Effect of Functional Strength Training on Half-Mile Speed

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Executive Summary

Functional strength training may increase speed for runners who are slower to start with. For runners with a starting half-mile time of 300 seconds, adding the training had an average effect of increasing speed by 8.4 seconds. But for runners with a starting time of 180 seconds, the change was not statistically significant. However, the training protocols in this study were not well-defined, so it is unclear without further work if this effect is really due to functional strength training, or is simply due to additional training.

Note: data was simulated, so this is not a real study. :(

Background and Goals

It has recently been proposed that functional strength training is useful for serious runners in that it helps them avoid injury. However, many runners dismiss training techniques that do not involve running because they believe that simply running is the best training tool to be a better runner. As a functional strength training program for runners is designed to strengthen the same muscles and the same "functions" as running, it may also make one faster, and so be more appealing to these runners. This study aims to test this hypothesis by investigating the effects of adding functional strength training on half-mile speed.

Study Design and Data

We recruited 40 individuals to participate in the study. Individuals had to be between 21 and 35 and been running at least one year. They were recruited on local running websites and by putting flyers up at stores. We recorded their age, sex, years running, and smoking status. Individuals were then completely randomized to two treatments; the treatment group added in functional strength training twice a week to existing training, and the control group simply continued existing training. Individuals were asked to run a half mile at top speed upon enrollment and then again one month later. Times were recorded to the nearest second.

This table shows descriptive statistics for the two groups at baseline; we see that all the potential covariates are similar.

	Control	**Trt**
Age, mean (sd)	25.20 (5.65)	26.50 (5.09)
Female, N (percent)	10 (50.0%)	12 (60.0%)
Years Running, mean (sd)	6.50 (3.10)	6.25 (3.43)
Smoking Yes, N (percent)	2 (10.0%)	2 (10.0%)
Before, mean (sd)	236.25 (48.50)	236.85 (45.61)

There were some minor discrepancies from the analysis plan, as follows. The plan was to stratify the treatment within Sex to avoid confounding, however this did not happen, so Sex will be treated as any other possible confounder. Additionally, one 37-year-old was accidentally recruited but was kept in the study.

Statistical Methods

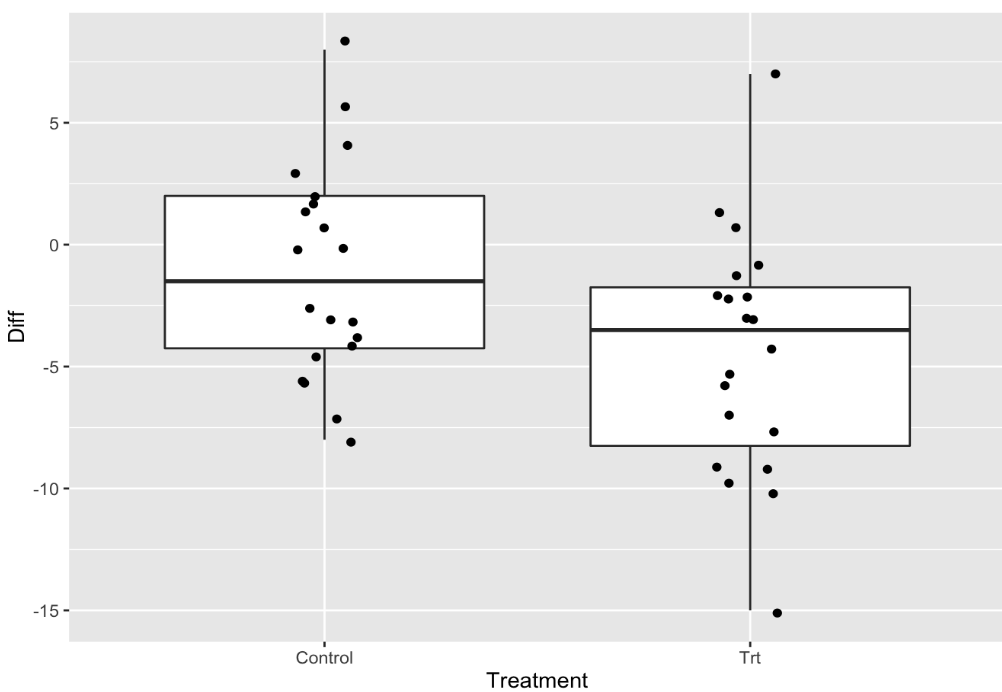
We used the difference between the before and the after times as the response; a negative difference means the runner got faster. We first tested for a difference between the two groups using an independent t-test with unequal variance; the assumption of roughly normally distributed data was tested by plotting boxplots for the two groups.

