Follow up Report for Jacob Matties

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Research Questions:

Can the different phone positions (shirt pocket, pants pocket, handheld) detect differences in balance between difficult stances?

What is a Generalized Linear Mixed Model (GLMM):

In this report, we used a generalized linear mixed model with a Gamma distribution. The response variable, acceleration measured as 24 m/s^2, was modeled using a gamma distribution to better model the right skewness. The generalized linear mixed model allows us to model data that is not normal by transforming our response variable with a **link** function. The link function we used was a log link function transforming our response ($\boldsymbol{\mu}$), in this case acceleration, using the log function $\boldsymbol{\eta = \log(\mu)}$. To interpret the results of our model estimates ($\boldsymbol{\eta}$) we back-transform by exponentiating using the **inverse link** function, $\boldsymbol{\mu = e^{\eta}}$, which transforms them back into the original units of the data. Using a generalized linear mixed model and a log link does not affect the tests for estimates in our model and we can still determine statistical significance from our tests.

Generalized Linear Mixed Model:

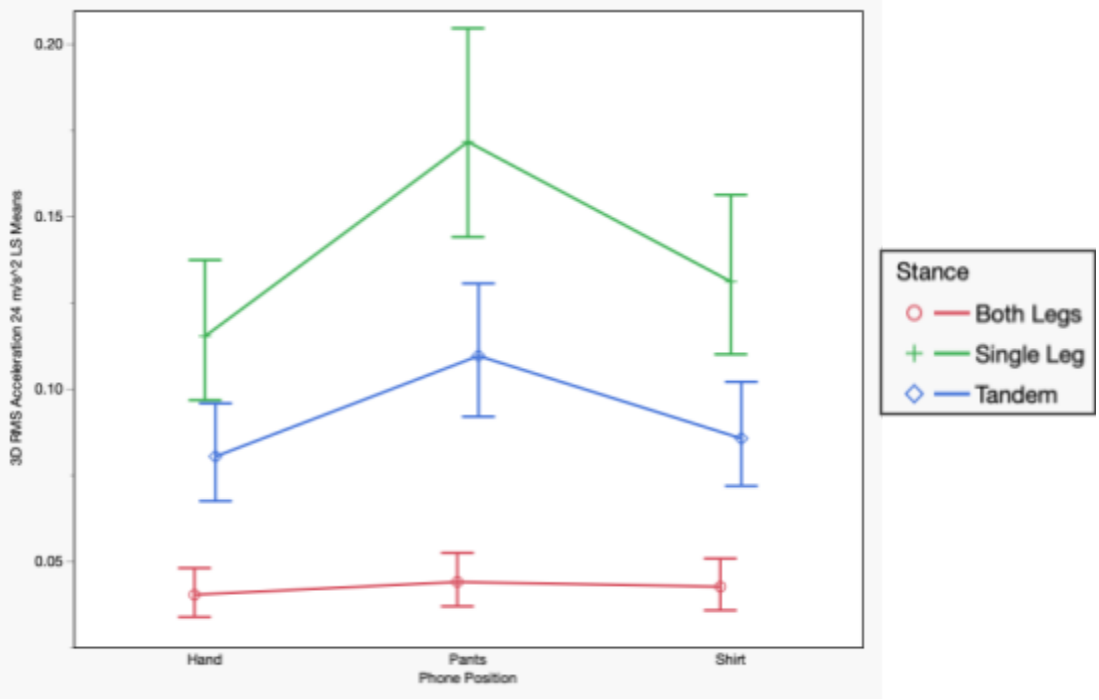
- Gamma distribution with log link
- Fixed effects: Phone position, stance, phone position * stance
- Random effects: participant

Fixed Effects Test Table:

Source	Nparm	DFNum	DFDen	F Ratio	Prob > F
Phone Position	2	2	160.0	11.111719	<.0001*
Stance	2	2	160.0	215.6561	<.0001*
Phone Position*Stance	4	4	160.0	1.4822293	0.2100

- Interaction effect was not found to be significant
  - F-statistic = 1.482
  - Degrees of Freedom = (2, 160)
  - p-value = 0.21
- All main fixed effects showed highly significant effects on RMS acceleration
  - F-statistics = 11.11; 215.66
  - Degrees of Freedom = (2, 160); (4, 160)
  - p-values < 0.0001
    - All three phone positions can detect significant differences in balance across stances of varying difficulty.

