ONLINE DATA SUPPLEMENT

Sleep Apnoea and Hypoventilation in Patients with Five Major Types of Muscular Dystrophy

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Statistical Methods

General Considerations

Our data involves results of 104 PSG studies conducted on 73 different patients. In analyzing such data, application of appropriate statistical techniques is important for valid results. The differences in muscular dystrophy types that we are interested are inherently questions about patients, but some of the associations that we probe involve patent characteristics that can change from PSG study to PSG study. Consequently, repeated studies on a single patient can aid in inference about muscular dystrophy types. Results from repeated studies on a single patient are generally more similar than results from the same number of studies on different patients. This within-patient correlation means that the amount of additional information provided by including a second PSG on a patient is less than that provided by including a new patient to the data set. A statistical approach known as Generalized Estimating Equations (GEE) [2] was developed to address within-patient correlations for data structured like ours. Heuristically, this approach can be thought of as estimating the within-patient correlation and using it to appropriately weigh responses from multiple PSGs on the same patients vis-à-vis responses from single PSGs from other patients.

We used the GEE approach with an exchangeable correlation structure [2] when examining associations. For responses modeled as continuous, such as heart rate or AHI, our GEE models used a normal distribution with the identity link function. For binary responses, such as apnoea or hypoventilation, our GEE models used a binomial distribution with the logistic link function.

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Although we have a reasonably large collection of muscular dystrophy patients with PSG data, we have more limited data on each individual muscular dystrophy type. With only 104 PSG studies and 73 patients altogether, our data set supports only small numbers of predictors in individual statistical models and limits statistical power. Consequently, we examined associations between response variable and individual predictor variables including limited adjustment for selected covariates like age, sex, and categorical BMI z-score. In general, we report p values without accounting for multiple testing although we employ the Tukey-Kramer procedure [3] for pairwise comparisons among types. For model fitting , we used PROC GENMOD in SAS (version 9.4).

When fitting models to continuous outcomes with the goal of comparing muscular dystrophy types and adjusting for covariates, we report mean values for each type or mean differences between pairs of types as estimated by the fitted model. The estimated means are associated with a specified set of covariate values but, under the models we used, the mean differences are not. We chose a set that we regarded as a reference baseline: male sex, normal BMI (a category with $-2 \leq$ BMI z-score ≤ 2), and age 15 yrs (a convenient integer value between the mean and median age of patients at the time of their PSG study). When fitting models to binary outcomes, we proceeded in the same way, but the quantities estimated are odds and odds ratios instead of means and mean differences, respectively.

Analysis of Heart Rates

We used the same statistical modelling approach for all three heart rate variables: initial heart rate (before sleep onset); average heart rate during sleep; and peak heart during sleep. Using GEE, we fit a regression modal with heart rate as the dependent variable; the model included muscular dystrophy type and $\log_2$(age in yrs) as predictors. We use $\log_2$(age) instead of age itself because the relationship between heart rate and $\log_2$(age) exhibited a linear, rather than curved, relationship. We examined residual plots for deviations from model assumptions. If we detected possible outliers with any heart rate, we conducted a sensitivity analysis by removing those outlying data points and refitting the model on the reduced data set. In every

instance, the original analysis and the sensitivity analysis reached similar conclusions. We report the analysis based on the full data set.

Analysis of AHI

Using GEE, we fit a regression model with AHI as the dependent variable; the model included muscular dystrophy type, age, sex, and categorical BMI z-score (described in the main text) as predictors. Because of some evidence of skewness in residuals from this model, we conducted a sensitivity analysis by transforming AHI to the square root of AHI and refitting the model. Because we reached similar conclusions with both models, we report the analysis using AHI (without transformation) as providing estimates in customary units (events/hr).

Separate Analyses of Sleep Apnoea and of Hypoventilation

Because sleep apnoea and hypoventilation are each binary variables (present/absent), we fit logistic regression models with either sleep apnoea or hypoventilation as the dependent variable using GEE. The model for sleep apnoea included five-category muscular dystrophy type, age, sex, and categorical BMI z-score as predictors. The model for hypoventilation included the same covariates except the categorization of muscular dystrophy type was modified because no patients with BMD exhibited hypoventilation. Consequently, we opted to combine BMD and DMD, two types with a closely related genetic origin, into a single type so the model for hypoventilation included a four-category muscular dystrophy type.

Joint Analysis of Hypoventilation and Sleep Apnoea

Using GEE, we assessed the association of hypoventilation with sleep apnoea using logistic regression models with hypoventilation as the dependent variable. In the first model where the only predictor was sleep apnoea, we assessed the association without adjustment for any other factors. In the second model, in addition to sleep apnoea, we included the four-category muscular dystrophy type (BMD and DMD combined), age, sex, and categorical BMI z-score. In sensitivity analyses, we interchanged the roles of sleep apnoea and hypoventilation – making sleep apnoea the dependent variable and hypoventilation the predictor – and fitting the same

two models. This sensitivity analysis did not modify conclusions about the association of hypoventilation and sleep apnoea, so we report results from models with hypoventilation as the dependent variable.

