

Point Constraint Statistics

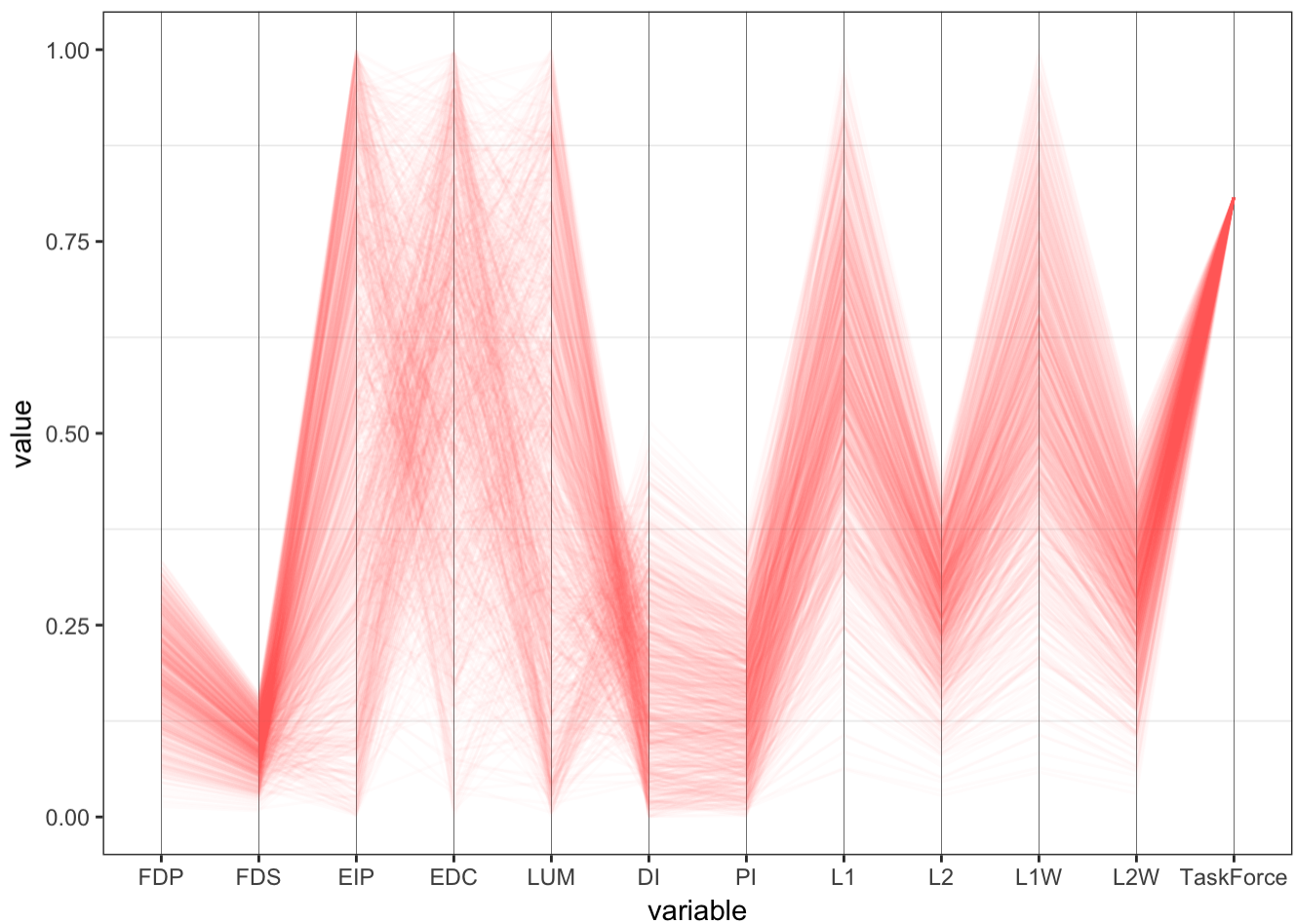
Point Constraint Statistics

Commands: Run selected chunk: *Cmd+Shift+Enter*. Insert chunk: *Cmd+Option+I*.

When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Cmd+Shift+K* to preview the HTML file). #Write cost functions

