Original Article

Sleep disturbances in the spinal cord injured: an epidemiological questionnaire investigation, including a normal population

F Biering-Sørensen*,1 and M Biering-Sørensen[1]

[1]Clinic for Para- and Tetraplegia, Department TH, The Neuroscience Centre, Rigshospitalet, Copenhagen University Hospital, Copenhagen, Denmark

Study design: Epidemiological review.

Objective: To evaluate sleep disturbances in the spinal cord injured.

Setting: The Clinic for Para- and Tetraplegia, Hornbæk/Copenhagen, Copenhagen University hospital, Denmark.

Methods: All patients admitted with traumatic SCI during the 20-year period 1968–1987 were reviewed. The normal population consisted of 339, 222 men and 117 women. These groups were asked to fill in the self-administered Nordic Sleep Questionnaire (NSQ) containing 21 questions. Questions were added regarding employment, smoking, alcohol, coffee or tea consumption, height and weight. The questionnaire for SCI individuals included questions about bladder emptying method, mobility, and spasms. For the SCI population age at injury, cause of injury, neurological level, and functional class were retrieved.

Results: Four hundred and eight SCI individuals, 331 men and 77 women, answered the NSQ corresponding to a response rate of 83.8%. Forty-seven per cent had a cervical cord lesion and about half of the population had a complete motor lesion. In comparison with the normal population the SCI individuals had greater difficulty in falling asleep, described more frequent awakenings, slept subjectively less well, were more often prescribed sleeping pills, slept more hours, took more and longer naps, and snored more and for more years. In particular, spasms, pain, paraesthesia, and troubles with voiding were claimed to be part of the sleep problems.

Conclusion: In spite of the same average age and a higher body mass index in the normal than the SCI population, the SCI individuals showed significantly more sleep problems than the normal population.

Spinal Cord (2001) **39,** 505–513

Keywords: spinal cord injury; paraplegia; tetraplegia; normal population; sleep; sleep disorder

Introduction

Spinal cord injured (SCI) individuals are commonly reported to complain about difficulty in sleeping.[1–5] According to Bonekat et al[1] they have restless sleep, complain of spasms, difficulty in initiating and maintaining sleep, snoring, often awaking in the early hours of the morning and are unable to fall asleep again, and during the day time they are tired and sleepy. SCI individuals often sleep in the supine position, have a tendency to obesity, commonly use sedatives, and all these factors may aggravate the quality of sleep.[1] In tetraplegics in particular, obstructive sleep apnea and arterial oxygen desatura-

tion may contribute to disruption of sleep and be responsible for many of the daytime symptoms.[1,2,4–13] As this hypothesis has not been exposed to epidemiological evaluation we have compared a SCI population with a normal population, using the Nordic Sleep Questionnaire (NSQ)[14] for this purpose. In preparation for the epidemiological survey we carried out a reproducibility study of the NSQ, and found it generally reliable, including for use in a SCI population.[15]

Questionnaire

The NSQ contains 21 sleep questions (Q1–21) (Tables 1 and 2). It should be noted that Q13–14 on time going to bed and waking up were not analyzed. The

*Correspondence: F Biering-Sørensen, Clinic for Para- and Tetraplegia, The Neuroscience Centre, Rigshospitalet, Copenhagen University Hospital, Havnevej 25, DK-3100 Hornbæk, Denmark

Table 1 Distribution of answers by 408 spinal cord injured (*SCI in italic*) and 339 normal individuals (NOR) to the ordered 5-point scale questions in the Nordic Sleep Questionnaire[a]

