Process Improvement - Exercise Time Increase

Ian Morris

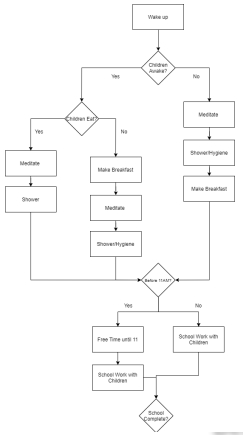
Key Dates --->	Define	Measure	Analyze	Improve	Control
	Complete 4/8/20	4/8 - 5/09/20	5/10 – 5/19/2020	5/19/20	6/3/20

DEFINE

Problem: How to increase daily exercise time by 20% and exceed a 40 minute threshold at an average 115 beats per minute in order to rehabilitate an injured shoulder and return to military duty?

Impact: An unfit soldier is prone to injury. A previously injured unfit soldier is prone to further injury! Injured soldiers can't train or deploy and can cost the Army $36,000 in losses (salary), physical therapy costs, surgery costs and cannot contribute to service and protection of the American People.

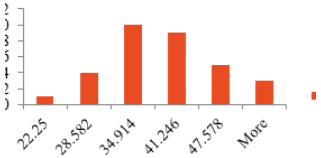
MEASURE



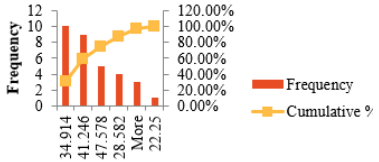
Convoluted process.
Too rigid.
Exercise is secondary

Total Observations = 32
Exercise Time Defects = 22
Average Heart Rate Defects = 3
Total Defects = 25
Total Opportunities = 64
DPO = Total Defects / Total Possible = 25/64
DPMO = .3906 x 1,000,000 = 390,625
SQL = Approx. 1.8

Exercise Time Hist



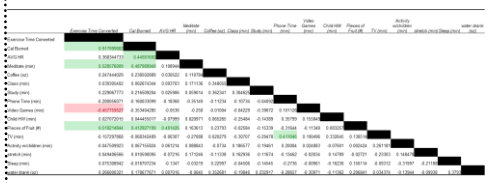
Exercise Time Pareto



Excessive entries falling below the established goal

ANALYZE

Correlation, Multiple Regression, Chi^2, Hypothesis Testing.



Sleep?
Irrelevant.
Water?
Irrelevant.
Study?
Irrelevant

obs	Weekend	
Y	N	
Low	2	6 8
Medium	7	7 14
High	0	9 9
Very High	0	1 1
	9	23 32

expec	Weekend	
Y	N	
Low	2.25	5.75 8
Medium	3.9375	10.0625 14
High	2.53125	6.46875 9
Very High	0.28125	0.71875 1
	9	23 32
p	0.063894	

??

??

Regression Statistics	
Multiple R	0.745375191
R Square	0.555584176
Adjusted R Square	0.507968195
Standard Error	5.61811072
Observations	32

	Coefficients	Standard Error	t Stat	P-value
Intercept	26.4798709	3.76178967	7.039168	1.17E-07
meditation	0.580888847	0.20090218	2.891401	0.007335
video games	-0.052030127	0.02252693	-2.30969	0.028495
fruit consumed	2.910580997	0.87837197	3.313609	0.00255

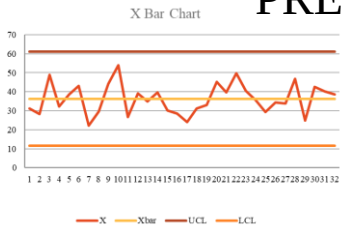
Oh. It's fruit.

Y = 26.4798 + .5808 * (meditation) + 2.91 (fruit) - .0520 * (video games)

Predict future response variable levels with most influential predictor variables

IMPROVE

PRE



Target 2 strongest positively correlated variables
And strongest negatively correlated variable

POST

CONTROL

Broke upper control limit and had a pattern of 10 consecutive days above the mean!

DPMO = ..15625 x 1,000,000 = 156,250

SQL = Approx. 2.5

DPMO	S.Q.L.	Yield
308,000	2	69.20%
274,000	2.1	72.60%
242,000	2.2	75.80%
212,000	2.3	78.80%
184,000	2.4	81.60%

Strict adherence to variable changes, standardized timing for exercise. Maintain minimum levels of time-wasting variables such as video games, while increasing fruit intake and meditation.

Define – Problem and Definition of Success

Problem Statement: The United States Army is in the midst of transitioning to a fitness program dedicated towards improving soldier health and fitness, reducing preventable injuries and enhancing mental toughness and stamina. This decision results from the observation that preventable musculoskeletal injuries account for 70% of the total medically non-deployable cases throughout the force. The price of one injury can be a significant cause for concern to the Army as personnel must be shifted to occupy organizational gaps, training time is squandered and personnel are forced to reassess into different jobs. More measurable costs associated with one injury may include: loss of approximately 180 duty days, $36,000 (salary), surgery, physical therapy or result in permanent medical retirement. While a significant blow on each individual basis, spread across the entire force, these injuries decrease organizational readiness and amount to loss of over 10 million limited duty days per year valued at approximately $500 Million.

How could an injured soldier prepare to transition to this fitness program and prevent further musculoskeletal injury?

Goal: Increase personal exercise time by 20%. Recently, complications from the subject's shoulder surgery reduced personal capacity to exercise. After initial physical therapy, medical professionals recommended 40+ minutes of physical exercise daily to expedite the rehabilitation process, prepare for future duty or face potential medical retirement.