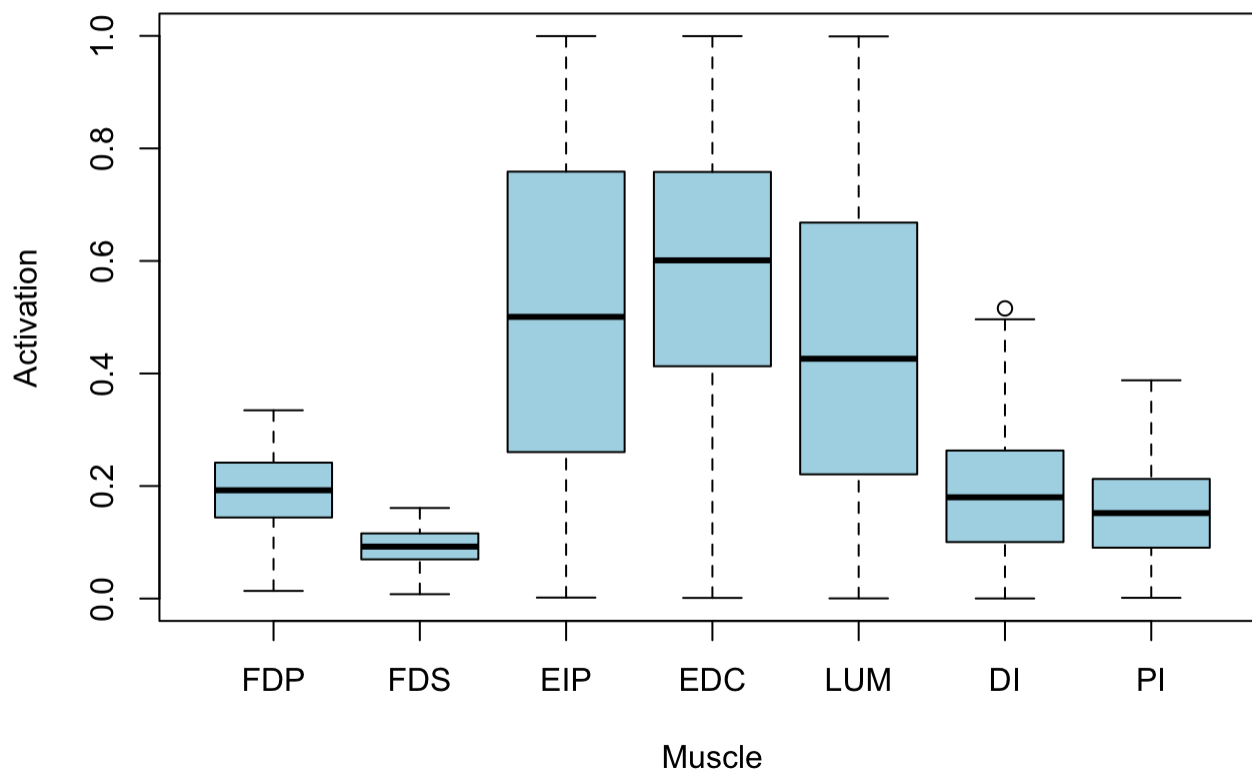
Load data and compute cost

All points for an 80%-of-max task



View all points as boxplots:

all 1000 solutions that perform an 80% distal fingertip force



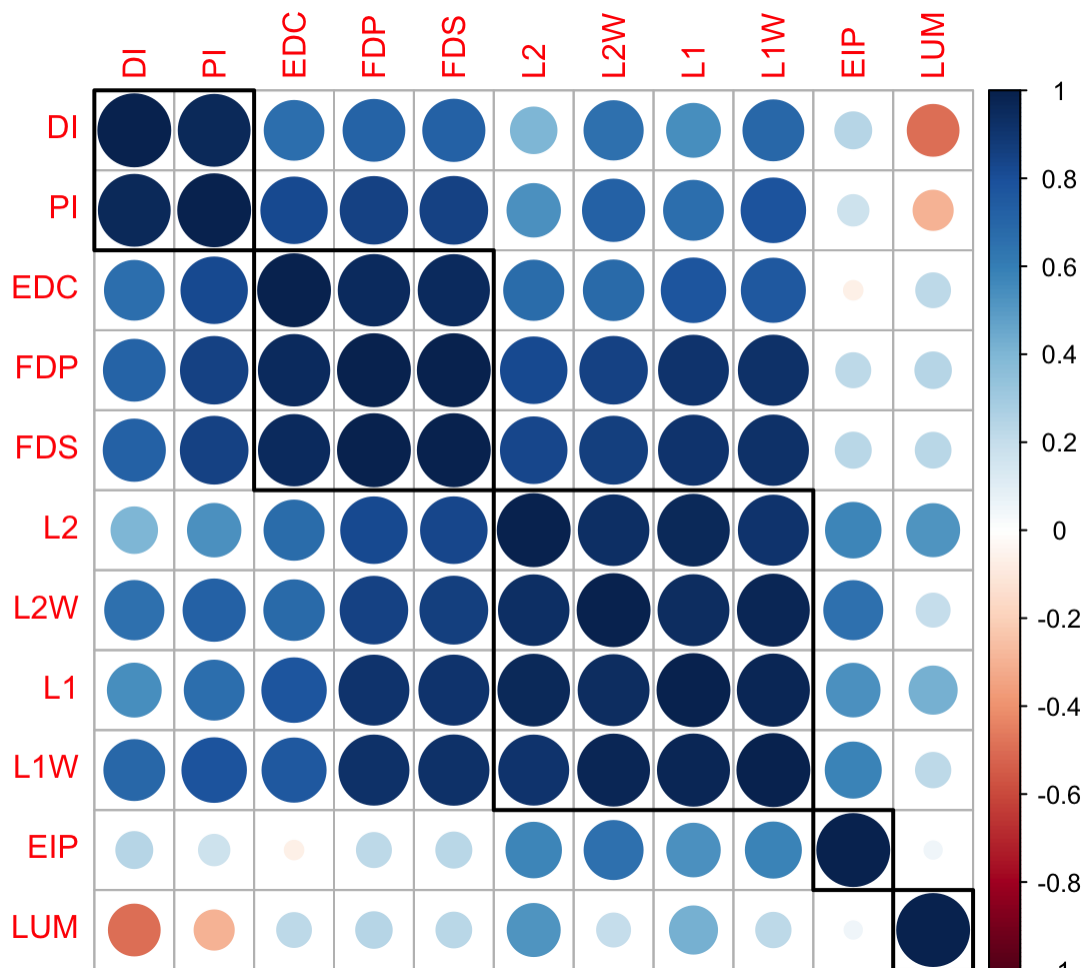
```
##           FDP           FDS           EIP
## Min.      :0.01357   Min.      :0.007762   Min.      :0.001747
## 1st Qu.:0.14430   1st Qu.:0.069695   1st Qu.:0.260326
## Median :0.19247   Median :0.092336   Median :0.500613
## Mean      :0.19100   Mean      :0.091863   Mean      :0.504462
## 3rd Qu.:0.24153   3rd Qu.:0.115783   3rd Qu.:0.758679
## Max.      :0.33463   Max.      :0.160963   Max.      :0.999629
##           EDC           LUM           DI
## Min.      :0.001132   Min.      :0.0003311   Min.      :0.0001764
## 1st Qu.:0.412881   1st Qu.:0.2209727   1st Qu.:0.1004263
## Median :0.601081   Median :0.4262012   Median :0.1799842
## Mean      :0.578074   Mean      :0.4469257   Mean      :0.1875894
## 3rd Qu.:0.758173   3rd Qu.:0.6677409   3rd Qu.:0.2629963
## Max.      :0.999588   Max.      :0.9990431   Max.      :0.5156824
##           PI
## Min.      :0.001317
## 1st Qu.:0.090575
## Median :0.151913
## Mean      :0.154694
## 3rd Qu.:0.212580
## Max.      :0.387905
```

