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# GENDER AND SPINAL/BULBAR ONSET INTERACTION ON ALS PROGRESSION

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## Background & Objectives

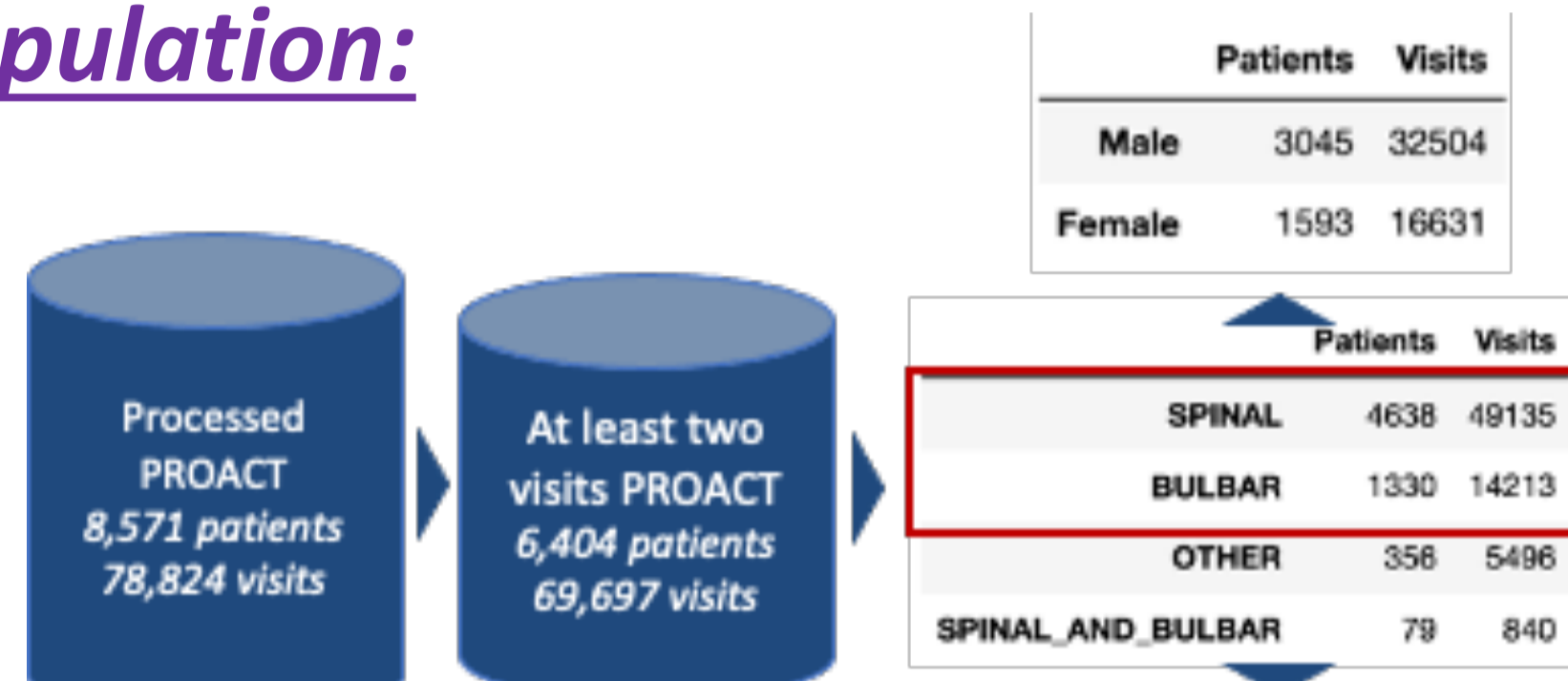
ALS is an adult onset heterogeneous neurodegenerative disease that occurs at a younger age than AD or PD (55, 60, 60 respectively). Descriptive studies show that the mean age and gender/ratio is different according to the phenotype. Compared to spinal onset form, bulbar-onset form, which represent 26 % of ALS cases, are more frequent in women (gender ratio of 1/2 vs 1/3 in spinal forms) and occurs later. The progression of bulbar forms is more rapid in bulbar-onset form with a mean survival of 24 months (vs 40 months in spinal forms). (Tysnes, Acta Neurol Scand 1991)

However the interaction between **gender** and **spinal/bulbar onset** on ALS progression remains under study.

To investigate this issue, we used a multivariate disease progression model in PROACT, a large dataset of ALS patients.

