

Candidate Terms:

1. weight
2. height
3. chest
4. abdom
5. knee
6. ankle
7. biceps
8. forearm
9. wrist

We are selecting variables based on p value...

Forward Selection: Step 1

+ abdom

Model Summary			
R	0.814	RMSE	4.514
R-Squared	0.662	Coef. Var	23.837
Adj. R-Squared	0.661	MSE	20.380
Pred R-Squared	0.652	MAE	3.631

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

ANOVA					
	Sum of Squares	DF	Mean Square	F	Sig.
Regression	9984.086	1	9984.086	489.903	0.0000
Residual	5094.931	250	20.380		
Total	15079.017	251			

p-value for regression on abdom is highlighted; it is the smallest p-value among all 9 regressions performed on individual candidates.

Parameter Estimates							
model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-35.197	2.462		-14.294	0.000	-40.046	-30.347
abdom	0.585	0.026	0.814	22.134	0.000	0.533	0.637

Forward Selection: Step 2

+ weight

Model Summary			
R	0.848	RMSE	4.127
R-Squared	0.719	Coef. Var	21.792
Adj. R-Squared	0.716	MSE	17.033
Pred R-Squared	0.709	MAE	3.344

RMSE: Root Mean Square Error  
MSE: Mean Square Error  
MAE: Mean Absolute Error

### Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-41.34812	2.41299	-17.136	< 2e-16 ***
weight	-0.13645	0.01928	-7.079	1.47e-11 ***
abdom	0.91514	0.05254	17.419	< 2e-16 ***

### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	10837.688	2	5418.844	318.13	0.0000
Residual	4241.328	249	17.033		
Total	15079.017	251			

weight has the smallest p-value among all 8 two-variable regressions with abdom already in the model

### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-41.348	2.413		-17.136	0.000	-46.101	-36.596
abdom	0.915	0.053	1.273	17.419	0.000	0.812	1.019
weight	-0.136	0.019	-0.517	-7.079	0.000	-0.174	-0.098

Forward Selection: Step 3

+ wrist

### Model Summary

R	0.853	RMSE	4.070
R-Squared	0.728	Coef. Var	21.491
Adj. R-Squared	0.724	MSE	16.565
Pred R-Squared	0.715	MAE	3.319

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	10970.834	3	3656.945	220.76	0.0000
Residual	4108.183	248	16.565		
Total	15079.017	251			

### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-24.761	6.316		-3.920	0.000	-37.201	-12.321
abdom	0.902	0.052	1.255	17.338	0.000	0.799	1.004
weight	-0.106	0.022	-0.400	-4.820	0.000	-0.149	-0.062
wrist	-1.146	0.404	-0.138	-2.835	0.005	-1.942	-0.350

Forward Selection: Step 4

+ forearm

### Model Summary

R	0.857	RMSE	4.021
R-Squared	0.735	Coef. Var	21.234

Adj. R-Squared	0.731	MSE	16.171
Pred R-Squared	0.721	MAE	3.276

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

#### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11084.706	4	2771.176	171.364	0.0000
Residual	3994.311	247	16.171		
Total	15079.017	251			

#### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-31.297	6.709		-4.665	0.000	-44.511	-18.083
abdom	0.921	0.052	1.282	17.747	0.000	0.819	1.024
weight	-0.126	0.023	-0.476	-5.479	0.000	-0.171	-0.080
wrist	-1.392	0.410	-0.168	-3.395	0.001	-2.199	-0.584
forearm	0.446	0.168	0.116	2.654	0.008	0.115	0.778

Forward Selection: Step 5

+ biceps

#### Model Summary

R	0.858	RMSE	4.016
R-Squared	0.737	Coef. Var	21.207
Adj. R-Squared	0.731	MSE	16.131
Pred R-Squared	0.721	MAE	3.272

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

#### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11110.845	5	2222.169	137.76	0.0000
Residual	3968.171	246	16.131		
Total	15079.017	251			

#### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-32.857	6.812		-4.824	0.000	-46.273	-19.440
abdom	0.924	0.052	1.285	17.804	0.000	0.822	1.026
weight	-0.138	0.025	-0.525	-5.536	0.000	-0.188	-0.089
wrist	-1.407	0.410	-0.170	-3.436	0.001	-2.214	-0.601
forearm	0.366	0.179	0.095	2.041	0.042	0.013	0.720
biceps	0.192	0.151	0.075	1.273	0.204	-0.105	0.490

Forward Selection: Step 6

+ ankle

Model Summary

R	0.859	RMSE	4.015
R-Squared	0.738	Coef. Var	21.202
Adj. R-Squared	0.732	MSE	16.123
Pred R-Squared	0.717	MAE	3.277

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11128.917	6	1854.820	115.043	0.0000
Residual	3950.099	245	16.123		
Total	15079.017	251			

Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-35.793	7.353		-4.868	0.000	-50.277	-21.310
abdom	0.938	0.053	1.304	17.528	0.000	0.832	1.043
weight	-0.149	0.027	-0.565	-5.530	0.000	-0.202	-0.096
wrist	-1.500	0.419	-0.181	-3.582	0.000	-2.324	-0.675
forearm	0.369	0.179	0.096	2.055	0.041	0.015	0.722
biceps	0.201	0.151	0.078	1.328	0.185	-0.097	0.499
ankle	0.212	0.200	0.046	1.059	0.291	-0.183	0.607

program default cutoff p-value is 0.300

No more variables to be added.

