Point Constraint Statistics

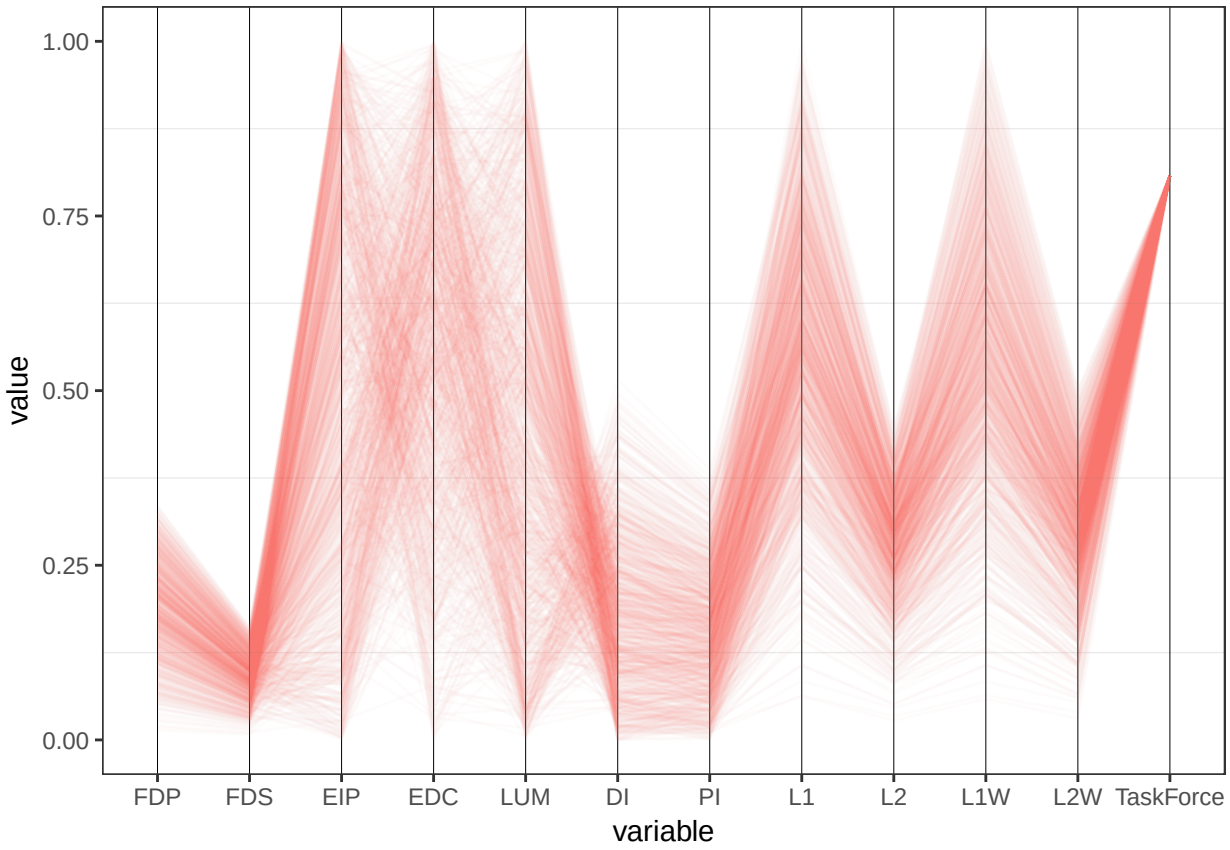
Commands: Run selected chunk: *Cmd+Shift+Enter*. Insert chunk: *Cmd+Option+I*.