Question	Group : n	*Answer possibilities in per cent*					P-*value*
		1	*2*	*3*	*4*	*5*	
Q1. Have you had difficulties in falling asleep?	*SCI : 402*	*47.3*	*17.7*	*13.4*	*8.2*	*13.4*	
	NOR : 338	64.5	26.3	5.9	2.1	1.2	<0.00001
Q3. How often do you awaken at night?	*SCI : 397*	*22.7*	*13.4*	*10.1*	*10.3*	*43.6*	
	NOR : 338	33.7	21.0	16.3	6.2	22.8	<0.00001
Q4. How many times do you usually wake up in one night?[b]	*SCI : 395*	*29.4*	*23.8*	*21.5*	*20.0*	*5.3*	
	NOR : 307	44.0	36.2	14.3	5.5	–	<0.00001
Q5. How often have you awakened very early in the morning without being able to fall back to sleep again?	*SCI : 390*	*53.1*	*17.4*	*11.8*	*8.2*	*9.5*	
	NOR : 338	68.3	21.0	7.1	2.1	1.5	<0.00001
Q6. How well have you been sleeping?[c]	*SCI : 405*	*31.4*	*32.1*	*26.4*	*8.4*	*1.7*	
	NOR : 339	37.8	39.8	19.2	2.7	0.6	0.0002
Q7. Have you used sleeping pills (by prescription)?	*SCI : 378*	*74.6*	*3.4*	*2.7*	*1.3*	*18.0*	
	NOR : 334	95.2	2.1	0.3	0.3	2.1	<0.00001
Q8. Do you feel excessively sleepy in the morning after awakening?	*SCI : 390*	*37.7*	*21.8*	*14.9*	*7.7*	*18.0*	
	NOR : 334	33.5	26.9	18.6	7.5	13.5	0.98
Q9. Do you feel excessively sleepy during the daytime?	*SCI : 387*	*29.7*	*23.3*	*20.2*	*9.8*	*17.1*	
	NOR : 334	29.9	32.6	21.9	7.2	8.4	0.017
Q10. Have you suffered from irresistible tendency to fall asleep while *at work*?	*SCI : 233*	*70.4*	*14.2*	*9.0*	*1.3*	*5.2*	
	NOR : 324	78.1	14.2	5.6	1.2	0.9	0.017
Q11. Have you suffered from irresistible tendency to fall asleep during *free time* (leisure time)?	*SCI : 365*	*44.9*	*22.5*	*15.1*	*7.1*	*10.4*	0.0002/
	NOR : 333	40.2	30.6	21.0	4.5	3.6	0.73
Q15a. How often do you have a nap during the daytime?	*SCI : 403*	*40.0*	*14.9*	*13.7*	*8.4*	*23.1*	
	NOR : 338	50.3	22.8	13.3	6.2	7.4	<0.00001
Q16. Do you snore while sleeping (ask other people)?	*SCI : 369*	*39.3*	*14.6*	*11.4*	*7.3*	*27.4*	0.0038/
	NOR : 325	40.0	21.2	16.0	4.6	18.2	0.067
Q17. In what way do you snore (ask other people about the quality of your snoring)?[d]	*SCI : 347*	*31.7*	*36.9*	*13.3*	*7.8*	*10.4*	0.013/
	NOR : 314	34.1	38.9	17.8	4.8	4.5	0.11
Q18. Have you had breathing pauses (sleep apnea) during sleep (have other people noticed that you have pauses in respiration when you sleep)?	*SCI : 335*	*87.5*	*3.3*	*3.6*	*2.1*	*3.6*	0.0030/
	NOR : 315	90.2	7.0	1.6	0.6	0.6	0.18

n : number who answered the particular question in the stated group (*SCI* or NOR). Tested with Mann–Whitney rank sum test. But in cases where two test-values are given then the first value is based on a χ^2-test, and the second value on a Mann–Whitney test. Both tests are only shown when major discrepancies were observed.
[a]The basic scale for the answer-alternatives is as follows (for exceptions see below): **1**, never or less than once per month; **2**, less than once per week; **3**, on 1–2 days per week; **4**, on 3–5 days per week; **5**, daily or almost daily. 'Nights' instead of 'days' if more appropriate. The questions generally ask about the past 3 months.
[b]Answer alternatives; **1**, usually I don't wake up at night; **2**, once per night; **3**, two times; **4**, 3–4 times; **5**, at least five times per night.
[c]Answer-alternatives: **1**, well; **2**, rather well; **3**, neither well nor badly; **4**, rather badly; **5**, badly.
[d]Answer-alternatives: **1**, I don't snore; **2**, my snoring sounds regular and it is of low voice; **3**, it sounds regular but rather loud; **4**, it sounds regular but it is very loud (other people hear my snoring in the next room); **5**, I snore very loudly and intermittently (there are silent breathing pauses when snoring is not heard and at times very loud snorts with gasping)

majority of the questions can be answered by a tick in the appropriate box, but some must be answered by a number of minutes, hours, years, or by time of day or night. The last question (Q21) is an open one, where sleep problems can be described in free text. The questionnaire asks the individual to describe his or her situation during 'the last three months'.

Some introductory questions were added regarding employment status, smoking habits, alcohol intake and the consumption of coffee or tea, together with questions on the respondent's height and weight, which were used to calculate the body mass index (BMI = weight (kg)/[height (m)]^2).

The questionnaire used for SCI individuals was supplemented with questions about bladder emptying method, how they got around (wheelchair/ambulation), and spasms at daytime and during the night.

Methods and populations

All records of patients with traumatic SCI admitted to the Rehabilitation hospital in Hornbæk, Denmark, during the 20-year period 1968–1987, were reviewed. In the study patients with a traumatic spinal cord or cauda equina lesion were included.

For all patients we determined the level of the spinal cord lesion as the most caudally normally functioning spinal cord segment at injury, and the functional level (Frankel or functional class)[16] at the latest follow-up. To facilitate the analysis of the influence of neuro-

Table 2 Distribution of answers by 408 spinal cord injured (*SCI in italic*) and 339 normal individuals (NOR) to the quantitative questions in the Nordic Sleep Questionnaire

