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Clinical Corner

A Comparative Study of Treatments for Positional Sleep Apnea

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Summary: Sixty male patients all with apnea plus hypopnea indices (A+HI) above 12.5, who met a criterion of positionality by having two or more times the rate of these events during supine sleep in comparison to their lateral sleep rate, were randomly assigned to one of four treatments for 8 weeks. All were restudied for two nights, one with and one without treatment devices. On treatment more than half the patients in each group reduced their A+HI to within normal limits and a third remained WNL without the use of devices. Half of those trained to sleep in the lateral position with the help of an alarm maintained this learning without the alarm as did half of those who were encouraged to learn this sleep posture on their own. There is an additive effect for the positional patient from wearing a tongue retaining device (TRD) if they continue to sleep in the supine position. Factors associated with successful treatment include overall severity, severity in the lateral position, weight, weight change, nasal patency and motivation to help their condition. **Key Words.** Apnea treatment, positional.

As early as 1972, Schwartz (1) pointed out the problem of sleep position when recording the sleep apneic patient in the laboratory. She remarked that many patients feel constrained by the monitoring equipment to remain on their backs despite repeated arousals due to coughing or choking. When asked to "choose their preferred position, they turn on their right side as they do at home" (p. 407).

It has now been well documented that a large proportion of unselected patients who sustain a sleep apnea diagnosis demonstrate a differential rate of apneic events when these are calculated separately by time in the lateral versus supine position (2–7). When a criterion for the presence of a positional effect is set at an apnea plus hypopnea index (A+HI) during the time in supine sleep that is two or more times the A+HI during sleep in the lateral position, 60.3% of 184 unselected cases with laboratory-documented sleep apnea were reported to meet this criterion (8).

Research on two treatments, the tongue retaining device (TRD) (9,10) and the posture alarm (PA) (5,6), has demonstrated that each can ameliorate the respiratory problem associated with the supine sleep position. In one study (10) the TRD was found to be more effective in reducing the number of apneic events and in improving the oxygenation selectively for those patients in the sample who showed a large positional difference in the A+HI. This study suggested that, if only those apneic patients who met a positional criterion were given a TRD, the success rate with this device would be increased. Presumably the critical factor is the ability of the TRD to prevent the flaccid tongue from retrolapsing during the time the patient sleeps in the supine position. Thus, with this device supine sleep can be tolerated by some positional patients with greater safety.

The PA was designed to train the patient to avoid supine sleep altogether by signalling with an auditory beep if the patient maintains this posture for more than 15 seconds. Again, in a small study of patients who were selected to meet a positional criterion, 7 out of 10 had an A+HI at or close to being within normal limits while wearing this device (5).

Given that both of these treatments are aimed at correcting the obstruction connected with supine sleep but act somewhat differently, the question arises whether one has any advantage over the other and whether there is any additional benefit from using both devices together. There is a further question of interest: are there differential selective factors for these various treatments? To address these issues a new study was

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TABLE 1. *Description of patients in sample by treatment group*

	Age		Ratio/ideal weight		Weight change (lb)		Weight lost (patients)	Systolic blood pressure n > 140	Diastolic blood pressure n > 100	Nasal pathology[a]	
	Mean	SD	Mean	SD	Mean	SD				Mean	SD
TRD	49.80	9.98	1.20	0.09	1.02	5.54	4	4	2	4.40	2.67
PA	48.93	9.45	1.35	0.30	0.75	3.87	5	6	7	3.40	2.67
Both	45.71	11.15	1.31	0.27	3.82	7.19	3	3	2	3.73	2.58
HH	50.47	8.90	1.28	0.21	−3.17	5.61	11	3	4	4.47	2.72

[a] Scale, 0–8.

designed to compare four treatments for positional sleep apneic patients.

The following questions guided this study:

1) Are the TRD and PA equally effective for the control of the abnormal respiratory events of the positional sleep apneic patient?
2) Is there any additive effect from using both of these together?
3) Are there differential selective factors associated with these devices that can improve their success rate?
4) Can patients learn to control their abnormal respiratory events without devices by being informed of the importance that they adopt a lateral sleep posture?

