles Dickens, erred badly in attributing the somnolence of their obese patients to hypercapnea. The frequent citing of this paper further reduced the likelihood that sleep apnea would be discovered by the pulmonary medicine community. To this day, evidence that hypercapnea causes true somnolence is completely lacking, although high levels of P_{CO_2} are certainly associated with impaired cerebral function. Nonetheless, the term "pickwickian syndrome" became an instant neologistic success and may have played a role in stimulating an interest in this syndrome by the European neurologists who were also interested in sleep.

In the 1960s, a small group of French neurologists began specializing in clinical neurophysiology and electroencephalography. An individual trained in France, Alberto Tassinari, joined the Italian neurologist Elio Lugaresi, in Bologna. These scientists then performed a crucial series of clinical sleep investigations that provided a complete description of the sleep apnea syndrome including the first observations of the occurrence of sleep apnea in nonobese patients, a description of the cardiovascular correlates, and a clear identification of the importance of snoring and hypersomnolence as diagnostic indicators. These pioneering studies are recounted in Lugaresi's book, *Hypersomnia with Periodic Apneas* [16]. Henri Gastaut and Elio Lugaresi were prompted to organize an international symposium in 1967, the proceedings of which were published as *Abnormalities of Sleep in Man*. These proceedings encompassed issues across a full range of pathologic sleep in humans. The meeting took place in Bologna and the papers presented covered many of what are now major topics in the sleep medicine field: insomnia, sleep apnea, narcolepsy, and periodic leg movements during sleep. It was an epochal meeting from the point of view of the clinical investigation of sleep. The only major issues not represented were clear concepts of clinical practice models and accurate estimates of the high population prevalence of sleep disorders. The event, however, finally triggered a serious international interest in sleep apnea syndromes. Another extremely important meeting was organized by Lugaresi in 1972. An account of this meeting is included in Lugaresi's 1978 book [16].

Despite all the laudatory clinical research, the concept of the all-night sleep recording as a clinical diagnostic test did not occur. An all-night diagnostic test, particularly if it was conducted on out-patients, was completely unprecedented. In addition, the cost of all-night polysomnographic recording was already quite high without adding the cost of hospitalization, although the latter would have legitimized a patient spending the entire night in a testing facility. It should also be clear that in 1970, only a tiny number of people understood that the complaint of daytime sleepiness represented something that had clinical significance. Even narcolepsy, which had been fully characterized as an interesting and disabling clinical syndrome, was not recognized as such in the larger medical community. The extreme neglect of patients with narcolepsy (we documented a mean of 15 years from onset of the characteristic symptoms of narcolepsy until recognition and accurate diagnosis by a clinician, and patients having seen a mean of 5.5 different physicians during the 15 years), however, well justified creating a medical specialty dedicated to such patients.

The evaluation of efficacy in the development of sedative hypnotics had quite reasonably begun to include all-night sleep recordings. When a pharmaceutical company wanted to evaluate a new hypnotic compound, it was necessary to recruit volunteer subjects for the research who manifested objective signs of insomnia. Recruiting insomniacs typically involved giving clinical advice and staying in touch. For these reasons, it became obvious to me early in 1970 that there needed to be a new clinical discipline that specialized in the diagnosis and treatment of individuals afflicted with one or other

of the then known sleep disorders. In the summer of 1970, with as much fanfare as we could muster, we announced the opening of the Stanford University Sleep Disorders Clinic and organized a press conference to publicize this event. Only one reporter attended the press conference, and he turned out to be more interested in the issue of whether or not children should sleep with their parents. In the early months and probably the first year or so of the existence of the Stanford University Sleep Disorders Clinic, there were very few referrals from community physicians. For quite some time, we were unable to achieve more than five or six referrals per week.

The all-night diagnostic sleep recordings were done on the side by technologists who at the time were funded by research projects. I and my sleep colleague, Dr. Vincent Zarcone, were also paid largely by research grants. One of the current giants of sleep medicine, Dr. Christian Guilleminault, a French neurologist and psychiatrist, had come to the sleep center as a research fellow and was doing basic research in the summer of 1970. He returned to France later in the year. Because most of our patients in the early days turned out to be afflicted with narcolepsy, we believed in the need to have a neurologist on the clinical staff. In the summer of 1971, Dr. Zarcone and I recruited Dr. Guilleminault to return to Stanford, which he did, arriving in January of 1972. Until his arrival, the Stanford group had not routinely used respiratory and cardiac sensors in their all-night sleep studies. Beginning in 1972, these measurements became a routine part of the all-night diagnostic test, which was finally dubbed "polysomnography" in 1974.