what about parcoord axes being parallel (few line crossings between muscle actiavtions)?

```
cor(points_w_cost$FDP, points_w_cost$FDS)
## [1] 0.9998411
```

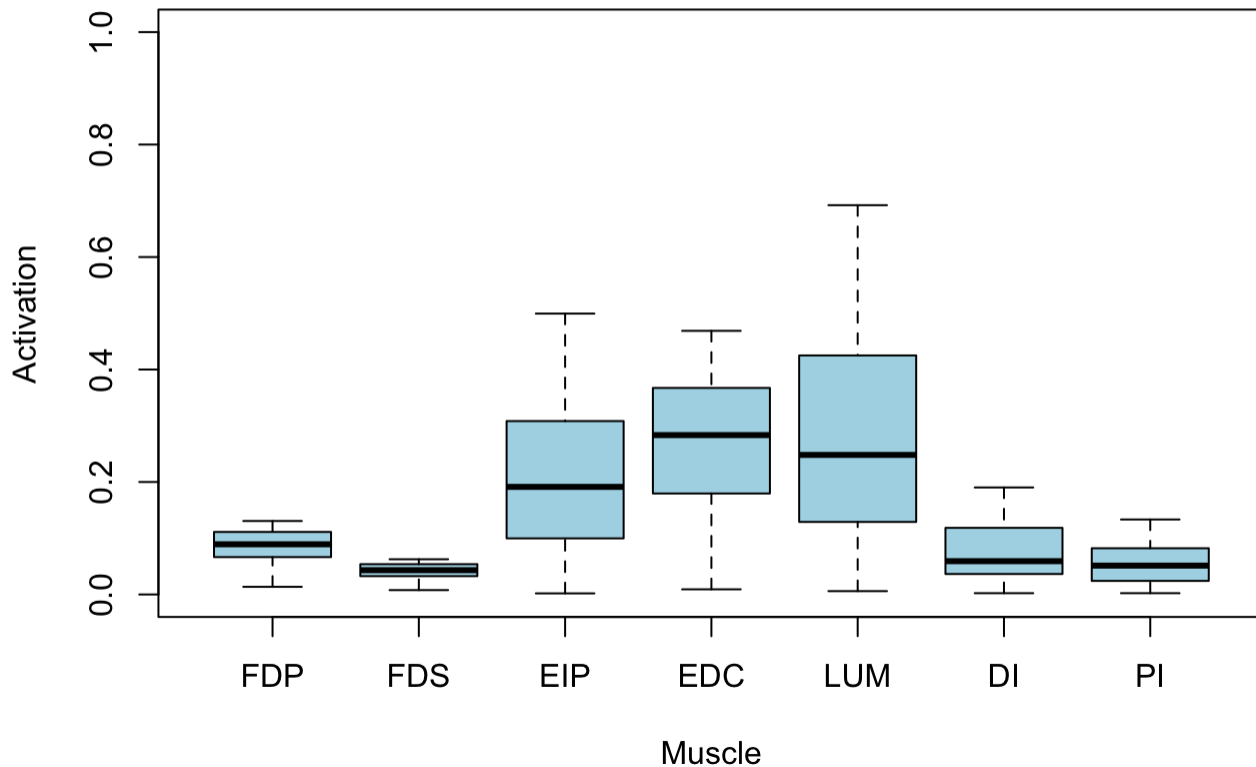
what about many crossings between two muscles?

```
cor(points_w_cost$LUM, points_w_cost$DI)
## [1] -0.4982628
cor(points_w_cost$EIP, points_w_cost$EDC)
## [1] -0.06642129
library(corrplot)
corrplot(cor(points_w_cost), order = "hclust", addrect=5)
```