METHODS

Subjects: Sixty male patients diagnosed by standard 12-channel polysomnographic recording as sustaining a sleep apnea diagnosis who also met the criterion of positionality used in previous studies (5,6) were invited to participate in a research program. This program offered to treat them, without cost, for an 8-week period after which they would be restudied in the laboratory for two further nights. All patients signed informed consent that they understood they would be randomly assigned to one of four treatments. If their initial treatment was not successful, they would be offered further help and crossed over into another treatment and again restudied after 8 weeks for two additional nights of laboratory evaluation. All subjects were given a medical examination by the second author who also recorded height, weight and blood pressure. An otolaryngeal examination was performed by the fourth author at this visit. The patient and wife also agreed to keep records at home of the patient's daytime sleepiness. A description of these patients will be found in Table 1.

All patients met an all-night A+HI of at least 12.5. Their original pretreatment severity on an all-night basis and in each of the two major sleep positions is given in Tables 2–5. All patients were interviewed by

TABLE 2. *All-night A + HI and A + HI during back and side sleep night 1 and after 8 weeks of treatment for TRD group*

	Pretreatment			Posttreatment			Within normal
Subject number	Side A + HI	Back A + HI	Total A + HI	Side A + HI	Back A + HI	Total A + HI	limits <5.5
1	35.2	71.0	48.9	51.1	120.0[a]	51.4	–
2	11.0	50.8	14.6	33.8	14.2	27.7	–
3	7.5	27.5	15.3	0.2	3.8	0.8	+
4	5.3	62.1	15.2	2.7	0.0	2.7	+
5	8.1	57.5	15.2	26.3	120.0	28.0	–
6	7.7	51.5	20.6	0.3	0.0	0.3	+
7	3.3	78.2	65.6	0.6	32.0	1.6[b]	+
8	0.0	23.0	17.1	0.2	17.1	0.3	+
9	12.9	46.5	30.0	4.6	11.3	5.0	+
10	0.0	64.9	14.3	4.9	16.1	6.7	–
11	22.0	64.4	57.9	0.0	0.9	0.3	+
12	0.5	72.6	41.6	0.0	18.0	8.0	–
13	0.0	24.7	12.8	4.1	3.2	3.7	+
14	5.7	22.4	15.1	0.8	5.8	2.9	+
15	0.0	35.8	26.2	0.0	26.3	26.3	–
Mean	7.95	50.79	27.36	8.64	25.91	11.38	9
SD	9.70	19.33	17.64	15.57	39.38	15.05	

[a] High rates of A + HI can occur when a very small number of minutes of sleep are recorded due to the fact that a 30-second epoch is only scored as sleep if for more than half the time (15 seconds) the patient is asleep. If an apnea occurs during sleep that wakes the patient, the apnea is scored, but sleep may not be scored for that epoch. To interpret the importance of some high values, Table 6, which gives minutes of sleep, needs to be consulted.

[b] Some prone sleep time occurred. The t test between total means: 27.36 and 11.38 = 2.85, df 14, $p < 0.02$.

TABLE 3. *All-night A + HI and A + HI during back and side sleep night 1 and after 8 weeks of treatment for PA group*

Subject number	Pretreatment			Posttreatment			Within normal limits <5.5
	Side A + HI	Back A + HI	Total A + HI	Side A + HI	Back A + HI	Total A + HI	
16	0.0	43.6	22.2	0.3	0.0	0.3	+
17	1.3	35.8	12.5	0.0	0.0	0.0	+
18	12.6	101.5	74.5	6.8	180.0	7.3	−
19	8.7	27.2	15.0	70.2	0.0	57.4[a]	−
20	1.0	98.7	16.7	0.2	0.0	0.2	+
21	20.2	90.9	68.6	96.3	222.9	97.8	−
22	5.6	31.2	19.6	6.4	0.0	6.4	−
23	1.9	66.6	33.8	0.0	0.0	1.0[a]	+
24	37.1	96.6	52.9	38.3	0.0	38.3	−
25	3.8	35.0	16.6	1.2	0.0	5.0[a]	+
26	11.5	35.6	15.5	4.5	90.0	5.3	+
27	18.9	40.0	22.6	2.4	0.0	2.4	+
28	6.9	45.2	33.9	3.2	0.0	2.3	+
29	10.4	103.1	30.3	38.6	0.0	38.6	−
30	6.7	86.9	64.1	57.8	0.0	50.1[a]	−
Mean	9.73	62.53	33.25	21.71	32.86	20.83	8
SD	9.74	30.05	21.30	30.99	72.20	29.25	

[a] Some prone sleep time occurred. The *t* test between total means: 33.25 and 20.83 = 1.88, df 14, $p < 0.10$.

the senior author who assigned them to a treatment group and instructed them in good health habits (HH) for sleep apnea. These include:

1) Lose (or maintain) weight by controlling diet.
2) Exercise at least 20 minutes a day.
3) Use no alcohol after 6 p.m.
4) Learn to sleep on your side and avoid the back sleep position.

