Evaluation of a computerised polysomnography system

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Abstract

Background Manual analysis of sleep, breathing, and oxygenation records is the "gold standard" for diagnosing sleep abnormalities but is time consuming and cumbersome. The accuracy and cost of a computerised sleep analysis system have therefore been investigated.

Methods Manual and computerised (CNS Sleep Lab) scores from 43 consecutive clinical sleep studies were prospectively compared for accuracy and the time and costs were recorded.

Results There were good correlations and no systematic differences between manual and computer scoring for total sleep time, sleep onset latency, and duration of REM sleep. There was a small but clinically insignificant systematic difference in breathing pattern analysis, the number of hypopnoeas/hour being lower with manual than with computer scoring (13 (SE 3) v 15 (SE 3)/hour). There was no difference between computer and manual scoring of the frequency of apnoeas, so the frequency of apnoeas + hypopnoeas was clinically insignificantly higher with computer scoring with a highly significant correlation between the two techniques. The time taken to perform the analyses was not different between the two methods (manual 83 (SE 8) v computer 86 (SE 8) minutes). The computer system was six times more expensive than the manual system and annual running costs, including full maintenance contract and 15% depreciation, were twice as great.

Conclusion The CNS Sleep Lab is sufficiently accurate for use in clinical sleep studies but is significantly more expensive and does not save technician time.

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The "gold standard" for diagnosing the sleep apnoea-hypopnoea syndrome and other sleep related disorders is polysomnography.¹ Manual analysis of polysomnograms is time consuming and thus expensive in terms of technician time; it also generates large volumes of paper trace—13 kg of paper measuring 15 × 32 × 45 cm per night in our

laboratory—with resultant purchase and storage costs. Data acquisition techniques which allow electronic storage of sleep studies and automated or semiautomated analysis could thus save time and money and be extremely useful if they were sufficiently accurate. We have therefore examined the accuracy of polysomnography carried out with the CNS Sleep Lab (CNS Inc, Chanhassen, Minnesota, USA) and have studied the potential for time and cost savings.

Methods

The CNS Sleep Lab is a fully interactive system in which the technician scans the individual sleep study and determines the thresholds to be used for that study. We prospectively compared the accuracy of manual and CNS Sleep Lab scoring and recorded the time spent scoring the studies by the two techniques. All scoring was performed by one polysomnographer with five years' full time experience of manual sleep scoring and one year's experience with the CNS Sleep Lab. The manual and CNS Sleep Lab records were analysed by the technician in a randomised order so that there was no knowledge or memory of the results of the alternative analysis. The scoring time included the time spent generating final reports.

Sleep studies were carried out in our standard fashion¹ with recording of air flow at the mouth and nostrils by thermocouples;² thoracoabdominal movement by Resptrace (Ambulatory Monitoring, Ardsley, New York, USA); ear oxygen saturation by Ohmeda 3700 Oximeter; and electrocardiography, anterior tibial electromyography (EMG), and sleep scoring by standard criteria³ with electroencephalography (EEG), EMG, and electro-oculography performed with our standard electrode placement.² All these signals were recorded on paper trace from a time base recorder (SLE 16b, Specialised Laboratory Equipment, Croydon, UK) running at 15 mm/second. All signals were also recorded on optical disk by the CNS Sleep Lab.

Forty three consecutive patients undergoing evaluation in our sleep laboratory took part in the study. The whole night of each of these records was scored to give the following sleep and respiratory variables that we normally obtain from all clinical sleep studies.

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Figure 1 Total sleep time (TST) by manual and computer (CASS) systems displayed (A) as an x/y plot ($r = 0.91$; $p < 0.001$) and (B) as a plot of the difference between the two techniques against their mean.

Figure 2 Rapid eye movement (REM) latency by manual and computer method displayed (A) as an x/y plot ($r = 0.44$; $p < 0.01$) and (B) as a plot of the difference between the two techniques against their mean.