We then investigated effects of the possible covariates, including the before time, by using a linear model. We checked for possible interactions by seeing if models with these interactions fit better than models without them. We checked the assumptions of linearity, normality, and equal variance, and all were satisfied. Because of the low numbers of smokers, smoking was not included in the model; we instead looked for any notable differences graphically and did not find any.

Finally, to make specific inference about the variables of interest, we reduced the model as possible to only include significant variables and calculated the average effects of each variable (with confidence intervals), and prediction intervals for several example individuals to demonstrate the potential effect on particular individuals.

Results and Interpretation

The group that added functional strength training got faster by an average of 4.4 seconds (95% CI: 2.1, 6.7), while the control group only got faster by an average of 1.1 seconds (95% CI: -1.0, 3.2). Using the t-test, this was a statistically significant difference; (p=0.034); the group that added strength training was 3.3 seconds faster (95% CI: 0.26, 6.33). These boxplots show the data for the two groups; individual data points are overlaid and jittered to avoid overplotting.



When adding the covariates, we found that there was a statistically significant before/treatment interaction (p=0.0017) and age effect (p=0.0042); years running was not statistically significant (p=0.17), nor was sex (p=0.068), or any other two-way interactions. The Anova table for this model follows.

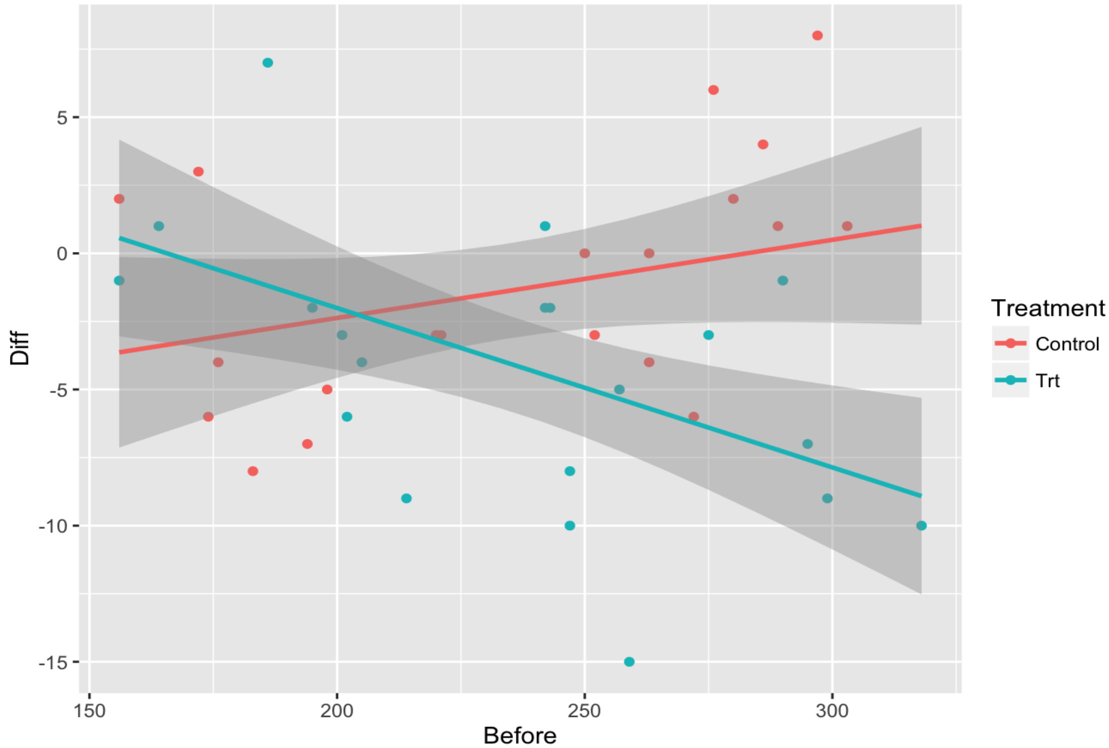
	Sum Sq	Df	F value	Pr(>F)
Treatment	81.0	1	6.02	0.020
Before	34.4	1	2.56	0.119
Sex	47.9	1	3.56	0.068
Age	127.2	1	9.45	0.004
YearsRunning	26.5	1	1.97	0.170
Treatment:Before	157.6	1	11.71	0.002
Residuals	444.1	33		