Equal numbers were assigned to each of the four treatment groups:

1) Fifteen patients were fitted individually with a TRD and instructed in its care.
2) Fifteen patients were given a PA and shown how to adjust it for sleep and record on a log each morning the total number of times the signal sounded as this was registered on a digital counter attached to the device.
3) Fifteen patients were given both a TRD and the PA.
4) Fifteen patients were given only the HH instructions and the questionnaires to be completed at home. They were urged to learn on their own to avoid supine sleep.

All patients were followed weekly by phone. Any equipment problems were detected in this way and corrected. All patients returned to the laboratory 8

TABLE 4. *All-night A + HI and A + HI during back and side sleep night 1 and after 8 weeks of treatment for combined TRD and PA groups*

Subject number	Pretreatment			Posttreatment			Within normal limits < 5.5
	Side A + HI	Back A + HI	Total A + HI	Side A + HI	Back A + HI	Total A + HI	
31	3.5	34.0	21.9[a]	1.1	0.0	1.1	+
32	13.8	67.9	17.1[a]	2.6	0.0	2.6	+
33	4.2	72.0	46.8	0.0	0.0	0.0	+
34	10.3	32.1	18.3	16.7	0.0	16.7	−
35	13.2	67.9	29.4	3.9	0.0	4.3[a]	+
36	7.3	83.5	37.9	36.4	0.0	36.4	−
37	32.1	106.5	44.8	37.7	120.0	36.2[a]	−
38	15.9	63.8	31.5[a]	2.8	0.0	5.0[a]	+
39	0.0	23.2	19.6	2.1	0.0	2.1	+
40	45.1	103.8	65.4	2.2	0.0	2.2	+
41	2.1	32.7	16.8	2.8	0.0	2.8	+
42	28.7	86.9	43.4	0.5	0.0	0.5	+
43	10.7	61.0	14.8	0.0	0.0	0.0	+
44	0.3	51.7	20.9	0.9	10.0	1.0	+
45	22.1	71.5	31.9	5.5	19.3	7.2	−
Mean	13.95	63.90	30.70	7.68	9.95	7.87	11
SD	13.04	25.59	14.54	12.59	30.92	12.27	

[a] Some prone sleep time occurred. The *t* test between total means: 30.70 and 7.89 = 5.24, df 14, $p < 0.01$.

TABLE 5. *All-night A + HI and A + HI during back and side sleep night 1 and after 8 weeks of treatment for health habits group*

Subject number	Pretreatment			Posttreatment			Within normal limits <5.5
	Side A + HI	Back A + HI	Total A + HI	Side A + HI	Back A + HI	Total A + HI	
46	5.4	87.9	18.8	7.3	66.7	9.5	–
47	0.0	257.6	17.3	0.0	0.0	0.0	+
48	11.0	93.2	36.7	6.5	0.0	6.5	–
49	8.3	108.0	26.0	9.8	56.5	12.4	–
50	0.3	32.5	12.5	2.1	0.0	1.9[a]	+
51	4.5	58.1	17.9	1.2	0.0	17.5[a]	–
52	4.6	96.8	24.5	1.8	0.0	1.6	+
53	4.9	49.7	14.8[a]	3.8	0.0	14.3[a]	–
54	12.1	70.1	36.2	5.5	0.0	5.5	+
55	35.9	170.5	61.6	28.2	223.4	37.3	–
56	9.2	27.6	22.6	0.2	0.0	0.1	+
57	12.8	74.7	40.3	1.4	7.0	2.2	+
58	0.9	98.0	36.9	0.2	0.0	0.2	+
59	1.3	39.6	15.6	0.8	0.0	0.8	+
60	4.6	45.1	18.6	0.0	48.6	5.1	+
Mean	7.72	87.29	26.69	4.61	26.81	7.72	9
SD	8.86	59.72	13.31	7.21	59.27	9.91	