Joint Analysis of Hypoventilation and AHI

For this analysis, we used GEE and fit a logistic regression model with hypoventilation as the dependent variable. Predictors included four-category muscular dystrophy type, age, sex, categorical BMI-z-score, and AHI. In a sensitivity analysis, we replaced AHI as a predictor in the model with the square root of AHI, but conclusions were unchanged.

Supplementary results

Heart rates in patients with muscular dystrophy

Three PSG studies failed to record baseline heart rate; 31 failed to record average and peak heart rate during sleep, leaving 101 and 73 studies representing 72 and 53 patients with data on baseline and in-sleep heart rates, respectively. Correlations of baseline heart rate measurements with in-sleep average and peak heart rate measurements were both high (0.83 and 0.73, respectively, $p<0.0001$ for each). The correlation of average and peak heart rates during sleep was also high (0.76, $p<0.0001$).

We compared the mean baseline heart rate and the mean average and peak heart rates during sleep among muscular dystrophy types after regression adjustment for log-transformed age (see supplementary statistical methods). Age-adjusted mean heart rates, whether measured at baseline or during sleep, varied among types (Table S7A) with DMD patients tending to have among the highest rates and DM patients among the lowest. Patients with DMD had significantly, or nearly significantly, higher baseline heart rate and average and peak heart rates during sleep than those of patients with DM; ($p=0.003$, $p<0.0001$, and $p=0.02$, respectively); mean differences were approximately 10 bpm (Table S7B). Similarly, patients with CMD had significantly higher average and peak heart rates during sleep than those of DM patients again with mean differences near 10 bpm ($p=0.03$, $p<0.0001$ and $p=0.0006$, respectively). Differences

in heart rate among other pairs of muscular dystrophy types were generally smaller and not statistically significant.

References

1. Berry RB, Brooks R, Gamaldo C, Harding SM, Lloyd RM, Quan SF, Troester MT, Vaughn BV. AASM Scoring Manual Updates for 2017 (Version 2.4). *J Clin Sleep Med* 2017: 13(5): 665-666.
2. Liang KY, Zeger SL. Longitudinal Data-Analysis Using Generalized Linear-Models. *Biometrika* 1986: 73(1): 13-22.
3. Hsu J. Multiple Comparisons: Theory and Methods. Chapman & Hall/CRC, London, 1996.

Table S1. Clinic characteristics of the 73 muscular dystrophy patients with 104 reports.

