BE 5382-LABORATORY PRINCIPLES

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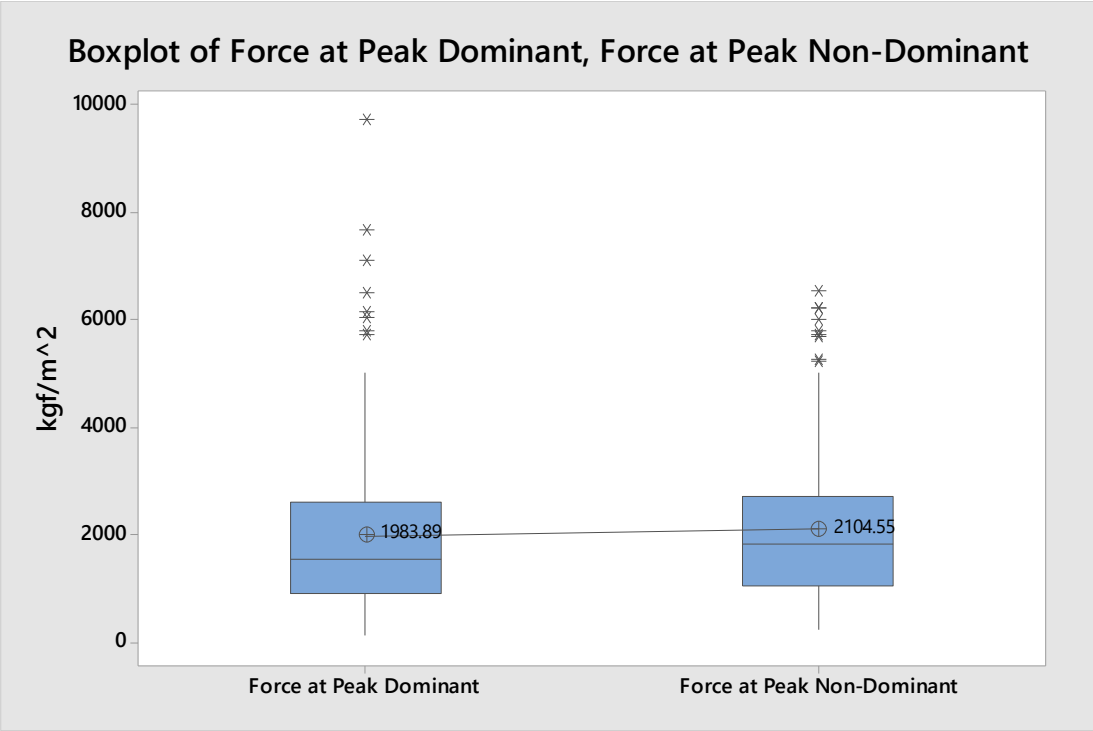
Skeletal Muscle Contraction & Motor Unit Recruitment

Null Hypothesis	Alternative Hypothesis
No Significant difference in mean value of force between dominant and non dominant. No Significant difference in mean value of Integrated EMG between dominant and non dominant. No Significant difference in mean value of Integrated EMG between Male and Female.	Significant difference in mean value of force between dominant and non dominant. Significant difference in mean value of Integrated EMG between dominant and non dominant. Significant difference in mean value of Integrated EMG between Male and Female.

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed	Paired sample T-Test / Two-sampled T-Test

Results

Parameters	Values
P-value	0.011
μ Force at Peak Dominant (kgf/m^2)	1984
μ Force at Peak Non-Dominant (kgf/m^2)	2105
σ Force at Peak Dominant	1582
σ Force at Peak Non-Dominant	1417



SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

Results

Male gender selected to remove gender influence Clench Force of Male subjects:

Attributes	P-value	Result
Dominant-Non Dominant during clench strength 1	0.735	No difference
Dominant-Non Dominant during clench strength 2	0.182	No difference
Dominant-Non Dominant during clench strength 3	0.313	No difference
Dominant-Non Dominant during clench strength 4	0.113	No difference
Dominant-Non Dominant during clench strength 5	0.738	No difference

NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

Comparison within clench strength

Clench Strength	Dominant hand	Non-Dominant hand
1-2	Significant Difference (P-value 0.000)	Significant Difference (P-value 0.000)
2-3	Significant Difference (P-value 0.000)	Significant Difference (P-value 0.000)
3-4	Significant Difference (P-value 0.002)	Significant Difference (P-value 0.000)
4-5	Significant Difference (P-value 0.000)	Significant Difference (P-value 0.000)

SIGNIFICANT

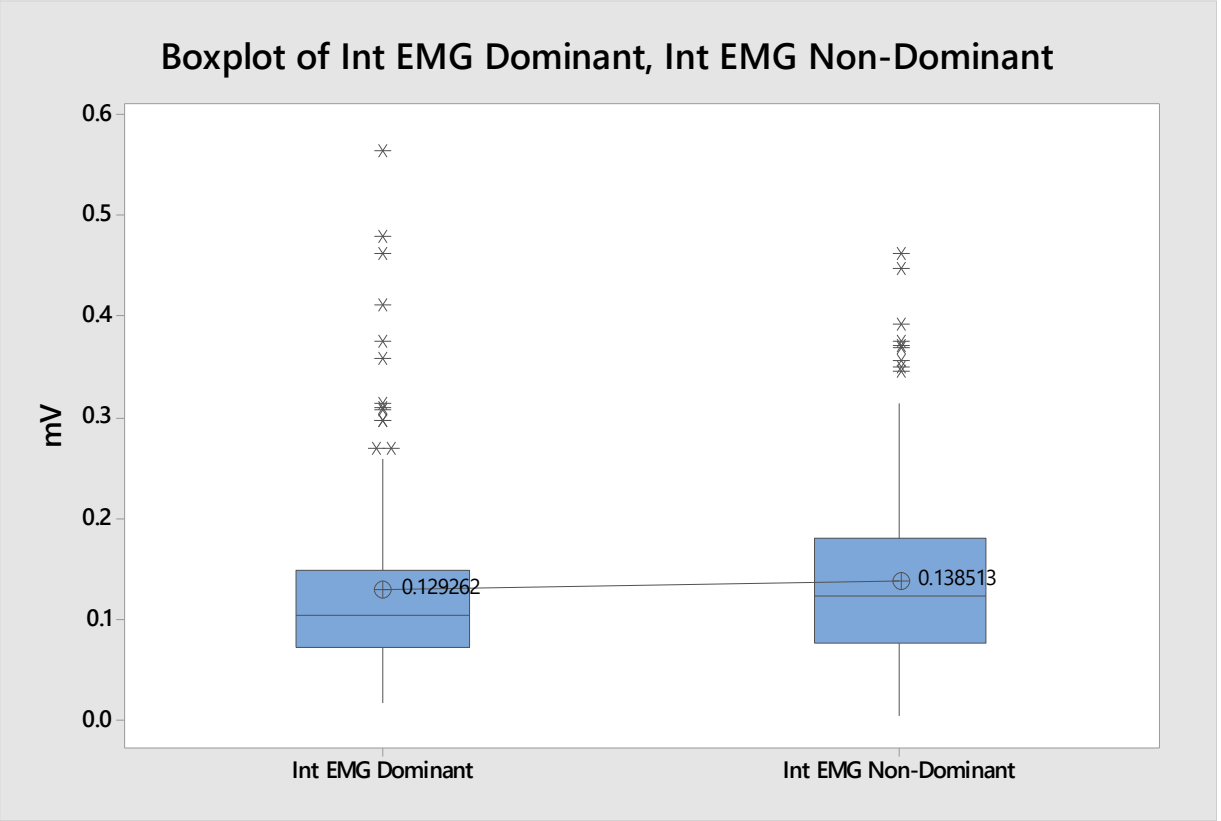
Reject Null Hypothesis in favor of Alternative Hypothesis