[a] Some prone sleep time occurred. The t test between total means: 26.69 and 7.72 = 524, df 14, $p < 0.01$.

weeks later for two nights of full polysomnographic recording, one with their treatment devices in place and for a second consecutive night without treatments. All patients wore a posture monitor during their nights of laboratory sleep cabled to the event marker of the polygraph. This recorded the sleep position continuously on the paper record. In this way time in each major sleep position and the associated respiratory events could be computed separately.

Patients returned for a follow-up interview and medical examination, during which blood pressure and weight were again recorded to compare to their pretreatment status. The results were reviewed with each patient and they were advised about their further care. A few who did not improve sufficiently with their first treatment were given a second treatment and reassessed again after another 8 weeks. If these were not successful, other treatments were used. Three went on continuous positive airway pressure (CPAP) and two had ENT surgery. Two of the CPAP patients had failed to improve on the PA treatment and one failed with the TRD. One uvulopalatopharyngoplasty patient failed the PA treatment and one failed the combined treatment. In all cases the data reported are from their original treatment. All 60 patients were followed until adequate control was achieved.

RESULTS

Tables 2–5 give the all-night A+HI data and Tables 6 and 7 give the amount of sleep time by position for the pretreatment point (night 1) and for the 8-week posttreatment night during which their treatment device was in place for each of the four treatment groups. An analysis of variance shows that there was no significant difference in the initial all-night A+HI (severity) between the four groups ($F = 0.34$, df 3,56) nor was there any significant difference in all-night A+HI at posttreatment for the four groups ($F = 1.71$, df 3,56). All groups showed a marked improvement in the A+HI. A t test is significant for the reduction in mean A+HI in all but the PA group. More important is the number of patients now within normal limits on total A+HI. More than half of the patients in each group reduced their A+HI to be within normal limits (less than 5.5/hour) while sleeping with their treatments in place. Overall the answer to the first question: "Are these treatments equally effective in controlling abnormal respiratory events for positional sleep apneic patients?" has to be answered in the affirmative. On an all-night basis, between 53 and 60% of the patients in the three single treatment groups (TRD, PA and HH) were at less than 5.5 events/hour. The combined treatment group had the highest success rate at 73% reaching this level of control. All groups reduced their time in the supine position significantly. This effect was least in the TRD group who had less direct help or emphasis on making this change than the other three groups.

The second question concerned the possibility of there being any additive effect from using both devices. To answer this question, the A+HI on the posttreatment night with the TRD was compared to this rate on the adjacent night without it for each sleep position. Here the presence of the TRD made no significant difference during lateral sleep. The mean A+HI during side sleep with the TRD of 8.64 (15.51) was not sig-

TABLE 6. *Time (minutes) in lateral and supine sleep positions before treatment and after for TRD and PA groups*

	Initial		Posttreatment			Initial		Posttreatment	
TRD	Lateral	Supine	Lateral	Supine	PA	Lateral	Supine	Lateral	Supine
1	197.5	122.5	135.0	0.5	16	194.5	202.5	392.0	0.0
2	262.5	26.0	225.5	101.5	17	239.0	115.5	354.0	0.0
3	247.0	157.0	321.5	64.0	18	100.0	230.0	334.0	1.0
4	205.0	43.5	356.5	0.0	19	219.5	112.5	166.5	0.0
5	213.5	35.5	294.5	5.5	20	235.5	45.0	274.0	0.0
6	187.5	78.0	394.5	13.5	21	92.0	200.0	304.0	3.5
7	55.0	272.5	177.0	7.5	22	149.0	181.0	326.5	0.0
8	94.0	271.5	374.0	3.5	23	187.5	183.0	281.0	0.0
9	167.0	173.0	246.0	16.0	24	170.0	61.5	277.0	0.0
10	215.0	61.0	245.5	51.5	25	156.5	108.0	197.0	0.0
11	41.0	227.5	215.5	128.0	26	251.0	50.5	390.0	4.0
12	126.0	167.0	169.5	136.5	27	304.0	64.5	302.5	0.0
13	144.0	155.5	177.0	111.5	28	104.5	249.5	283.5	6.5
14	178.0	228.0	222.0	166.5	29	235.5	64.0	329.5	0.0
15	55.0	151.0	0.0	244.0	30	98.5	248.5	57.0	35.5
Mean	157.20	144.63	236.93	70.00		182.47	141.07	291.23	3.37
SD	71.84	82.81	102.68	75.02		65.41	75.56	81.81	9.11
t test	144.63 and 70.00 = 2.84, $p < 0.02$					141.07 and 3.37 = 7.42, $p < 0.01$			