Success Measure

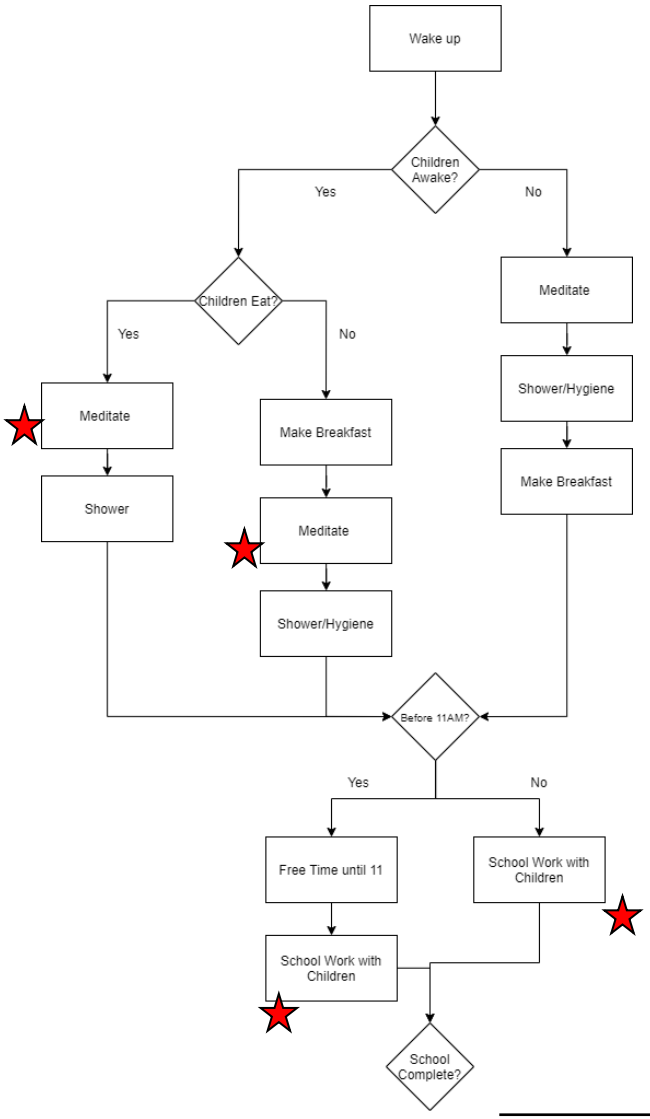
Success is measured by increasing exercise time by 20% from baseline and exceeding 40+ minutes while maintaining >= 115 continuous average heart beats per minute. The 20% increase is chosen because we have not established baseline data and the assumption is that it will be significantly less than 40 minutes.

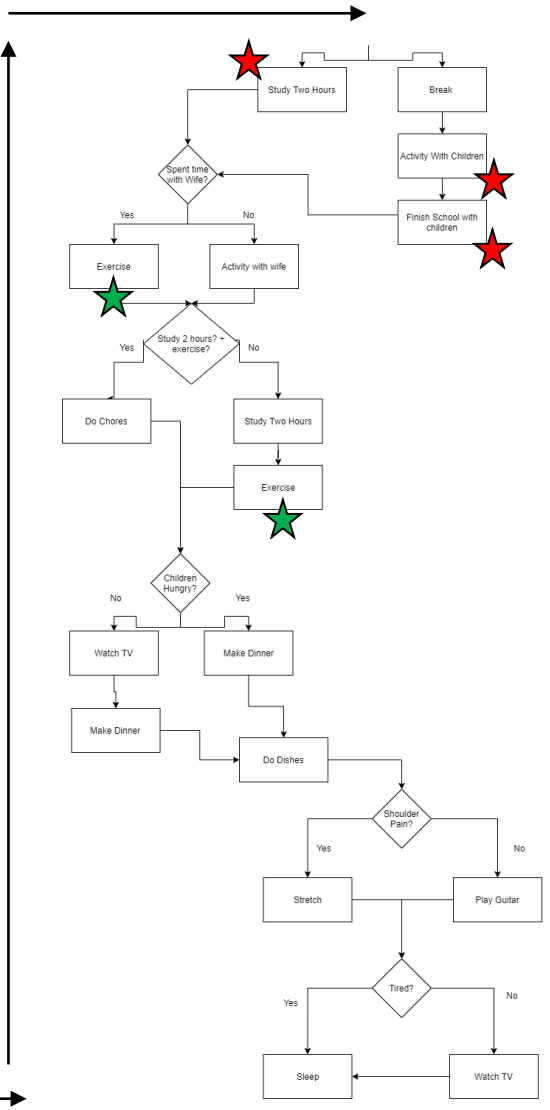
Define

Process: The current exercise regimen process is quite disorganized. There is no standard period of time established for exercise. There is also no flexibility built into the process. As it stands, a number of tasks must be completed before exercise is even considered, such as: meditation, study, store trips, cooking, chores.

Are these artificial exercise-inhibiting activities necessary? Why must a series of tasks such as these be done prior to exercise? How many times might these activities limit exercise time, intensity or force a missed exercise session?