% increase between clench

Clench Strength	Dominant hand	Non-Dominant hand
1-2	5.32%	7.19%
2-3	6.98%	6.34%
3-4	6.10%	6.32%
4-5	10.42%	7.36%

Motor Unit Recruitment

Parameters	Values
P-value	0.044
μ Integrated EMG Dominant (mV)	0.129
μ Integrated EMG Non Dominant (mV)	0.138
σ Integrated EMG Dominant	0.08754
σ Integrated EMG Non Dominant	0.08795

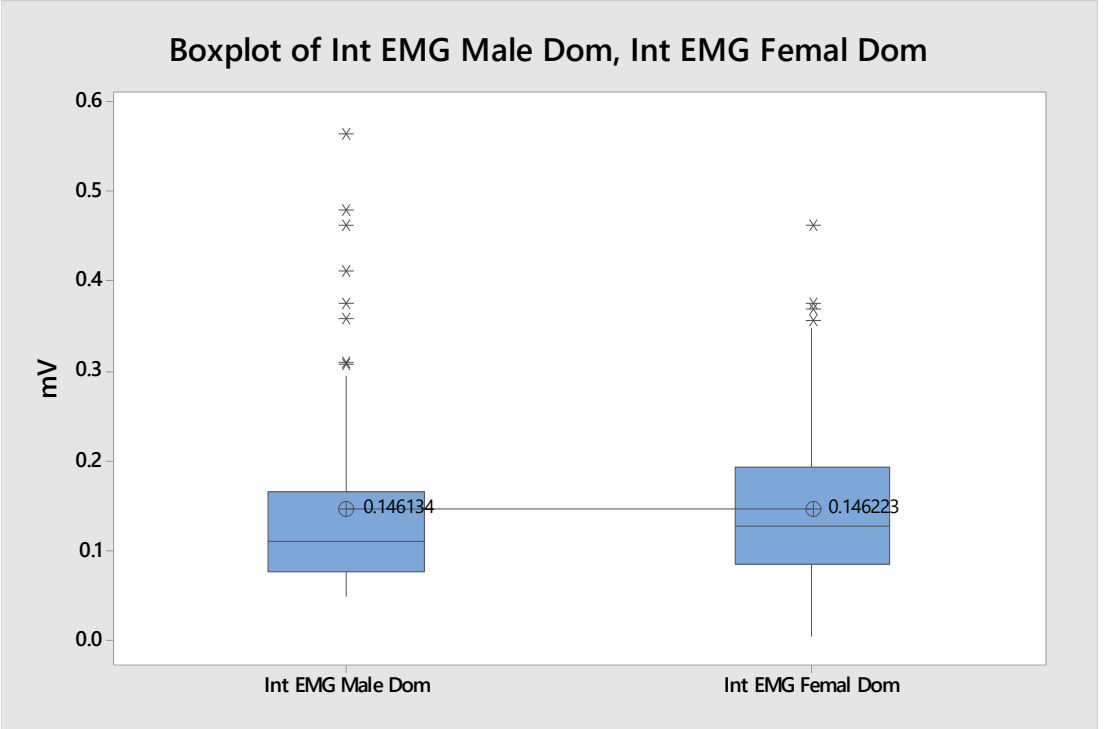


SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

Effect of gender:

Parameters	Values
P-value	0.995
μ Integrated EMG Male dominant (mV)	0.146
μ Integrated EMG Female dominant(mV)	0.146
σ Integrated EMG Male Dominant	0.105
σ Integrated EMG female Dominant	0.0926



SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

DISCUSSION

- The variation in firing rate of motor unit leads to the difference.
- Stable increase of force due to increase in firing frequency of MU increasing strength.
- Release of calcium ions increases.
- Higher percent of MU in dominant hand was recruited from low range, hence mean of dominant is less than non dominant
- Gender have influence on Integrated EMG as female will bring more Motor Units into action.

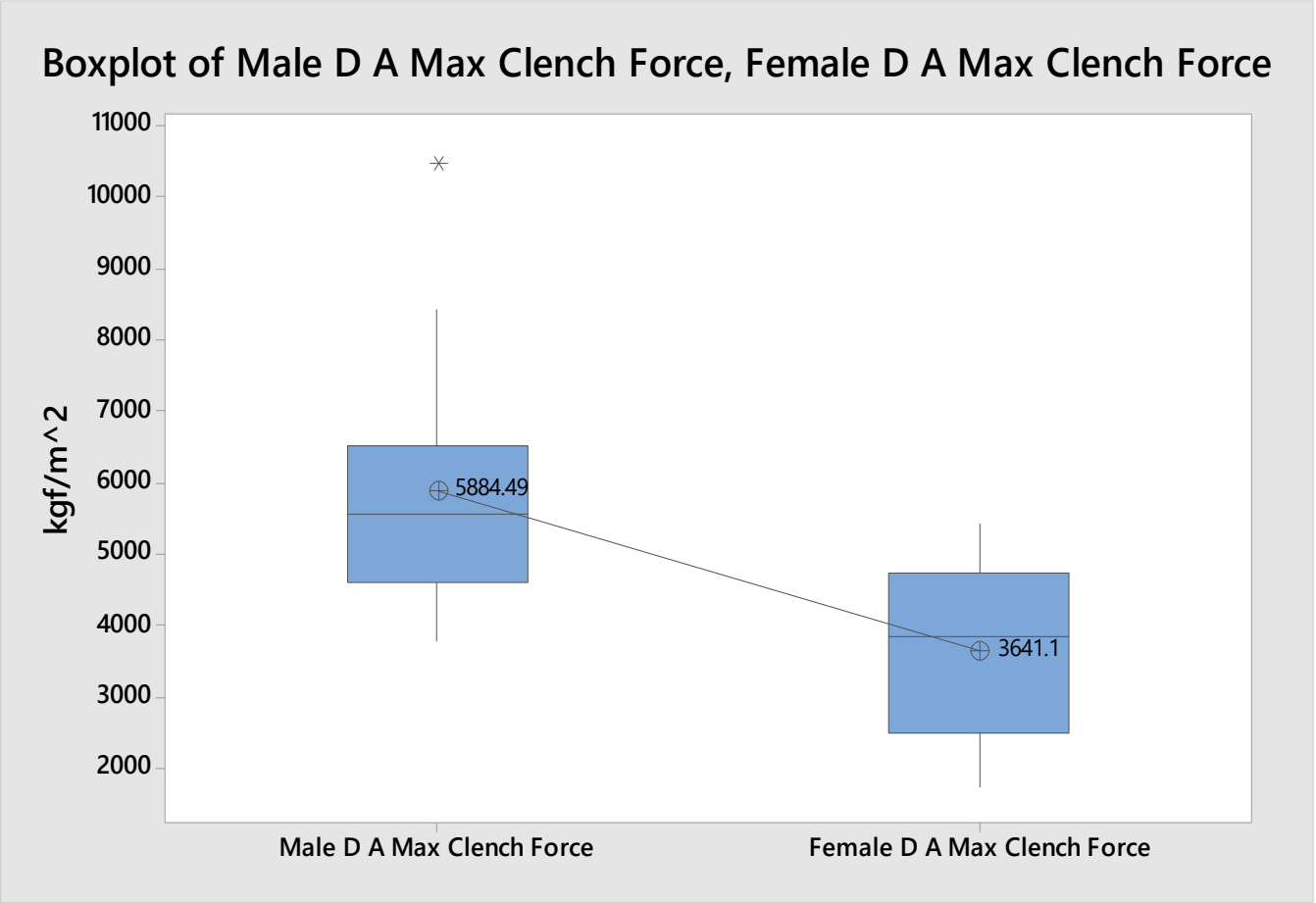
Effect of gender on maximum clench force & fatigue

Null Hypothesis	Alternative Hypothesis
No Significant difference in mean value of maximum clench force of dominant arm between male and female. No Significant difference in mean time to fatigue of dominant arm between male and female.	Significant difference in mean value of maximum clench force of dominant arm between male and female. Significant difference in mean time to fatigue of dominant arm between male and female.