We then built a smaller model using only the significant terms to make more specific inference about them. The significant Before/Treatment interaction means that we have evidence that the effect of the treatment differs depending on what the Before time was. The effect of adding strength training for a runner of average age of 25.9 and an average before time of 236.6 seconds is on average 2.83 seconds faster (95% CI: 0.353, 5.298). Additionally, for every second faster the before time is, the average increase in speed compared to the control group is 0.087 seconds (95% CI: 0.033, 0.142). Finally, for every year older, runners ran an average of 0.358 seconds faster the second time, regardless of which treatment group they were in (95% CI: 0.113, 0.603).

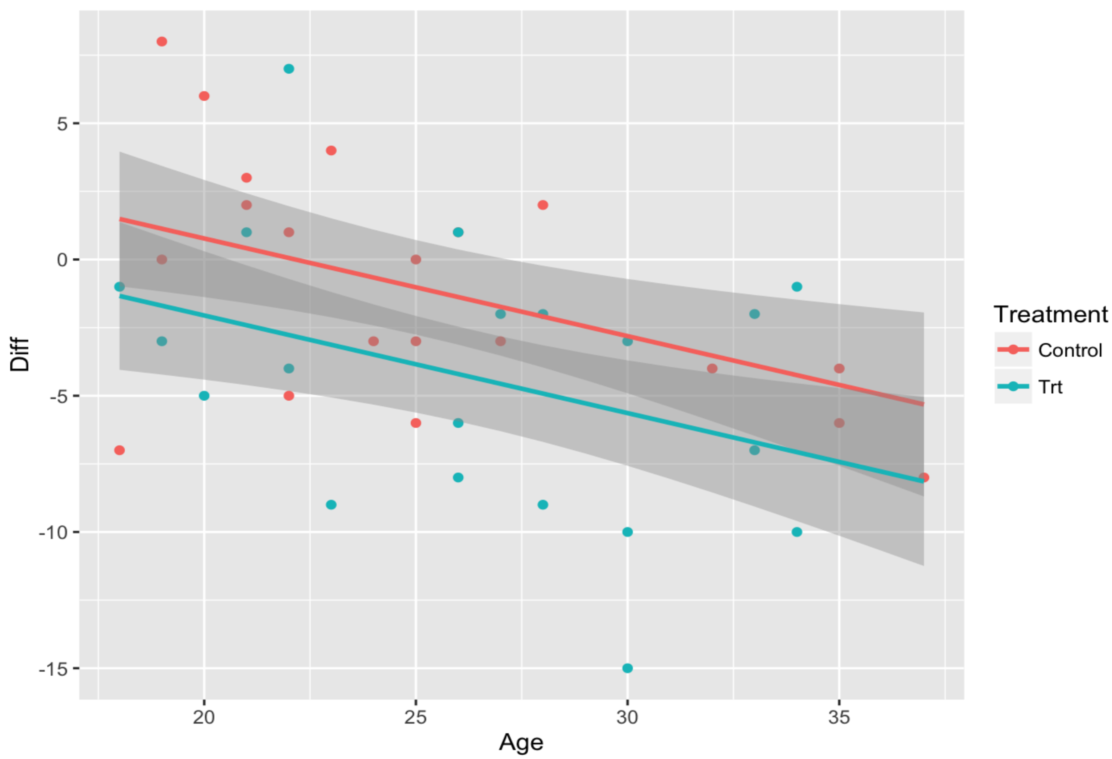
This table shows the coefficients from this model, where Age and Before score are centered around their mean values so that coefficients can be interpreted directly, as above.