Variable/question	Group: n	Mean	SD	Median	Range	P-value
Q2. For how long a time (how many minutes as an average) do you stay awake in bed before you fall asleep (after lights out)?						
a. working days	*SCI: 224*	*21.77*	*27.43*	*10.00*	*1–210*	
	NOR: 308	9.99	10.37	5.00	1–75	<0.00001
b. during free time	*SCI: 343*	*26.48*	*32.49*	*15.00*	*1–240*	
	NOR: 313	10.42	10.91	8.00	1–80	<0.00001
Q12. How many hours do you usually sleep per night?	*SCI: 394*	*7.07*	*1.38*	*7.00*	*2–12*	
	NOR: 338	6.86	0.80	7.00	4–9	0.011
Q15b. If you take a nap, how long does it usually last? (minutes)	*SCI: 275*	*63.41*	*35.47*	*60.00*	*5–210*	
	NOR: 228	47.24	25.98	45.00	4–150	<0.00001
Q19a. If you snore at least 1–2 times per week, how many years have you been snoring (ask other people if you don't know)?	*SCI: 137*	*18.27*	*13.77*	*16.00*	*1–70*	
	NOR: 111	14.25	10.89	10.00	2–60	0.011
Q19b. Age when you started to snore?	*SCI: 123*	*25.95*	*11.06*	*26.00*	*1–52*	
	NOR: 100	35.00	12.13	36.00	0–60	<0.00001
Q20. How many hours of sleep do you need per night (how many hours would you sleep if you had the possibility to sleep as long as you need to)?	*SCI: 367*	*7.61*	*1.16*	*8.00*	*4–14*	
	NOR: 332	7.62	0.94	8.00	4.5–10	0.90

n: number who answered the particular question in the stated group (*SCI* or NOR). SD: standard deviation

logical and functional level for the various sleep parameters we calculated a combined variable, called 'neurofunction':

- '$C_{1-5}/A-C$': neurological level C_{1-5} and functional class $A-C$;
- '$C_{6-8}/A-C$': neurological level C_{6-8} and functional class $A-C$;
- '$T_{1-6}/A-C$': neurological level T_{1-6} and functional class $A-C$;
- '$>T_6/A-C$': neurological level T_6-S_2 and functional class $A-C$;
- 'D': all with functional class D;
- 'E': all with functional class E.

This division describes high and low tetra- and paraplegics with no useful motor function below the level of lesion. Class D represents a very heterogeneous group.[17] The individuals in class E are nearly normal.

Date of birth, gender, date of injury, and highest level of spinal fracture were extracted from the hospital records. In case of death the date of death was verified by death certificate.

Everyone alive and still living in Denmark were traced and sent a questionnaire with a letter describing the purpose of the investigation and the importance of their reply. In addition, a pre-stamped return envelope was included with the mailing to each individual. If the questionnaire was not returned within approximately 2 months a reminder was sent.

The study was approved by the regional Ethical Committee.

As no normal data exists for the NSQ we collected answers to the NSQ from a non-SCI population without major physical disabilities, but a similar age distribution. The questionnaires were filled in anonymously, mainly by hospital employees.

Statistical calculations were carried out with parametric (*t*-test and ANOVA) as well as non-parametric tests (Fisher's exact, χ^2-test, Mann-Whitney and Kruskal-Wallis rank sum tests). Five per cent was chosen as the level of significance.

Results

Normal population
The normal population consisted of 339 individuals, 222 men and 117 women. The age was in mean 42.9 years (SD 12.2; median 42.0, range 18–84; unknown for five), with no significant gender difference.

SCI population
A total of 601 traumatic SCI were admitted to the Rehabilitation hospital in Hornbæk during 1968–1987. Details are given in Table 3. The response-rate to the NSQ for those alive at the time of the investigation was 83.8%, of whom 84.3% answered the first mailing.

Of the non-respondent group seven were living abroad (Australia, Bulgaria, England, Iceland, Syria (two persons) and Yugoslavia), and one had aphasia (thus unable to answer the questionnaire).

No significant differences were found between the groups in Table 3 regarding gender, neurological level or functional class. Age at injury was significantly ($P<0.0001$) higher for those who had died, but when excluding this group from the test no significant

Table 3 The total spinal cord injured population of 601 divided by gender, age at injury in years, cause of injury, neurological level at injury and functional class (Frankel) at last follow-up,[16] for responders to 1st and 2nd mailing, non-responders, and those who were dead at the time of the investigation

	Responded to 1st mailing	Responded to 2nd mailing	Non-responder	Dead	Total
Men	274	57	60	90	480
Women	70	7	19	25	121
Total	344	64	79	114	601
Age at injury					
Mean	31.0	27.2	30.8	47.9	33.8
SD	13.7	12.4	13.7	17.2	15.9
Cause of injury (unknown for 6 cases)					
Traffic accident	46%	55%	51%	47%	48%
Fall	24%	14%	21%	32%	24%
Shallow water diving	10%	5%	3%	4%	7%
Sports accident	5%	13%	1%	1%	4%
Suicide attempt	5%	3%	15%	7%	6%
Violence	3%	3%	4%	–	3%
Other causes	7%	8%	5%	10%	8%
Neurological level at injury					
C1–C8	47%	47%	47%	54%	49%
T1–T6	10%	8%	10%	11%	10%
T7–T12	24%	22%	20%	22%	23%
L1–S2	18%	23%	23%	12%	18%
Functional class (Frankel class)					
A	37%	28%	25%	31%	33%
B	15%	11%	15%	15%	14%
C	9%	8%	8%	14%	10%
D	25%	36%	38%	29%	29%
E	15%	17%	14%	11%	14%

difference was observed among the three other groups. More falls were found in the group who had died, on the other hand more diving accidents were recorded for the primary responders, and relatively more suicide attempts in the non-respondent group. The overall differences regarding cause of injury was tested and the described variations corresponded to $P = 0.001$ ($\chi^2 = 32.79$, *df*. 12, when adding shallow water diving and the sports accident causes, and adding the suicide and violence causes – to give enough numbers in each cell). Twenty-five of the 38 suicide attempts registered in the material were by women ($P < 0.00005$).[18]

There was a known spinal fracture in 463 of the SCI, 212 cervical, 152 thoracic, and 99 lumbar; 28.7% of the fractures were in vertebrae C5–6, and 25.3% in vertebrae T12–L1. There was no fracture in 89 instances. This information is unknown for 49 individuals. No significant difference between the four 'responder-groups' was found regarding this aspect. Those who died before the time of investigation were a mean of 55.8 (SD 18.0) years of age at the time of death, and the mean time from injury to death was 7.9 years (SD 5.6).