## Methods

### Population:



### Clinical Endpoints:

- BMI
- ALSFRS-R Respiratory
- ALSFRS-R Bulbar
- ALSFRS-R Gross Motor
- ALSFRS-R Fine Motor
- Percent Forced Vital Capacity (PFVC) (Brändli, Thorax 1996)

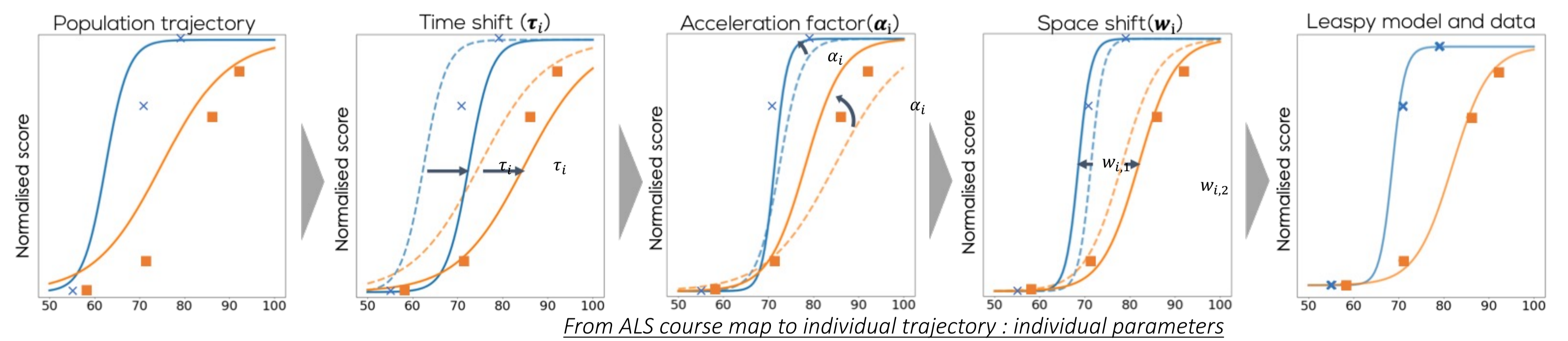
### Statistical Methods:

J.-B. Schiratti 2017  
leaspy (Bayesian mixed-effect model)

### Useful for:

- Temporal progression
- Continuous endpoints
- Multivariate analysis
- Robust to missing data

Scores are normalized thanks to these scales, and BMI and PFVC thanks to box-cox transformation and [-3,3] normalization.