	Estimate	Std. Error	95% CI	Pr(>|t|)
(Intercept)	-1.324	0.858	(-3.065, 0.417)	0.132
TreatmentTrt	-2.825	1.218	(-5.298, -0.353)	0.026
BeforeC	0.029	0.019	(-0.010, 0.067)	0.138
AgeC	-0.358	0.121	(-0.603, -0.113)	0.005
TreatmentTrt:BeforeC	-0.087	0.027	(-0.142, -0.033)	0.002

We can visually see these effects in the following plots; this plot shows the difference plotted again the before score, with average fits and confidence intervals added for individuals of average age. We see the treatment group has a notable decrease (so they get faster) as the before time increases, especially compared to the control group, which has a small (though not statistically significant, p=0.138) increase.



This plot shows the difference plotted against age, with average fits and confidence intervals added for individuals of average before score; the difference decreases (so they get faster) the older they are.



Finally, we report 95% confidence intervals and prediction intervals for representative individuals; the confidence intervals tell us about how precisely we can estimate the average effect, while the prediction intervals tell us about the effect it might have on a particular individual.

We see that a faster and younger individual (age 20, before time 180sec) on average would decrease by 0.9 seconds with no treatment, but there is substantial person-to-person variability, and the actual change in time for most people is between 9.3 seconds faster and 7.6 seconds slower. Comparing these values to those with the treatment, we see that for these indivuduals, the effect of treatment is not noticable.

However, while a slower and older individual (age 30, before time 300 sec), on average would decrease by similar amounts with no treatment, the average effect after adding the strength training is 9.3 seconds faster, and although there is still substantial individual variability, most individuals will get between 1.0 and 17.7 seconds faster, compared to between 9.5 seconds faster and 7.5 seconds slower without the strength training.

Treatment	**Age**	**Before**	**Avg Confidence Diff Interval**	**Prediction Interval**
Control	20	180	-0.9 (-4.2, 2.5)	(-9.3, 7.6)
Trt	20	180	1.3 (-2.0, 4.5)	(-7.2, 9.7)
Control	30	180	-4.4 (-7.2, -1.7)	(-12.7, 3.8)
Trt	30	180	-2.3 (-5.2, 0.6)	(-10.6, 6.0)
Control	20	300	2.6 (-0.4, 5.6)	(-5.7, 10.9)
Trt	20	300	-5.8 (-9.1, -2.4)	(-14.2, 2.7)
Control	30	300	-1.0 (-4.5, 2.5)	(-9.5, 7.5)
Trt	30	300	-9.3 (-12.5, -6.2)	(-17.7, -1.0)

Conclusions and Improvements

We conclude that there is evidence that functional strength training can increase speed for runners who are slower to start with.

However, the protocol for adding the strength training is not well defined; if participants simply added this to their existing training regimen, the effect may be due to more training in general, not to specifically adding strength training. Additional studies should consider recording the total amount of training, adding in additional training to the control group, or replacing existing training with strength training in the treatment group.

Additionally, there was more variation in times within individuals than was expected; this suggests that a more precise way of measuring speed could result in better results. One idea is to measure each individual multiple times both before and after and use their average time.