Process Map

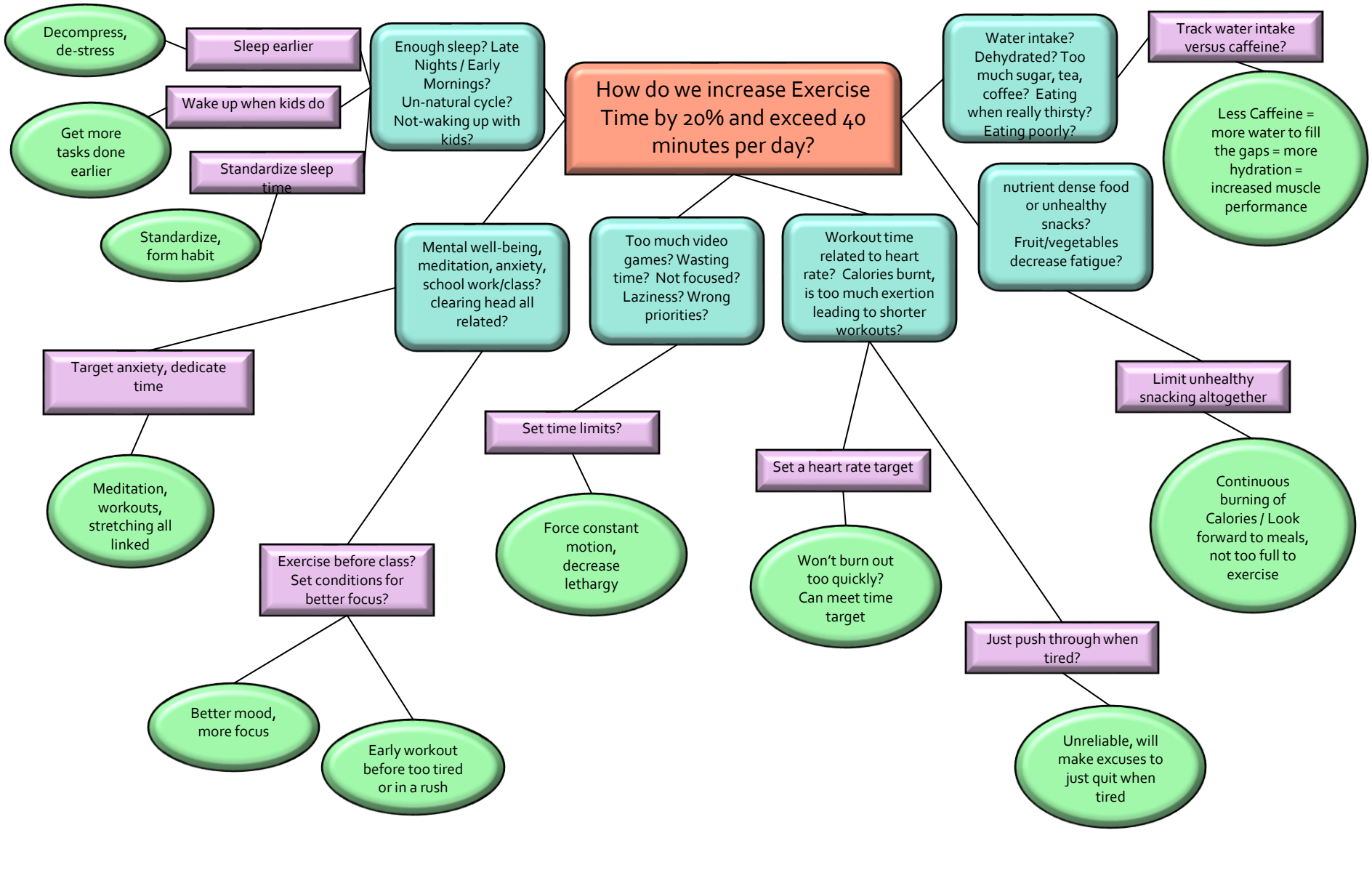




Potential Exercise Inhibitors

Potential Exercise Windows

Define – Thought Process



Measure – Data Types

Data Types

We are collecting both continuous and discrete data. Our independent variable, "Exercise Time" is measured as a continuous variable in minutes. For the independent variables, continuous data is predominantly measured by time or volume. At times, the independent variable, exercise is converted to discrete data and binned into "low", "medium", and "high" categories to perform Chi-Square tests. The Discrete independent variables are often a binary "yes" or "no" but in the case of "Fruit," represented as a count, and standardized by weight according to the type of "fruit" consumed – explained in the following slide.

Continuous Data

Calories Burned
Average Heart Rate
Meditation Time
Coffee Drank
Class Time
Study Time
Phone Time
Video Games Time
Child Homework Time
Television Time
Activities with Children Time
Stretch Time
Sleep Time
Water Drank

Discrete Data

Weekend or Weekday
Make Breakfast or Not
Make Dinner or Not
Pieces of Fruit Consumed
Went to Store or Not

Measure – Data Definitions

Variable	Definition
Exercise Time (Dependent Variable “Y”)	Amount of time in minutes of continuous weight lifting / cardiovascular activity or calisthenics
Energy Expended (cal)	Total calories expended during record exercise process
Average Heart Rate (bpm)	Average heart beats per minute recorded during exercise
Weekend (Y/N)	“Yes” means that the activity occurred on a Saturday or Sunday, “No” means that it occurred Monday-Friday
Meditate (minutes)	Recorded minutes performing a mobile-app-assisted meditation regimen alone in a quiet room that day
Make Breakfast (Y/N)	“Yes” means that the subject of the study made breakfast that day, “No” means that the subject did not.
Coffee (ounces)	Total ounces of black coffee the subject drank during the day
Class (minutes)	Minutes spent in one of two online classes during the day
Study (minutes)	Minutes spent reading, studying or performing tasks related to one of two online classes during the day
Phone time (minutes)	Minutes spent watching videos, reading non-study or class related materials or browsing social media that day

Measure – Data Definitions

Variable	Definition
Video Games (minutes)	Total minutes spent playing Nintendo Switch or Computer Video games during the day
Child Homework (minutes)	Total minutes spent assisting children perform their online work, video classes, reading or math
Make Dinner (Y/N)	“Yes” means that the subject of the study made dinner that day, “No” means that the subject did not.
Pieces of Fruit (count)	“One piece of fruit” = 1 x 4 oz apple, 1 banana, 8 strawberries, 1 peach, 32 grapes, ½ cup or raisins
Television (minutes)	Total minutes spent actively watching television during the day
Activity with Children (minutes)	Total minutes spent playing games, hiking, sports with children during the day
Stretch (min)	Total daily minutes spent doing deliberate stretching
Store (Y/N)	“Yes” = subject went to at least one store for time > 20m
Sleep (min)	Total minutes the subject slept beginning the previous night
Water (oz)	Total ounces of water the subject drank during the day

Measure – Data Collection Methods

Data will be collected every day, through various methods, see below. The subject will jump rope, weight train, conduct calisthenics, run, box or walk with a weighted military vest and backpack. A workout will be the only contribution toward "exercise" time and consists of continuous, uninterrupted physical exertion from start to finish. This can be conducted alone or in a group. A chest heart rate monitor will be worn during the exercise, linked to the Samsung Health Mobile Application. The subject is responsible for properly calibrating the heart rate monitor and ensuring proper starting and ending times for each workout. Once complete, the subject will enter the data into an excel spreadsheet. At the conclusion of each day, the subject will enter the data for the remaining variables in the same excel spreadsheet. Measurement error will be listed below, according to each variable. We will minimize measurement error by trying to adhere to the collection method as strictly as possible. Since Some of the key variables in the study are recorded digitally, we only need to set an alarm to make sure we record everything properly at the end of the night.

Variable	Collection Method	Potential Measurement Error
Exercise Time (Dependent Variable "Y")	Recorded on cell phone via Samsung Health App. Time will start when warm-up begins and will end as soon as the workout is concluded by the subject.	Failure to charge cellphone forgetting to start or stop the app / pausing the app / deleting an entry / improper transfer to xls file
Energy Expended (cal)	Recorded on Samsung Health App. Calories expended begins when the workout timer is started, similarly to exercise time / ends when workout is concluded by subject	Unknown if the Samsung app tracks calories as a function of "workout time" or if it adjusts for exertion through both workout time and heart rate.
Average Heart Rate (bpm)	A Polar Wearlink heart rate monitor will be worn around the subjects chest during each workout, linked to the Samsung Health App.	The heart rate monitor loses connection to the phone / incorrectly measures heart rate / slips from the designated spot on the wearer
Weekend (Y/N)	Recorded nightly, on an excel spreadsheet	Excel input error
Meditate (minutes)	Via Brightmind Android App, guided meditation – app collects and stores meditation duration, subject will input nightly	Interruptions / app crash / excel recording error
Make Breakfast (Y/N)	Recorded nightly, on an excel spreadsheet	Excel input error