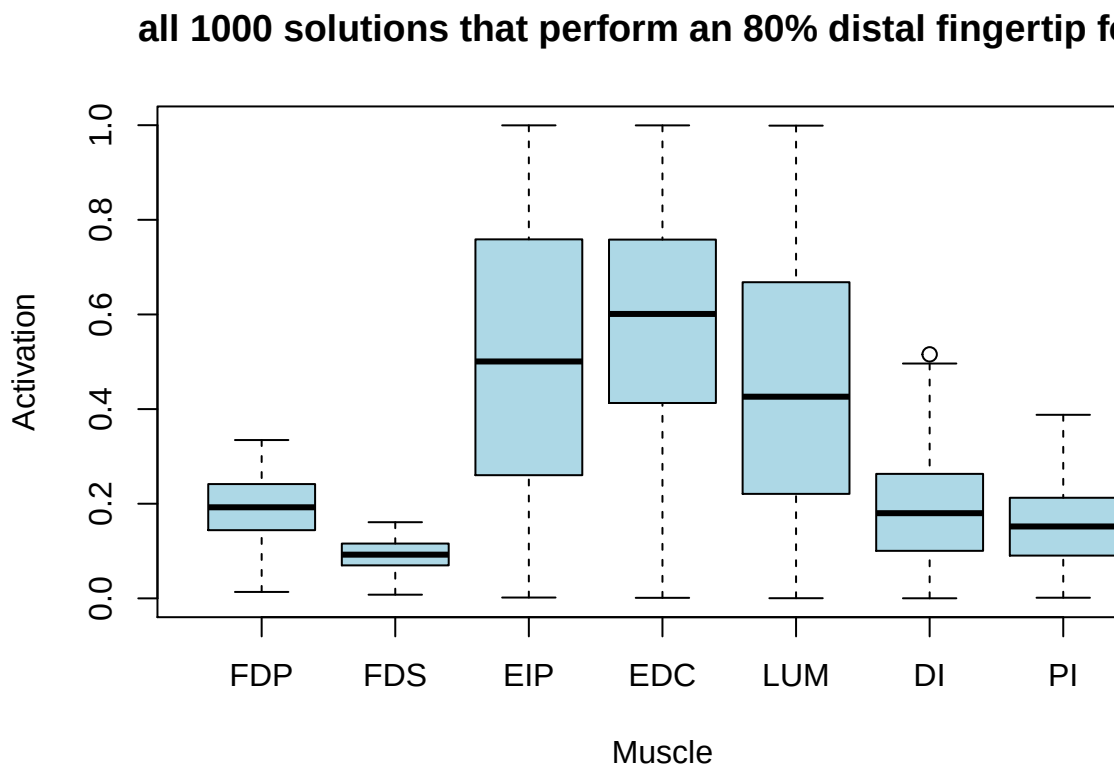
When you save the notebook, an HTML file containing the code and output will be saved alongside it (click the *Preview* button or press *Cmd+Shift+K* to preview the HTML file). #Write cost functions

Load data and compute cost

All points for an 80%-of-max task

```
## Loading required package: GGally
## Warning: package 'GGally' was built under R version 3.3.2
## Loading required package: ggplot2
## Warning: package 'ggplot2' was built under R version 3.3.2
```