Patient	DM Type	Age(yr)	Sex	Echo.	Beta blocker	ABG (PCO_2/bicarb)	MIP/MEP	Trach.	On Ventil.	Snore	Epwo.	Hypo.	AHI	Vital Status	Age at death
3	BMD	3.4	M	NL LVEF	-	/19(v)	unable	-	-	-	n/d	0	19.9	alive	n/a
3	BMD	4.1	M	NL LVEF	-	/19(v)	unable	-	-	-	12	0	0.6	alive	n/a
55	BMD	18.0	M	38% LVEF	+	47/26(v)	n/d	-	-	-	4	0	39.0	deceased	18
58	BMD	15.1	M	NL LVEF	-	n/d	n/d	-	-	-	21	0	2.4	alive	n/a
60	BMD	58.5	M	NL LVEF	+	n/d	n/d	-	-	-	4	0	35.5	alive	n/a
66	BMD	54.4	M	n/d	-	n/d	n/d	-	-	-	10	0	32.2	alive	n/a
66	BMD	57.5	M	n/d	-	n/d	n/d	-	-	-	9	0	17.6	alive	n/a
6	CMD	11.5	M	n/d	-	n/d	n/d	-	-	-	n/d	0	4.2	alive	n/a
6	CMD	13.4	M	n/d	-	n/d	n/d	-	-	-	n/d	0	0.3	alive	n/a
6	CMD	14.3	M	NL LVEF	-	32/25	22/25(23%/15%)	-	-	-	n/d	1	6.7	alive	n/a
7	CMD	17.1	M	NL LVEF	-	n/d	27/45(28%/26%)	-	-	-	n/d	1	9.0	alive	n/a
13	CMD	15.5	M	NL LVEF	-	45/24	25/15(26%/9%)	-	-	-	2	0	0.3	alive	n/a
29	CMD	12.3	M	NL LVEF	-	n/d	85/57	-	-	-	n/d	1	10.9	alive	n/a
35	CMD	4.4	M	n/d	-	52/24	unable	+	-	-	n/d	0	1.7	deceased	6
43	CMD	14.2	M	NL LVEF	-	45/26	55/60(57%/35%)	-	-	-	n/d	1	0.0	alive	n/a
69	CMD	19.3	F	NL LVEF	+	62/33	n/d	-	-	-	n/d	0	12.6	deceased	21
2	DM	69.2	F	NL LVEF	-	/30(v)	14/23	-	-	-	5	1	6.3	alive	n/a
9	DM	28.7	F	n/d	-	n/d	n/d	-	-	-	11	0	0.0	alive	n/a
12	DM	47.5	M	n/d	-	n/d	n/d	-	-	-	n/d	0	14.2	n/d	n/a
12	DM	50.9	M	n/d	-	n/d	n/d	-	-	-	n/d	1	6.6	alive	n/a
15	DM	13.0	F	n/d	-	n/d	n/d	+	+	-	n/d	0	0.0	deceased	28
16	DM	57.4	M	NL LVEF	-	/29(v)	n/d	-	-	-	n/d	1	15.5	alive	n/a
17	DM	26.8	F	n/d	-	/27(v)	n/d	-	-	-	9	0	0.1	alive	n/a
18	DM	57.5	M	NL LVEF	-	/25(v)	n/d	-	-	-	5	0	0.5	alive	n/a
19	DM	22.0	M	n/d	-	n/d	n/d	-	-	-	n/d	1	5.6	alive	n/a
19	DM	22.0	M	n/d	-	n/d	n/d	-	-	-	n/d	1	6.8	alive	n/a
19	DM	31.7	M	NL LVEF	-	/33(v)	n/d	-	-	-	12	0	6.5	alive	n/a
24	DM	12.6	F	NL LVEF	-	50/23	n/d	+	-	-	0	0	2.2	alive	n/a
24	DM	1.3	F	n/d	-	n/d	n/d	+	-	-	n/d	0	0.2	alive	n/a
24	DM	15.4	F	NL LVEF	-	/29(v)	n/d	+	-	-	n/d	1	18.2	alive	n/a
24	DM	2.8	F	n/d	-	n/d	n/d	-	-	-	n/d	1	3.4	alive	n/a
24	DM	5.3	F	n/d	-	n/d	n/d	+	-	-	n/d	0	0.7	alive	n/a

24	DM	7.3	F	n/d	-	n/d	n/d	+	-	-	4	1	3.3	alive	n/a
24	DM	7.7	F	n/d	-	n/d	n/d	+	-	-	n/d	1	0.8	alive	n/a
24	DM	8.5	F	n/d	-	n/d	n/d	+	-	-	4	0	3.4	alive	n/a
25	DM	12.3	M	n/d	-	n/d	12/23	-	-	-	0	0	7.3	alive	n/a
26	DM	47.3	M	NL LVEF	-	75/40	unable	-	-	-	14	1	10.4	deceased	51
30	DM	32.5	F	NL LVEF	-	37/26	n/d	-	-	+	n/d	1	5.6	alive	n/a
32	DM	12.1	M	n/d	-	n/d	n/d	-	-	-	n/d	0	0.6	alive	n/a
42	DM	9.2	F	NL LVEF	-	/29(v)	n/d	-	-	-	n/d	0	4.7	alive	n/a
45	DM	26.7	F	n/d	-	n/d	n/d	-	-	-	6	0	0.2	n/d	n/a
47	DM	0.3	M	NL LVEF	-	n/d	n/d	-	-	-	n/d	0	1.4	alive	n/a
47	DM	0.5	M	n/d	-	41/18	n/d	-	-	-	0	0	10.2	alive	n/a
47	DM	0.9	M	n/d	-	n/d	n/d	-	-	-	8	0	9.0	alive	n/a
52	DM	5.5	M	n/d	-	/30(v)	n/d	+	-	-	n/d	0	7.9	alive	n/a
52	DM	7.7	M	NL LVEF	-	/34(v)	n/d	+	-	-	11	1	9.6	alive	n/a
54	DM	45.3	F	NL LVEF	-	/27(v)	n/d	-	-	-	9	0	39.4	alive	n/a
56	DM	4.3	M	NL LVEF	-	n/d	n/d	-	-	-	n/d	0	9.0	alive	n/a
57	DM	66.1	F	NL LVEF	+	n/d	49/68	-	-	-	n/d	0	6.0	alive	n/a
64	DM	31.0	F	n/d	-	n/d	38/43	-	-	-	n/d	0	7.6	alive	n/a
68	DM	28.3	F	n/d	-	n/d	n/d	-	-	-	n/d	1	9.7	alive	n/a
70	DM	26.2	F	n/d	-	34/21	n/d	-	-	-	n/d	0	10.6	deceased	27
73	DM	33.3	F	n/d	-	n/d	n/d	-	-	+	15	1	10.8	alive	n/a
1	DMD	2.8	M	NL LVEF	-	/26(v)	unable	+	-	-	n/d	0	6.4	alive	n/a
5	DMD	12.2	M	low LVEF	-	/25(v)	n/d	-	-	-	n/d	0	3.5	alive	n/a
8	DMD	23.9	M	NL LVEF	+	n/d	n/d	-	-	-	0	0	14.2	alive	n/a
8	DMD	25.4	M	NL LVEF	-	44/30	43/28	-	-	-	0	1	3.8	alive	n/a
10	DMD	13.9	M	low LVEF	-	n/d	n/d	-	-	-	4	0	13.6	deceased	15
11	DMD	13.7	M	35-40% LVEF	-	n/d	8/28(8%/16%)	-	-	-	4	0	1.2	deceased	17
14	DMD	20.3	M	NL LVEF	-	n/d	32/33	-	-	-	2	0	8.0	deceased	26
20	DMD	14.3	M	NL LVEF	-	n/d	n/d	-	-	-	n/d	1	49.2	deceased	21
21	DMD	11.5	M	33% LVEF	-	/28(v)	n/d	-	-	-	n/d	1	3.3	deceased	15
22	DMD	12.7	M	48% LVEF	-	/28(v)	35/45(36%/26%)	-	-	-	17	0	9.8	alive	n/a
23	DMD	16.3	M	NL LVEF	-	35/24	n/d	-	-	-	n/d	1	12.5	alive	n/a
27	DMD	12.3	M	NL LVEF	-	35/20	40/53	-	-	-	8	1	9.7	alive	n/a
27	DMD	18.7	M	NL LVEF	-	/22(v)	43/	-	-	-	7	0	24.1	alive	n/a
28	DMD	12.3	M	48% LVEF	-	n/d	unable	-	-	-	n/d	1	4.0	alive	n/a
28	DMD	13.6	M	52% LVEF	-	n/d	n/d	-	-	-	8	0	1.8	alive	n/a