Interaction Plot:



Main Effect of Stance:

- Both Legs stance consistently had the lowest RMS acceleration (most stable).
- Single Leg stance had the highest RMS acceleration (least stable).
- Tandem stance was intermediate.

Main Effect of Phone Position:

- Pants pocket generally had higher RMS acceleration (less stable) than handheld or shirt pocket in the Single Leg stance.
- No significant interaction between phone position and stance ($p = 0.21$), meaning the effect of stance is consistent across phone positions.
- All phone positions ranked stances identically
    - Both Legs < Tandem < Single Leg (from most to least stable).

Fixed Effects Table:

Stance	Estimate	Std Error	DF	Lower 95%	Upper 95%	Mean Estimate	Mean Std Error	Mean Lower 95%	Mean Upper 95%
Both Legs	-3.165236	0.06690102	34.83	-3.301076	-3.029396	0.04220417	0.00282350	0.03684349	0.04834482
Single Leg	-1.986216	0.06690102	34.83	-2.122056	-1.850376	0.13721364	0.00917973	0.11978507	0.15717804
Tandem	-2.398170	0.06690102	34.83	-2.534010	-2.262330	0.09088413	0.00608024	0.07934023	0.10410765

Phone Position	Estimate	Std Error	DF	Lower 95%	Upper 95%	Mean Estimate	Mean Std Error	Mean Lower 95%	Mean Upper 95%
Hand	-2.632591	0.06690102	34.83	-2.768431	-2.496751	0.07189192	0.00480964	0.06276037	0.08235210
Pants	-2.367155	0.06690102	34.83	-2.502995	-2.231315	0.09374709	0.00627178	0.08183955	0.10738717
Shirt	-2.549876	0.06690102	34.83	-2.685716	-2.414036	0.07809133	0.00522439	0.06817234	0.08945351

Multiple Comparisons for Phone Position*Stance

Custom Estimates

Phone Position	Stance	Estimate	Std Error	DF	Lower 95%	Upper 95%	Mean Estimate	Mean Std Error	Mean Lower 95%	Mean Upper 95%
Hand	Both Legs	-3.213346	0.08829572	88.087	-3.388813	-3.037880	0.04022179	0.00355141	0.03374871	0.04793643
Hand	Single Leg	-2.161954	0.08829572	88.087	-2.337421	-1.986487	0.11509998	0.01016283	0.09657639	0.13717642
Hand	Tandem	-2.522474	0.08829572	88.087	-2.697940	-2.347007	0.08026083	0.00708669	0.06734408	0.09565505
Pants	Both Legs	-3.125159	0.08829572	88.087	-3.300625	-2.949692	0.04392997	0.00387883	0.03686011	0.05235584
Pants	Single Leg	-1.763573	0.08829572	88.087	-1.939040	-1.588107	0.17143119	0.01513664	0.14384196	0.20431210
Pants	Tandem	-2.212732	0.08829572	88.087	-2.388199	-2.037265	0.10940135	0.00965967	0.09179488	0.13038479
Shirt	Both Legs	-3.157204	0.08829572	88.087	-3.332670	-2.981737	0.04254454	0.00375650	0.03569765	0.05070469
Shirt	Single Leg	-2.033121	0.08829572	88.087	-2.208588	-1.857654	0.13092627	0.01156023	0.10985569	0.15603824
Shirt	Tandem	-2.459304	0.08829572	88.087	-2.634771	-2.283837	0.08549442	0.00754879	0.07173540	0.10189245

Phone Position	Stance						Least Squares Mean
Pants	Single Leg	A					-1.763573
Shirt	Single Leg	A	B				-2.033121
Hand	Single Leg		B	C			-2.161954
Pants	Tandem		B	C	D		-2.212732
Shirt	Tandem			C	D		-2.459304
Hand	Tandem				D		-2.522474
Pants	Both Legs					E	-3.125159
Shirt	Both Legs					E	-3.157204
Hand	Both Legs					E	-3.213346