For those who responded to the questionnaire the mean age at questionnaire answering for responders was 42.5 years (SD 14.1; median 40.4, range 17–86; unknown for 19) and the period from injury to questionnaire response was 12.1 years (SD 6.3; median 11.4, range 2.5–45.1; unknown for 19). No significant

differences were observed between the responder-groups.

Comparing the 408 individuals who answered the questionnaire in response to the 1st mailing with the 2nd showed no significant differences with respect to bladder emptying regime, or spasms by day or during the night. Regarding mobility, we found a significant difference ($P = 0.02$) between those who responded to the 1st and the 2nd mailing, ie manual wheelchair use was relatively more frequent among the 1st mailing responders, while walking with orthosis/crutches was more common in the group responding to the 2nd mailing.

Basic questions

The age-distribution was similar ($P = 0.70$) in the SCI responders and the normal population. The gender distribution showed significantly more men in the responding SCI-population than in the normal population ($P < 0.00005$), although both groups had clearly more men than women included.

Gainful employment was equal in the two 'responder groups', but significantly ($P = 0.01$) more men (38%) than women (15%) claimed to be gainfully employed.

Smoking was significantly ($P = 0.01$) more common among responders to the 2nd mailing (68%), than for those to the 1st mailing (50%) (unknown for eight). In

general the SCI-population did smoke significantly ($P < 0.00005$) more than the normal population, in whom 34% were smoking (unknown for two).

For the SCI-population, intake of alcohol (unknown for 12) and coffee/tea (unknown for 13) showed no significant differences between the 'responder groups'. In all, 48 (12%) claimed never to drink alcohol, 242 (61%) did not drink daily, 89 (22%) had 1–4 drinks daily, and 17 (4%) had five or more drinks daily. No significant difference was found between the SCI and the normal population regarding drinking alcohol daily.

Cups of coffee/tea taken at night were in the SCI-population (unknown for 13) more than four in 44 (11%), 3–4 in 76 (19%), two in 97 (25%), one in 90 (23%), and none in 88 (22%). Intake of coffee/tea in the SCI-population was significantly more than in the normal population (unknown for four) ($P = 0.002$).

Between the two SCI 'responder groups' there was no significant difference regarding height (mean 175.5 cm, SD 9.1; unknown for 36), weight (mean 72.0 kg, SD 15.0; unknown for 42), or BMI (mean 23.3 kg/m^2, SD 4.2; unknown for 46). Likewise, we found no difference regarding these measures between the groups for the 'neurofunction' variable. Comparing the SCI and the normal populations the BMI was significantly higher in the normal population both for men (SCI: 23.5 kg/m^2, $n = 297$; normal: 24.5 kg/m^2, $n = 221$; $P = 0.0034$) and women (SCI: 21.2 kg/m^2, $n = 64$; normal: 22.4 kg/m^2, $n = 108$; $P = 0.022$).

Considering the SCI population answering either the 1st or 2nd mailing ($n = 408$) in relation to the six 'neurofunction' classes, no significant differences were found among the classes regarding gender, smoking, alcohol or coffee/tea intake. Participants from group 'D' were significantly the oldest (mean 47.7 years, SD 16.8, median 46.5) when answering the NSQ, followed by group 'E', with participants in group 'T1–6/A–C' being the youngest (37.6 years, SD 13.8, median 34.1). Group 'E' participants were significantly more often gainfully employed (59%) than the others. The total employment rate was 34%. Regarding bladder emptying methods significantly ($P = 0.0001$) more women (26%) than men (8%) had an indwelling catheter, while more men (28%) than women (11%) used suprapubic tapping ($P = 0.001$). Normal voiding

was reported by 29%, ie by 77% in group 'E', and 59% in group 'D'. Spasms in the daytime as well as during the night was in particular a problem in the three most disabled 'neurofunction' groups, and they reported treatment necessary in a frequency of 30–37%, while this for group 'D' was 15% and group 'E' 2%.

Sleep parameters

Regarding the sleep questions (Tables 1 and 2) there were no differences between those who responded to the 1st *versus* the 2nd NSQ mailing. The discrepancies seen in the results of the statistical tests (χ^2-test and Mann-Whitney rank sum test) in Table 1 are due to the differences in the ranking distribution between the SCI and the normal population, to which the Mann-Whitney rank sum is insensitive to.

Regarding questions related to work (Q2a, Q10) the number of responses is naturally fewer in the SCI population as they are less often gainfully employed than the normal population.

Except for two questions (Q16 and Q20) no differences were observed between men and women.