28	DMD	14.5	M	53% LVEF	-	/27(v)	n/d	-	-	-	0	0	6.8	alive	n/a
31	DMD	17.3	M	59% LVEF	-	/27(v)	n/d	-	-	-	8	0	12.2	alive	n/a
36	DMD	6.7	M	NL LVEF	-	/22(v)	n/d	-	-	-	n/d	0	0.1	alive	n/a
37	DMD	11.9	M	NL LVEF	-	n/d	n/d	-	-	-	8	1	2.4	alive	n/a
38	DMD	22.7	M	32% LVEF	+	n/d	n/d	-	-	-	8	0	0.2	alive	n/a
39	DMD	10.1	M	n/d	-	/27(v)	n/d	-	-	-	n/d	0	0.5	alive	n/a
44	DMD	11.7	M	55% LVEF	-	n/d	55/73	-	-	-	0	0	11.0	alive	n/a
46	DMD	10.2	M	NL LVEF	-	/30(v)	71/35(79%/26%)	-	-	-	n/d	1	1.4	alive	n/a
48	DMD	16.9	M	56% LVEF	-	n/d	64/51(67%/30%)	-	-	-	n/d	0	6.6	alive	n/a
48	DMD	18.5	M	49% LVEF	-	n/d	61/41	-	-	-	1	0	0.0	alive	n/a
48	DMD	20.2	M	n/d	-	/27(v)	51/43	-	-	-	0	1	0.0	alive	n/a
49	DMD	10.4	M	NL LVEF	-	n/d	31/30(35%/36%)	-	-	-	7	1	1.4	alive	n/a
50	DMD	10.5	M	NL LVEF	-	n/d	n/d	-	-	+	20	0	5.0	alive	n/a
50	DMD	6.6	M	NL LVEF	-	n/d	n/d	-	-	-	n/d	0	1.7	alive	n/a
50	DMD	9.2	M	NL LVEF	-	n/d	n/d	-	-	-	n/d	0	5.3	alive	n/a
51	DMD	10.9	M	NL LVEF	-	34/21	n/d	-	-	-	11	1	8.4	alive	n/a
53	DMD	5.1	M	NL LVEF	-	n/d	unable	-	-	-	12	0	0.6	alive	n/a
59	DMD	12.2	M	NL LVEF	-	/25(v)	n/d	-	-	-	7	0	3.3	alive	n/a
59	DMD	15.5	M	low LVEF	-	n/d	47/51(49%/30%)	-	-	-	n/d	1	2.3	alive	n/a
59	DMD	18.1	M	41% LVEF	-	/29(v)	45/48	-	-	-	n/d	1	9.8	alive	n/a
71	DMD	18.1	M	n/d	-	58/29	unable	-	-	-	n/d	1	22.6	deceased	19
72	DMD	13.1	M	NL LVEF	-	40/27(v)	35%/26%	-	-	-	n/d	0	17.2	alive	n/a
72	DMD	16.3	M	n/d	-	n/d	n/d	-	-	-	1	1	12.6	alive	n/a
4	LGMD	68.8	M	NL LVEF	+	/28(v)	n/d	-	-	+	7	-99	6.0	alive	n/a
33	LGMD	26.7	M	NL LVEF	+	59/24	n/d	-	-	-	3	0	1.3	alive	n/a
34	LGMD	10.7	F	NL LVEF	-	n/d	71/47	-	-	-	10	0	3.4	alive	n/a
34	LGMD	13.3	F	NL LVEF	-	n/d	36/72	-	-	-	11	0	4.6	alive	n/a
34	LGMD	15.0	F	NL LVEF	-	n/d	71/62	-	-	-	13	0	3.3	alive	n/a
34	LGMD	16.0	F	NL LVEF	-	/26(v)	n/d	-	-	-	14	0	3.3	alive	n/a
40	LGMD	23.1	M	NL LVEF	-	/27(v)	n/d	-	-	-	7	0	9.2	alive	n/a
41	LGMD	12.8	M	n/d	-	/27(v)	n/d	-	-	-	n/d	1	7.6	alive	n/a
61	LGMD	44.7	M	n/d	-	n/d	n/d	-	-	-	9	1	11.1	alive	n/a
62	LGMD	54.4	F	NL LVEF	-	n/d	n/d	-	-	-	3	0	2.4	alive	n/a
63	LGMD	9.8	F	NL LVEF	-	/30(v)	42/40	-	-	-	2	0	1.0	alive	n/a
65	LGMD	34.0	M	50% LVEF	-	/30(v)	43/37	-	-	-	11	0	2.5	deceased	47
67	LGMD	41.3	M	NL LVEF	-	n/d	n/d	-	-	+	n/d	0	22.0	deceased	45