Let's grab the bottom 10% of L2W cost and see how the muscle activations are distributed

Bottom 100 L2W Solutions

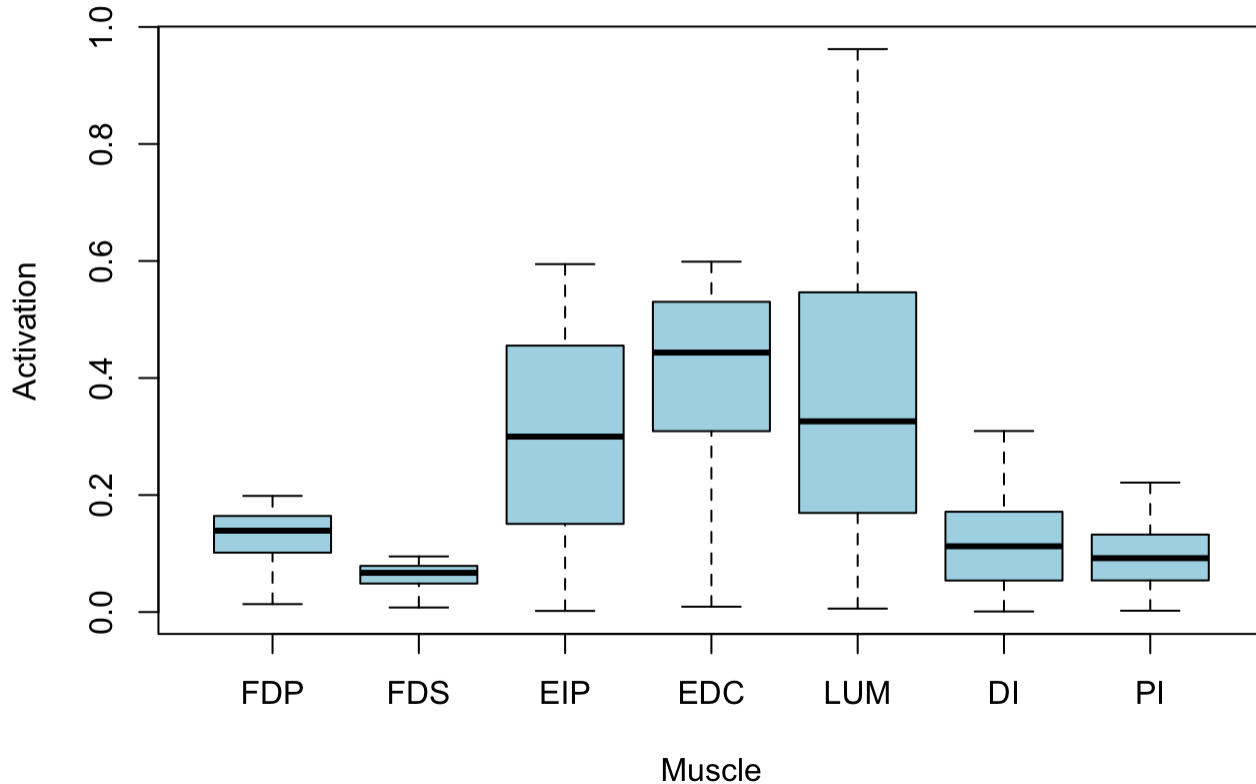


```
##           FDP           FDS           EIP
## Min.      :0.01357   Min.      :0.007762   Min.      :0.001936
## 1st Qu.:0.06686   1st Qu.:0.032769   1st Qu.:0.099902
## Median :0.08922   Median :0.043177   Median :0.191305
## Mean    :0.08594   Mean    :0.041834   Mean    :0.205708
## 3rd Qu.:0.11054   3rd Qu.:0.053781   3rd Qu.:0.308059
## Max.    :0.13065   Max.    :0.062602   Max.    :0.499439
##           EDC           LUM           DI
## Min.      :0.009153   Min.      :0.005913   Min.      :0.002266
## 1st Qu.:0.180492   1st Qu.:0.129539   1st Qu.:0.036946
## Median :0.283373   Median :0.248116   Median :0.059195
## Mean    :0.269663   Mean    :0.283379   Mean    :0.074878
## 3rd Qu.:0.365629   3rd Qu.:0.424265   3rd Qu.:0.117655
## Max.    :0.468751   Max.    :0.692210   Max.    :0.190278
##           PI
## Min.      :0.002277
## 1st Qu.:0.024293
## Median :0.051305
## Mean    :0.054887
## 3rd Qu.:0.081641
## Max.    :0.133341
```

Limiting one muscle:

Our dataset can be used to simulate a 40% reduction in activation (due to muscle dysfunction, for example) in the two index finger muscles innervated by the radial nerve (EIP and EDC).