#View all points as boxplots:

```
##       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?

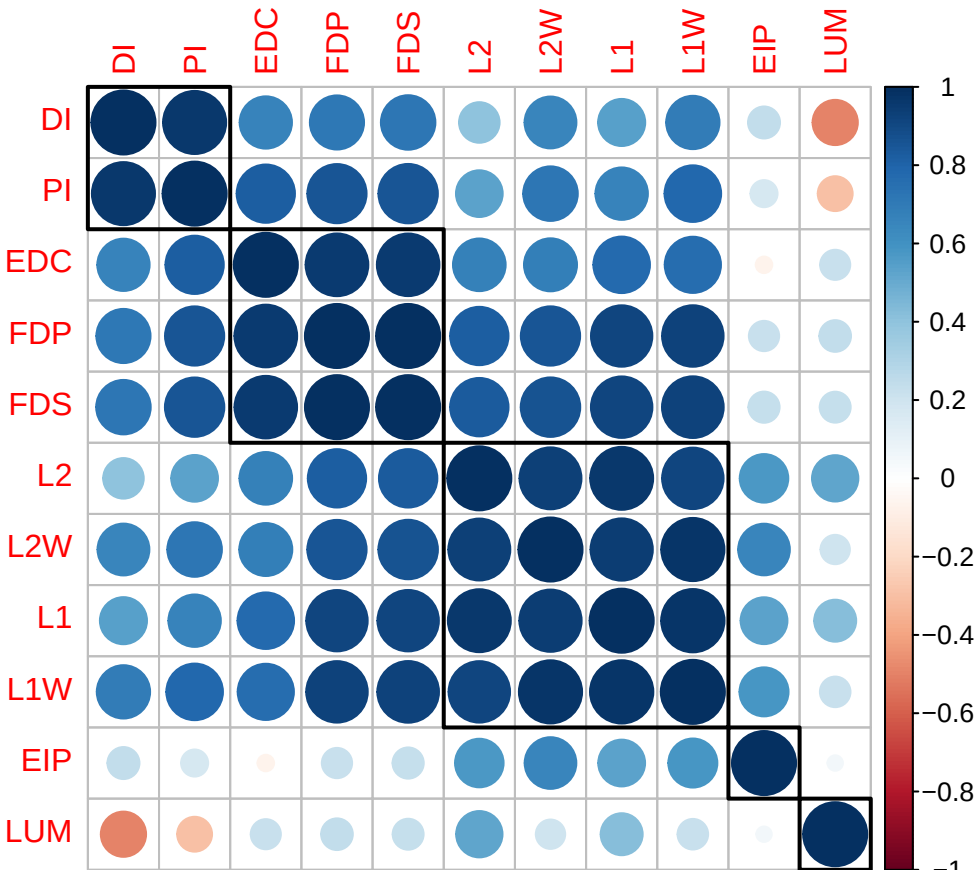
```
cor(points_w_cost$LUM, points_w_cost$DI)
```

```
## [1] -0.4982628
```

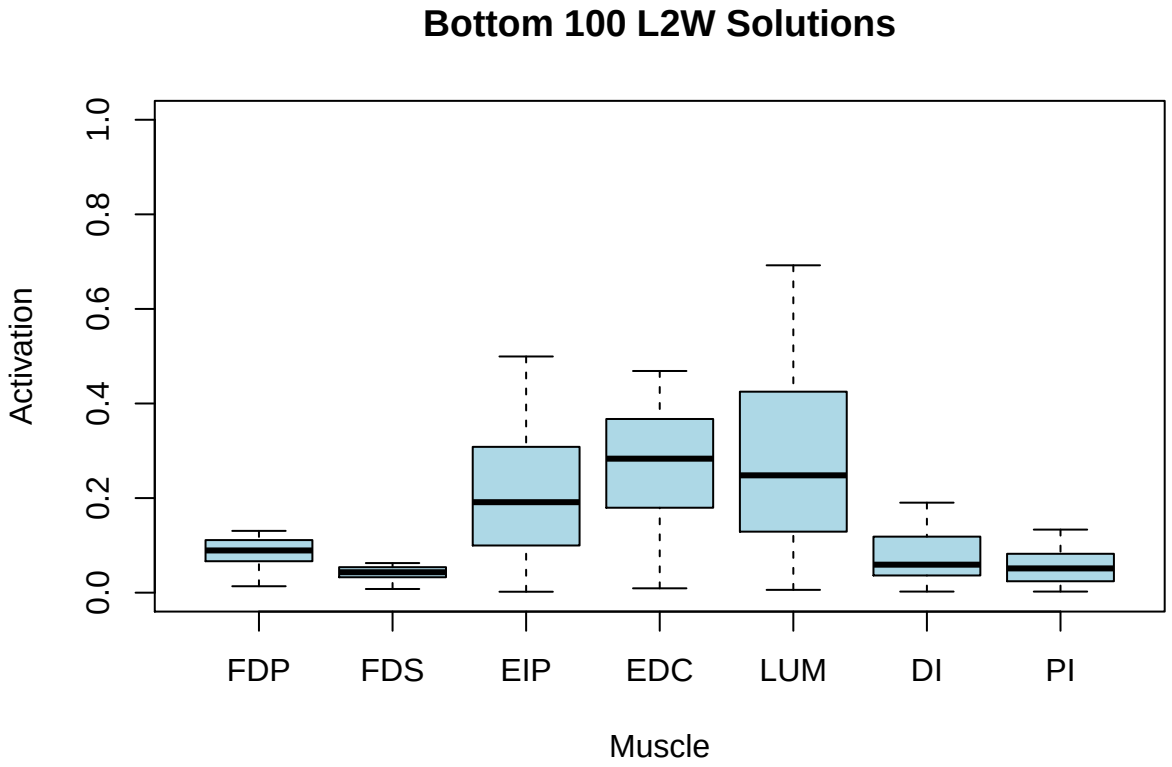
```
cor(points_w_cost$EIP, points_w_cost$EDC)
```