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed	Paired sample T-Test / Two-sampled T-Test

Result

Parameters	Values
P-value	0.000
μ Male Dominant Arm Max Clench Force (kgf/m^2)	5884
μ Female Dominant Arm Max Clench Force (kgf/m^2)	3641
σ Integrated EMG Male Dominant	1781
σ Integrated EMG female Dominant	1143

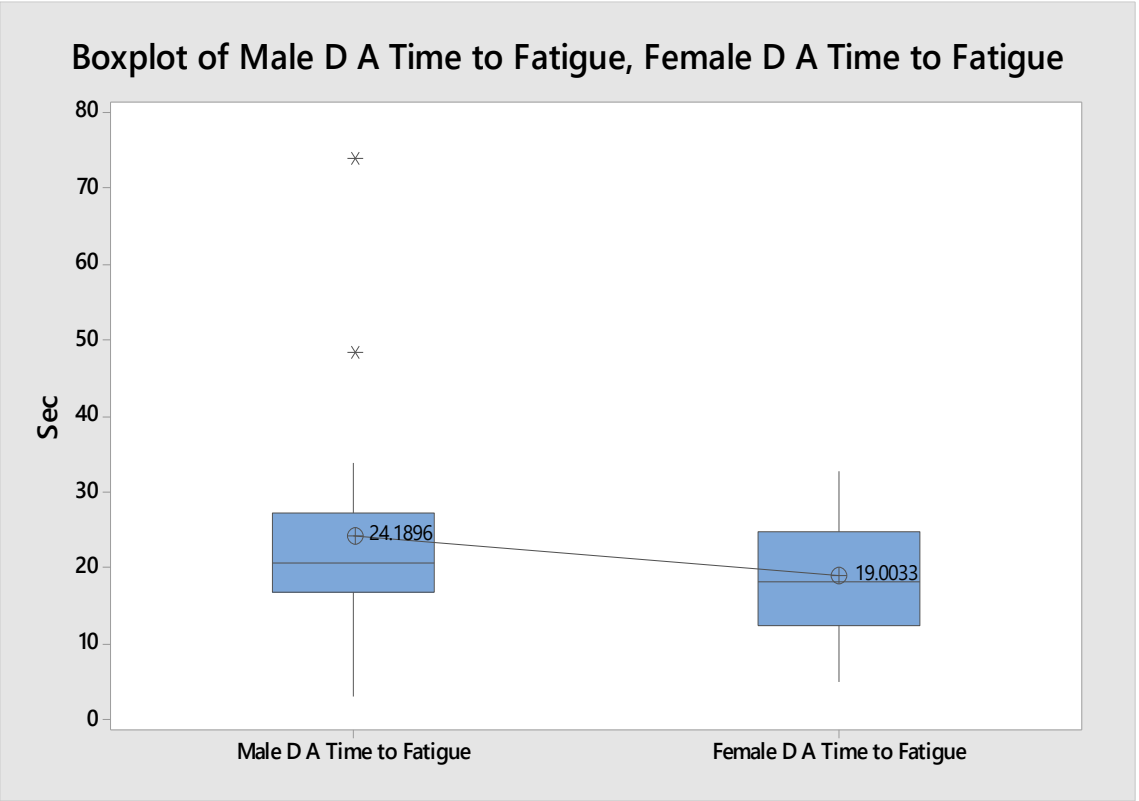


SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

Result

Parameters	Values
P-value	0.288
μ Male Dominant Arm time to fatigue (Sec)	24.2
μ Female Dominant Arm time to fatigue (Sec)	19
σ Male Dominant Arm time to fatigue	17.2
σ Female Dominant Arm time to fatigue	8.20



NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

DISCUSSION

- Significant change in clench force between male and female.
- Blood lactate concentration increase performance in men.
- But requirement of less muscle oxygen, neuromuscular efficiency, utilizing fat efficiently, estrogen increase resistance to fatigue for women.
- Men can produce more power but Women can recover faster.
- Environmental factors, muscle-fiber composition, sample size, physical strength, concentration of the subjects influence result.

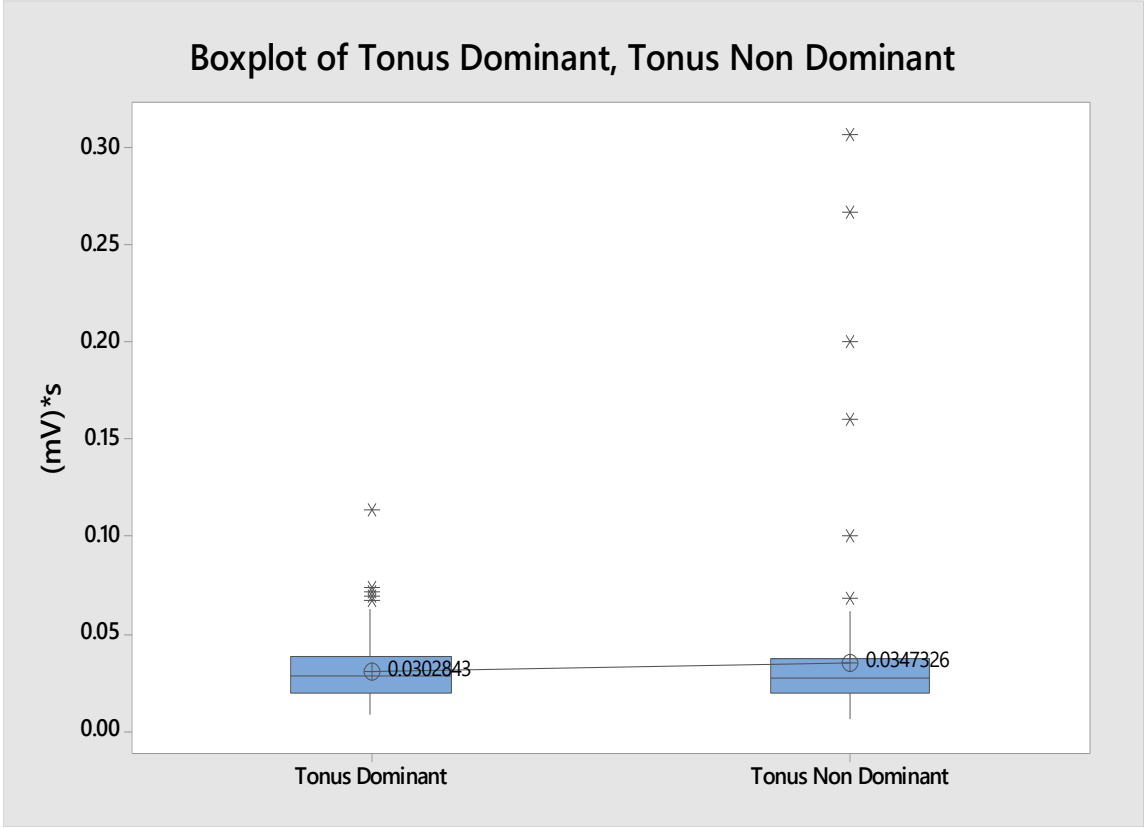
Effect of hand dominance on tonus measurements and fatigue