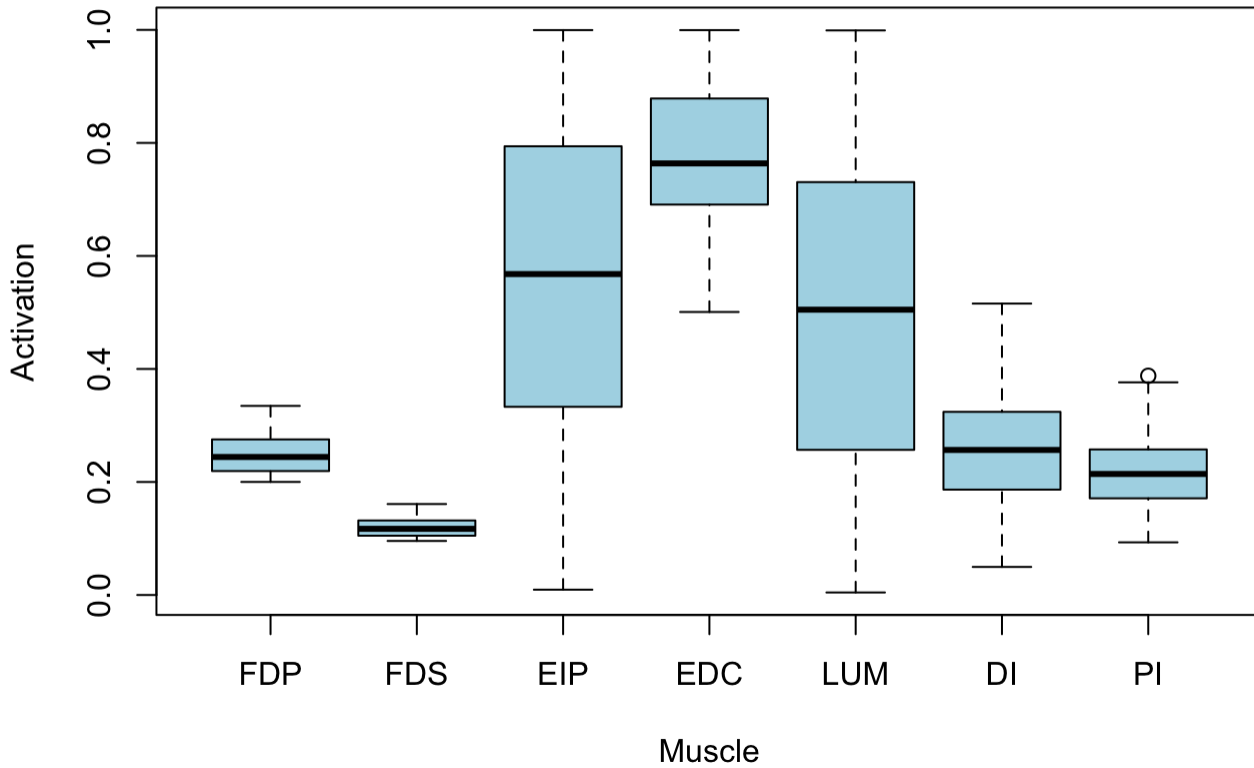
290 /1000 solutions remain when radial nerve limits EIP and EDC to 0.0



```
##           FDP           FDS           EIP
## Min.    :0.01357   Min.    :0.007762   Min.    :0.001936
## 1st Qu.:0.10158   1st Qu.:0.048847   1st Qu.:0.150776
## Median :0.13908   Median :0.067052   Median :0.299853
## Mean    :0.13068   Mean    :0.063065   Mean    :0.300343
## 3rd Qu.:0.16418   3rd Qu.:0.078859   3rd Qu.:0.455278
## Max.    :0.19852   Max.    :0.095062   Max.    :0.594677
##           EDC           LUM           DI
## Min.    :0.009153   Min.    :0.005913   Min.    :0.001012
## 1st Qu.:0.309293   1st Qu.:0.170160   1st Qu.:0.053976
## Median :0.443477   Median :0.325978   Median :0.112468
## Mean    :0.408749   Mean    :0.370912   Mean    :0.116461
## 3rd Qu.:0.530161   3rd Qu.:0.545670   3rd Qu.:0.171332
## Max.    :0.598835   Max.    :0.962193   Max.    :0.309409
##           PI
## Min.    :0.002277
## 1st Qu.:0.054151
## Median :0.092123
## Mean    :0.094562
## 3rd Qu.:0.132383
## Max.    :0.221263
```

When flexor digitorum profundus has resting tonicity of 0.2:

473 /1000 solutions remain when FDP hypertonic to above 0.2



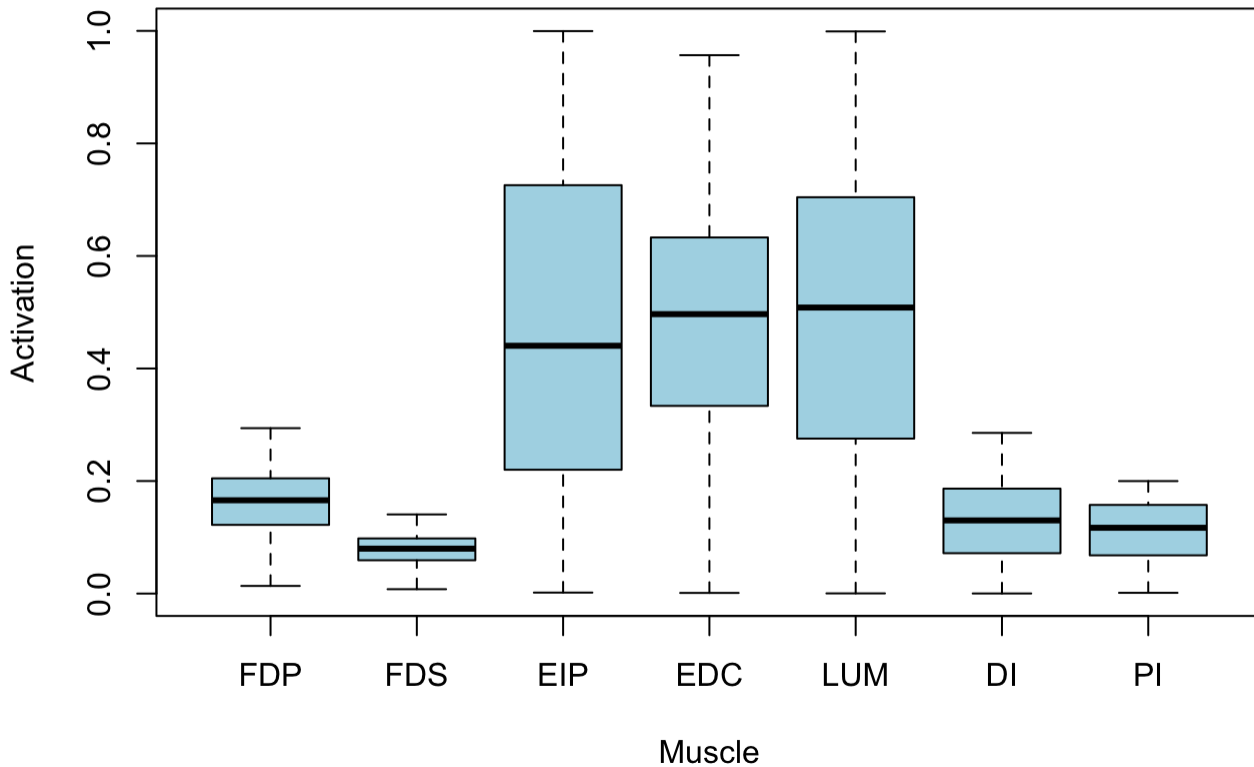
##	FDP	FDS	EIP	EDC
##	Min. :0.2001	Min. :0.09564	Min. :0.009423	Min. :0.5008
##	1st Qu.:0.2193	1st Qu.:0.10493	1st Qu.:0.332995	1st Qu.:0.6909
##	Median :0.2442	Median :0.11709	Median :0.567915	Median :0.7637
##	Mean :0.2492	Mean :0.11946	Mean :0.553988	Mean :0.7777
##	3rd Qu.:0.2753	3rd Qu.:0.13190	3rd Qu.:0.794048	3rd Qu.:0.8786
##	Max. :0.3346	Max. :0.16096	Max. :0.999629	Max. :0.9996
##	LUM	DI	PI	
##	Min. :0.004486	Min. :0.04966	Min. :0.0932	
##	1st Qu.:0.256842	1st Qu.:0.18648	1st Qu.:0.1711	
##	Median :0.504870	Median :0.25665	Median :0.2142	
##	Mean :0.496704	Mean :0.25766	Mean :0.2171	
##	3rd Qu.:0.730647	3rd Qu.:0.32410	3rd Qu.:0.2576	
##	Max. :0.999043	Max. :0.51568	Max. :0.3879	

Manual observations on the effects upon other muscles when FDP activation is kept above 0.2: - FDS becomes constrained between .09 and 0.16, with middle 50% of solutions in a range spanning only .02697 (between .13190 and .10493) - EDC goes from being redundant (with bounds of 0 and 1), to being only in the upper half (0.5 to 0.88)

Which muscle, when hypotonic, slices the FAS more—PI or DI?