Only clinical reports within ± 6 months of the sleep study are included.

BMD: Becker muscular dystrophy; CMD: congenital muscular dystrophy; DM: myotonic dystrophy; DMD: Duchenne muscular dystrophy; LGMD: Limb-Girdle muscular dystrophy. +: yes; -: no; n/d: no data; n/a: not applicable; Echo: echocardiogram; NL LVEF: normal left ventricular ejection fraction; v: venous chemistry; M: male; F: female; echo: echocardiogram; ABG: arterial blood gases; PCO_2: partial pressure of carbon dioxide; trach.: tracheostomy; ventil.: ventilation; Epwo.: Epworth; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; AHI: apnea hypopnea index.

Echocardiogram is reported as normal (NL) LVEF or percentage of the normal value of LVEF.

ABG(PCO_2/bicarb) is presented as either both PCO_2 and bicarbonate separated by '/' or bicarbonate after '/' from venous chemistry only.

MIP/MEP is presented as original values and percentages of the normal values, when available.

On ventilation refers to the time of the sleep study.

For the eight patients on beta blocker, all were on metoprolol except one patient (pID=60) who was on bisoprolol.

Vital status assessed as of January 2023.

Table S2. Muscular dystrophy patients with multiple PSG studies: 73 patients and 104 total studies.

Number of studies	Number of Patients	Percentage of Patients
1	57	78.1
2	7	9.6
3	7	9.6
4	1	1.4
5	0	0.0
6	0	0.0
7	0	0.0
8	1	1.4

Table S3. Summary statistics of age, BMI, and heart rate for available studies.