From ALS course map to individual trajectory: individual parameters

## Results

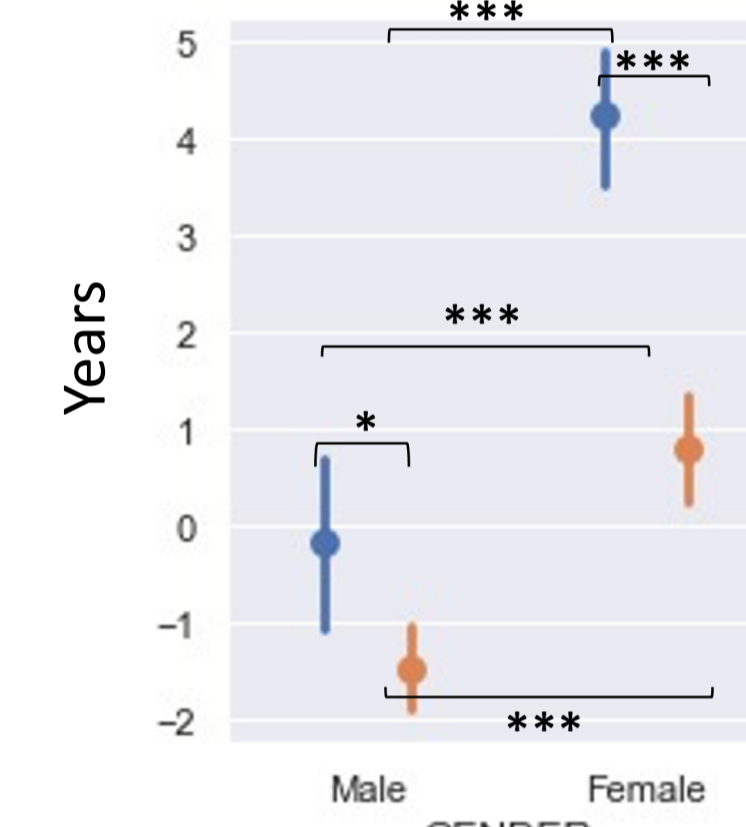
| Endpoints                     | Spinal Male          | Bulbar Male          | Spinal Female        | Bulbar Female        | Interaction p-value | Subgroup relations |
|-------------------------------|----------------------|----------------------|----------------------|----------------------|---------------------|--------------------|
| Age at baseline (y)           | 53.9 ± 11.8          | 55.7 ± 11.5          | 56.8 ± 11.1          | 60.5 ± 9.6           | 7.5e-03             | SM<(BM,SF)<BF      |
| Follow up (y)                 | 1.0 ± 0.5            | 0.9 ± 0.4            | 0.9 ± 0.5            | 1.0 ± 0.4            | 1.3e-01             |                    |
| Number of visits              | 10.6 ± 5.9           | 10.6 ± 4.7           | 10.4 ± 5.5           | 10.7 ± 5.0           | 2.4e-01             |                    |
| Active arm                    | 1836 (60.3 %)        | 382 (57.1 %)         | 957 (60.1 %)         | 360 (54.5 %)         |                     |                    |
| Placebo arm                   | 951 (31.2 %)         | 242 (36.2 %)         | 503 (31.6 %)         | 232 (35.1 %)         |                     |                    |
| Observational arm             | 258 (8.5 %)          | 45 (6.7 %)           | 133 (8.3 %)          | 69 (10.4 %)          |                     |                    |
| Age at first symptoms (y)     | 51.8 ± 11.7 (91.3 %) | 54.1 ± 11.5 (90.7 %) | 54.6 ± 11.2 (91.3 %) | 58.7 ± 9.7 (91.7 %)  | 1.8e-02             | SM<(BM,SF)<BF      |
| Age at diagnosis (y)          | 52.4 ± 11.8 (52.1 %) | 54.8 ± 11.4 (53.4 %) | 55.2 ± 11.5 (52.2 %) | 59.4 ± 10.0 (52.6 %) | 6.1e-02             | SM<BM<SF<BF        |
| Patients with gastrostomy     | 19.8 %               | 45.4 %               | 21.4 %               | 58.5 %               |                     |                    |
| Patients dead                 | 26.9 %               | 35.1 %               | 30.3 %               | 38.1 %               |                     |                    |
| Length of the disease (y)     | 2.6 ± 1.2 (25.7 %)   | 2.2 ± 0.8 (32.7 %)   | 2.7 ± 1.1 (29.1 %)   | 2.4 ± 0.8 (36.0 %)   | 8.8e-02             | BM<BF<SM<SF        |
| Time betw. sympt. and bsl (y) | 1.9 ± 1.5 (91.3 %)   | 1.5 ± 0.9 (90.7 %)   | 2.0 ± 1.3 (91.3 %)   | 1.5 ± 0.9 (91.7 %)   | 7.8e-01             |                    |

### Legend:

- B: Bulbar,
- S: Spinal,
- M: Male,
- F: Female,
- PFVC: Percent of Forced Vital Capacity,
- <: earlier or slower
- \*: <5e-2
- \*\* : <1e-2
- \*\*\*: <1e-3