```
## [1] -0.06642129
```

```
library(corrplot)
corrplot(cor(points_w_cost), order = "hclust", addrect=5)
```



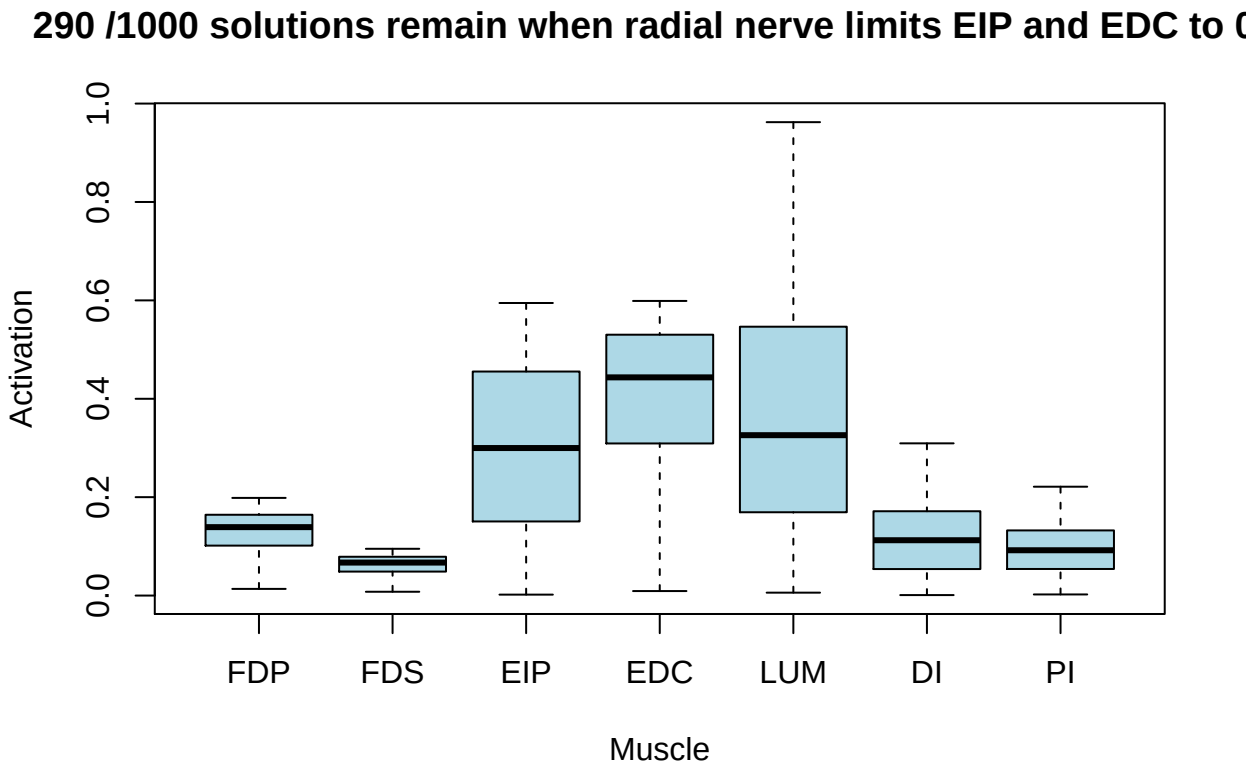
Let's grab the bottom 10% of L2W cost and see how the muscle activations are distributed