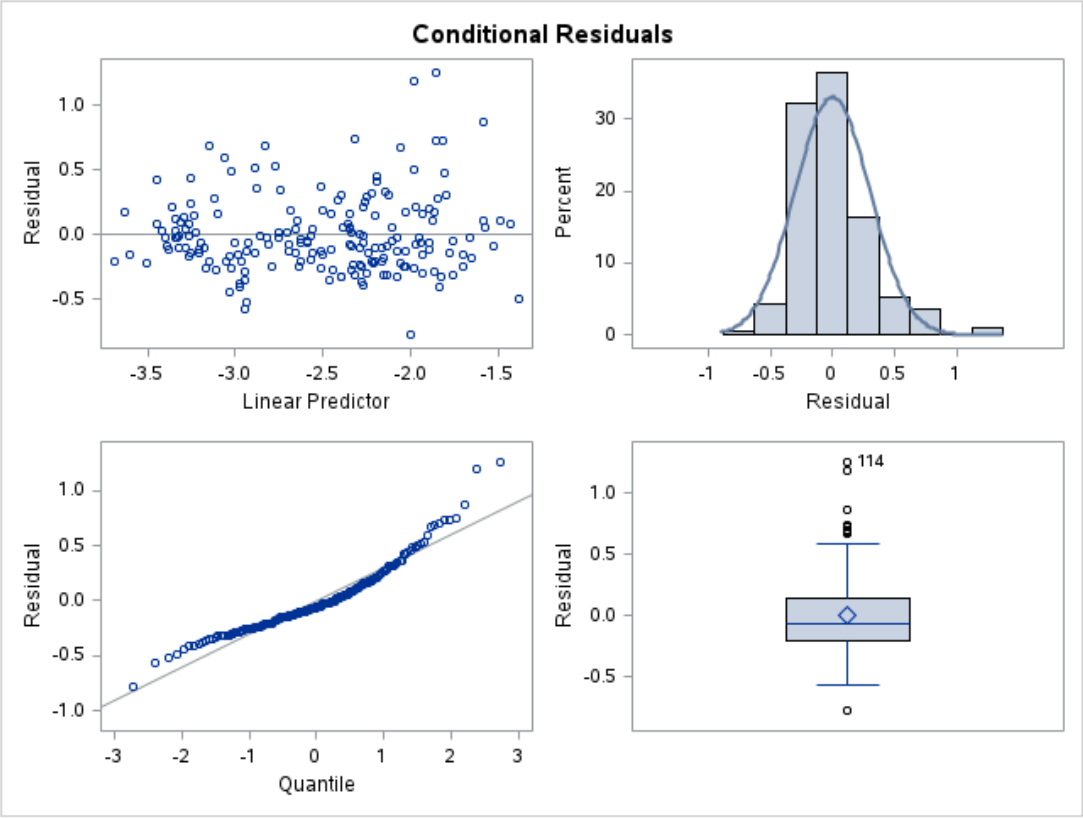
Levels not connected by same letter are significantly different.

Sample Interpretations:

- **Pants, Single Leg**
  - Estimate:
    - For individuals like those in the study with the phone in their pants and in the single leg stance the estimated mean acceleration is 0.171 m/s^2.
  - Confidence Interval:
    - We are 95% confident that the true mean value for acceleration for individuals like those in the study with the phone in their pants in the single leg stance is between 0.144 and 0.204 m/s^2.
- **Pants, Tandem**
  - Estimate:
    - For individuals like those in the study with the phone in their pants and in the tandem stance the estimated mean acceleration is 0.109 m/s^2.
  - Confidence Interval:
    - We are 95% confident that the true mean value for acceleration for individuals like those in the study with the phone in their pants in the tandem stance is between 0.092 and 0.130 m/s^2.
- **Handheld, Both Legs**
  - Estimate:
    - For individuals like those in the study with the phone in their hands and in the both legs stance the estimated mean acceleration is 0.040 m/s.
  - Confidence Interval:
    - We are 95% confident that the true mean value for acceleration for individuals like those in the study with the phone handheld and in the both legs stance is between 0.034 and 0.048 m/s^2.

Model Fit:

- Gamma distribution with log link was appropriate (residual diagnostics supported assumptions).
- Random subject effects accounted for individual variability (estimated variance = 0.059).
    - There is some participant-to-participant variation not accounted for by the model.



- JMP instructions:
    - Analyze > Fit Model,
    - Set personality to Generalized Linear Mixed Model
    - Add acceleration to Y
    - Add phone position, stance and their interaction to fixed effects
    - Add participant to random effects
    - Click run