During 1972, the search for sleep abnormalities in patients with sleep-related complaints continued. We also attempted to conceptualize the pathophysiologic process as both an entity and as the cause of the presenting symptom. With this approach, a number of phenomena seen during sleep were rapidly linked to the fundamental sleep-related presenting complaints. Toward the end of 1972, the basic concepts and protocols of sleep disorders medicine were sculpted sufficiently to offer a day-long course through Stanford University's Division of Postgraduate Medicine. This course was offered under the title "The Diagnosis and Treatment of Sleep Disorders." The topics covered were normal sleep architecture; the diagnosis and treatment of insomnia with drug-dependent insomnia, pseudoinsomnia, central sleep apnea, and periodic leg movement as diagnostic entities; and the diagnosis and treatment of excessive daytime sleepiness or hypersomnia with narcolepsy, non-REM narcolepsy, and obstructive sleep apnea as diagnostic entities.

Professional organizations

In 1964, the Stanford University Sleep Research Program hosted the fourth annual meeting of persons interested in sleep research. This was still somewhat informal, but before the occasion a small group met with the idea of creating some sort of professional organization. The first suggestion for the name of such an organization was the Association for the Study of Sleep, until someone noticed the acronym. Finally, because of the interest in both the physiology of sleep and the phenomenon of dreaming, it was agreed that the organization should be named the Association for the Psychophysiological Study of Sleep (APSS). Every since, there have been annual meetings of the APSS without exception.

By 1975, there were five centers diagnosing and treating patients with sleep-related complaints. Following the launching of the Stanford University Sleep Disorders Clinic, the second such clinic was initiated by the late Dr. Elliot Weitzman who spent a sabbatical year, 1974 to 1975, at Stanford. In a 1976 meeting at O'Hare Airport in Chicago, the Association of Sleep Disorders Centers (ASDC) was formally organized. The charter members were from medical schools at Stanford, Montefiore, Baylor, Cincinnati, and Pittsburgh.

The APSS continued to meet annually, and at a certain point the issue of sponsoring a scientific journal arose. The journal *Sleep* was sponsored jointly by the APSS, the European Society for Sleep Research, and the ASDC. The first issue appeared in September 1978.

Because the sleep disorders discipline was clearly established and growing, the first president of the ASDC and secretary began to think about achieving more notice from the National Institutes of Health and some support from the US Congress. In a first visit to Washington, Dr. Merrill Mitler encountered a Washington lobbyist, Mr. Harley Dirks, who had been chief of staff for the Chairman of the Senate Appropriations Committee. After leaving his congressional position, Mr. Dirks established the Health and Medicine Council of Washington, which is now headed by his son, Mr. Dale Dirks. In 1986, to increase the lobbying clout of the sleep organizations, it was decided to meld them into one overall organization. This entailed the difficulty that two of the organizations consisted of individual members, whereas the third consisted of member centers. A fourth organization was temporarily created called the Clinical Sleep Society to facilitate this process and after several organizing meetings, the Association of Professional Sleep Societies came into being. There was, however, a problem with leadership and finances such that the

organizations almost immediately separated into a loose coalition renamed the Associated Professional Sleep Societies.

I was elected president of the ASDC for four consecutive 3-year terms, after which it was decided that a 1-year presidency would suffice and more managerial responsibility should devolve to the Executive Director. The first formal national office of the APSS and what is now the American Academy of Sleep Medicine was located in Rochester, Minnesota; it was later moved to a less out of the way location in Westbrook, Illinois, a suburb of Chicago. A fourth professional society came into being in 1991 to serve the interests of dentists, called the Academy of Dental Sleep Medicine. In addition, under the aegis of the American Academy of Sleep Medicine, several tax exempt foundations were formed. The first examination by what is now the American Board of Sleep Medicine was administered in 1977. Today, there are more than 7000 individual members of the professional sleep societies, more than 1400 accredited sleep disorder centers, and more than 10 scientific journals around the world devoted to sleep disorders, sleep research, and biologic rhythms.

Complications of obstructive sleep apnea

The disability and cardiovascular complications of severe obstructive sleep apnea are very serious. In the early years of sleep medicine, treatment options were limited to weight loss and chronic tracheostomy. Chronic tracheotomy dramatically ameliorated the symptoms and complications of the illness. Many patients with severe obstructive sleep apnea, however, nonetheless strongly resisted being treated by means of chronic tracheostomy. In addition, the broader medical community was extremely skeptical about the use of chronic tracheostomy mainly because of ignorance about the sleep disorders field. Securing the proper management was a major challenge, as illustrated by the case history of one of the first patients referred to the Stanford Clinic, a 10-year-old boy, Raymond M. The overall difficulties are illustrated in a personal account by Dr. Christian Guilleminault.