- Sleep:
- Sleep period time (SPT)
 - Sleep onset latency (SOL)
 - Total sleep time (TST)
 - Rapid eye movement (REM) sleep latency
 - REM sleep duration
- Respiratory apnoeas:⁴
- Total per night and per hour TST
- Respiratory hypopnoeas:⁵
- Total per night and per hour TST

STATISTICAL ANALYSIS

The results of the two analytical techniques were compared by Student's *t* test, correlation analysis, and the method of Bland and Altman.⁶

Table 1 Comparison of manual and computer scoring of sleep and respiratory variables

	Manual scoring		CNS Sleep Lab		Difference		
	Mean	SD	Mean	SD	Mean	95% CI	
TST	335	56	331	55	3	-4	+10
SPT	395	33	389	36	5	-1	+8
SOL	211	24	21	24	-0.2	-2	+2
REMIlat	113	71	103	66	9	-13	+31
REMdur	40	28	35	26	5	-1	+11
AI	0.5	2	0.5	2	0	-0.3	+0.3
HI	3	17	1.5	17	-1	0	+2
A + HI	14	18	15	18	-1	0	+2

TST—total sleep time (min); SPT—sleep period time (min); SOL—sleep onset latency (min); REMlat—REM latency (min); REMdur—REM duration (min); AI—apnoea index (events hour); HI—hypopnoea index (events/hour); A + HI—apnoea + hypopnoea index (events hour).

Results

Adequate traces were obtained on both the time base recorder and the CNS computer for sleep pattern analysis in all 43 patients. There was a good correlation (fig 1) between manual and computer scoring of TST with no systematic difference in the results of manual or computer scoring (table 1; fig 1).

Similarly there were no significant differences (table 1) between manual and computer scoring for SOL ($p = 0.86$; $r = 0.97$, $p < 0.001$), REM sleep latency ($p = 0.42$; $r = 0.44$, $p < 0.01$; fig 2) or REM sleep duration ($p = 0.13$; $r = 0.85$, $p < 0.001$).

Thirty four breathing traces were technically suitable for analysis by both techniques. There was a small but consistent difference between the manual and computer scoring of frequency of apnoeas + hypopnoeas (fig 3).

Table 2 Comparison of costs of manual and computer scoring systems

Costs	Manual (£)	Computer (£)
Capital	15 686	88 125
Annual		
Paper or disk	3 280	1 213
Full maintenance contract	1 568	7 038
Depreciation at 15%	2 353	13 219
Paper storage	3 240	-
Total annual costs	10 441	21 470

Figure 3 Episodes of apnoea and hypopnoea/hour slept ($A + H/h$) by manual and computer (CASS) techniques displayed (A) as an x/y plot ($r = 0.99$; $p < 0.001$) and (B) as the difference between the results of the two methods against their mean.

This small discrepancy was because of a higher number of hypopnoeas recorded with computer scoring ($p < 0.05$), but there was no difference in the low number of apnoeas detected by the two methods.

The mean time taken to perform the full analyses of sleep and breathing patterns was not different between the two methods (manual, 83 (SE 8) *v* computer, 86 (SE 8) minutes). Similarly, there was no difference in the time taken to score sleep durations (39 (SE 2) *v* 40 (SE 3) minutes) or breathing pattern (43 (SE 8) *v* 46 (SE 7) minutes).

COSTS

The capital costs of the recording systems used are nearly six times greater for the computer system (table 2). Annual running costs are based on 200 studies per recorder per year and the assumption that all data will be stored for five years. Annual running costs, including a full maintenance contract, the cost of paper storage (disk storage will normally be free as disks will be stored within the laboratory), and 15% depreciation of capital costs, were over twice as high for the CNS Sleep Lab system as for a paper recording system (SLE polygraph). These figures do not include technician time or the costs of the other apparatus used in the sleep laboratory, all of which will be similar for the two methods.

Discussion

This study shows that the accuracy of computer interactive scoring of sleep and breathing records is similar to that of manual scoring. It also shows, however, that the computer system used does not save technician time when compared with the abbreviated manual scoring system used in our laboratory.

Automatic or semiautomatic systems for monitoring sleep, breathing and oxygenation, or both, have proliferated in recent years. These range from computer programs for analysing overnight oximetry through limited sleep studies incorporating breathing and

oxygenation such as the MESAM⁷ to full polysomnography systems.⁸ The advantages of the polysomnography systems are that they should theoretically be able to detect all the abnormalities picked up at routine polysomnography, including respiratory events not associated with desaturation that occur in at least 25% of cases,¹ as well as disturbances of sleep pattern due to non-respiratory causes. In addition, computerised polysomnographic equipment should be able to be used to document daytime sleepiness and sleep onset REM sleep during multiple sleep latency tests if sleep and REM sleep latency can be accurately assessed. The CNS system has the additional advantage of being interactive, allowing the technician to set specific thresholds for each patient.