Null Hypothesis	Alternative Hypothesis
No Significant difference in mean value of tonus measurement between dominant hand and non dominant hand No Significant difference in mean time to fatigue between dominant hand and non dominant hand	Significant difference mean value of tonus measurement between dominant hand and non dominant hand Significant difference in mean time to fatigue between dominant hand and non dominant hand

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed	Paired sample T-Test / Two-sampled T-Test

Result

Parameters	Values
P-value	0.176
μ Tonus Dominant (mV)*s	0.03028
μ Tonus Non-Dominant (mV)*s	0.03473
σ Tonus Dominant	0.01512
σ Tonus Non-Dominant	0.03796

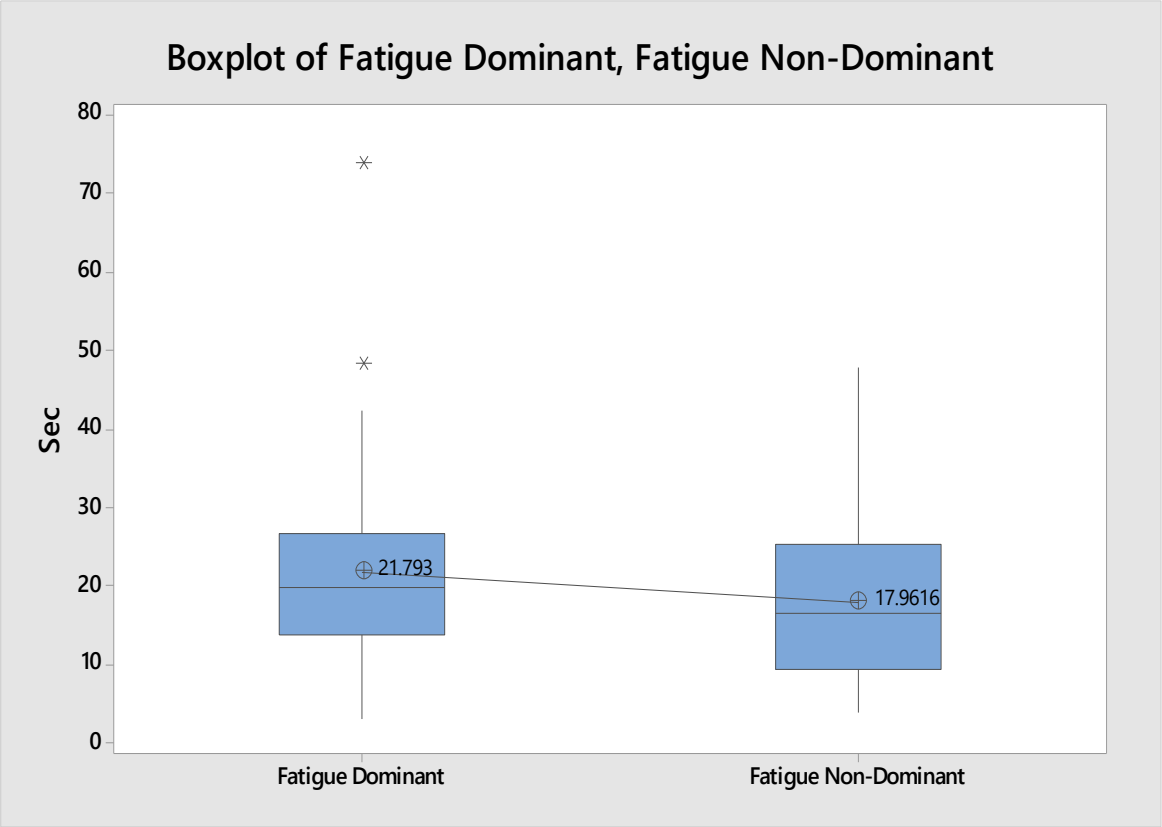


NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

Result

Parameters	Values
P-value	0.014
μ Fatigue Dominant (Sec)	21.79
μ Fatigue Non-Dominant (Sec)	17.96
σ Fatigue Dominant	13.78
σ Fatigue Non-Dominant	10.66



SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

DISCUSSION

- Tonus measurement is the measure of low level activity to maintain constant tension and to keep the muscles ready, hence it doesn’t have effect on hand dominance.
- Fiber synthesize more myofilaments, increasing strength.
- Day to Day activities also impact endurance.

Effect of body position & state on heart rate (supine, seated, start of inhale, start of exhale, after exercise)

Null Hypothesis	Alternative Hypothesis
No significant difference in heart rate when the body position is Supine vs Seated. No significant difference in heart rate during Start of Inhale vs Start of Exhale. No significant difference in heart rate after exercise for Male and Female	Significant difference in heart rate when the body position is Supine vs Seated. Significant difference in heart rate during Start of Inhale vs Start of Exhale. Significant difference in heart rate after exercise for Male and Female

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 30)	Paired sample T-Test / Two-sampled T-Test

Results

HR SUPINE VS SEATED

Parameters	Values
P-value	0.0000
μ DURING SUPINE (BPM)	76.28
μ DURING SEATED (BPM)	84.74
σ DURING SUPINE	12.94
σ DURING SEATED	15.29

SIGNIFICANT
Reject Null Hypothesis in favor of Alternative Hypothesis

HR DURING INHALE VS EXHALE

Parameters	Values
P-value	0.0000
μ DURING INHALE (BPM)	85.77
μ DURING EXHALE (BPM)	75.16
σ DURING INHALE	13.59
σ DURING EXHALE	14.30