### Time-shift distributions

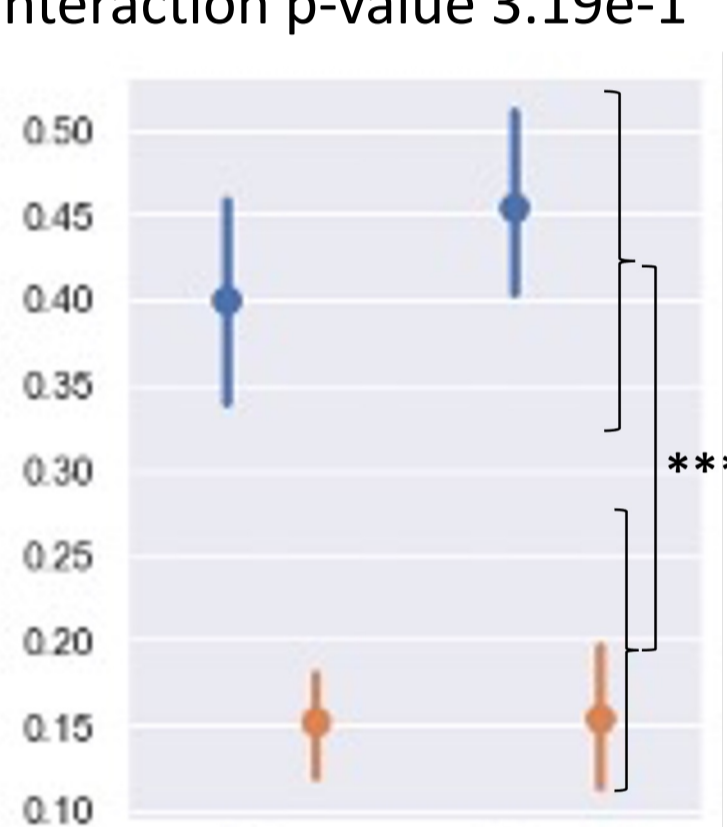
Interaction p-value 2.9e-3



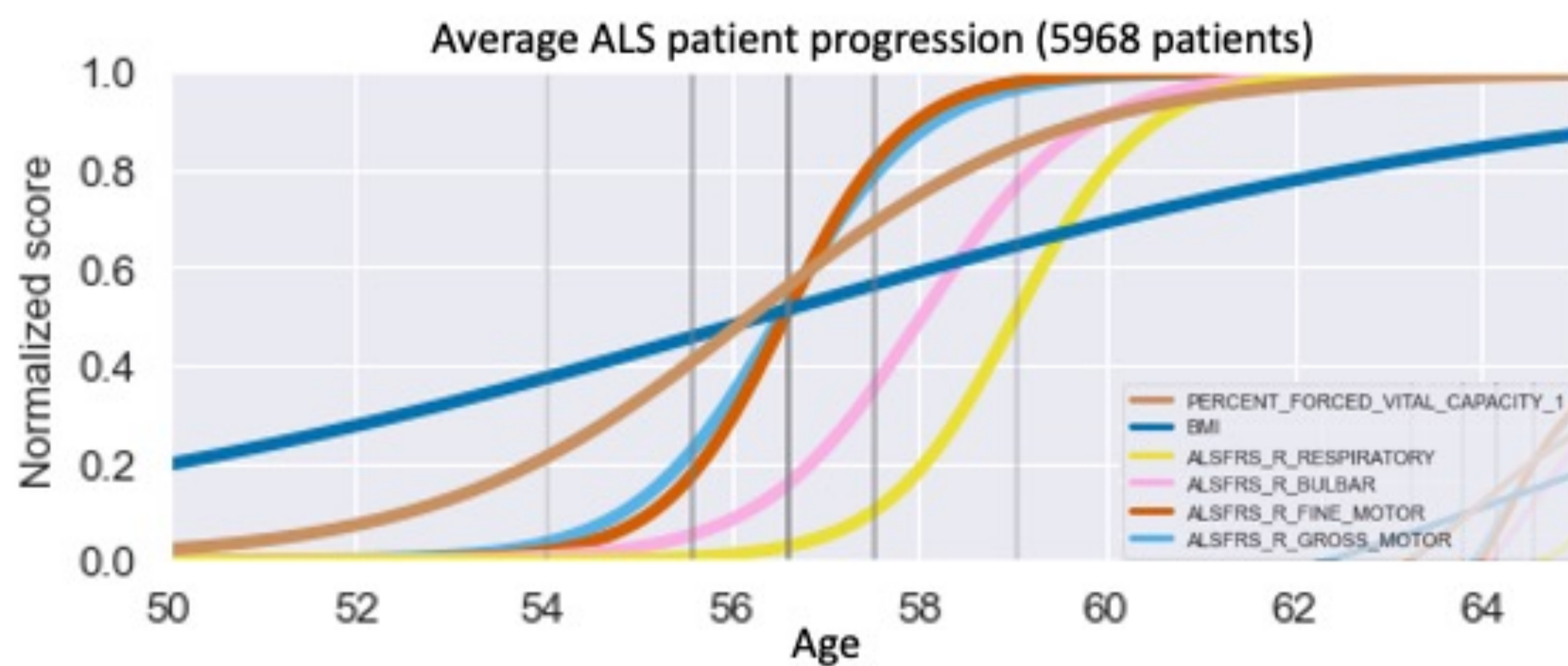
SM < (BM, SF) < BF

### Log acceleration factor distributions

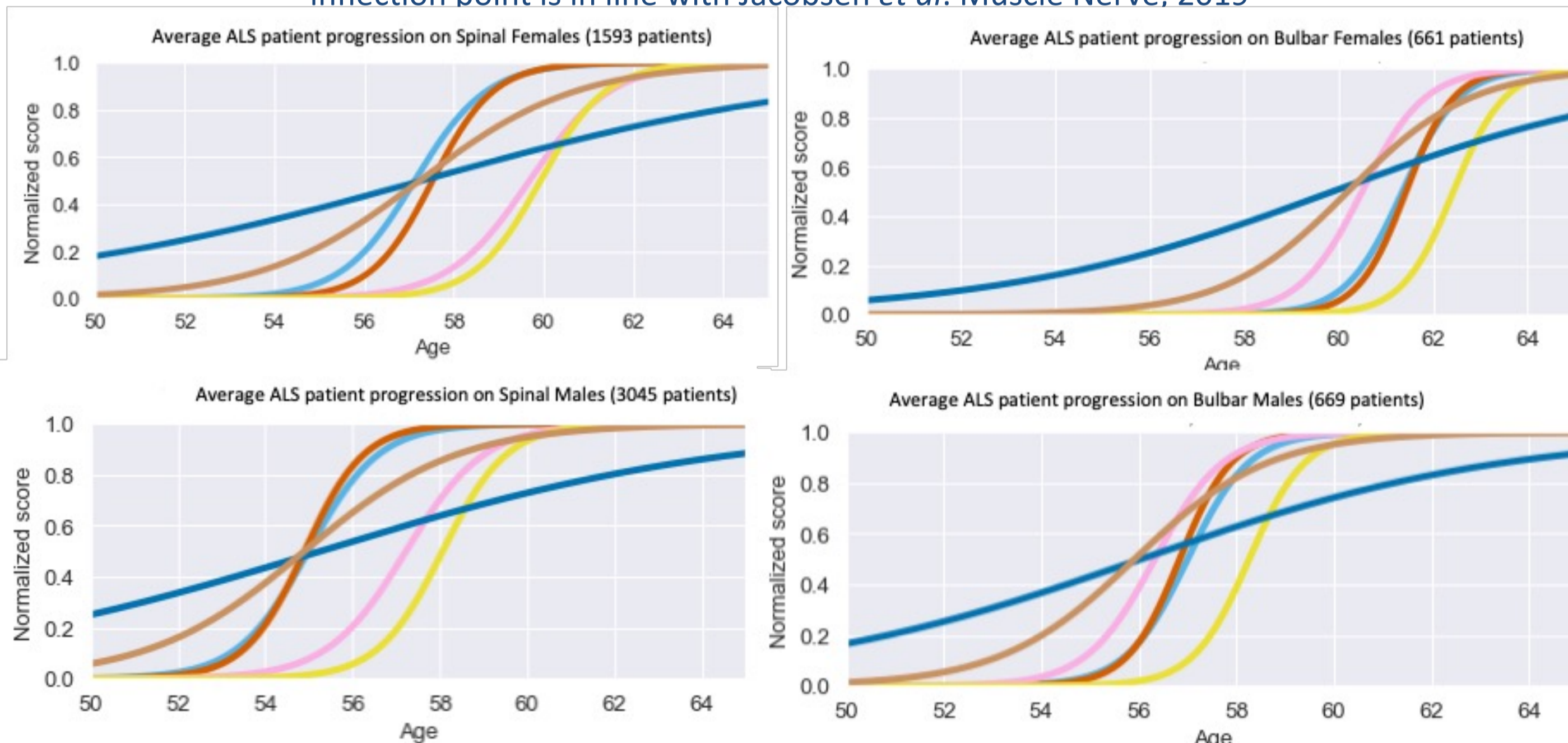