The differences in snoring (Q16), with more men than women snoring can be seen in Table 4. In addition the table shows the significantly higher age and BMI among the snorers, in particular those snoring daily or almost daily. Similarly, those 12 SCI individuals who experienced sleep apnea daily or almost daily had a mean age of 48.7 years (SD 12.4), compared to the overall mean age of 42.0 ($n = 321$, SD 13.8), and a mean BMI of 27.4 kg/m^2 (SD 3.4), compared to the overall mean BMI of 23.2 kg/m^2 ($n = 295$, SD 4.4).

The number of hours the individual reported needing to sleep per night (Q20) was for men a mean of 7.53 (SD 1.19) and for women 8.01 (SD 0.87) ($P = 0.002$).

None of the questions in the NSQ found significant differences among the six 'neurofunction' groups. Even when testing the high tetraplegics ('C1–5/A–C') against the least disabled SCI group ('E') alone no differences were observed.

The sleep problems (Q21) reported by the responders are given in Table 5. The 'other somatic problems' include difficulties in turning over in bed.

Table 4 Q16: 'Do you snore while sleeping (ask other people)?' by gender ($P = 0.01$, Mann–Whitney rank sum test), age ($P = 0.0016$, ANOVA), and body mass index (BMI) ($P = 0.00016$, ANOVA). Data from the spinal cord injured population

	Men (n = 306)	Women (n = 63)	Age in years			BMI		
			n	mean	SD	n	mean	SD
1. never or less than once per month	36%	57%	139	38.9	14.9	121	21.6	4.5
2. less than once per week	16%	10%	50	42.2	11.0	48	23.0	4.7
3. on 1–2 days per week	13%	5%	41	43.2	12.9	39	23.2	4.6
4. on 3–5 days per week	7%	8%	27	42.5	12.1	24	23.9	3.8
5. daily or almost daily	29%	21%	95	46.5	13.7	94	24.5	4.7

SD: standard deviation

Table 5 Grouping of answers to Q21: 'If you have problems with your sleep, what kind of problems do you have (describe your problems with your own words)'. Up to three problems were registered in accordance to priority judged from the answers. Data from the spinal cord injured population

Number (%)	Primary problem (n = 158)	Secondary problem (n = 38)	Tertiary problem (n = 9)	Total (n = 205)
Spasms	32 (20.3)	1 (2.6)	–	33 (16.1)
Pain and paraesthesia	50 (31.7)	5 (13.2)	–	55 (26.8)
Voiding	28 (17.7)	11 (29.0)	1 (11.1)	40 (19.5)
Gastrointestinal problems	2 (1.3)	3 (7.9)	1 (11.1)	6 (2.9)
Sweating, warm or cold feeling	8 (5.1)	1 (2.6)	3 (33.3)	12 (5.9)
Other somatic problems	10 (6.3)	4 (10.5)	2 (22.2)	16 (7.8)
Dreams, nightmares	9 (5.7)	1 (2.6)	–	10 (4.9)
Speculations	8 (5.1)	6 (15.8)	1 (11.1)	15 (7.3)
Other given problems	11 (7.0)	6 (15.8)	1 (11.1)	18 (8.8)

Discussion

With a response rate above 80% and no major differences between responders and non-responders regarding gender, age at injury, neurological level and functional class, responders can be considered representative of the total SCI population.

Problems of initiating and maintaining sleep (corresponding to Q1–5) seem to be more common in our normal population than found in previous studies in general populations,[19–21] although this interpretation has to be taken with caution due to different wording and setting of the questions. Likewise, the prevalence of excessive daytime sleepiness (corresponding to Q9 in particular) in our normal population was higher than experienced by others.[19,21] Our normal population on the other hand used fewer sleeping pills (Q7),[20] but this may be due to the fact that we only asked for those on prescription. The general sleep (Q6) appears to be less good in our normal population.[20] For such comparisons it is to be noted that several studies[20–26] have shown women and increasing age to be associated with more sleep disturbances in general, and the various studies are not directly comparable in these respects.

Considering snoring and obstructive sleep apnea, males on the other hand show a higher prevalence, and obesity (high BMI) is another major risk indicator. Smoking, alcohol consumption, medications as aids to sleep, and poor physical fitness appear to be additional risk indicators.[27–40]

In comparison with the normal population the age of the SCI population is similar, but the normal population is a little more obese judged from the BMI. Nevertheless our results show more frequent problems with sleep in the SCI population. Snoring in our SCI population was also more common in men and individuals of older age and with higher BMI (Table 4).

Results from Tables 1 and 2 show that the individuals in the SCI population have a poorer sleep quality as assessed by nearly all parameters tested, which is similar to the findings of Hyyppä and Kronholm.[3] They found sleep complaints to be even more frequent in individuals with paraplegia than among individuals with other somatic diseases such as myocardial infarction and rheumatic disease. Results from previous investigations have shown that people with physical and mental health problems, including chronic illnesses such as hypertension, diabetes, and obstructive pulmonary disease give rise to more sleep disorders.[19,21,23,25,27,34,36,38] The same is found for the more physically disabled individuals with poliomyelitis and multiple sclerosis.[41–43]

Despite the differences found between the two populations, the number of hours the responders usually sleep per night (Q12), as well as the number of hours of sleep they feel they need per night (Q20), is similar.