nificantly different from the A+HI during side sleep the next night without it in place when the mean was 7.37 (6.13). However, there were nine subjects who slept on their backs some of the time on all recording nights (nos. 2, 3, 6, 9, 10, 11, 12, 13, 14) for whom the TRD made a substantial difference in the rate of apnea recorded in that position. For these patients the mean A+HI during back sleep time was initially 47.26 (18.69). This was reduced with the TRD to 8.03 (6.93) ($t = 7.21$, df 8, $p < 0.01$). On the alternate postnight without the TRD the rate was again very high, 60.29 (36.43) (*t* test, $p < 0.01$). Sleeping on the side certainly was effective with or without the TRD for this group as a whole. Where the TRD was additionally useful was to protect those who continued to sleep on their backs part of the time.

In the combined TRD and PA treatment group a comparison of the apnea rate during side sleep at posttreatment with the TRD and without it showed a similar effect. With the TRD in place the mean A+HI was almost identical to the rate found in the single treatment TRD group, 8.25 (12.41), and without it the rate was 14.74 (16.97). This is a nonsignificant difference.

These findings suggest that only some positional sleep apneics benefit from using a TRD in addition to learning to sleep in the lateral position—those who maintain some significant supine sleep time.

The third question investigated the factors associ-

TABLE 7. *Time (minutes) in lateral and supine sleep positions before treatment and after for combined PA and TRD and HH groups*

PA and	Initial		Posttreatment			Initial		Posttreatment	
TRD	Lateral	Supine	Lateral	Supine	HH	Lateral	Supine	Lateral	Supine
31	156.5	137.5	326.5	0.0	46	222.0	43.0	252.0	13.5
32	317.5	26.5	369.0	0.0	47	235.5	17.0	242.0	0.0
33	71.0	120.0	355.0	0.0	48	240.0	109.5	343.0	0.0
34	227.0	131.0	338.0	0.0	49	325.0	70.0	363.0	39.5
35	272.0	114.0	290.0	0.0	50	194.5	118.0	288.5	0.0
36	205.5	138.0	318.5	0.0	51	281.0	94.0	208.5	0.0
37	302.5	62.0	309.0	1.0	52	273.0	75.0	332.5	0.0
38	196.0	96.0	283.5	0.0	53	245.0	64.0	187.5	21.5
39	59.5	325.5	365.5	0.0	54	188.0	133.5	330.0	0.0
40	203.5	107.5	349.5	0.0	55	187.0	44.0	297.5	14.5
41	196.5	181.5	193.0	0.0	56	124.0	267.0	334.5	67.0
42	267.5	90.5	369.5	0.0	57	173.5	139.0	290.0	51.5
43	342.5	30.5	301.5	0.0	58	200.0	117.5	327.0	0.0
44	179.0	119.5	351.0	6.0	59	185.5	110.5	302.5	0.0
45	274.0	68.0	296.5	43.5	60	221.5	117.0	334.5	39.5
Mean	218.03	116.53	321.00	3.37		219.70	101.27	302.20	16.47
SD	82.15	71.24	46.07	11.21		49.68	58.41	52.20	22.44
t test	116.53 and 33.7 = 5.91, $p < 0.01$					101.27 and 16.47 = 6.59, $p < 0.01$			

TABLE 8. *The relation of five factors to posttreatment total A + HI*

	All cases	TRD	PA	Both	HH
A + HI pre (severity)	0.378**	0.095	0.527*	0.172	0.524*
A + HI lateral	0.369**	0.555*	0.464	0.172	0.777**
Initial weight	0.289*	0.098	0.270	0.491*	0.246
Weight change	0.107	0.045	0.010	−0.584*	0.010
Nasal patency	0.021	0.573*	−0.145	−0.210	0.303

* $p < 0.05$.
** $p < 0.01$.

ated with the success or failure of these treatments. One obvious factor is the severity of the original A+HI. It has been suggested that sleep position is only important in the mild apneic patient and, if this were true, the overall severity may be one important selection factor for noninvasive treatments.