Interaction p-value 3.19e-1



S < B

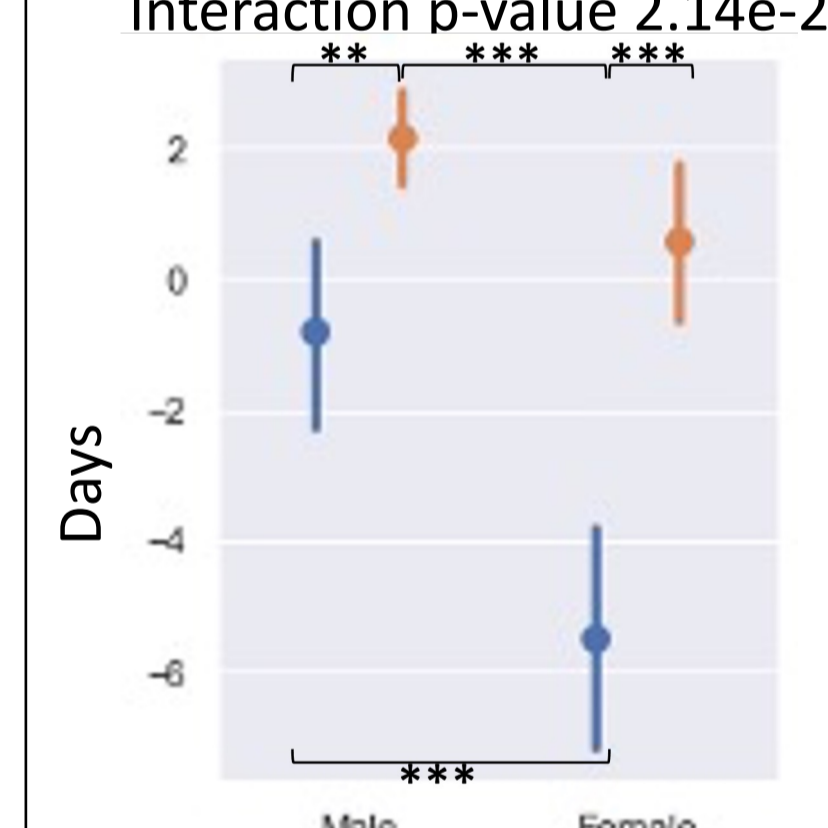


disease progression of the typical patient: Symptoms develop between the age of 55 and 75. Slope at inflection point is in line with Jacobsen et al. Muscle Nerve. 2019