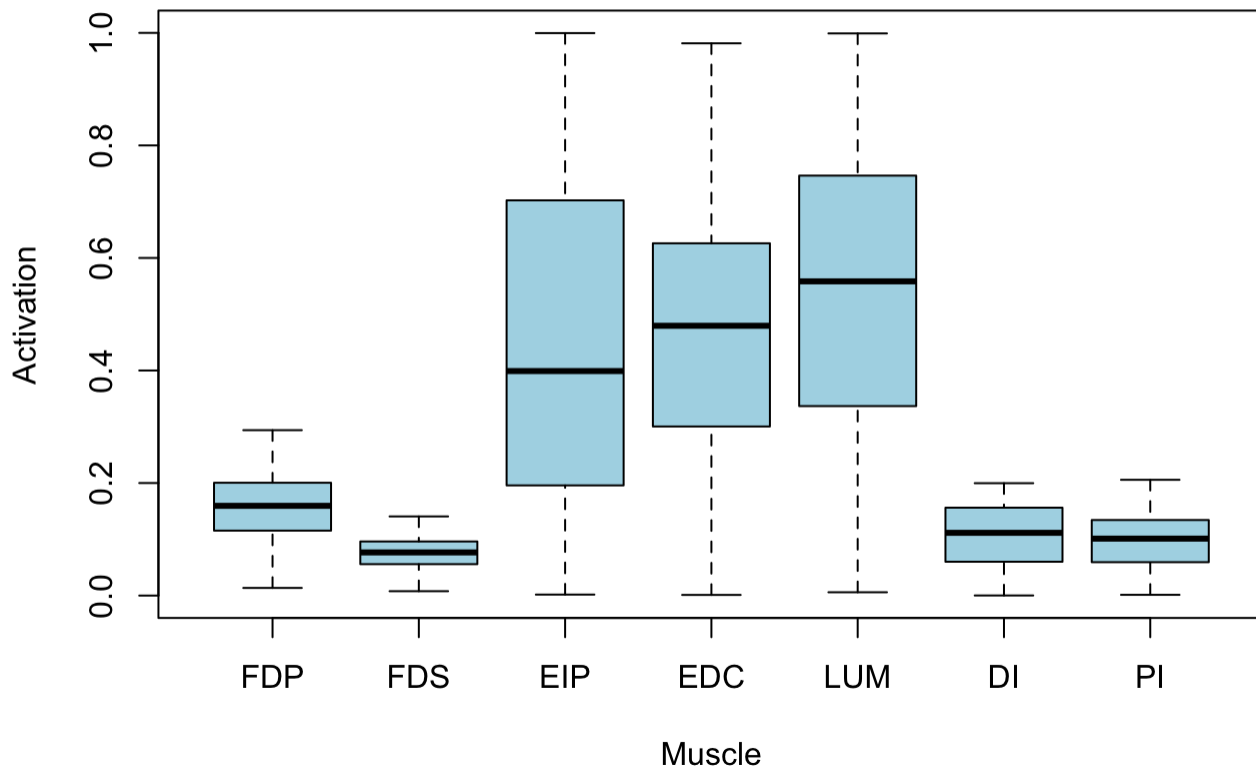
Let's limit each to 20% of maximal distal fingertip force.