```
##       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
```

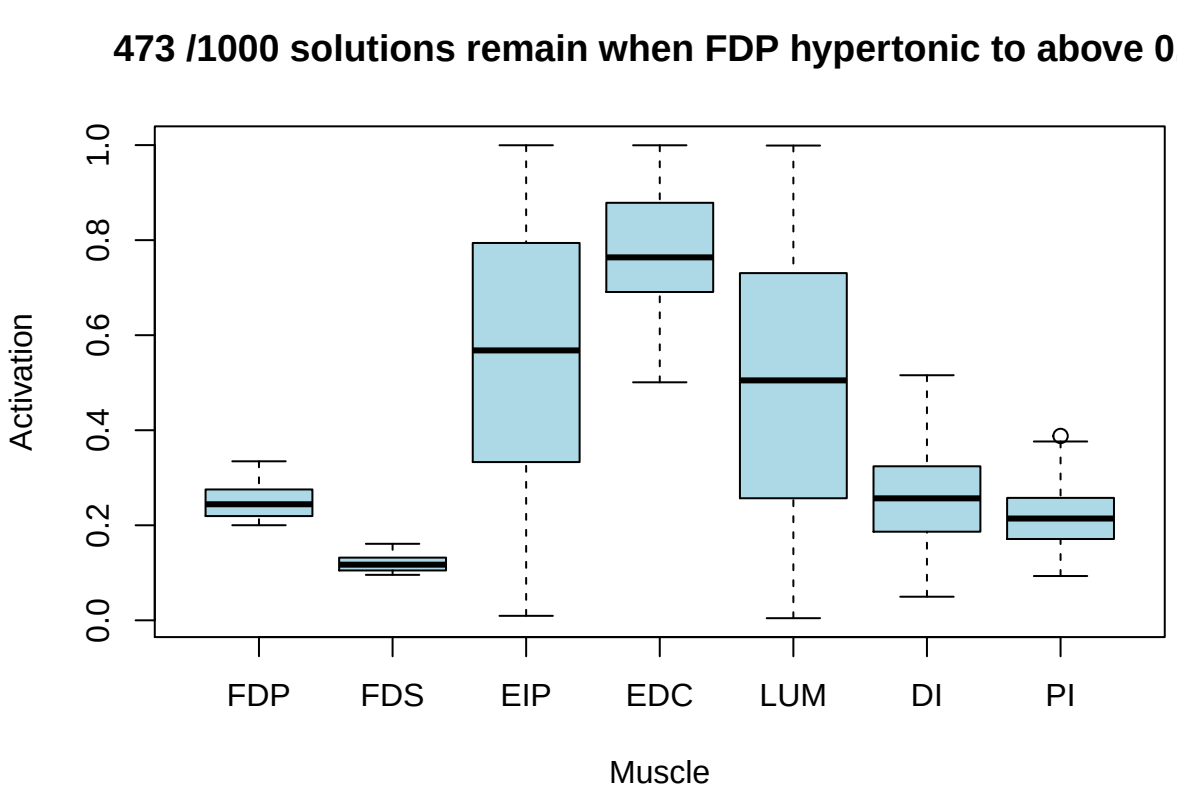
Limiting one muscle:

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).




```
##       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:

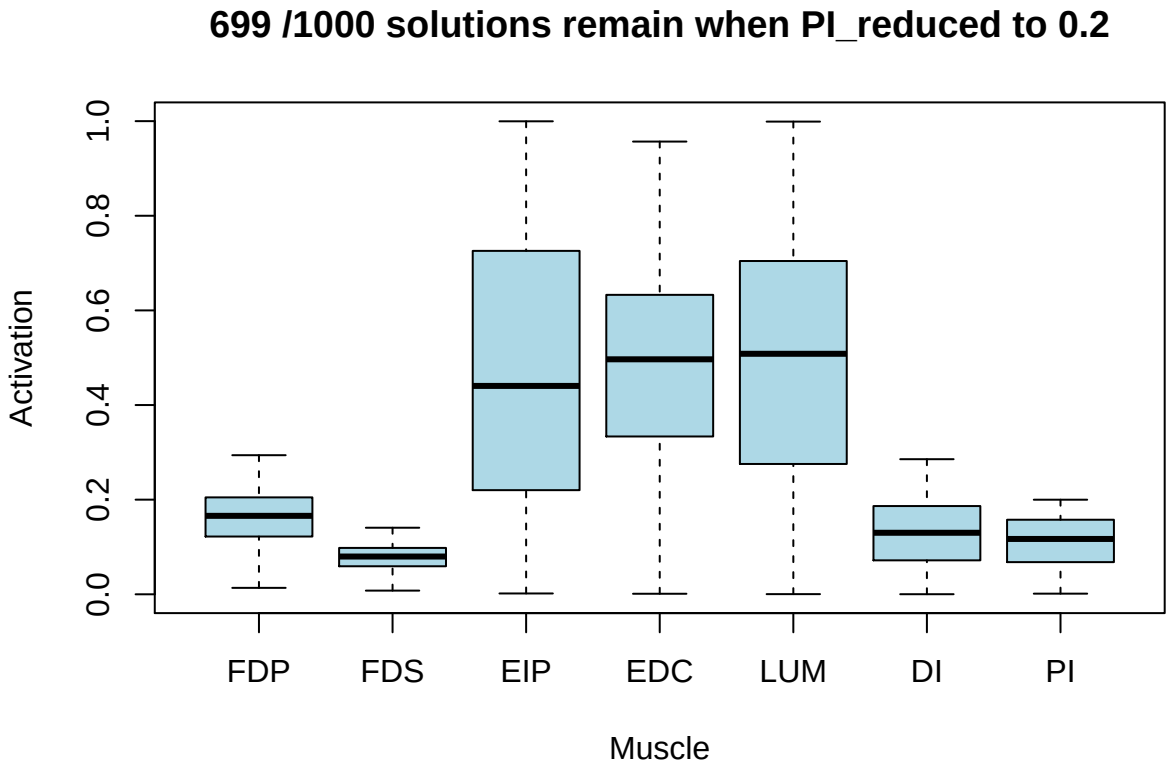



```
##       FDP              FDS               EIP               EDC
##  Min.   :0.2001   Min.   :0.09564   Min.   :0.009423   Min.   :0.5008
##  1st Qu.:0.2193   1st Qu.:0.10493   1st Qu.:0.332995   1st Qu.:0.6909
##  Median :0.2442   Median :0.11709   Median :0.567915   Median :0.7637
##  Mean   :0.2492   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
```