Variables Entered:

+ abdom  
+ weight  
+ wrist  
+ forearm  
+ biceps  
+ ankle

Final Model Output

Coefficients: (height, chest, knee are the only remaining candidates to add to the model one at a time)

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-31.30258	9.30651	-3.364	0.000893 ***
weight	-0.13967	0.02946	-4.741	3.62e-06 ***
abdom	0.91782	0.05911	15.528	< 2e-16 ***
ankle	0.20534	0.20069	1.023	<b>0.307255</b>
biceps	0.18564	0.15260	1.217	0.224943
forearm	0.36785	0.17954	2.049	0.041553 *
wrist	-1.45205	0.42328	-3.430	0.000707 ***
height	-0.06453	0.08186	-0.788	<b>0.431309</b>

Model Summary

R	0.859	RMSE	4.015
R-Squared	0.738	Coef. Var	21.202
Adj. R-Squared	0.732	MSE	16.123
Pred R-Squared	0.717	MAE	3.277

RMSE: Root Mean Square Error

Note the p-value for ankle increased from 0.291 to 0.307 when height was added.

MSE: Mean Square Error  
 MAE: Mean Absolute Error

#### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11128.917	6	1854.820	115.043	0.0000
Residual	3950.099	245	16.123		
Total	15079.017	251			

#### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-35.793	7.353		-4.868	0.000	-50.277	-21.310
abdom	0.938	0.053	1.304	17.528	0.000	0.832	1.043
weight	-0.149	0.027	-0.565	-5.530	0.000	-0.202	-0.096
wrist	-1.500	0.419	-0.181	-3.582	0.000	-2.324	-0.675
forearm	0.369	0.179	0.096	2.055	0.041	0.015	0.722
biceps	0.201	0.151	0.078	1.328	0.185	-0.097	0.499
ankle	0.212	0.200	0.046	1.059	0.291	-0.183	0.607

> k

#### Selection Summary

Step	Variable Entered	R-Square	Adj. R-Square	C(p)	AIC	RMSE
1	abdom	0.6621	0.6608	65.7980	1478.8012	4.5144
2	weight	0.7187	0.7165	15.2244	1434.5921	4.1272
3	wrist	0.7276	0.7243	9.0240	1428.5544	4.0700
4	forearm	0.7351	0.7308	4.0106	1423.4707	4.0214
5	biceps	0.7368	0.7315	4.4006	1423.8162	4.0163
6	ankle	0.7380	0.7316	5.2875	1424.6659	4.0153

```
> plot(k)
>
> #Stepwise Backward Regression
> #Build regression model from a set of candidate predictor variables by removing predictors
> # based on p values, in a stepwise manner until there is no variable left to remove any more.
> # The model should include all the candidate predictor variables.
> #If details is set to TRUE, each step is displayed.
>
```

```
> k <- ols_step_backward_p(lmod,details=TRUE)
Backward Elimination Method
```

#### Candidate Terms:

- 1 . weight
- 2 . height
- 3 . chest
- 4 . abdom
- 5 . knee
- 6 . ankle
- 7 . biceps
- 8 . forearm
- 9 . wrist

We are eliminating variables based on p value...

Coefficients:	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	-34.24314	11.06960	-3.093	0.002211 **
weight	-0.14863	0.03417	-4.350	2.01e-05 ***
height	-0.06603	0.08261	-0.799	0.424944
chest	-0.01352	0.08731	-0.155	<u>0.877055</u>
abdom	0.92484	0.06999	13.214	< 2e-16 ***
knee	0.16115	0.21102	0.764	0.445812
ankle	0.17465	0.20471	0.853	0.394429
biceps	0.19028	0.15322	1.242	0.215497
forearm	0.36827	0.18172	2.027	0.043802 *
wrist	-1.46894	0.42747	-3.436	0.000694 ***

These p-values are TYPE III p-values: for example, the p-value for adding chest to the model after all 8 other variables are included in the model. The p-value for weight is the p-value for adding weight to the model after all 8 other variables are included in the model.

x chest

The chest p-value is the largest and is also larger than 0.30 so it is removed first.