Type	N	Min.	1st Quantile	Median	Average	3rd Quantile	Max.
			Age (yrs)				
BMD	7	3.4	3.4	18.0	30.1	54.4	58.5
CMD	9	4.4	11.5	14.2	13.6	14.3	19.3
DM	37	0.3	7.3	22.0	23.7	31.7	69.2
DMD	38	2.8	10.5	13.4	14.0	16.9	25.4
LGMD	13	9.8	12.8	23.1	28.5	34.0	68.8
All Types	104	0.3	10.5	14.4	20.3	25.4	69.2
			BMI (kg/m^2)				
BMD	7	16.5	16.5	29.0	26.9	31.3	33.6
CMD	8	10.8	16.5	17.7	17.4	19.5	20.4
DM	37	13.3	16.1	19.5	21.7	24.2	38.4
DMD	38	13.8	16.9	23.6	24.0	27.3	45.2
LGMD	13	15.4	17.1	22.3	24.1	26.4	49.7
All Types	103	10.8	16.8	21.1	22.9	27.8	49.7
			Baseline Heart Rate (bpm)				
BMD	7	55.0	55.0	84.0	79.3	87.0	110.0
CMD	7	78.0	78.0	96.0	95.6	96.0	114.0
DM	36	42.0	69.0	79.5	84.9	95.0	130.0
DMD	38	72.0	85.0	96.0	97.6	110.0	125.0
LGMD	13	60.0	66.0	86.0	83.5	88.0	114.0
All Types	101	42.0	75.0	89.0	89.9	100.0	130.0
			Sleep Average Heart Rate (bpm)				
BMD	6	48.0	48.0	62.8	67.2	71.9	102.2
CMD	1	90.1	90.1	90.1	90.1	90.1	90.1
DM	22	50.0	65.3	76.2	77.2	81.0	110.0
DMD	28	62.0	86.9	93.9	93.1	100.0	117.7
LGMD	10	54.3	64.2	82.3	78.8	86.6	95.0
All Types	67	48.0	71.0	85.3	83.4	94.4	117.7
			Sleep Peak Heart Rate (bpm)				
BMD	6	80.0	80.0	111.5	112.7	116.0	154.0
CMD	2	123.0	123.0	125.5	125.5	128.0	128.0
DM	22	79.0	90.0	111.0	114.7	128.0	197.0
DMD	33	89.0	120.0	126.0	125.5	135.0	140.0
LGMD	10	68.0	93.0	116.0	112.0	121.0	129.0
All Types	73	68.0	109.0	121.0	119.3	129.0	197.0
			Baseline CO_2 (mm Hg)				
BMD	7	22.0	22.0	38.0	36.9	41.0	43.0
CMD	7	36.0	36.0	47.0	45.9	48.0	58.0
DM	34	27.0	38.0	40.5	42.1	46.0	59.0
DMD	37	29.0	36.0	40.0	39.9	43.0	52.0

LGMD	12	34.0	37.0	40.0	40.2	41.0	48.0
All Types	97	22.0	37.0	40.0	40.9	45.0	59.0
			Sleep Average CO_2 (mm Hg)				
BMD	5	35.1	35.1	40.7	40.1	40.7	47.0
CMD	6	37.0	37.0	49.8	49.5	50.0	62.0
DM	4	38.0	38.0	40.5	43.6	41.0	55.4
DMD	29	26.4	41.7	44.0	44.0	47.6	55.2
LGMD	10	38.6	38.9	44.8	44.4	46.0	49.0
All Types	54	26.4	41.0	44.1	44.3	47.7	62.0
			Sleep Peak CO_2 (mm Hg)				
BMD	5	40.1	40.1	46.0	47.8	46.0	55.0
CMD	8	44.0	45.0	55.0	58.0	61.0	90.0
DM	29	40.0	48.6	52.0	53.4	56.0	77.0
DMD	38	35.2	46.0	50.2	50.2	54.0	65.0
LGMD	9	47.0	47.0	49.0	49.6	51.0	53.2
All Types	89	35.2	47.0	51.0	51.7	54.9	90.0
			AHI (events/hr)				
BMD	7	0.60	0.60	19.90	21.03	32.20	39.00
CMD	9	0.00	0.30	4.20	5.08	6.70	12.60
DM	37	0.00	0.80	6.30	6.87	9.00	39.40
DMD	38	0.00	1.40	5.15	7.80	9.80	49.20
LGMD	13	1.00	2.40	3.40	5.98	6.00	22.00
All Types	104	0.00	1.70	5.80	7.90	10.20	49.20

Table S4. Odds of sleep apnoea among muscular dystrophy types estimated by fitting logistic regression models adjusted for age, sex, and category of BMI z-score using GEE. (**A**) Adjusted odds of sleep apnoea by muscular dystrophy type for a male patient aged 15 years with BMI z-score between -2 and 2; and (**B**) Pairwise adjusted odds ratios (ORs) comparing risk of sleep apnoea between muscular dystrophy types. This analysis used 103 PSG studies and 73 patients (one subject with only one PSG was missing).

A. Estimated adjusted odds of sleep apnoea prevalence by muscular dystrophy type for a male patient aged 15 years with BMI z-score between -2 and 2. [a]

Type	Estimated Odds	95% Confidence Limits	
BMD	0.68	0.17	2.69
CMD	0.76	0.21	2.67
DM	1.68	0.77	3.85
DMD	0.91	0.38	2.21
LGMD	0.33	0.11	0.98

[a] We chose 15 years as an integer-valued age between the mean and median of the entire sample. Though estimated odds of sleep apnoea would differ at other ages and for females or patients having extreme BMI z-scores, the regression model used implies that odds ratios between muscular dystrophy types adjusted to this particular set of covariate values match corresponding odds ratios estimated at other sets of values.