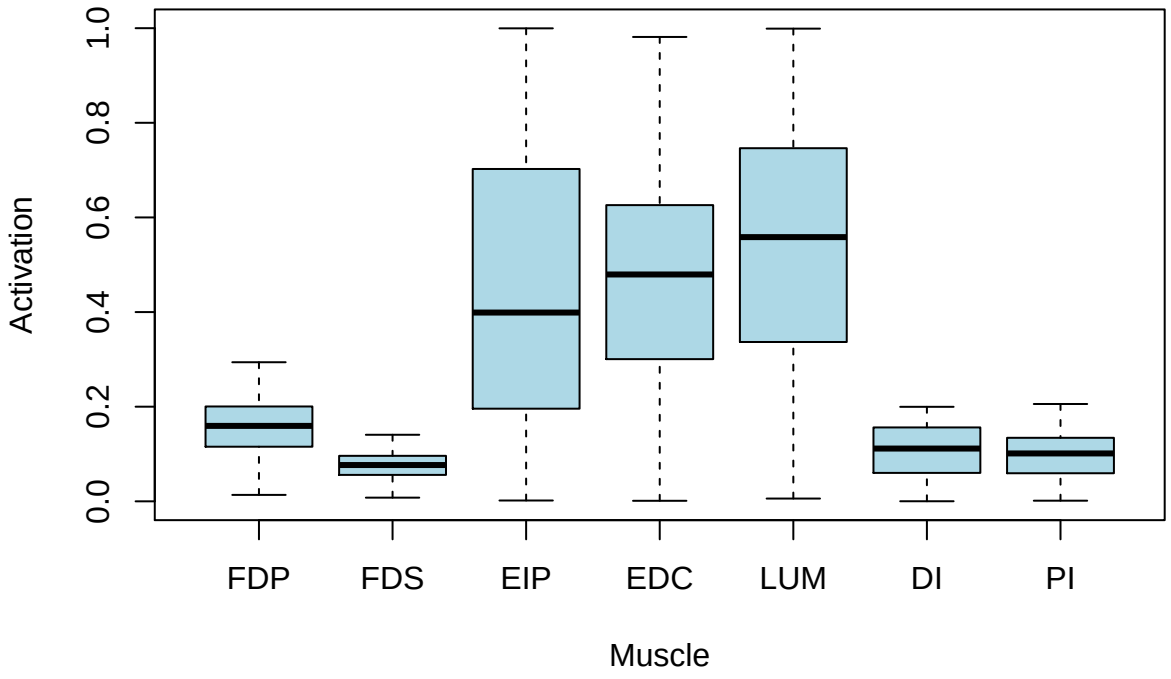
Manual observations on the effects upon other muscles when FDP activation is kept above 0.2: - FDS becomes constrained between .09 and 0.16, with middle 50% of solutions in a range spanning only .02697 (between .13190 and .10493) - EDC goes from being redundant (with bounds of 0 and 1), to being only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




```
##       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
```




```
##       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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```
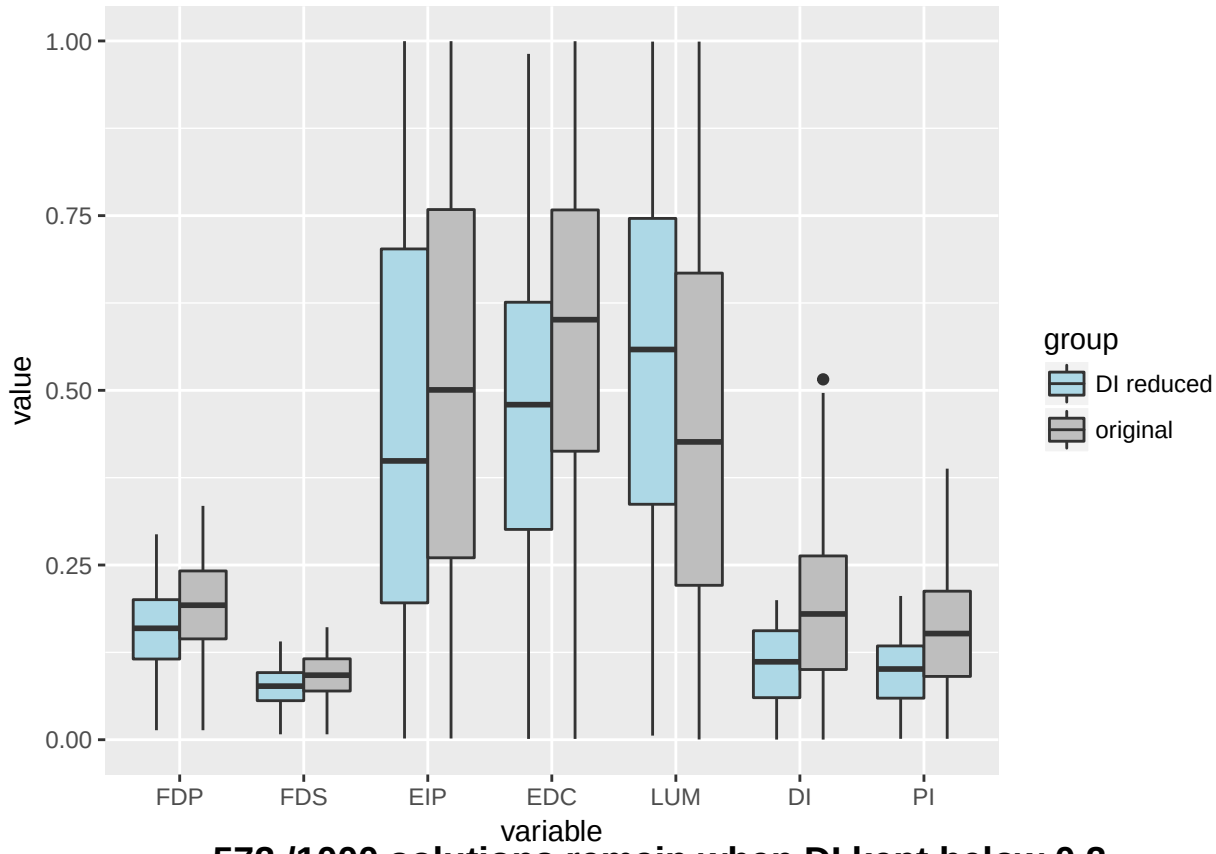