Measure – Data Collection Methods

Variable	Collection Method	Potential Measurement Error
Coffee (ounces)	Coffee will be dispensed from a Keurig 2.0 coffee machine via the 10 oz, 8 oz, or 6 oz setting / recorded nightly	Excel Input error / not fully consuming / machine failure to dispense uniform amounts
Class (minutes)	Recorded on nights that the subject has one of two classes	Excel input error
Study (minutes)	Recorded nightly after subject has viewed lectures, read or completed homework	Interruptions / excel input error / daydreaming / checking phone or other minor tasks which detract from process
Phone time (minutes)	Recorded nightly, added total length in minutes of all youtube videos, manual memory	Difficult to measure each instance the subject views phone throughout the day
Video Games (minutes)	Recorded nightly, on an excel spreadsheet	Excel input error / failure to keep track of time
Child Homework (minutes)	Total minutes spent assisting children perform their online work, video classes, reading or math	Excel input error / failure to keep track of time
Make Dinner (Y/N)	Recorded nightly, on an excel spreadsheet	Excel input error / failure to keep track of time
Pieces of Fruit (count)	Recorded nightly according to data definitions, scale	Failure to weigh fruit according to data definitions
Television (minutes)	Recorded nightly, on an excel spreadsheet	Excel input error / failure to keep track of time
Activity with Children (minutes)	Recorded nightly, on an excel spreadsheet	Excel input error / failure to keep track of time
Stretch (min)	Recorded nightly, on an excel spreadsheet	Excel input error / failure to keep track of time
Store (Y/N)	Recorded nightly, on an excel spreadsheet	Excel input error / failure to keep track of time
Sleep (min)	Recorded every morning after waking up via Samsung Health App suggested sleep range	Excel input / App suggests time from when subject stopped using phone, not when fell asleep / wakeup suggestion inconsistent
Water (oz)	Recorded via Samsung Health App after every glass is consumed	Approximation of total ounces / failure to record / input error

Measure

Sample Size & SQL Computation

Sample Size
Desired 5% margin of error at 95% confidence level.

ME = z* [SQRT[((P)*(1-P))/N]]

.05 >= 1.96 * SQRT[((.5)*(.5))/N]
.05 >= 1.96 * SQRT[(.25)/N]
(.05)/(1.96) >= SQRT[.25/N]
196/5 <= SQRT[N]/.5
39.2 <= SQRT[N]/.5
39.2 * .5 <= SQRT[N]
19.6 <= SQRT[N]
19.6^2 <= N

N >= 385

Our sample size should be >= 385 for the desired margin of error at 95% confidence level, however, we chose a sample size of 32 based on available time. Because our sample size is smaller than what is necessary, our margin of error will increase.

Exercise Time	Converted	AVG HR
31.08		115
28.23		122
49		121
32.16		113
38.7		125
43.2		125
22.25		119
29.64		121
44.16		132
53.91		144
26.75		111
39.08		121
35		114
39.75		116
30.18		123
28.66		116
24		125
31.08		130
33.09		132
45.33		116
39.7		117
49.58		120
40.55		121
35.45		127
29.25		118
34.34		119
33.9		120
46.9		130
24.75		126
42.64		122
40.16		128
38.58		121

Total Observations = 32

Exercise Time Defects = 22

Average Heart Rate Defects = 3

Total Defects = 25

Total Opportunities = 64

DPO = Total Defects / Total Possible = 25/64

DPMO = .3906 x 1,000,000 = 390,625

SQL = Approx. 1.8

DPMO	S.Q.L.	Yield
570,000	1.3	43.00%
540,000	1.4	46.00%
500,000	1.5	50.00%
460,000	1.6	54.00%
420,000	1.7	58.00%
382,000	1.8	61.80%
344,000	1.9	65.60%

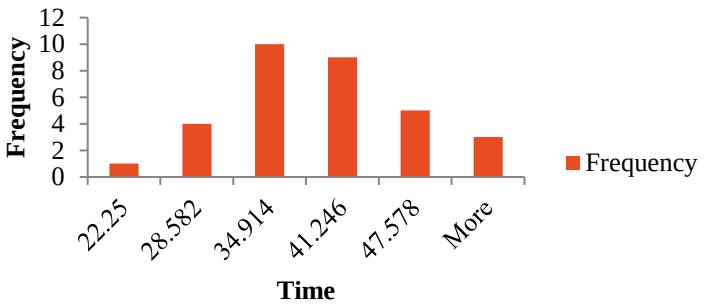
Defect Definition
SQL is really a blend between Define and Measure, given that we have just collected the data. A defect is considered each time we fail to workout for 40+ minutes or achieve a average heart rate of at least 115+ BPM. Defects are highlighted in red.

Analyze

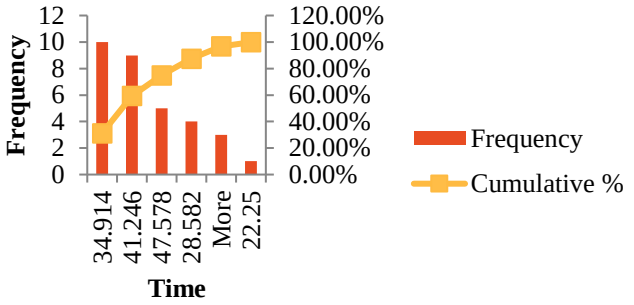
Descriptive Statistics

Exercise Time Converted	AVG HR
31.08	115
28.23	122
49	121
32.16	113
38.7	125
43.2	125
22.25	119
29.64	121
44.16	132
53.91	144
26.75	111
39.08	121
35	114
39.75	116
30.18	123
28.66	116
24	125
31.08	130
33.09	132
45.33	116
39.7	117
49.58	120
40.55	121
35.45	127
29.25	118
34.34	119
33.9	120
46.9	130
24.75	126
42.64	122
40.16	128
38.58	121
Mean	36.28281	122.1875
Standard Error	1.415855	1.192583
Median	35.225	121
Mode	31.08	121
Standard Deviation	8.009284	6.746265
Sample Variance	64.14863	45.5121
Kurtosis	-0.60332	2.16966
Skewness	0.261638	1.068912
Range	31.66	33
Minimum	22.25	111
Maximum	53.91	144
Sum	1161.05	3910
Count	32	32