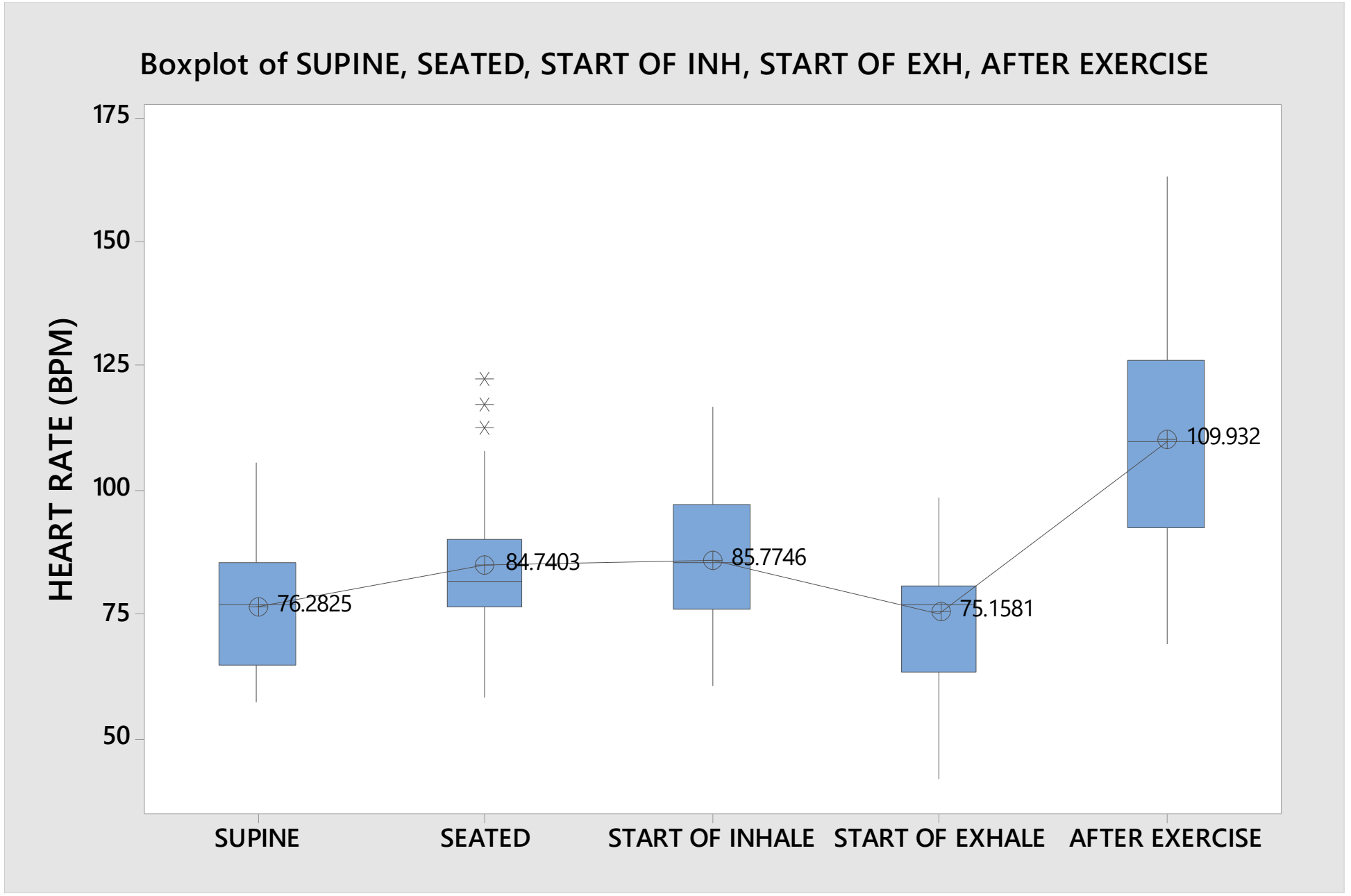
SIGNIFICANT
Reject Null Hypothesis in favor of Alternative Hypothesis

HR FEMALE VS MALE

Parameters	Values
P-value	0.624
μ of Female	111.9
μ of Male	107.9
σ of Female	26.6
σ of Male	16.4

NOT SIGNIFICANT
Reject Alternative Hypothesis in favor of Null Hypothesis

BOX PLOT OF SUPINE, SEATED, START OF INHALATION, START OF EXHALATION, AFTER EXERCISE



Discussion

- Heart Rate is more when the human body is seated when compared to Supine position. The effect of gravity influences the heart rate to increase.
- When lying down more blood returns to hear thus the body will pump more blood per beat where there will only be less beats per minute which is sufficient enough to satisfy body's blood demand. Sudden increase in Heart rate when moved from supine.
- Heart rate is higher for Inhalation and lower for Exhalation. During Inhalation lung need more blood for expanding, which makes the heart to pump more and thus increases the Heart rate.
- No significant change in heart rate for Male and Female after exercise.

Effect of gender and exercise on FEV and MVV.

Null Hypothesis	Alternative Hypothesis
No significant difference in FEV1 for Male and Female	Significant difference in FEV1 for Male and Female
No significant difference in FEV1 for person doing vs not doing regular exercises	Significant difference in FEV1 for person doing vs not doing regular exercises
No significant difference in MVV for Male and Female	Significant difference in MVV for Male and Female
No significant difference in MVV for person doing vs not doing regular exercises	Significant difference in MVV for person doing vs not doing regular exercises

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 11)	Two-sampled T-Test

Results

FEV1% GENDER

Parameters	Values
P-value	0.057
μ FEMALE (%)	44.8
μ MALE (%)	24.2
σ FEMALE	26.3
σ MALE	18.4

SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

FEV1% EXERCISE

Parameters	Values
P-value	0.039
μ NO (%)	47.0
μ YES (%)	26.6
σ FEMALE	23.7
σ MALE	19.2

SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

MVV GENDER

Parameters	Values
P-value	0.548
μ FEMALE (liters/min)	43.3
μ MALE (liters/min)	38.8
σ FEMALE	17.6
σ MALE	15.5

NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

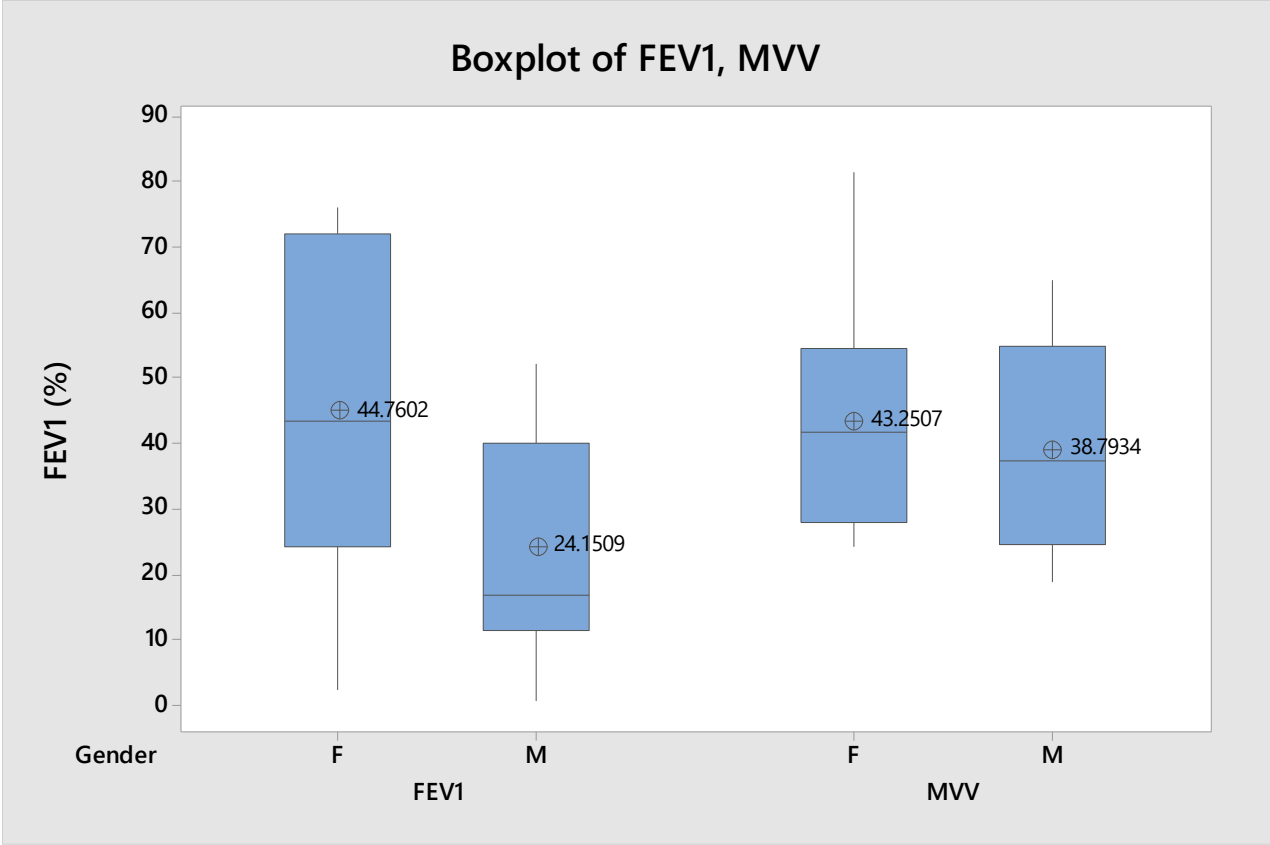
MVV EXERCISE

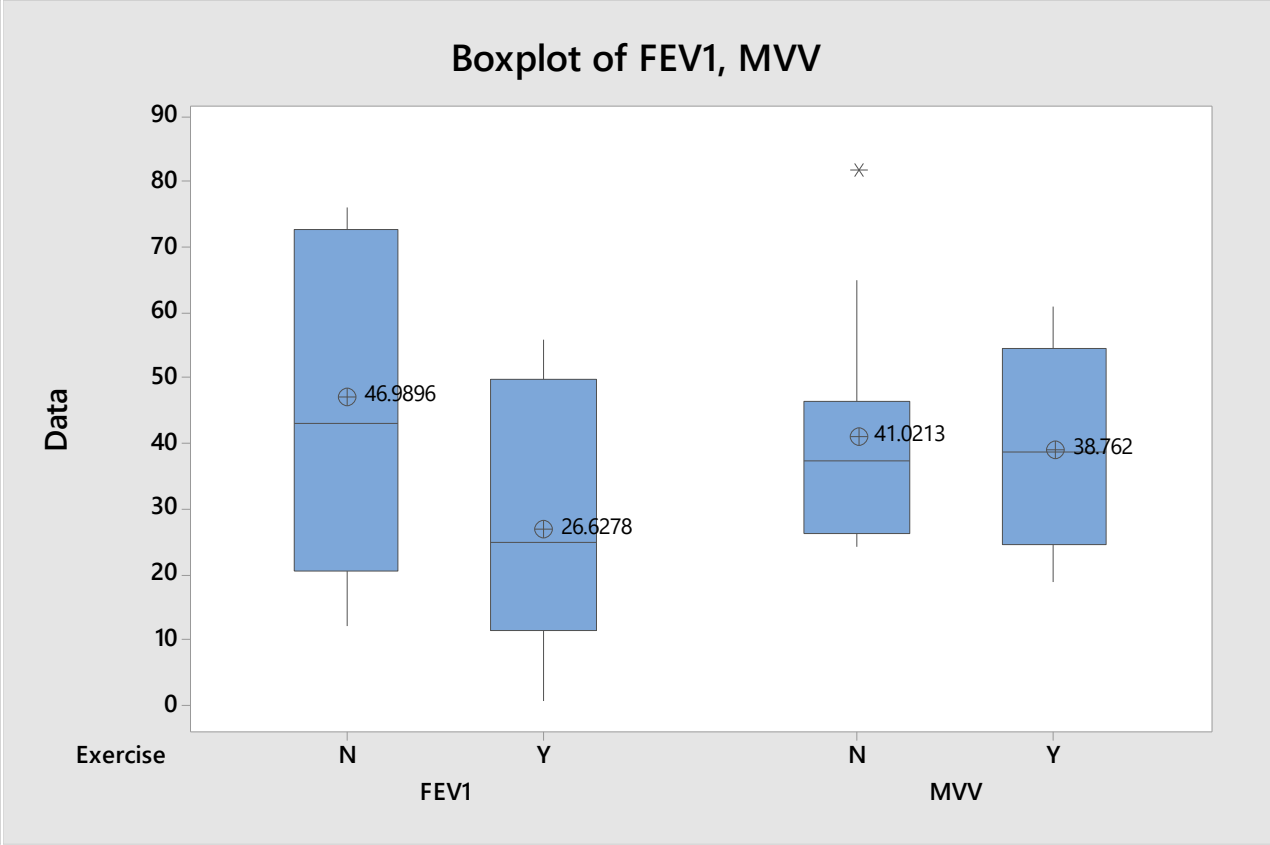
Parameters	Values
P-value	0.749
μ NO (liters/min)	41.0
μ YES (liters/min)	38.8
σ FEMALE	17.9
σ MALE	14.6

NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

BOX PLOT OF FEV1, MVV FOR MALE AND FEMALE & EXERCISING AND NON-EXERCISING





Discussion

- FEV is more for Female when compared to Male. FEV is Forced expiratory volume which is the amount of air exhale during a forced breath. Female's heart rate is normally higher than Male. To maintain the rate, Female expire and inhale more volume of air out and in.
- FEV is less for those subjects who do regular exercise when compared to those who are not doing regularly. Factors that influences FEV are fat-free mass, chest difference and power of respiratory muscles.
- There is no significant change in the case of MVV across the subject and across the regular exercise group. But physiologically, there has to be significant change as in the case of exercise group, there will be more bronchodilation which decreases the resistance to the respiratory pathway and increase flow.

Effect of gender and exercise on lung capacities.

Null Hypothesis	Alternative Hypothesis
No significant difference in TLC for Male and Female	Significant difference in TLC for Male and Female
No significant difference in TLC for person doing vs not doing regular exercises	Significant difference in TLC for person doing vs not doing regular exercises
No significant difference in VC for Male and Female	Significant difference in VC for Male and Female
No significant difference in VC for person doing vs not doing regular exercises	Significant difference in VC for person doing vs not doing regular exercises

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 12)	Two-sampled T-Test

Results

TLC GENDER

Parameters	Values
P-value	0.192
μ FEMALE (L)	2.961
μ MALE (L)	3.56
σ FEMALE	0.892
σ MALE	1.06

NOT SIGNIFICANT
Reject Alternative Hypothesis in favor of Null Hypothesis

TLC EXERCISE

Parameters	Values
P-value	0.353
μ NO (L)	3.46
μ YES (L)	3.053
σ NO	1.16
σ YES	0.631

NOT SIGNIFICANT
Reject Alternative Hypothesis in favor of Null Hypothesis

VC GENDER

Parameters	Values
P-value	0.063
μ FEMALE (L)	1.701
μ MALE (L)	2.446
σ FEMALE	0.771
σ MALE	0.959