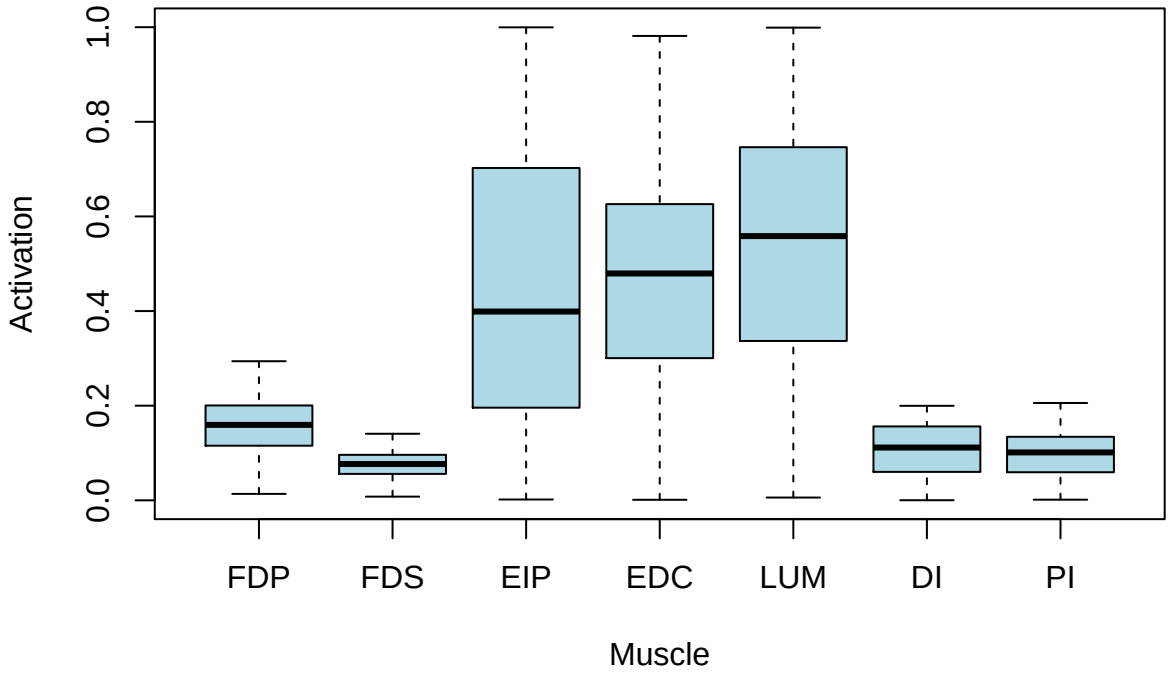



572 /1000 solutions remain when DI kept below 0.2




```
##       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
```

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

```
high_force_points <- read.csv("finger_forcevector_25.379547626496084_1484881649920.csv")
par(mfrow=c(3,3))
lapply(1:7,
       function(x) {
        hist(high_force_points[,x], xlim=c(0,1))
        summary(high_force_points[,x])
        }
       )
```

```
## [[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
```