Measuring the Affect of Diabetes on Sleep Disordered Breathing

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Intro:

Sleep disordered breathing is characterized by abnormalities on the respiratory pattern during sleep, called hypopneas and apneas. The respiratory disturbance index (RDI) is used to quantify sleep disordered breathing by measuring the average number of abnormal breathing events per hour of sleep, with a normal RDI being less than five.

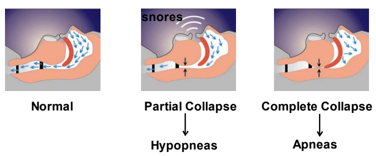

Figure 1: Normal, partial and complete collapse that result in hypopneas and apneas during sleep

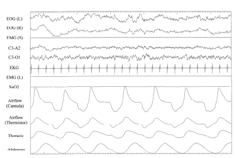

Figure 2: Normal Respiration During Sleep

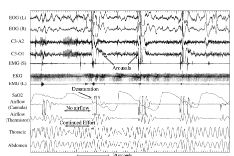

Figure 3: Obstructive Sleep Apnea

Data:

Data was used from the Sleep Heart Health Study, a longitudinal, cohort study centered around the United States. Participants represented a wide range of geographies and ethnicities of middle-aged adults.

	Mean	Median	25th percentile	75th percentile	Standard Deviation
Age	64.846	65.000	57.000	73.000	10.440
BMI	28.954	28.232	25.320	31.780	5.340
RDI	9.350	5.065	1.602	12.227	12.120

Table 1: Summary statistics of the data used.

Gender	Non Diabetic	Diabetic	Total
Female	2,930	358	3,288
Male	2,406	258	2,664
Total	5,336	616	5,952

Table 2: Breakdown of gender by diabetic status.

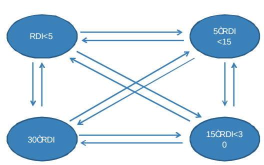

Figure 4: Visual representation of the multi-state model.

Methods:

The multi-state model describes how a participant moves through states over time. If an individual is in state S(t) at time t, his or her movement between states 1, ...,R is controlled by transition intensities q_{rs} (t,z,z(t)):r,s=1,...,R, which may be dependent on time t or a time-dependent explanatory variable z(t). The q_{rs} forms a matrix Q whose rows sum to zero. The multi-state model relies on the Markov assumption that an individualÕs future state is only dependent on his or her current state, or is $q_{RS}(t,z(t),F_t)$ is independent of F_t, the individualÕs observation history prior to time t.

Models:

Models were run using a combination of the covariates diabetes, gender, age, and body mass index (BMI) to model the participantÕs transition between states of RDI from Visit 1 to Visit 2. RDI was divided into four states: State 1(RDI<5), State 2 (5ÒRDI<15), State 3 (15ÒRDI<30), and State 4 (30ÒRDI). For example, q_{12} describes the transition from State 1 to State 2.

1: y=ɓ$_0$+ɓ$_1$*diabete
2: y=ɓ$_0$+ɓ$_1$*diabete+ ɓ$_2$*bmi
3: y=ɓ$_0$+ɓ$_1$*diabete+ ɓ$_2$*gender
4: y=ɓ$_0$+ɓ$_1$*diabete+ ɓ$_2$*age+ ɓ$_3$*bmi
5: y=ɓ$_0$+ɓ$_1$*diabete+ ɓ$_2$*gender+ ɓ$_3$*bmi
6: y=ɓ$_0$+ɓ$_1$*diabete+ ɓ$_2$*bmi+ ɓ$_3$*bmi*diabete

Results:

Model 2: y=β_0+β_1*diabete+ β_2*bmi

Visit 1 RDI	Visit 2 RDI	ɓ$_0$	ɓ$_1$	ɓ$_2$
State 1	State 1	-0.068589		
State 1	State 2	0.054221	0.8705500	1.0580
State 1	State 3	0.012358	1.6750204	1.0347
State 1	State 4	0.002010	2.3369804	1.0524

Table 3: Beta coefficients for Model 2.

Acknowledgements:

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Model 2 Transition Matrix by Diabetes

	Diabetes at Visit 1	State 1	State 2	State 3	State 4
State 1	Diabetic	0.71551	0.16789	0.08353	0.03307
	Non-Diabetic	0.73124	0.19365	0.05620	0.01891
State 2	Diabetic	0.13695	0.61603	0.15481	0.09222
	Non-Diabetic	0.16241	0.64848	0.13030	0.05881
State 3	Diabetic	0.08798	0.17727	0.58298	0.15177
	Non-Diabetic	0.09177	0.19982	0.55185	0.15657
State 4	Diabetic	0.02476	0.15128	0.17576	0.64821
	Non-Diabetic	0.03640	0.11988	0.14092	0.70280

Table 4: Probability of transitioning between RDI states for diabetic and non-diabetic patients when BMI is used as a covariate.

Interpretation:

Taking into account a patientÕs diabetic status and BMI (Model 2), he or she will take an average of 14.7 years to move out of State 1, 18.4 years to move out of State 2, 80.9 years to move out of State 3, and 497.5 years to move out of State 4. By adding in the covariate of BMI, it takes a patient, on average, fewer years to transition between RDI States.

The transition matrix for the second model was found using the average BMI (BMI=29) and has similar data as Model 1. A non-diabetic patient has a higher chance of staying in or lowering his or her RDI State from visit 1 to visit 2 and a lower chance of having an increased RDI at visit 2 than a diabetic patient.

Conclusions:

From the models, we can conclude that a diabetic patient has a greater probability of transitioning into a higher RDI state than a non-diabetic patient. Non-diabetic patients are more likely to maintain their RDI or transition into a lower RDI state than diabetic patients. Models 2 and 3 also show that an increase in a patient's age and BMI will result in an increase in RDI at a later visit. In models 4, when comparing males and females, both diabetic and non-diabetic males are more likely to transition to a higher RDI state than females.