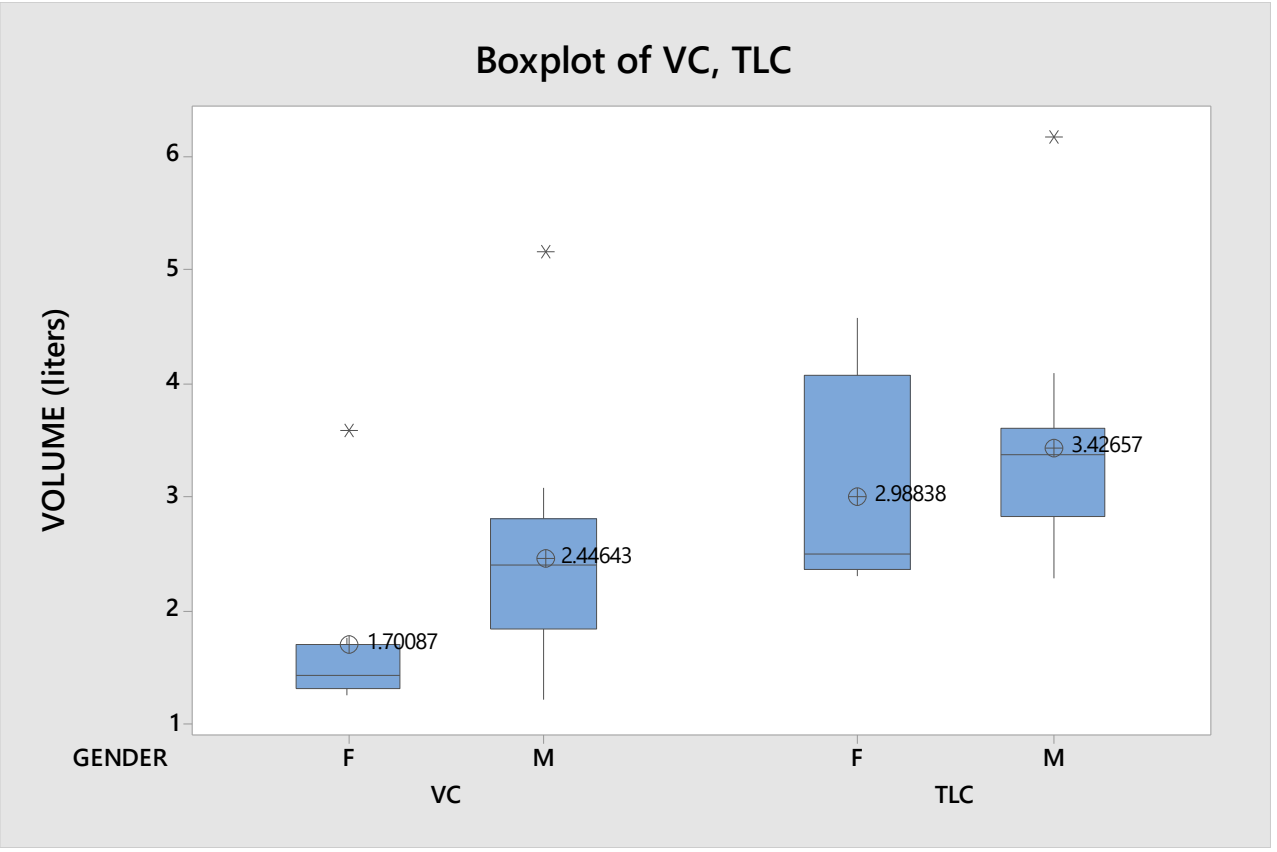
SIGNIFICANT
Reject Null Hypothesis in favor of Alternative Hypothesis

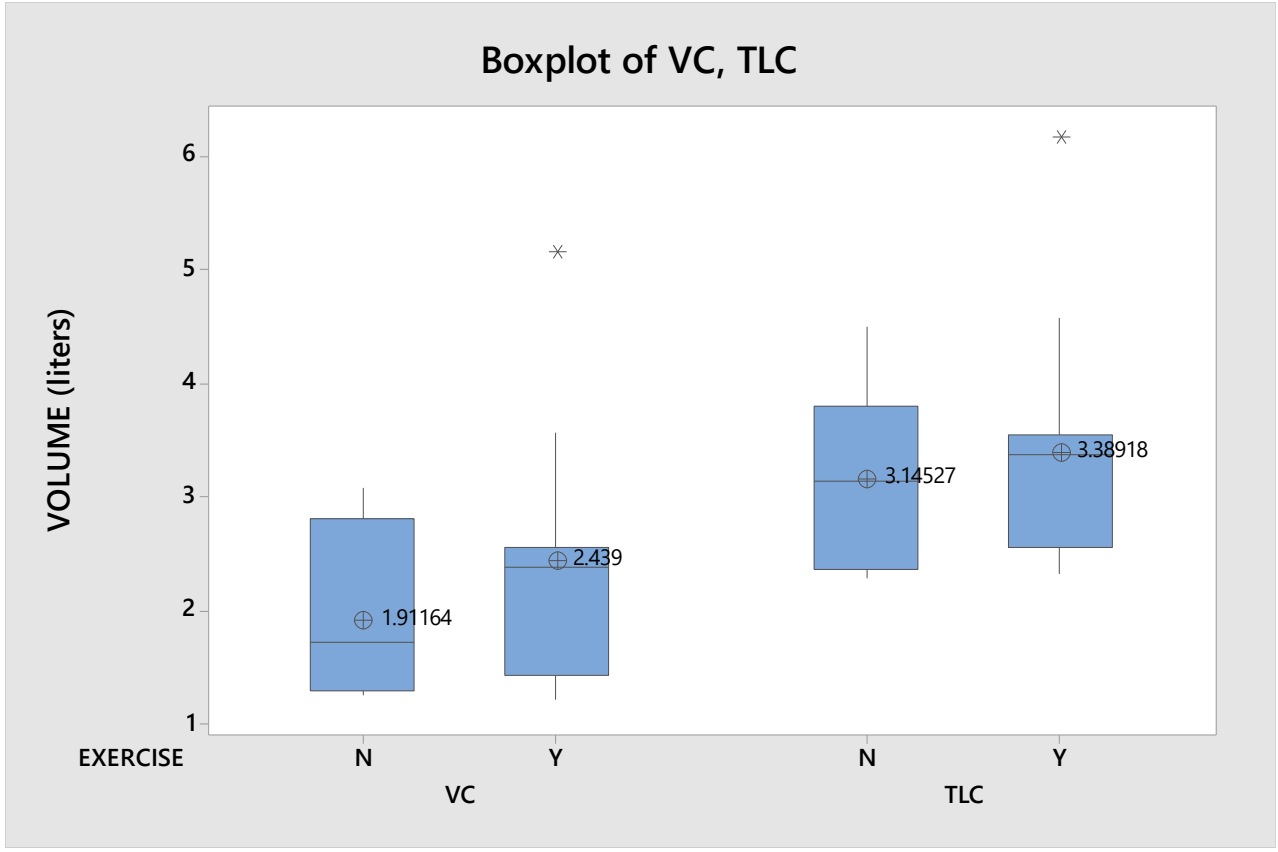
VC EXERCISE

Parameters	Values
P-value	0.204
μ NO (L)	1.919
μ YES (L)	2.44
σ NO	0.694
σ YES	1.12

NOT SIGNIFICANT
Reject Alternative Hypothesis in favor of Null Hypothesis

BOX PLOT OF VC AND TLC FOR GENDER AND EXERCISE





Discussion

- TLC has no significant change across the gender. But the mean value of Male is more when compared to female. TLC depends on body weight, fat content, force of respiratory muscles. As males normal weight high than female, TLC is more in the case of female
- TLC has no significant change across the exercising group.
- VC for Male is more when compared to Female. Total lung volume of male is more when compared to female which makes them to take in more air than female.
- VC in the case of TLC has no significant change across the exercising group.