The responders from the SCI population snored more often (Q16), more loudly (Q17), had been snoring for more years (Q19a), and from a younger age (Q19b) compared with the normal population. The frequency of snoring daily, or almost daily, was for the normal population 18.2%, which was similar to previous experiences in general populations,[22,30,32,39,44] although lower, as well as higher, frequencies of habitual snoring have been reported.[22,31,35,37,40] Taking the above mentioned risk indicators for snoring into consideration the SCI population smoked more and used more sleeping medication, while there were relatively fewer men and a higher BMI in the normal population. Alcohol consumption was the same in the two population groups. In the study by Hyyppä and Kronholm[3] no significant difference was found between those with paraplegia and the controls, but the controls in their study had a similar frequency of habitual snorers as in the present investigation.

More SCI than normal individuals reported sleep apnea, as there seems to be continuum between heavy-snoring and sleep apnea syndrome,[27] although self-reported hypersomnia and snoring are not sensitive enough alone to identify those with sleep apnea.[32] The reported frequency of at least weekly sleep apnea in the normal population was 2.8% (Q18 grade 3 + 4 + 5, Table 1), while for the SCI population it was 9.3%.

Estimated on the frequency of habitual snores and the results of polysomnography the minimal prevalence of sleep apnea among 30–70-year-old men has been found to be 1.3–2.7%.[31,44] Frequencies between 1% and 8.5% have been reported in general populations.[36,37,40.45–47] In 33 non-obese individuals with cervical spinal cord injury Klefbeck et al[4] found 15% to have obstructive sleep apnea when employing overnight sleep recordings. Burns et al[2] found 40% of 20 randomly selected individuals with SCI had sleep apnea, even commonly diagnosed in motor incomplete injuries, with a trend towards a greater prevalence in tetraplegia. The high frequency in the SCI population is important, as Lu et al[48] in relation to delayed apnea in patients with cervical SCI pointed out that sleep was a risky period of time. Furthermore, in patients with spinal cord lesions due to myelomeningocele more than 20% of the identified causes of death reported were due to sleep-disordering breathing, or sudden explained death during sleep. Of the 13 349 patients involved in the survey, 3.1% had been diagnosed with moderate to severe sleep-disordered breathing, indicating severe underdiagnosing of this potentially dangerous condition.[49] Likewise, it has been found that a large segment of the tetraplegics, not least those of older age, may be at risk of potentially serious nocturnal hypoxic episodes,[5,6,9,10] in particular when there is diaphragmatic dysfunction.[8] Sleep related hypoxia may be associated with cardiovascular events and a risk of stroke,[50] and cognitive disturbances in patients with tetraplegia.[12]

It was a little surprising that only a few in the SCI population reported decreased ability to change position as a sleep problem because many SCI individuals mostly sleep supine, and this position has been shown to be associated with sleep disordered breathing.[51] Adverse sleeping position may even be part of the explanation for the occurrence of periodic leg movements found in patients with SCI.[52] On the other hand none of the questions in the NSQ showed significant differences among the six 'neurofunction' groups, even when testing the high tetraplegics ('C1–5/A–C') against the least disabled SCI group ('E') alone.

However, pain and paraesthesia (Table 5) were reported to be the single most troublesome factor related to the sleep among the SCI individuals. Pain is also known as a major problem for the sleep for rheumatic patients.[53,54]

Spasm was another serious problem mentioned as a disturber of the sleep, as in patients with multiple sclerosis.[41] In our SCI population 19% found their spasms of such a magnitude during the daytime and 12% during the night that they needed treatment. Spasmolytic medication in itself may compromise the sleep.[55]

Another major issue disturbing sleep among SCI individuals was difficulty with voiding. For those with suprasacral lesions using reflex-voiding by tapping, bladder distension with autonomic dysreflexia may be one reason for waking during the night. Another problem could be incontinence, which is common in a SCI population.

Mello et al[56] found that sleep might be improved in paraplegics after physical activity. Moderate exercise, especially early in the evening, has been shown to have positive effects on sleep in middle-aged normal persons.[57] In addition, four-fifths of those exercising with a frequency of at least twice per month spontaneously reported exercising as a factor in promoting sleep.[58]

In those individuals with obstructive sleep apnea or weak respiratory muscles, treatment with CPAP (Continuous Positive Airway Pressure) or other similar aids will often be beneficial.[7,59–61]

Acknowledgements

References

1 Bonekat HW, Andersen G, Squires J. Obstructive disordered breathing during sleep in patients with spinal cord injury. *Paraplegia* 1990; **28:** 392–398.

2 Burns SP *et al*. Sleep apnea syndrome in chronic spinal cord injury: associated factors and treatment. *Arch Phys Med Rehabil* 2000; **81:** 1334–1339.

3 Hyyppä MT, Kronholm E. Quality of sleep and chronic illnesses. *J Clin Epidemiol* 1989; **42:** 633–638.

4 Klefbeck B *et al*. Obstructive sleep apneas in relation to severity of cervical spinal cord injury. *Spinal Cord* 1998; **36:** 621–628.

5 Short DJ, Stradling JR, Williams SJ. Prevalence of sleep apnoea in patients over 40 years of age with spinal cord lesions. *J Neurol Neurosurg Psychiatry* 1992; **55:** 1032–1036.