B. Pairwise adjusted odds ratios (ORs) comparing prevalence of sleep apnoea between muscular dystrophy types.

Contrast	OR	Simultaneous 95% Confidence Limits[a]		p value[a]
BMD - CMD	0.89	0.11	7.24	1.00
BMD - DM	0.40	0.05	3.31	0.76
BMD - DMD	0.74	0.12	4.66	0.99
BMD - LGMD	2.07	0.25	16.98	0.88
CMD - DM	0.45	0.07	2.97	0.78
CMD - DMD	0.83	0.15	4.67	1.00
CMD - LGMD	2.32	0.33	16.37	0.77
DM - DMD	1.84	0.33	10.35	0.87
DM - LGMD	5.15	1.47	18.03	0.003
DMD - LGMD	2.80	0.45	17.57	0.54

[a] The p values and confidence limits were adjusted via the Kramer-Tukey method to control the error rate simultaneously for all ten pairwise comparisons at $\alpha = 0.05$.

Table S5. AHI means and mean differences among muscular dystrophy types estimated by fitting regression models adjusted for age, sex, and category of BMI z-score using GEE. (**A**) Adjusted mean AHI by muscular dystrophy type for a male patient aged 15 years with BMI z-score between -2 and 2; and (**B**) Pairwise adjusted mean difference comparing risk of sleep apnoea between muscular dystrophy types. This analysis used 103 PSG studies and 72 patients (one subject with only one PSG was missing BMI).

A. Estimated mean AHI (events/hr) by muscular dystrophy type for a male patient aged 15 years with BMI z-score between -2 and 2. [a]

Type	Estimated mean	95% Confidence Limits	
BMD	17.8	8.7	27.0
CMD	5.6	0.9	10.4
DM	5.8	2.2	9.3
DMD	7.5	3.7	11.2
LGMD	4.2	1.0	7.3

[a] We chose 15 years as an integer-valued age between the mean and median of the entire sample. Though estimated mean AHI would differ at other ages and for females or patients having extreme BMI z-scores, the regression model used implies that mean differences between muscular dystrophy types adjusted to this particular set of covariate values match corresponding mean differences estimated at other sets of values.

B. Pairwise adjusted mean difference in AHI (events/hr) between muscular dystrophy types.

Contrast	Estimated Mean Difference	Standard Error	z value	p value[a]	Simultaneous 95% Confidence Limits[a]	
BMD - CMD	12.2	5.1850	2.36	0.13	26.36	-1.93
BMD - DM	12.1	4.8200	2.50	0.09	25.21	-1.08
BMD - DMD	10.4	5.0484	2.05	0.24	24.13	-3.41
BMD - LGMD	13.6	4.7873	2.85	0.04	26.71	0.59
CMD - DM	-0.1	1.9761	-0.07	1.00	-5.54	5.24
CMD - DMD	-1. 9	2.3880	-0.78	0.94	-8.37	4.66
CMD - LGMD	1.4	2.4528	0.59	0.98	-5.26	8.13
DM - DMD	-1.7	2.1171	-0.81	0.93	-7.48	4.07
DM - LGMD	1.6	1.7363	0.91	0.89	-3.15	6.32
DMD - LGMD	3.3	2.4360	1.35	0.66	-3.35	9.94

[a] The p values and confidence limits were adjusted via the Kramer-Tukey method to control the error rate simultaneously for all ten pairwise comparisons at $\alpha = 0.05$.

Table S6. Odds of hypoventilation among muscular dystrophy types estimated by fitting logistic regression models adjusted for age, sex, and category of BMI z-score using GEE. (**A**) Adjusted odds of hypoventilation by muscular dystrophy type for a male patient aged 15 years with BMI z-score between -2 and 2; and (**B**) Pairwise adjusted odds ratios (ORs) comparing risk of hypoventilation between muscular dystrophy types. Because no BMD subjects exhibited hypoventilation, we combined types BMD and DMD, which each carry mutations in the same gene, into a single combined type "B_DMD" for this analysis. This analysis used 102 PSG studies and 71 patients (one subject missing BMI had only one PSG; another subject missing hypoventilation status also had only one PSG).

A. Estimated adjusted odds of hypoventilation prevalence by muscular dystrophy type for a male patient aged 15 years with BMI z-score between -2 and 2. [a]

Type	Estimated Odds	95% Confidence Limits	
B_DMD	0.40	0.14	1.12
CMD	0.83	0.22	3.23
DM	0.69	0.28	1.72
LGMD	0.13	0.02	0.91

[a] We chose 15 years as an integer-valued age between the mean and median of the entire sample. Though estimated odds of hypoventilation would differ at other ages and for females or patients having extreme BMI z-scores, the regression model used implies that odds ratios between muscular dystrophy types adjusted to this particular set of covariate values match corresponding odds ratios estimated at other sets of values.

B. Pairwise adjusted odds ratios (ORs) comparing prevalence of hypoventilation between muscular dystrophy types.

Contrast	OR	Simultaneous 95% Confidence Limits[a]		p value[a]
B_DMD - CMD	0.48	0.09	2.68	0.69
B_DMD - DM	0.58	0.12	2.80	0.81
B_DMD - LGMD	3.06	0.18	50.76	0.74
CMD - DM	1.20	0.18	7.97	0.99
CMD - LGMD	6.40	0.34	119.76	0.36
DM - LGMD	5.31	0.53	53.76	0.25

[a] The p values and confidence limits were adjusted via the Kramer-Tukey method to control the error rate simultaneously for all six pairwise comparisons at $\alpha = 0.05$.