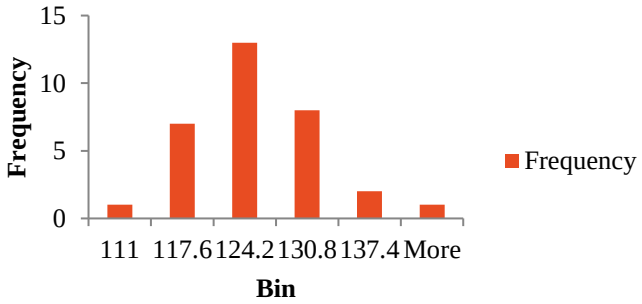
Exercise Time Hist



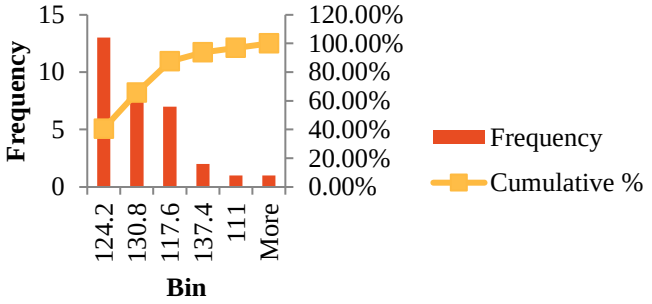
Exercise Time Pareto



Average Heart Rate Hist



Average Heart Rate Pareto



Assessment

Collection of raw data, excluding independent variables. The main focus is exercise time, with a secondary focus on average heart rate. The mean exercise time was 36.28 minutes per day, with a standard deviation of 8, which is important because the mean is under the target of 40+ minutes, and with such a high standard deviation our process is not meeting the mark as it is inconsistent. As shown by the pareto, there are 10 observations alone binned at 34.9 illustrating that approximately 30% of all observations are failing to exceed the 40 minute standard. The range is extensive at 31.66 – meaning that the range is nearly equal to the mean. A few long-duration workouts are compensating for the majority of workouts where the established goal (40+min) is not being met.

Heart rate is less of a concern, given that the mean is 122.2 and standard deviation is 6.7, exceeding the benchmark of 115bpm in all but a few cases. The histogram shows a normal distribution, high kurtosis, with a high peak around the mean.

Analyze

Correlation Plot

	Exercise Time Converted	*Cal Burned*	*AVG HR*	*Meditate (min)*	*Coffee (oz)*	*Class (min)*	*Study (min)*	*Phone Time (min)*	*Video Games (min)*	*Child HW (min)*	*Pieces of Fruit (#)*	*TV (min)*	*Activity w/children (min)*	*stretch (min)*	*Sleep (min)*	*water drank (oz)*
Exercise Time Converted																
Cal Burned	0.917999882															
AVG HR	0.368344733	0.44581692														
Meditate (min)	0.528576009	0.487989949	0.108944													
Coffee (oz)	0.247444029	0.238502889	0.030522	0.110784												
Class (min)	0.039305402	0.002674344	0.093703	0.171136	0.348055											
Study (min)	0.229067773	0.216509204	0.025906	0.059014	0.362341	0.304625										
Phone Time (min)	-0.280056071	-0.160033099	-0.18368	-0.35149	-0.11234	-0.10734	-0.04092									
Video Games (min)	-0.457759527	-0.353404285	-0.0536	-0.258	-0.01004	-0.04229	-0.39672	0.101126								
Child HW (min)	0.027072015	0.044455017	-0.07999	0.020971	0.065265	-0.25484	-0.14389	0.35799	0.155849							
Pieces of Fruit (#)	0.518214844	0.412927199	0.491426	0.163613	0.23793	-0.02584	-0.15339	-0.31644	-0.11348	0.083257						
TV (min)	-0.157297868	-0.068342489	-0.00307	-0.27088	0.020279	-0.30707	-0.29478	0.411046	0.190496	0.332645	0.138514					
Activity w/children (min)	-0.047509923	0.067155824	0.061214	0.088843	-0.0734	0.186577	-0.19461	0.20004	0.024883	-0.07601	0.002424	0.261181				
stretch (min)	0.049406566	0.010590095	-0.07216	0.171246	-0.11338	0.162936	-0.11674	-0.13462	-0.02034	0.14789	-0.02721	-0.23303	0.148478			
Sleep (min)	0.075308942	-0.018707234	-0.1347	-0.03219	0.22997	-0.04506	-0.14545	-0.2736	-0.00961	-0.16236	0.156114	-0.09312	-0.31997	-0.21188		
water drank (oz)	0.266000321	0.178677671	0.007016	-0.0045	0.352681	-0.19846	0.232917	-0.28657	-0.30971	-0.11362	0.206841	0.034374	-0.13944	-0.09938	0.3793	

Assessment

Based on the thought process map, there were several things we were looking for in this correlation plot. We were very confident that sleep time, Coffee drank and water drank would have a strong positive correlation with exercise time. Sleep time had the weakest correlation between the three, to our confusion. All three of these variables had weak / essentially no correlation with exercise time: coffee = .25, water = .27 and sleep .08. Though it wasn't anticipated, it makes sense that pieces of Fruit had at least some positive correlation with exercise time. This correlation was .52. Meditation had an unexpectedly similar correlation with exercise time at .53. Both of these two variables shared an interesting positive correlation with calories burned while pieces of fruit also shared a positive correlation with average heart rate. Altogether these values were much lower than expected.

We expected that study time, phone time, video games, tv time and activity with children would have a significant impact on exercise time, expecting at least a moderate negative correlation. While phone time and activity with children did have a negative correlation, it was very weak. Video game time had the lowest recorded negative correlation at -.46.