There has, however, been a paucity of studies validating computerised techniques against routine paper trace polysomnography, the only published studies on the CNS Sleep Lab system being abstracts on small numbers of patients.^{9,10} This study shows that the CNS system can be used to adequately score sleep and breathing patterns. There is a degree of variability between the results obtained by a manual scoring system and the CNS Sleep Lab, but this must be seen against an up to 15% interobserver variability in the manual scoring of sleep traces.

The technician took as long to score the records on the computer as from the paper trace. The reasons for this include the use of the abbreviated sleep score, in which non-REM sleep is not subclassified; this we consider adequate for clinical sleep studies as subdivisions of non-REM sleep are not clinically important. Nevertheless, the CNS system produces a much more detailed breakdown of the overnight sleep, breathing, and oxygenation changes and some laboratories might find this facility useful. In this study the technician was seeking the most accurate scoring possible from the CNS Sleep Lab system and it might have been possible to perform some of the analyses faster at the expense of accuracy. During the CNS Sleep Lab scoring time there were short periods of

less than five minutes when the technician could leave the computer to proceed with the analysis, but in practice these gaps were too brief to allow other major tasks to be performed. The only area in which our data show that the CNS Sleep Lab was sufficiently inaccurate to cause concern in clinical practice was in the scoring of REM sleep latency (fig 2). Although the computer system was accurate in most cases, there was considerable variability and this might be important in the recognition of early REM sleep, which is particularly important during the multiple sleep latency test.¹¹

A definite advantage of the CNS system is the replacement of the paper trace by optical disk. This not only gets around practical problems, such as pens failing, paper sticking and storage, but also greatly aids retrieval of earlier sleep studies. Reviewing previous paper records is a major logistic and physical feat in many sleep laboratories. In addition, some laboratories believe that it may be possible to dispense with an overnight technician when paperless systems are used.

The CNS Sleep Lab system is adequately accurate for clinical sleep studies but does not save technician time and is associated with much higher capital costs than conventional paper trace polysomnography.

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- 1 Douglas NJ, Thomas S, Jan MA. Clinical value of polysomnography. *Lancet* 1992;339:347-50.
- 2 Douglas NJ, Calverley PMA, Leggett RJE, Brash HM, Flenley DC, Brezinova V. Transient hypoxaemia during sleep in chronic bronchitis and emphysema. *Lancet* 1979;i:1-4.
- 3 Rechtschaffen A, Kales A, eds. *A manual of standardized terminology, techniques and scoring systems for sleep stages of human subjects*. Publication No 204. Bethesda: National Institutes of Health, 1968.
- 4 Guilleminault C, van den Hoed J, Mitler MM. In: Guilleminault C, Dement WC, eds. *Sleep apnea syndromes*. New York: AR Liss 1978, 1-12.
- 5 Gould GA, Whyte KF, Rhind GB, Airlie MAA, Catterall JR, Shapiro CM, et al. The sleep hypopnea syndrome. *Am Rev Respir Dis* 1988;137:895-8.
- 6 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986;i:307-10.
- 7 Penzel T, Amend G, Meinzer K, Peter JH, von Wichert P. MESAM: a heart rate and snoring recorder for detection of obstructive sleep apnea. *Sleep* 1990;13:175-82.
- 8 Burgess RC. Computerised polysomnographic analysis systems. *J Clin Neurophysiol* 1990;7:145-54.
- 9 Orr WC, Hansotia P, Anderson MW, Cohen D. Computer assisted sleep staging and visual scoring. *Sleep Res* 1988;17:344.
- 10 Hanson RR, Glazier J, Hicklin GA, Steffen DA, Delanoit J. A comparison of CNS "CASS" and manual methods. *Sleep Res* 1989;18:391.
- 11 Carskadon MA, Dement WC, Mitler MM, Roth T, Westbrook PR, Keenan S. Guidelines for the multiple sleep latency test (MSLT): a standard measure of sleepiness. *Sleep* 1986;9:519-24.