> Raymond M. was a 10 ½ -year-old boy referred to the pediatrics clinic in 1971 for evaluation of unexplained hypertension which had developed progressively over the preceding 6 months. There was a positive family history of high blood pressure, but never so early in life. Raymond was hospitalized and had determination of renin, angiotensin, and aldosterone, renal function studies including contrast radiographs, and extensive cardiac evaluation. All results had been normal except that his blood pressure oscillated between 140-170/90-100. It was noticed that he was somnolent during the daytime and Dr. S. suggested that I see him for this 'unrelated' symptom.
>
> I reviewed Raymond's history with his mother. Raymond had been abnormally sleepy 'all his life.' However, during the past two to three years, his schoolteachers were complaining that he would fall asleep in class and was at times a 'behavioral problem'—not paying attention, hyperactive, and aggressive. His mother confirmed that he had been a very loud snorer since he was very young, at least since age two, perhaps before.
>
> Physical examination revealed an obese boy with a short neck and a very narrow airway. I recommended a sleep evaluation which was accepted. An esophageal balloon and measurement of end tidal CO_2 was added to the usual array. His esophageal pressure reached 80 to 120 cm H_2O, he had values of 6% end tidal CO_2, apneic events lasted between 25 and 65 sec, and the apnea index was 55. His SaO_2 [arterial oxygen saturation] was frequently below 60%.
>
> I called the pediatric resident and informed him that the sleep problem was serious. I also suggested that the sleep problem might be the cause of the as yet unexplained hypertension. The resident could not make sense of my information and passed it to the attending physician. I was finally asked to present my findings at the weekly pediatric case conference which was led by Dr. S. I came with the recordings, showed the results, and explained why I believed that there was a relationship between the hypertension and the sleep problem. There were a lot of questions. They simply could not believe it. I was asked what treatment I would recommend, and I suggested a tracheostomy. I was asked how many patients had this treatment in the United States, and how many children had ever been treated with tracheostomy. When I had to answer 'zero' to both questions, the audience was somewhat shocked. It was decided that such an approach was doubtful at best, and completely unacceptable in a child. However, they did concede that if no improvement was achieved by medical management, Raymond would be reinvestigated, including sleep studies.
>
> This was Spring 1972. In the Fall, he was, if anything, worse in spite of vigorous medical treatment. At the end of 1972, Raymond finally had his tracheostomy. His blood pressure went down to 90/60 within 10 days, and he was no longer sleepy. During the five years we were able to follow Raymond, he remained normotensive and alert, but I had to fight continuously to prevent outside doctors from closing his tracheostomy. I don't know what happened to him since.

Discipline identity and discipline overlap

In July of 1981 I wrote a note for the ASDC newsletter. The title was "Does Somnology (a.k.a Sleep

Medicine) Exist?" It was patterned after an analogous discussion titled "Does Gerontonology Exist?", which appeared elsewhere. A dozen criteria defining the existence of a clinical scientific discipline were posed. They were paraphrased by me and answered. In 1981, the title of someone who practiced sleep medicine was "clinical polysomnographer," a name of which no one was particularly fond. The criteria are presented below, slightly updated for this article.

1. *Does clinical polysomnography and sleep research have the broad academic organization to provide career lines for teachers and researchers?* No. Tenured appointments are controlled by departments. As far as I know, no medicinal school has a department of sleep medicine.
2. *Does society provide support for sleep research?* Although there are a fair number of federal grants for sleep research, they are not easy to obtain. Certainly, there is no official large government mandate for such funding. There is, however, a small Center for Sleep Disorders Research (2 FTEs) in the National Heart, Lung, and Blood Institute.
3. *Is there a student demand for courses?* Although the need is great, the demand is small. It is increasing, however, as are applications to sleep centers for postgraduate training.
4. *Is there a demand for graduates?* Yes, definitely. Many institutions interested in starting sleep disorders centers need trained and experienced sleep specialists to serve as medical directors; the dearth of well-trained people actually hampers development of the field.

Questions five through seven concern a would-be discipline's relation to its subject matter.

5. *Does sleep research study some distinct part of nature?* Yes. Sleep research is concerned with the sleeping organism, the determinants of sleep, the mechanisms of sleep, the circadian rhythm of sleep and wakefulness and its determinants, the role of sleep in waking function, and the pathology of all systems and mechanisms responsible for the sleep-wake cycle. Certainly, sleep research overlaps with other disciplines. Sleep-induced respiratory disturbances concern pulmonary specialists. Many sleep disorders have significant hemodynamic impact, of interest to cardiologists. Hypersomnia is still considered to be a neurologic problem. Sleep research provides the umbrella or the forum in which professionals from different areas can share their findings and forge new diagnostic and therapeutic approaches.
6. *Is there at least a social group to be studied?* Not applicable.
7. *Is there at minimum a social problem to be studied?* Not applicable unless it is the impact of waking sleepiness in all components of society.