Analyze

Chi-Square Test

obs			
	Weekend		
	Y	N	
Low	2	6	8
Medium	7	7	14
High	0	9	9
Very High	0	1	1
	9	23	32

expec			
	Weekend		
	Y	N	
Low	2.25	5.75	8
Medium	3.9375	10.0625	14
High	2.53125	6.46875	9
Very High	0.28125	0.71875	1
	9	23	32
p	0.063894		

obs			
	Bfst		
	Y	N	
Low	5	3	8
Medium	6	8	14
High	3	6	9
Very High	0	1	1
	14	18	32

expec			
	Bfst		
	Y	N	
Low	3.5	4.5	8
Medium	6.125	7.875	14
High	3.9375	5.0625	9
Very High	0.4375	0.5625	1
	14	18	32
p	0.50832		

obs			
	Dinner		
	Y	N	
Low	5	3	8
Medium	7	7	14
High	4	5	9
Very High	0	1	1
	16	16	32

expec			
	Dinner		
	Y	N	
Low	4	4	8
Medium	7	7	14
High	4.5	4.5	9
Very High	0.5	0.5	1
	16	16	32
p	0.656873		

obs			
	Store		
	Y	N	
Low	4	4	8
Medium	3	11	14
High	2	7	9
Very High	0	1	1
	9	23	32

expec			
	Store		
	Y	N	
Low	2.25	5.75	8
Medium	3.9375	10.0625	14
High	2.53125	6.46875	9
Very High	0.28125	0.71875	1
	9	23	32
p	0.43167		

Assessment

Chi-Square test for independence was performed between exercise time and four variables, weekend (y/n), made breakfast (y/n), made dinner (y/n) and went to store (y/n). Given that these are categorical variables and the exercise time is continuous, exercise time was discretized to "low" <30m , "medium" 30 -39.99m, "high" 40-49.99m and "very high" > 50m categories. Observed and expected values were recorded and p values were shown at the bottom. None of the p values were lower than our chosen alpha of .05 so we concluded that exercise time and these variables were independent.

Analyze

Multiple Regression for Highest Correlated Variables

Regression Statistics	
Multiple R	0.745375191
R Square	0.555584176
Adjusted R Square	0.507968195
Standard Error	5.61811072
Observations	32

	Coefficients	Standard Error	t Stat	P-value
Intercept	26.4798709	3.76178967	7.039168	1.17E-07
meditation	0.580888847	0.20090218	2.891401	0.007335
video games	-0.052030127	0.02252693	-2.30969	0.028495
fruit consumed	2.910580997	0.87837197	3.313609	0.00255

Y = 26.4798 + .5808 * (meditation) + 2.91 (fruit) - .0520 * (video games)

Assessment

Having determined that Fruit, video games and meditation correlated with exercise time, we performed a multiple regression which yielded the above regression equation. All of the P values are significant (below .05) and the adjusted R square is .507, meaning that the proportion of variability in the response variable (exercise time) is explained 50% by the predictor variables. While this is a relatively low adjusted R square, we assumed this would be the case given similar r values shown in the correlation plot (none of them were significantly greater than .5).

Improve

Adjustments + Anticipated changes w/ regression equation

		Fruit		Video Games		Meditation
Pre	Mean	2.84375		73.59375		9.21875
	Standard Deviation	1.167003		46.4764		5.253167
	Range	4		180		20
	Minimum	1		0		0
	Maximum	5		180		20
Post	Mean	5.5625		42.5		14.375
	Standard Deviation	0.629153		29.66479		1.707825
	Range	2		120		5
	Minimum	4		0		10
	Maximum	6		120		15

$$Y = 26.4798 + .5808\,(15) + 2.91\,(6) - .0520\,(45)$$

$$Y = 50.3118$$

Assessment

Based on our analysis, we determined that most of the variables did not correlate with exercise time, as we thought they might, however, we still chose 3 variables to target to see if they would have a positive effect. Fruit intake, which correlated with heart rate, calories burned and exercise time at values between .41 to .52 was increased from an average daily consumption of 2.8 pieces per day, to 5.5 pieces per day. Video games, which had a negative correlation with exercise time of -.45 was reduced from 73.6 minutes per day to 42.5 minutes per day. Meditation with a .53 correlation to exercise time and a .48 correlation to calories burned was increased from 9.2 minutes per day to 14.375 minutes per day. To illustrate how we believe this might effect exercise time moving forward, we used the regression equation calculated from multiple regression to determine that a day which included 15 minutes of meditation, 6 pieces of fruit and held firm at 45 minutes of video games might yield an exercise time of 50.3118 minutes.

Hypothesis Test

We will conduct two hypothesis tests: one to determine if our improvement process has increased our exercise time by 20% (as was our original goal) and another to determine if our improvement process has increased exercise time at all. We will be conducting a 1 tail test, lower-left tail and using calculating the z value given the sample size.

Did we really increase our exercise time by 20% more than the original sample?
-2 sample hypothesis test

Ho: sample 1(1.2) >= sample 2
Ha: sample 1(1.2) < sample 2

Xbar1 = 36.28(1.2) = 43.536
Xbar2 = 43.87
sd1 = 8.01
Sd2 = 7.31
N1 = 32
N2 = 16
Alpha = .05

Z = xbar1 – xbar 2 / SQRT [sd^2_1/N1 + sd^2_2/N2]
Z = (43.536-43.87) / SQRT[2.005 + 3.3398]
Z = (--.334)/ 2.31188
Z = --.14447
P value = ..442564

Do not reject Null

Did we really increase our exercise time from the original sample?

Ho: sample 1 >= sample 2
Ha: sample 1 < sample 2

Xbar1 = 36.28
Xbar2 = 43.87
sd1 = 8.01
Sd2 = 7.31
N1 = 32
N2 = 16
Alpha = .05

Z = xbar1 – xbar 2 / SQRT [sd^2_1/N1 + sd^2_2/N2]
Z = (36.28-43.87) / SQRT[2.005 + 3.3398]
Z = (-7.59)/ 2.31188
Z = -3.283
P value = .00051