### BMI inter-marker spacing distributions

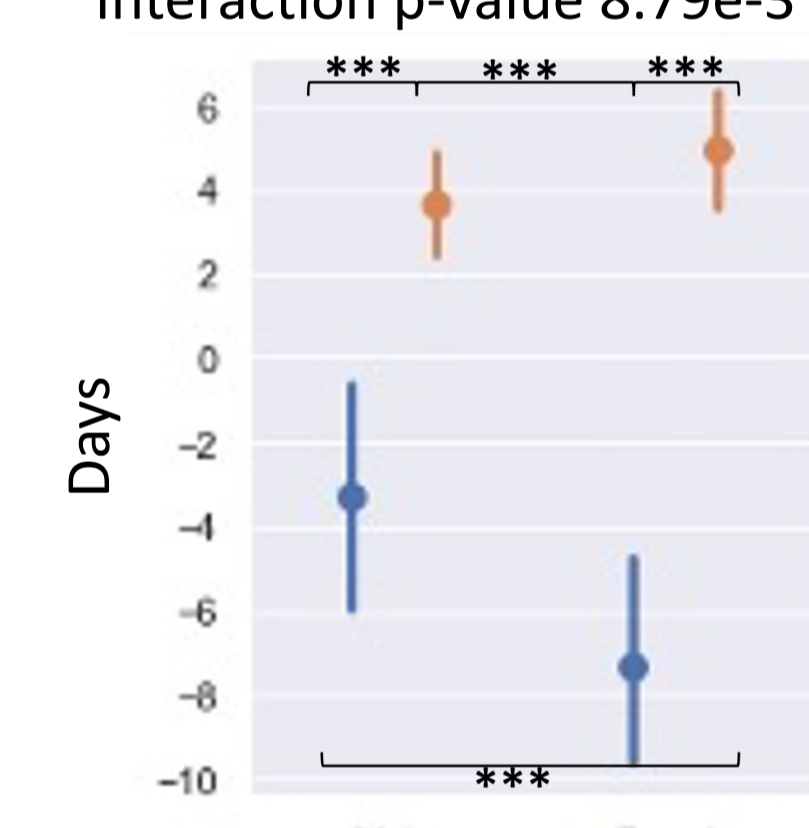
Interaction p-value 2.14e-2



FB < FS  
MB < MS

### PFVC inter-marker spacing distributions

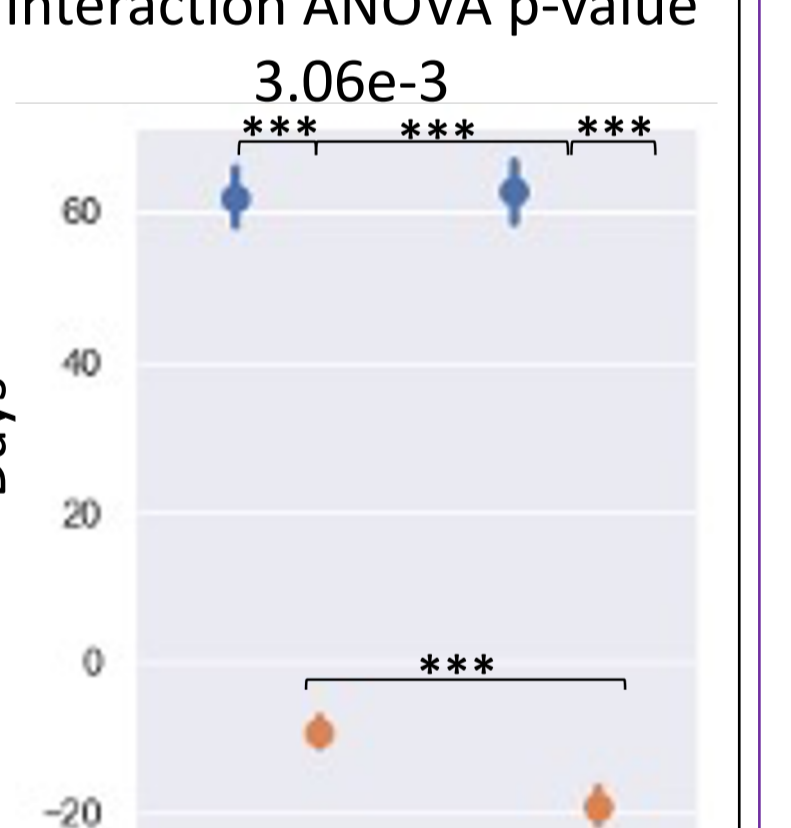