The last set of questions concerns the internal criteria or maturity of the discipline.

8. *Does the work of sleep researchers share a unique method?* Certainly. Polysomnography, sleep scoring, characterization of sleep patterns, and sleep deprivation studies all are good examples of approaches unique to the field.
9. *Does sleep research have a theory?* Yes. Although there are many questions as yet unanswered, several models have been developed that generate testable hypotheses.
10. *Can the knowledge of the field be linked in an integrated whole?* The answer is now "yes." Although there is minor disagreement about what might be regarded as common knowledge within the discipline, there are now several textbooks.
11. *Do scholars, teachers, and practitioners find it useful to share interaction?* As with any field investigating widespread and serious medical disorders, the answer to this question is an unqualified "yes."

The overall answer to these questions is "yes." Clearly, sleep research qualifies as a full-fledged academic discipline concerned with, for example, physiology during sleep, sleep mechanisms, state regulation and sequencing in the organism, chronobiology as it relates to sleep and wakefulness rhythms, sleepiness and alertness and related variables, and the diagnosis and treatment of pathologies in all of these areas.

Unlike many newcomers to the medical mainstream, sleep medicine is not the child of a single parent discipline. Rather, clinical and basic sleep research have been the foster children of many disciplines but have been the favored children of none. In the early days, we were passed from hand to hand as then current findings had practical significance for other specialties. Early research on REM deprivation provided models for psychosis and depression. Sleep apnea syndromes, sleep-induced gastroesophageal reflux with secondary laryngospasm, and general sleep-related respiratory load increase have intrigued those in pulmonary medicine. REM sleep-related penile tumescence is of great diagnostic value to urologists in the study of impotence. Pediatricians work with sleep specialists to unravel sudden infant death syndrome and the impact of sleep disturbances on normal development. REM sleep muscle inhibition and sleep-related changes in the balance of the autonomic and parasympathetic nervous system concern practitioners caring for patients already compromised

(eg, those with poliomyelitis, familial dysautonomia, muscular dystrophy, diabetes, and so forth). Those concerned with biologic rhythms share an interest in the important circadian rhythms of sleep and wakefulness.

Minimal penetration of the mainstream educational system

The clinical scientific discipline of sleep medicine has not yet been widely embraced by academic medicine. Although such surveys are difficult, it is likely that there are fewer than five tenured professorships in American medical schools designated specifically for sleep research and sleep medicine. There does not exist in any medical school a department of sleep medicine. There are, however, at least a few divisions of sleep medicine, eg, at Harvard University in the Department of Medicine, at the University of Pennsylvania in the Department of Medicine, at Stanford University in the Department of Psychiatry, and at the University of Michigan in the Department of Neurology. An unsuccessful proposal was made by one medical school to establish a division in its department of ear, nose, and throat surgery.

At the undergraduate level, there is very little systematic teaching about sleep knowledge, circadian rhythms, dreaming, and sleep disorders in the nearly 4000 colleges and universities. In a very recent survey of Stanford undergraduates, fewer than 2% had received systematic teaching about sleep before matriculating.

The first sleep disorders clinic did not exist before 1970 and until the invention of continuous positive airway pressure for the treatment of sleep apnea, the standard treatment using chronic tracheostomy posed a major obstacle to the rapid expansion of the diagnosis and treatment of sleep apnea. The discipline of sleep medicine did not become truly viable until the 1980s.

Unfortunately, clinicians have now reached a time when expansion and growth in many components of society has flattened or slowed. The number of medical schools in America today is essentially the same as it was four decades ago, and no undergraduate department of psychology or human biology offers a well-organized and complete teaching program involving the sleep-related disciplines.

Final thoughts

The need for an effective societal understanding of sleep-related issues is great and urgent. It is possible that the entire human race has not achieved its full behavioral and intellectual capacity because of chronic sleep deprivation and the accumulation of sleep debt. Extrapolating from the report by Young and coworkers [17] in 1993, there are at least 30 million victims of obstructive sleep apnea in the United States. It is not inconceivable that new cases are developing at a rate that is higher than the rate of cases that are identified and effectively treated. The complaint of insomnia is extremely widespread and the underlying causes are reasonably well characterized.

Sleep medicine in all its ramifications is a field that should take its destiny into its own hands as much as possible. We must penetrate the educational system. We must prevail on elected representatives to do more for the field both at the national and the state levels. If both patients and sleep professionals can be mobilized, the numbers are there to achieve many things. There are still far too many sleep-related accidents, far too many undiagnosed and untreated victims of sleep disorders, and many individuals continue to organize their lives based more on mythologic beliefs than the true facts of sleep and wakefulness.

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