699 /1000 solutions remain when PI_reduced to 0.2



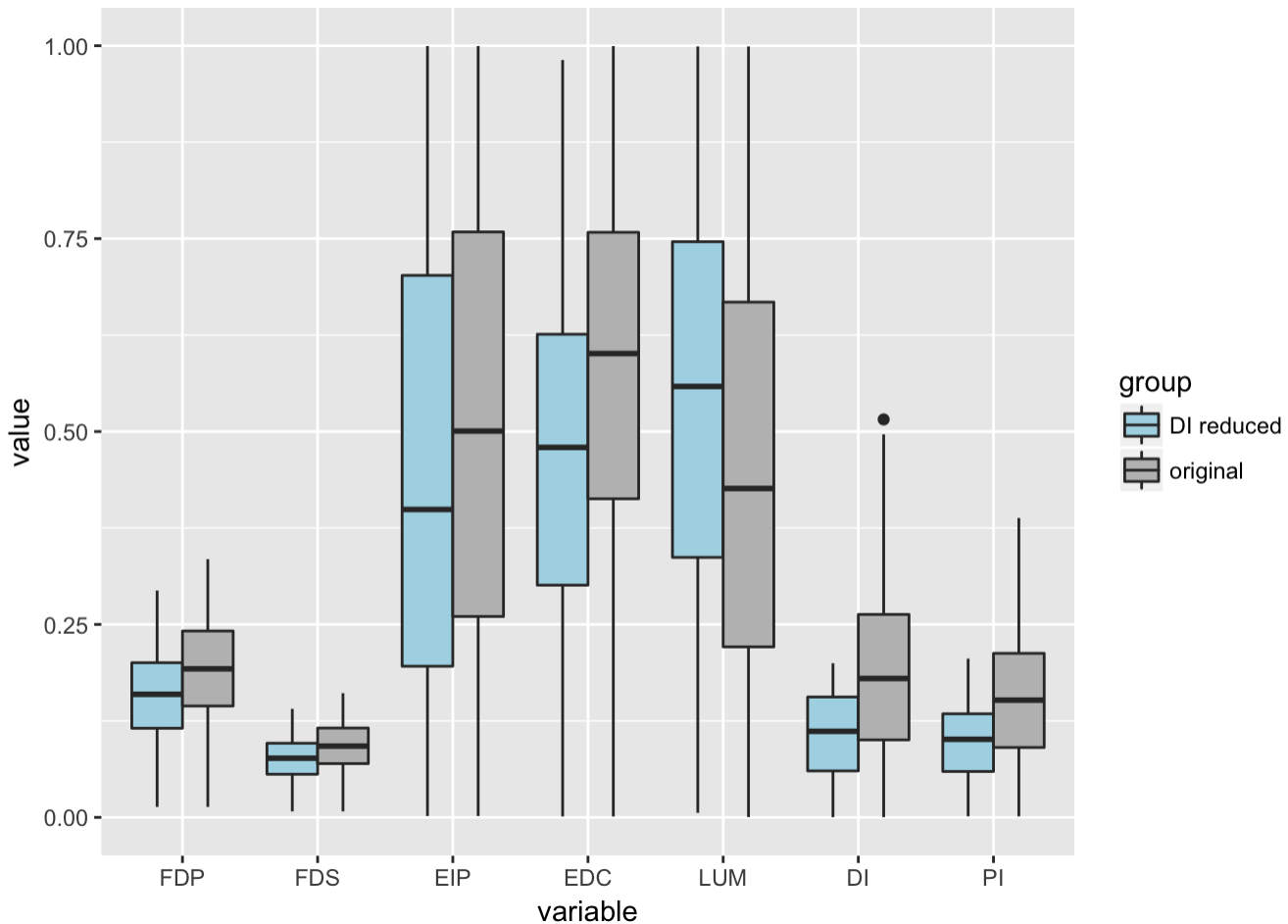
```
##      FDP      FDS      EIP
## Min.   :0.01357 Min.   :0.007762 Min.   :0.001747
## 1st Qu.:0.12208 1st Qu.:0.059204 1st Qu.:0.220062
## Median :0.16583 Median :0.079812 Median :0.440370
## Mean   :0.16200 Mean   :0.078000 Mean   :0.469318
## 3rd Qu.:0.20481 3rd Qu.:0.098008 3rd Qu.:0.725786
## Max.   :0.29395 Max.   :0.140646 Max.   :0.999629
##      EDC      LUM      DI
## Min.   :0.001132 Min.   :0.0003311 Min.   :0.0001764
## 1st Qu.:0.333529 1st Qu.:0.2754155 1st Qu.:0.0717440
## Median :0.496606 Median :0.5083091 Median :0.1300251
## Mean   :0.480370 Mean   :0.4957852 Mean   :0.1308368
## 3rd Qu.:0.632880 3rd Qu.:0.7043622 3rd Qu.:0.1864969
## Max.   :0.956826 Max.   :0.9990431 Max.   :0.2855284
##      PI
## Min.   :0.001317
## 1st Qu.:0.067947
## Median :0.116917
## Mean   :0.111577
## 3rd Qu.:0.157552
## Max.   :0.199896
```

572 /1000 solutions remain when DI kept below 0.2



```
##      FDP      FDS      EIP
## Min.   :0.01357 Min.   :0.007762 Min.   :0.001747
## 1st Qu.:0.11548 1st Qu.:0.055890 1st Qu.:0.195862
## Median :0.15946 Median :0.076669 Median :0.398982
## Mean   :0.15664 Mean   :0.075365 Mean   :0.448702
## 3rd Qu.:0.20042 3rd Qu.:0.096050 3rd Qu.:0.702340
## Max.   :0.29395 Max.   :0.140646 Max.   :0.999629
##      EDC      LUM      DI
## Min.   :0.001132 Min.   :0.005877 Min.   :0.0001764
## 1st Qu.:0.300929 1st Qu.:0.336927 1st Qu.:0.0601682
## Median :0.479448 Median :0.558418 Median :0.1115024
## Mean   :0.465338 Mean   :0.543292 Mean   :0.1086178
## 3rd Qu.:0.626037 3rd Qu.:0.746026 3rd Qu.:0.1559808
## Max.   :0.981464 Max.   :0.999043 Max.   :0.1997135
##      PI
## Min.   :0.001317
## 1st Qu.:0.059449
## Median :0.101185
## Mean   :0.097346
## 3rd Qu.:0.134199
## Max.   :0.205729
```

```
## No id variables; using all as measure variables
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```

showing the wide bounds with small IQR for a muscle at higher force (not 80%)

```
## [[1]]
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.06631 0.13230 0.16320 0.15970 0.19010 0.25230
##
## [[2]]
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.06907 0.10000 0.11430 0.11270 0.12690 0.15680
##
## [[3]]
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.0004144 0.2560000 0.4773000 0.4917000 0.7363000 0.9996000
##
## [[4]]
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.3448 0.6543 0.7756 0.7600 0.8826 0.9996
##
## [[5]]
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.007945 0.371700 0.559700 0.553000 0.757300 0.996100
##
## [[6]]
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.8785 0.9350 0.9594 0.9552 0.9791 1.0000
##
```

```
## [[7]]
##      Min.   1st Qu.   Median     Mean   3rd Qu.    Max.
## 2.949e-05 1.344e-02 2.624e-02 2.844e-02 4.074e-02 8.130e-02
```