Interaction p-value 8.79e-3



FB < FS  
MB < MS

### ALSFRS-R gross motor inter-marker spacing distributions

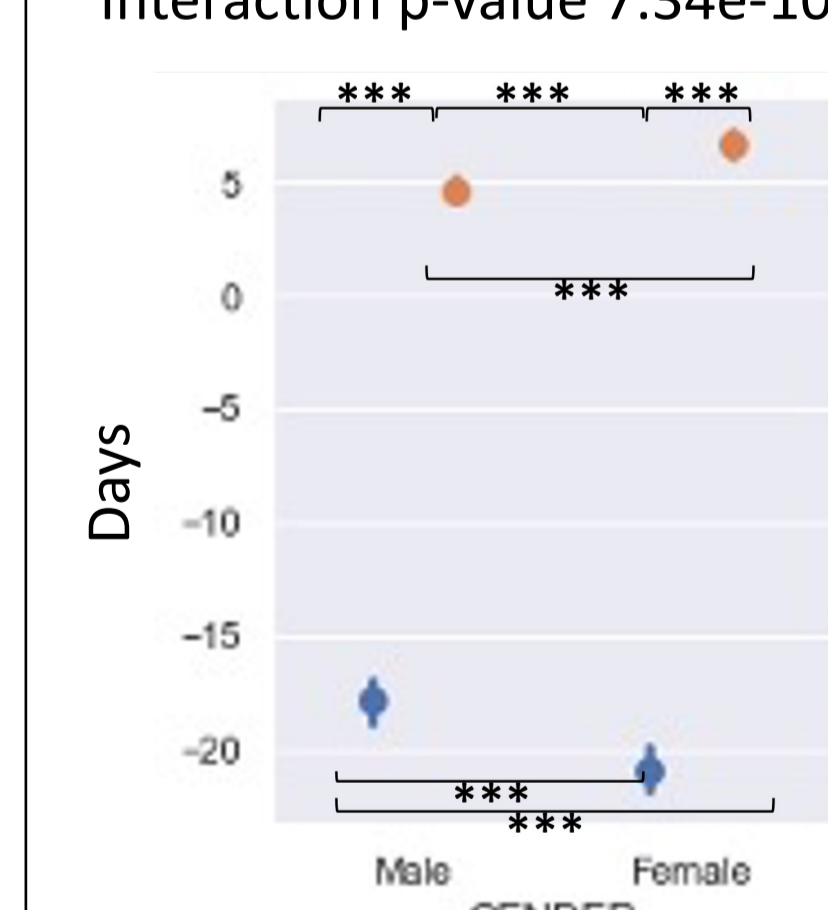
Interaction ANOVA p-value 3.06e-3



SF < SM < (BM, BF)