A second factor of this kind is the A+HI when the patient is sleeping in the lateral position. If sleeping on the side is to be effective, the degree of severity of the problem while the patient is in this position may need to be at, or close to, being within normal limits. This should not be a limiting factor for the TRD however.

A third variable that has been found to relate to the success of the TRD (10) and to a positional difference in apnea rate (4) is obesity. Therefore the effect on success of the degree to which the patient's weight was above the ideal for his height was computed using the formula 106 + 6 lb for each inch of height above 5 ft.

A fourth factor was change in body weight from the initial level to that of the posttreatment evaluation time. Weight loss was suggested to all patients who were above (1.00) their ideal weight, and significant weight loss has been found to reduce apnea within other studies (12).

A fifth variable explored for its relation to the successful treatment is nasal patency, as wearing a TRD requires the patient to be able to breath nasally. This was calculated from a report form completed by the otolaryngologist describing the nasal airway. Right and left nasal airway were rated as normal, mildly, moderately or severely obstructed. This was converted to a scale of 0–8.

Table 8 shows the Pearson (r) correlations of these five variables with the total A+HI after 8 weeks with the treatment in place for the group as a whole and each treatment subgroup.

From Table 8 it appears that a somewhat different weighting of these factors is associated with the posttreatment A+HI in the several groups. For the TRD, patency of the nasal airway is clearly important for this treatment, for example, but not for others.

Multiple correlations were run between the posttreatment A+HI and these five variables and all are significant.

The final question asked, "Can patients take charge of their own care, if instructed in the habit changes important to their health?" The fact that all patients in this group improved and 10 of the 15 did not sleep in the supine position at all when restudied shows they had learned to avoid this posture. In comparison, only two patients treated only with the TRD successfully avoided this sleep position. Patients in the HH group who were placed on their own clearly had stronger motivation to help themselves. This is confirmed by their weight loss. Eleven made some reduction of their weight in the 8 weeks, whereas only four in the TRD, five in the PA and three in the combined treatment group lost any weight. Telling patients what they need to do to improve, and telling them they would be tested to see how well they could do this, worked very well for most of these patients.

When treatments were removed on the second posttreatment night, 20 of the 60 patients remained within normal limits: only three in the TRD group, five in the PA group and five in the combined group. However, seven in the HH group who "did it themselves" stayed below the criterion A+HI <5.5. After using the PA for 8 weeks of home training six patients in this group and eight in the combined group showed no supine sleep time when recorded without the alarm in place (see Table 9). Seven of those in the HH were also able to avoid supine sleep altogether on the second night.

DISCUSSION

Relatively simple treatments, less cumbersome to maintain than CPAP and less invasive than surgery, appear to be effective for patients whose apnea is positional.

It appears that half of those who wore the PA did learn to avoid supine sleep. They were able to maintain this position without the PA after the home training period. How long this training lasts without reinforcement has not been established. Half of the HH patients were also able to learn this skill on their own. Some did this only by remembering to turn from side to side, but some invented techniques such as tennis balls pinned to the pajama back or to a belt worn around

TABLE 9. *Time in supine sleep (ST) and total A + HI on second posttreatment night (without treatments)*