Table S7. Age-adjusted heart rate estimated by GEE for each type of muscular dystrophy. (**A**) Adjusted mean heart rate (bpm) at age 15 years with 95% confidence limits; and (**B**) Pairwise differences in adjusted mean heart rate between muscular dystrophy types.

A. Estimated mean heart rate (bpm) at age 15 years[a]

Type	Mean	95% Confidence Limits	
Baseline heart rate (101 studies, 72 patients)			
BMD	83.1	65.0	101.3
CMD	93.0	87.8	98.3
DM	82.8	78.5	87.1
DMD	95.3	90.2	100.4
LGMD	87.6	82.4	92.7
In-sleep average heart rate (73 studies, 53 patients)			
BMD	69.7	48.5	90.9
CMD	89.0	88.0	90.1
DM	75.9	72.3	79.4
DMD	91.4	87.1	95.7
LGMD	81.3	75.4	87.2
In-sleep peak heart rate (73 studies, 53 patients)			
BMD	114.4	94.6	134.1
CMD	123.9	123.4	124.3
DM	112.4	106.9	117.9
DMD	122.6	119.0	126.3
LGMD	120.1	114.1	126.1

[a] We chose 15 years as an integer-valued age between the mean and median of the entire sample. Though estimates at other ages would differ since heart rate tended to decrease with increasing age, differences between types are the same at all ages under the regression model used for estimation.

Table S7 continued

B. Pairwise differences in adjusted mean heart rate between types						
Contrast	Estimated Mean Difference	Standard Error	z value	p value[a]	Simultaneous 95% Confidence Limits[a]	
Baseline heart rate						
BMD - CMD	-9.94	9.7906	-1.01	0.85	-36.64	16.77
BMD - DM	0.28	9.3756	0.03	1.00	-25.29	25.86
BMD - DMD	-12.18	9.7509	-1.25	0.72	-38.78	14.42
BMD - LGMD	-4.47	9.2128	-0.48	0.99	-29.60	20.67
CMD - DM	10.22	3.5241	2.90	0.03	0.60	19.83
CMD - DMD	-2.24	3.6990	-0.61	0.97	-12.33	7.85
CMD - LGMD	5.47	3.8826	1.41	0.62	-5.12	16.06
DM - DMD	-12.46	3.4611	-3.60	0.003	-21.90	-3.02
DM - LGMD	-4.75	3.2909	-1.44	0.60	-13.72	4.23
DMD - LGMD	7.71	3.8261	2.02	0.26	-2.72	18.15
In-sleep average heart rate						
BMD - CMD	-19.36	10.8988	-1.78	0.39	-49.09	10.37
BMD - DM	-6.17	10.9500	-0.56	0.98	-36.04	23.70
BMD - DMD	-21.71	11.1750	-1.94	0.30	-52.19	8.77
BMD - LGMD	-11.60	10.7134	-1.08	0.82	-40.82	17.62
CMD - DM	13.19	1.8518	7.12	<0.0001	8.13	18.24
CMD - DMD	-2.35	2.2402	-1.05	0.83	-8.46	3.76
CMD - LGMD	7.76	3.0920	2.51	0.09	-0.68	16.19
DM - DMD	-15.54	2.8120	-5.53	<0.0001	-23.21	-7.87
DM - LGMD	-5.43	3.6049	-1.51	0.56	-15.26	4.41
DMD - LGMD	10.11	3.8492	2.63	0.07	-0.39	20.61
In-sleep peak heart rate						
BMD - CMD	-9.48	10.1502	-0.93	0.88	-37.16	18.21
BMD - DM	1.97	10.4681	0.19	1.00	-26.59	30.52
BMD - DMD	-8.26	10.3622	-0.80	0.93	-36.53	20.01
BMD - LGMD	-5.72	10.2058	-0.56	0.98	-33.56	22.11
CMD - DM	11.44	2.8482	4.02	0.0006	3.67	19.21
CMD - DMD	1.21	1.8377	0.66	0.96	-3.80	6.23
CMD - LGMD	3.75	3.1176	1.20	0.75	-4.75	12.26

DM - DMD	-10.23	3.4160	-2.99	0.02	-19.55	-0.91
DM - LGMD	-7.69	4.0058	-1.92	0.31	-18.62	3.24
DMD - LGMD	2.54	3.6505	0.69	0.96	-7.42	12.49

[a] The p values and confidence limits were adjusted via the Kramer-Tukey method to control the error rate simultaneously for all ten pairwise comparisons for a given response at $\alpha = 0.05$.