6 Bach JR, Wang T-G. Pulmonary function and sleep disordered breathing in patients with traumatic tetraplegia: A longitudinal study. *Arch Phys Med Rehabil* 1994; **75:** 279–284.

7 Biering-Sørensen M, Norup PW, Jacobsen E, Biering-Sørensen F. Treatment of sleep apnoea in spinal cord injured. *Paraplegia* 1995; **33:** 271–273.

8 Braun SR, Giovannoni R, Levin AB, Harvey RF. Oxygen saturation during sleep in patients with spinal cord injury. *Am J Phys Med* 1982; **61:** 302–309.

9 Cahan C *et al*. Arterial oxygen saturation over time and sleep studies in quadriplegic patients. *Paraplegia* 1993; **31:** 172–179.

10 Flavell H *et al*. Hypoxia episodes during sleep in high tetraplegia. *Arch Phys Med Rehabil* 1992; **73:** 623–637.

11 Klefbeck B, Mattsson E, Weinberg J, Svanborg E. Oxygen desaturation during exercise and sleep in fit tetraplegia patients. *Arch Phys Med Rehabil* 1998; **79:** 800–804.

12 Sajkov D *et al*. Sleep apnoea related hypoxia is associated with cognitive disturbances in patients with tetraplegia. *Spinal Cord* 1998; **36:** 231–239.

13 Star AM, Osterman AL. Sleep apnea syndrome after spinal cord injury. Report of a case and literature review. *SPINE* 1988; **13:** 116 – 117.

14 Gislason T *et al. Basic Nordic Sleep Questionnaire.* Scandinavian Society for Sleep Research, 1988.

15 Biering-Sørensen F, Biering-Sørensen M, Hilden J. Reproducibility of Nordic Sleep Questionnaire in spinal cord injured. *Paraplegia* 1994; **32:** 780 – 786.

16 Frankel HL *et al.* The value of postural reduction in the initial management of closed injuries in the spine with paraplegia and tetraplegia. *Paraplegia* 1969; **7:** 179 – 192.

17 Biering-Sørensen F, Pedersen V, Clausen S. Epidemiology of spinal cord lesions in Denmark. *Paraplegia* 1990; **28:** 105 – 118.

18 Biering-Sørensen F, Pedersen W, Müller PG. Spinal cord injury due to suicidal attempts. *Paraplegia* 1992; **30:** 139 – 144.

19 Gislason T, Almqvist M. Somatic diseases and sleep complaints. An epidemiological study of 3201 Swedish men. *Acta Med Scand* 1987; **221:** 475 – 481.

20 Karacan I *et al.* Prevalence of sleep disturbance in a primarily urban Florida county. *Soc Sci Med* 1976; **10:** 239 – 244.

21 Klink M, Quan SF. Prevalence of reported sleep disturbances in a general population and their relationship to obstructive airways diseases. *CHEST* 1987; **91:** 540 – 546.

22 Ancoli-Israel S. Epidemiology of sleep disorders. *Clinics Geriatric Med* 1989; **5:** 347 – 362.

23 Bixler EO *et al.* Prevalence of sleep disorders in the Los Angeles Metropolitan area. *Am J Psychiatry* 1979; **136:** 1257 – 1262.

24 Bliwise DL, King AC, Harris RB, Haskell WL. Prevalence of self-reported poor sleep in a healthy population aged 50-65. *Soc Sci Med* 1992; **34:** 49 – 55.

25 Habte-Gabr E *et al.* Sleep patterns in rural elders: Demographic, health, and psychobehavioral correlates. *J Clin Epidemiol* 1991; **44:** 5 – 13.

26 Rosekind MR. The epidemiology of insomnia. *J Clin Psychiatry* 1992; **53-6**(Suppl): 4 – 6.

27 Berry DTR, Webb WB, Block AJ, Switzer DA. Sleep-disordered breathing and its concomitants in a subclinical population. *Sleep* 1986; **9:** 478 – 483.

28 Bixler EO *et al.* Sleep apneic activity in older health subjects. *J Appl Physiol* 1985; **58:** 1597 – 1601.

29 Block AJ, Boysen PG, Wynne JW, Hunt LA. Sleep apnea, hypopnea and oxygen desaturation in normal subjects. A strong male predominance. *New Engl J Med* 1979; **300:** 513 – 517.

30 Bloom JW, Kaltenborn WT, Quan SF. Risk factors in a general population for snoring. Incidence of cigarette smoking and obesity. *CHEST* 1988; **93:** 678 – 683.

31 Cirignotta F *et al.* Prevalence of every night snoring and obstructive sleep apnoeas among 30-69-year-old men in Bologna, Italy. *Acta Psychiatr Scand* 1989; **79:** 366 – 372.

32 Jennum P, Sjøl A. Epidemiology of snoring and obstructive sleep apnoea in a Danish population, age 30-60. *J Sleep Res* 1992; **1:** 240 – 244.

33 Jennum P, Hein HO, Suadicani P, Gyntelberg F. Cardiovascular risk factors in snorers. A Cross-sectional study of 3.323 men aged 54 to 74 years: The Copenhagen male study. *CHEST* 1992; **102:** 1371 – 1376.