Subject number	TRD			PA			Combined			HH	
	ST	A + HI		ST	A + HI		ST	A + HI		ST	A + HI
1	26.5	24.5	16	0.0	0.2	31	30.5	17.1	46	0.0	15.3
2	37.0	19.7	17	0.0	0.0	32	0.0	23.7	47	3.5	2.2
3	135.0	5.2	18	57.0	36.4	33	0.0	0.0	48	0.0	2.4
4	18.0	9.6	19	0.0	43.2	34	0.0	9.1	49	0.0	1.9
5	9.5	14.8	20	29.0	7.0	35	11.5	30.0	50	113.0	9.8
6	6.0	2.7	21	28.0	71.5	36	18.0	8.9	51	0.0	38.2
7	0.0	5.3	22	110.5	14.1	37	0.0	59.4	52	0.0	5.7
8	119.5	14.4	23	0.0	0.2	38	0.0	18.3	53	0.0	0.0
9	0.0	10.5	24	58.5	25.0	39	3.5	2.1	54	16.5	26.2
10	32.5	13.3	25	0.0	2.7	40	172.0	11.5	55	44.0	33.4
11	294.0	31.7	26	0.5	1.1	41	0.0	2.0	56	91.5	0.9
12	48.5	18.9	27	16.5	22.8	42	94.0	38.0	57	148.5	6.1
13	0.0	7.2	28	106.0	17.0	43	0.0	0.0	58	0.0	0.5
14	120.5	9.7	29	1.5	34.2	44	44.5	2.3	59	0.0	2.9
15	250.0	40.0	30	0.0	29.2	45	0.0	18.6	60	40.0	5.3
Mean		15.7			20.32			16.07			10.77
(SD)		(10.40)			(20.41)			(16.57)			(12.67)
Within normal limits		3			5			5			7

the waist. A bolster pillow placed lengthwise in the bed was also used by some patients.

Marked obesity proved to be related to fluctuating results from night to night in the side index. This was detrimental to the PA group that had a disproportionate number of such patients. In future work, those with ideal weight ratios above 1.50 should probably be excluded from these treatments.

One underlying mechanism contributing to postionality that has been identified is an adequate posterior airway space. A portion of these patients (n = 20) who had cephalometric x-rays was found to differ from unselected apneic patients in having normal AP dimensions (12).

Patients whose apnea shows a marked positional differential should be considered for one or more noninvasive treatments. The five factors associated with treatment success should be taken into account in making these treatment choices along with a sixth, which is motivation, both to learn to sleep in the lateral position and to lose weight. The TRD had the limitation of requiring a patent nasal airway but the advantage of allowing some patients who cannot sleep on their sides due to back problems or joint pain in the neck or shoulders to sleep supine with considerable control of the apnea.

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REFERENCES

1. Schwartz, B. Sleep and clinical pathological states. In: Chase M, ed. *The sleeping brain.* Los Angeles: Brain Research Institute, 1972;363–446.
2. Kavey N, Blitzer A, Gidro-Frank, Korstanje K. Sleeping position and sleep apnea syndrome. *Am J Otolaryngol* 1985;6:373–7.
3. Jackson E, Schmidt J. Modification of sleeping position in the treatment of obstructive sleep apnea. In: Chase M, Webb W, Jones R, eds. *Sleep research.* Los Angeles: Brain Research Institute, 1982;11:149.
4. Cartwright R. Effect of sleep position on sleep apnea severity. *Sleep* 1984;7:110–4.
5. Cartwright R, Lloyd S, Lilie J, Kravitz H. Sleep position training as treatment for sleep apnea syndrome: a preliminary study. *Sleep* 1985;8:87–94.
6. Cartwright R. Home modification of sleep position for sleep apnea control. In: Miles L, Broughton R, eds. *Clinical evaluation and physiological monitoring in the home and work environment.* Palo Alto: Raven Press, 1990:123–9.
7. Sharp J, Druz W, Kondragunta V. Diaphragmatic responses to body position changes in obese patients with obstructive sleep apnea. *Am Rev Respir Dis* 1986;133:32–7.
8. Lloyd S, Cartwright R. Physiologic basis of therapy for sleep apnea. Letter to the editor. *Am Rev Respir Dis* 1987;136:525–6.
9. Cartwright R, Stefoski,D, Caldarelli D et al. Toward a treatment logic for sleep apnea: the place of the tongue retaining device. *Behav Res Ther* 1988;26:121-6.
10. Cartwright R. Predicting response to the tongue retaining device for sleep apnea syndrome. *Arch Otolaryngol* 1985;111:385–8.
11. Aubert-Tulkens B, Culee C, Rodenstein D. Cure of sleep apnea syndrome after long-term nasal continuous positive airway pressure therapy and weight loss. *Sleep* 1989;12:216–22.
12. Ristanovic R, Alder G, Lloyd S, Cartwright R. Cephalometric analysis in positional sleep apneics. In: Chase M, Lydic R, O'Connor C, eds. *Sleep research.* Los Angeles: Brain Research Institute, 1989;18:249.