### ALSFRS-R bulbar inter-marker spacing distributions

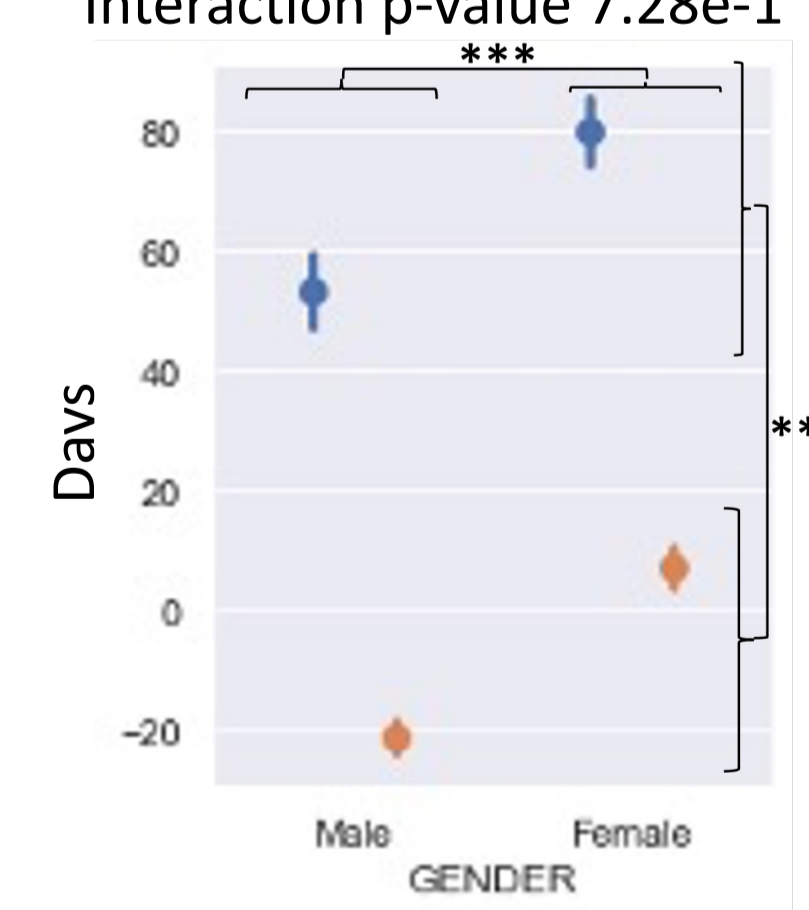
Interaction p-value 7.34e-10



BF < BM < SM < SF

### ALSFRS-R Fine motor inter-marker spacing distributions

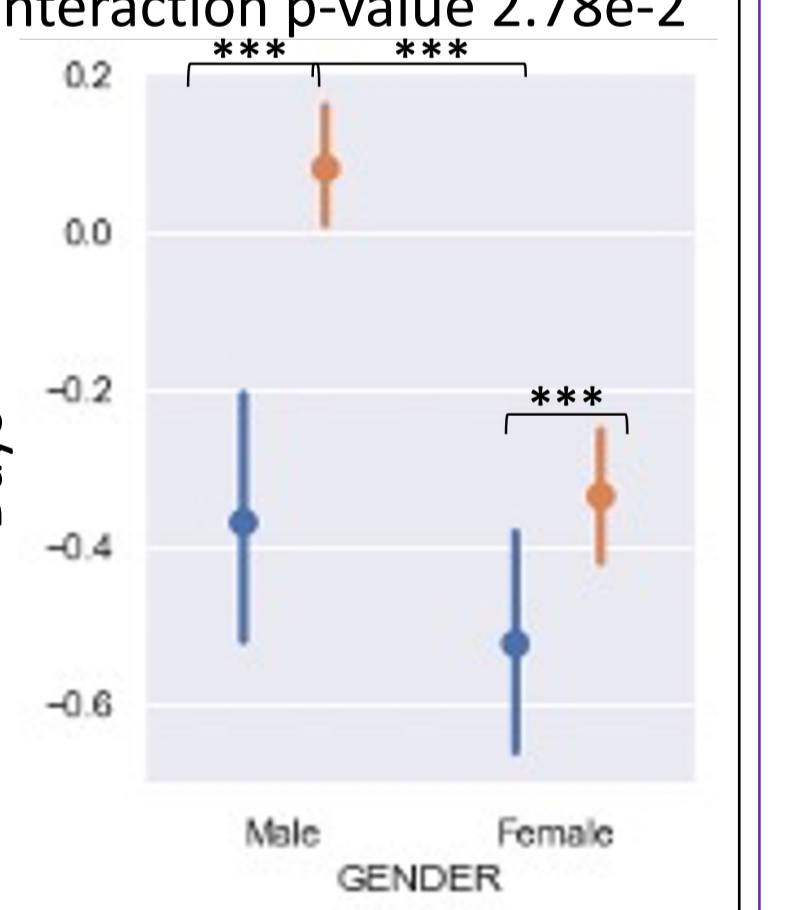
Interaction p-value 7.28e-1



S < B  
M < F

### ALSFRS-R Respiratory inter-marker spacing distributions

Interaction p-value 2.78e-2



FB < FS  
MB < MS

Distribution of relative timing of endpoints on the different subgroups

## Discussion

- Our method allows to validate that patients with bulbar onset have a faster progression although the disease starts later (Chio, Neurology 2020) and that for both gross and fine motor scores progression starts earlier (and bulbar score and BMI later) for spinal patients regardless of the gender (Rooney, J Neurol Neurosurg Psychiatry 2016) (Moglia, J Neurol Neurosurg Psychiatry 2019), with a **large number of patients** and a **methodology not based on survival model** that allows to use **six major outcome of ALS**.

- We exhibited, that **female starts later in both spinal and bulbar onset**, which might be linked to hormone protection as suggested in Trosjii, Int J Mol Sci. 2020.

- We show that, **fine motor progression starts earlier for spinal male patients** and **gross motor progression starts earlier for spinal female patients**, which might be associated to gender early socialization as suggested in Dinkel, Infant Behav Dev 2020.