Backward Elimination: Step 1

Variable chest Removed

Model Summary

R	0.860	RMSE	4.021
R-Squared	0.739	Coef. Var	21.234
Adj. R-Squared	0.731	MSE	16.171
Pred R-Squared	0.714	MAE	3.268

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11149.433	8	1393.679	86.183	0.0000
Residual	3929.584	243	16.171		
Total	15079.017	251			

Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig.	lower	upper
(Intercept)	-34.860	10.308		-3.382	0.001	-55.164	-14.555
weight	-0.150	0.032	-0.570	-4.652	0.000	-0.214	-0.087
height	-0.065	0.082	-0.031	-0.788	0.431	#	0.097
abdom	0.919	0.059	1.279	15.533	0.000	0.803	1.036
knee	0.167	0.207	0.052	0.805	0.422	-0.241	0.575
ankle	0.176	0.204	0.038	0.861	0.390	-0.226	0.578
biceps	0.189	0.153	0.074	1.239	0.217	-0.112	0.490
forearm	0.365	0.180	0.095	2.028	0.044	0.010	0.719
wrist	-1.475	0.425	-0.178	-3.475	0.001	-2.312	-0.639

Remove height next

x height

Backward Elimination: Step 2

Variable height Removed

Model Summary

R	0.859	RMSE	4.018
R-Squared	0.739	Coef. Var	21.217
Adj. R-Squared	0.731	MSE	16.146
Pred R-Squared	0.716	MAE	3.275

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11139.382	7	1591.340	98.559	0.0000
Residual	3939.635	244	16.146		

Total	15079.017	251
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Parameter Estimates							
model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-39.352	8.584		-4.584	0.000	-56.259	-22.444
weight	-0.160	0.030	-0.605	-5.316	0.000	-0.219	-0.101
abdom	0.939	0.054	1.306	17.532	0.000	0.833	1.044
knee	0.167	0.207	0.052	0.805	0.422	-0.241	0.575
ankle	0.183	0.204	0.040	0.895	0.371	-0.219	0.584
biceps	0.205	0.151	0.080	1.351	0.178	-0.094	0.503
forearm	0.365	0.180	0.095	2.035	0.043	0.012	0.719
wrist	-1.523	0.420	-0.183	-3.627	0.000	-2.350	-0.696

Remove knee next

x knee

Backward Elimination: Step 3

Variable knee Removed

Model Summary			
R	0.859	RMSE	4.015
R-Squared	0.738	Coef. Var	21.202
Adj. R-Squared	0.732	MSE	16.123
Pred R-Squared	0.717	MAE	3.277

RMSE: Root Mean Square Error

MSE: Mean Square Error

MAE: Mean Absolute Error

#### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11128.917	6	1854.820	115.043	0.0000
Residual	3950.099	245	16.123		
Total	15079.017	251			

#### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-35.793	7.353		-4.868	0.000	-50.277	-21.310
weight	-0.149	0.027	-0.565	-5.530	0.000	-0.202	-0.096
abdom	0.938	0.053	1.304	17.528	0.000	0.832	1.043
ankle	0.212	0.200	0.046	1.059	0.291	-0.183	0.607
biceps	0.201	0.151	0.078	1.328	0.185	-0.097	0.499
forearm	0.369	0.179	0.096	2.055	0.041	0.015	0.722
wrist	-1.500	0.419	-0.181	-3.582	0.000	-2.324	-0.675

ankle has the highest p-value but its p-value < 0.300 so the backward elimination procedure stops

No more variables satisfy the condition of p value = 0.3

Variables Removed:

x chest

```
x height  
x knee
```

#### Final Model Output

Model Summary			
R	0.859	RMSE	4.015
R-Squared	0.738	Coef. Var	21.202
Adj. R-Squared	0.732	MSE	16.123
Pred R-Squared	0.717	MAE	3.277

RMSE: Root Mean Square Error

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#### ANOVA

	Sum of Squares	DF	Mean Square	F	Sig.
Regression	11128.917	6	1854.820	115.043	0.0000
Residual	3950.099	245	16.123		
Total	15079.017	251			

#### Parameter Estimates

model	Beta	Std. Error	Std. Beta	t	Sig	lower	upper
(Intercept)	-35.793	7.353		-4.868	0.000	-50.277	-21.310
weight	-0.149	0.027	-0.565	-5.530	0.000	-0.202	-0.096
abdom	0.938	0.053	1.304	17.528	0.000	0.832	1.043
ankle	0.212	0.200	0.046	1.059	0.291	-0.183	0.607
biceps	0.201	0.151	0.078	1.328	0.185	-0.097	0.499
forearm	0.369	0.179	0.096	2.055	0.041	0.015	0.722
wrist	-1.500	0.419	-0.181	-3.582	0.000	-2.324	-0.675

> k

#### Elimination Summary

Step	Variable Removed	Adj.		C(p)	AIC	RMSE
		R-Square	R-Square			
1	chest	0.7394	0.7308	8.0240	1427.3537	4.0213
2	height	0.7387	0.7312	6.6430	1425.9974	4.0182
3	knee	0.738	0.7316	5.2875	1424.6659	4.0153