34 Katsumata K *et al.* Incidence of sleep apnea syndromes in general patients at a hospital for internal medicine. *Nagoya J Med Sci* 1986; **48:** 47 – 53.

35 Kauffmann F *et al.* The relation between snoring and smoking, body mass index, age, alcohol consumption and respiratory symptoms. *Eur Respir J* 1989; **2:** 599 – 603.

36 Partinen M, Telakivi T. Epidemiology of obstructive sleep apnea syndrome. *Sleep* 1992; **15:** S1 – S4.

37 Phillips B, Cook Y, Schmitt F, Berry D. Sleep apnea: Prevalence of risk factors in a general population. *Southern Med J* 1989; **82:** 1090 – 1092.

38 Schmidt-Nowara WW *et al.* Snoring in a Hispanic-American population. *Arch Intern Med* 1990; **150:** 597 – 601.

39 Stradling JR, Crosby JH. Predictors and prevalence of obstructive sleep apnoea and snoring in 1001 middle aged men. *Thorax* 1991; **46:** 85 – 90.

40 Young T *et al.* The occurrence of sleep-disordered breathing among middle-aged adults. *New Engl J Med* 1993; **328:** 1230 – 1235.

41 Clark CM *et al.* Sleep disturbance, depression, and lesion site in patients with multiple sclerosis. *Arch Neurol* 1992; **49:** 641 – 643.

42 Fischer A. Sleep-disordered breathing as a late effect of poliomyelitis. *Birth Defect* 1987; **23:** 115 – 119.

43 Kralingen KWv *et al.* Sleep complaints in postpolio syndrome. *Arch Phys Med Rehabil* 1996; **77:** 609 – 611.

44 Gislason T *et al.* Prevalence of sleep apnea syndrome among Swedish men – an epidemiological study. *J Clin Epidemiol* 1988; **41:** 571 – 576.

45 Kripke DF *et al.* Prevalence of sleep-disordered breathing in ages 40-64 years: a population-based survey. *Sleep* 1997; **20:** 65 – 76.

46 Neven AK *et al.* The prevalence of clinically significant sleep apnoea syndrome in The Netherlands. *Thorax* 1998; **53:** 638 – 642.

47 Zamarron C *et al.* Prevalence of sleep disordered breathing and sleep apnea in 50- to 70-year-old individuals. A survey. *Respiration* 1999; **66:** 317 – 322.

48 Lu K, Lee T-C, Liang C-L, Chen H-J. Delayed apnea in patients with mid- to lower cervical cord injury. *SPINE* 2000; **25:** 1332 – 1338.

49 Kirk VG, Morielli A, Brouillette RT. Sleep-disordered breathing in patients with myelomeningocele: the missed diagnosis. *Developmental Med Child Neurol* 1999; **41:** 40 – 43.

50 Harding SM. Complications and consequences of obstructive sleep apnea. *Curr Opin Pulm Med* 2000; **6:** 485 – 489.

51 McEvoy RD *et al.* Sleep apnoea in patients with quadriplegia. *Thorax* 1995; **50:** 613 – 619.

52 Dickel MJ, Renfrow SD, Moore PT, Berry RB. Rapid eye movement sleep periodic leg movements in patients with spinal cord injury. *Sleep* 1994; **17:** 733 – 738.

53 Hultgren S *et al.* Sleep disturbances in outpatients with ankylosing spondylitis – a questionnaire study with gender implications. *Scand J Rheumatol* 2000; **29:** 365 – 369.

54 Leigh TJ, Bird HA, Hindmarch I, Wright V. A comparison of sleep in rheumatic and non-rheumatic patients. *Clin Exp Rheumatol* 1987; **5:** 363 – 365.

55 Finnimore AJ, Roebuck M, Sajkov D, McEvoy RD. The effects of the GABA agonist, baclofen, on sleep and breathing. *Eur Respir J* 1995; **8:** 230 – 234.

56 Mello MT *et al.* Correlation between K complex, periodic leg movements (PLM), and myoclonus during sleep in paraplegic adults before and after an acute physical activity. *Spinal Cord* 1997; **35:** 248 – 252.

57 Vuori I, Urponen H, Hasan J, Partinen M. Epidemiology of exercise effects on sleep. *Acta Physiol Scand* 1988; **133**(Suppl.574): 3 – 7.

58 Shapiro CM, Bachmayer D. Epidemiological aspects of sleep in general public and hospital outpatient samples. *Acta Physiol Scand* 1988; **133**(Suppl.574): 41 – 43.

59 Bach JR, Robert D, Leger P, Langevin B. Sleep fragmentation in kyphoscoliotic individuals with alveolar hypoventilation treated by NIPPV. *CHEST* 1995; **107:** 1552 – 1558.

60 Iber C, Davies SF, Mahowald MW. Nocturnal rocking bed therapy: Improvement in sleep fragmentation in patients with respiratory muscle weakness. *Sleep* 1989; **12:** 405 – 412.

61 Krieger J, Imbs J-L, Schmidt M, Kurtz D. Renal function in patients with obstructive sleep apnea. Effects of nasal continuous positive airway pressure. *Arch Intern Med* 1988; **148:** 1337 – 1340.