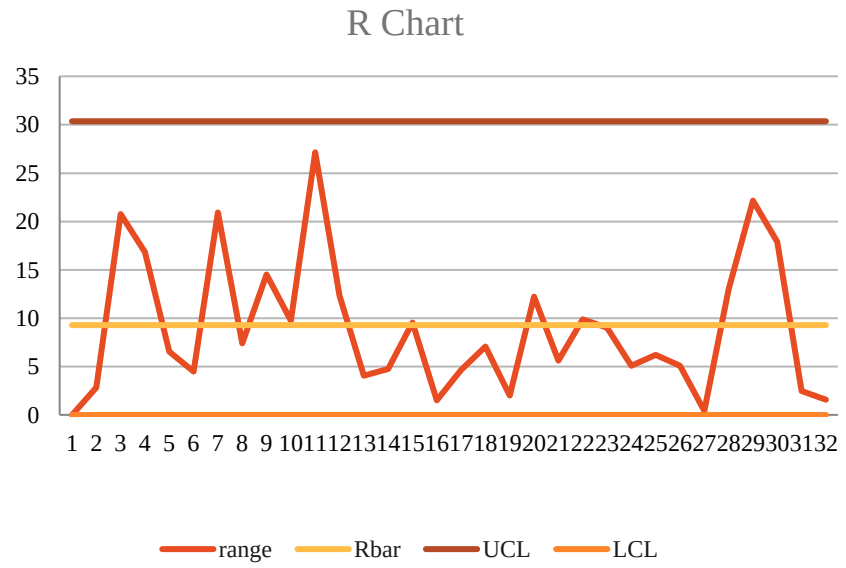
Reject Null

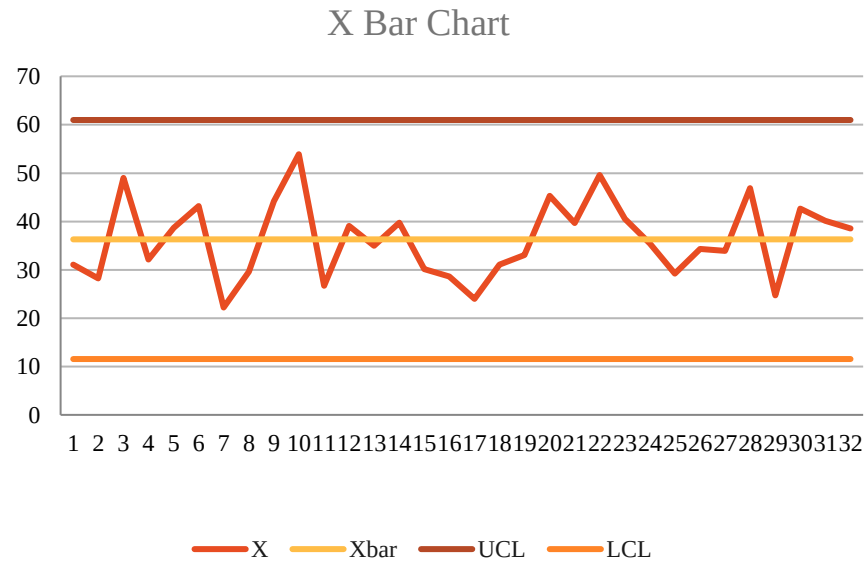
Assessment

We performed 2 hypothesis tests because there are really two metrics: The first was the desire to increase exercise time by 20% of the baseline. The baseline mean was 36.2 minutes. Our average for sample 2 was 43.87min, which is greater than a 20% increase. However, we cannot say that our process improvement was statistically significant toward increasing exercise time by 20% due to a p value of .442564. Because our other metric of success was to increase our average workout time to 40+ minutes, we are going to test to see if our improvements were statistically significant in simply increasing workout time as compared to the pre-improvement sample. In this case, our calculated p value was .00051, which means that our improvements were statistically significant in increasing exercise time (just not by 20%).

Improve

Pre-Improvement Control Charts



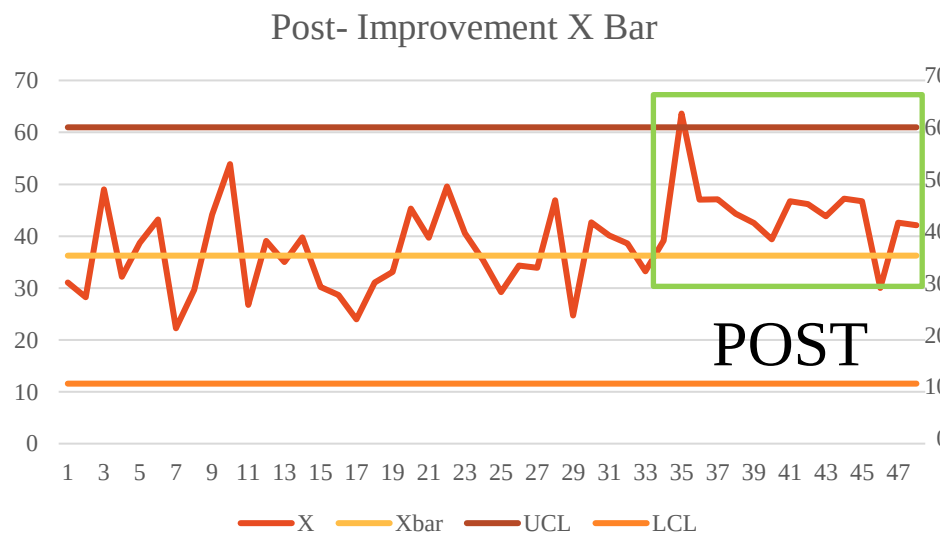


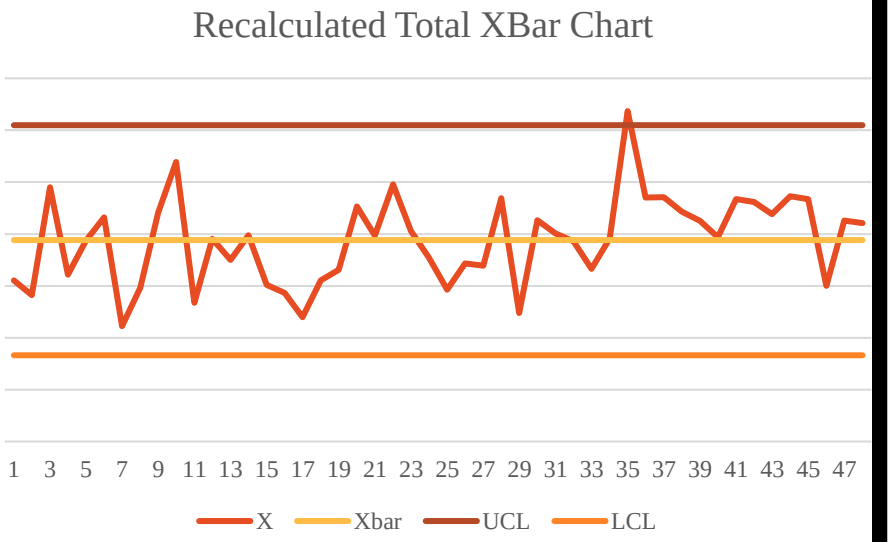
Assessment

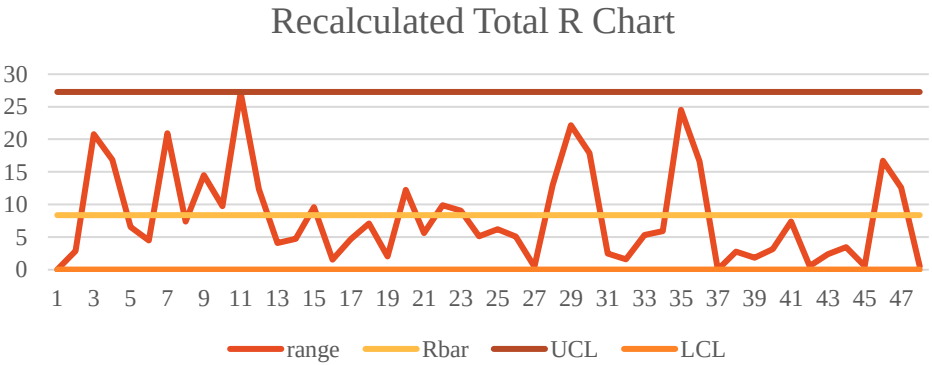
We developed control charts to first, identify if our pre-improvement process is varying predictably or due to a special cause. For the first 32 days, we can see that the process is proceeding in a controlled manner, but we have identified that we have not reached the 40+ minute average. While there are fluctuations of 20+ minutes from day to day, there is never a day where a value is so much outside of the norm that it breaks the upper or lower control limit. The next step is to add our post-improvement process data to the charts in two forms. The first form will include the values of the new sample with the limits of the old sample, to see if we are noticeably breaking the upper control limit or trending above the established mean line. In the second chart, we will calculate new R charts and X bar charts to analyze the data further.

Improve/Control

Post-Improvement Control Charts







Assessment: After making adjustments to the process, we added the new data to the pre-improvement control chart. After 2 observation of normal variation, we noticed an increase that broke the upper control limit, followed by **10** additional days above the center line. It was clear that the improvements had the positive effect of increasing exercise time by a significant amount. To illustrate how we would proceed forward, we recalculated the R chart for all Data and the Xbar chart for all data. Because the Xbar shows excessive continuous datapoints above the newly calculated mean, we would likely recalculate with solely post-improvement data.

SQL 2

Exercise Time	AVG HR
31.08	115
28.23	122
49	121
32.16	113
38.7	125
43.2	125
22.25	119
29.64	121
44.16	132
53.91	144
26.75	111
39.08	121
35	114
39.75	116
30.18	123
28.66	116
24	125
31.08	130
33.09	132
45.33	116
39.7	117
49.58	120
40.55	121
35.45	127
29.25	118
34.34	119
33.9	120
46.9	130
24.75	126
42.64	122
40.16	128
38.58	121

Post SQL Calculation for Total Data and Post-Specific

Exercise	HR
33.26	122
39.16	111
63.66	142
47.06	121
47.08	119
44.33	133
42.52	128
39.37	101
46.75	121
46.18	129
43.81	126
47.26	128
46.72	126
30	120
42.6	128
42.1	132

Total Data

Total Observations = 48

Exercise Time Defects = 25

Average Heart Rate Defects = 5

Total Defects = 30

Total Opportunities = 96

DPO = Total Defects / Total Possible = 30/96

DPMO = .3125 x 1,000,000 = 312,900

SQL = Approx. 2

DPMO	S.Q.L.	Yield
308,000	2	69.20%
274,000	2.1	72.60%
242,000	2.2	75.80%
212,000	2.3	78.80%
184,000	2.4	81.60%

New Data

Total Observations = 16

Exercise Time Defects = 3

Average Heart Rate Defects = 2

Total Defects = 5

Total Opportunities = 32

DPO = Total Defects / Total Possible = 5/32

DPMO = ..15625 x 1,000,000 = 156,250

SQL = Approx. 2.5

DPMO	S.Q.L.	Yield
308,000	2	69.20%
274,000	2.1	72.60%
242,000	2.2	75.80%
212,000	2.3	78.80%
184,000	2.4	81.60%
158,000	2.5	84.20%

Conclusion

When conducting a process improvement project directed towards self improvement, I believe that it is more difficult to determine root causes. For exercise in particular, it is easier to extend a workout "a few minutes longer" to meet an artificially set goal. Never during the process did I ever feel like I couldn't exercise any further, rather I occasionally hit a threshold and "stopped" or "pushed" because I had the process improvement project in mind. I think that this could be categorized as a sort of "measurement error." It is very difficult to remain objective when you "want" a particular result to occur. I recall instances during the project where I know I could have gone further, but instead I stopped because then I knew that I could "have a larger % increase in the improvement" phase. While I am not happy with the way this manifested, it does remind me of a passage in Donald Wheeler's *Understanding Variation*, where he states that there are three ways to meet a goal: improve the system, distort the process of distort the data. While data was not distorted, I wonder if I occasionally distorted the process by setting daily arbitrary workout goals or making other subconscious to get an outcome that I desired. I am happy to experience how something like this could manifest in a business setting with a process much more important than exercise duration

Given the above statement, I still executed the process step by step to develop an implementable plan that achieved 2 of 3 goals. While workout time was technically increased by 20%, the margins were so small that the hypothesis test revealed that it might not be entirely due to my process-improvement steps. I did set a new baseline average of 43.87 minutes of exercise per day with an average heart rate of 124 beat per minute. This was an increase of 7.59 minutes and 2 beats per minute from the pre-improvement data.

In "Define" I determined my success metrics, mapped out the process, which was a flow-chart of my daily activities; developed a thought-process map which allowed me to identify what I thought practical contributing factors would be and brainstormed potential confounding factors. In "Measure" I identified the types of data I would collect and how I would measure, accounting for measurement error. I identified my desired sample size, which I noted that I would not be able to collect, then collected my data and calculated the SQL to identify that my process was failing in many regards. In analyze, I conducted summary statistics on my Y and other key variables then constructed correlation plot to confirm if my preconceived notions were accurate. After a Chi^2 test, hypothesis test and regression, I determined my 3 most important predictor variables and utilized my regression equation to predict future outcomes. Once complete, I calculated my pre-control charts, collected my second sample of data and compared this data to both my pre-control chart and newly constructed control charts. There I noticed a marked increase in exercise time which broke the upper control limit and also disrupted the nature variation in the mean. Finally I reassessed my project effectiveness and calculated my SQL a second time, noticing an increase from 1.8 to 2.5 (and SQL of 2 if accounting for total data).

If I were to do this process again, I would also look very closely at the food I ate, my average heart rate and calories burnt. I believe a standardized workout would also help to limit variation or assist in meeting a time goal. Perhaps time is a bad measurement for workouts altogether and there are better metrics for actually improving fitness and reducing injury.