Effect of fasting/non-fasting on EGG signals

Null Hypothesis	Alternative Hypothesis
No significant differences in amplitude and frequency before and after intake in fasting and non fasting subjects	There is significant differences in amplitude and frequency before and after intake in fasting and non fasting subjects

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 30)	Paired sample T-Test / Two-sampled T-Test

Result

Freq. baseline (NF) Vs. Freq. after Intake (NF)

Sample	N	Mean(Hz)	StDev(Hz)
Freq. baseline (NF)	11	0.036753	0.016397
Freq. after Intake (NF)	11	0.038752	0.013698
P value α =0.1	0.7>0.1	Insignificant Diffrences	

Freq. baseline (F) Vs. Freq. after Intake (F)

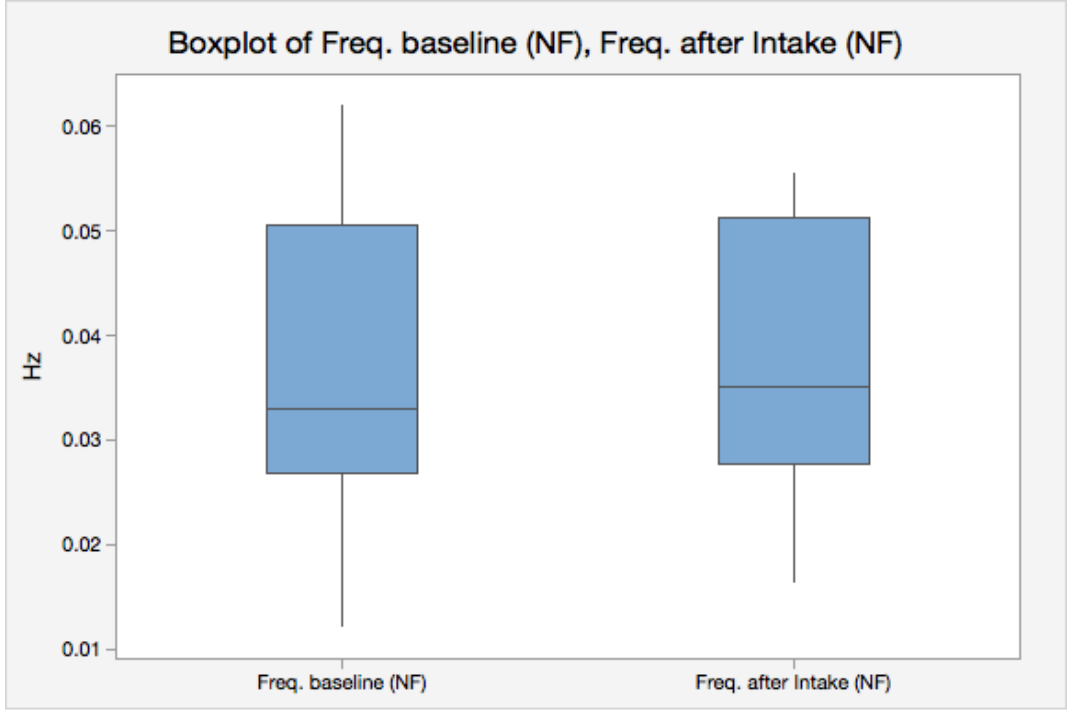
Sample	N	Mean	StDev
Freq. baseline (F)	11	0.031716	0.012191
Freq. after Intake (F)	11	0.037996	0.014090
P value α =0.1	0.2>0.1	**Insignificant Diffrences**	

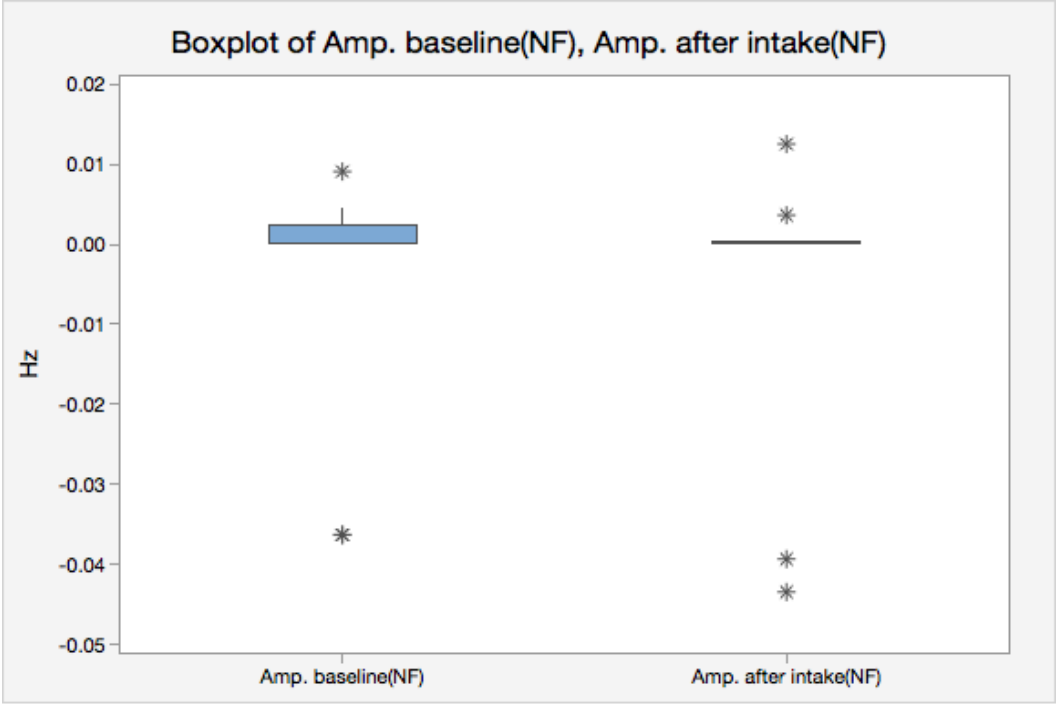
Amp baseline (NF) Vs Amp after Intake (NF)

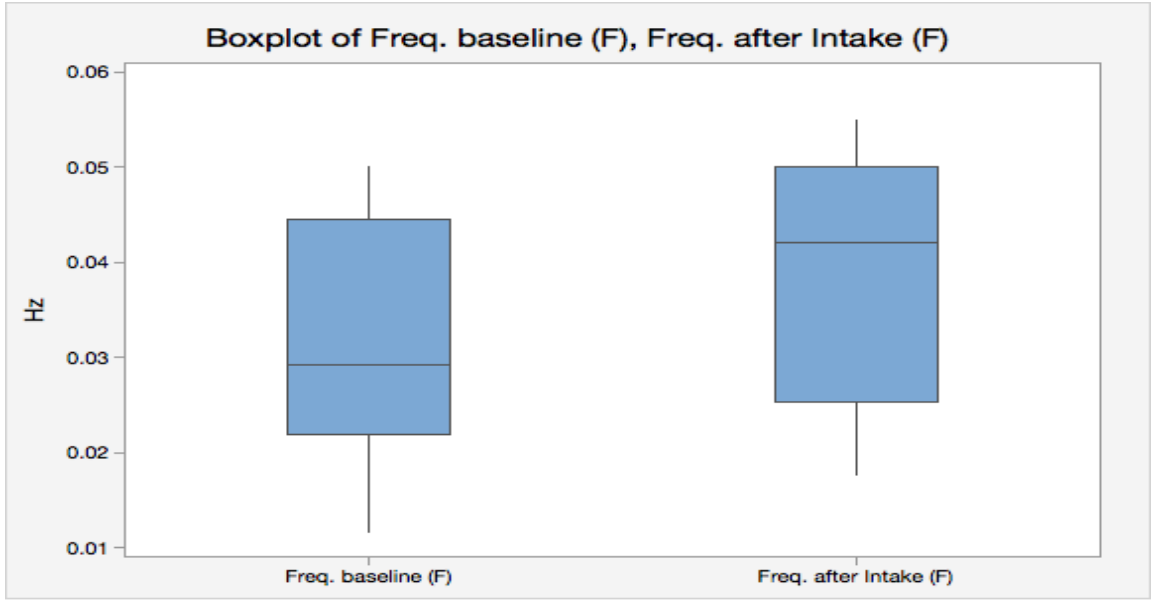
Sample	N	Mean	StDev
Amp. baseline(NF)	11	-0.005096	0.015655
Amp. after intake(NF)	11	-0.006002	0.017881
P value α =0.1	0.31>0.1	**Insignificant Diffrences**	

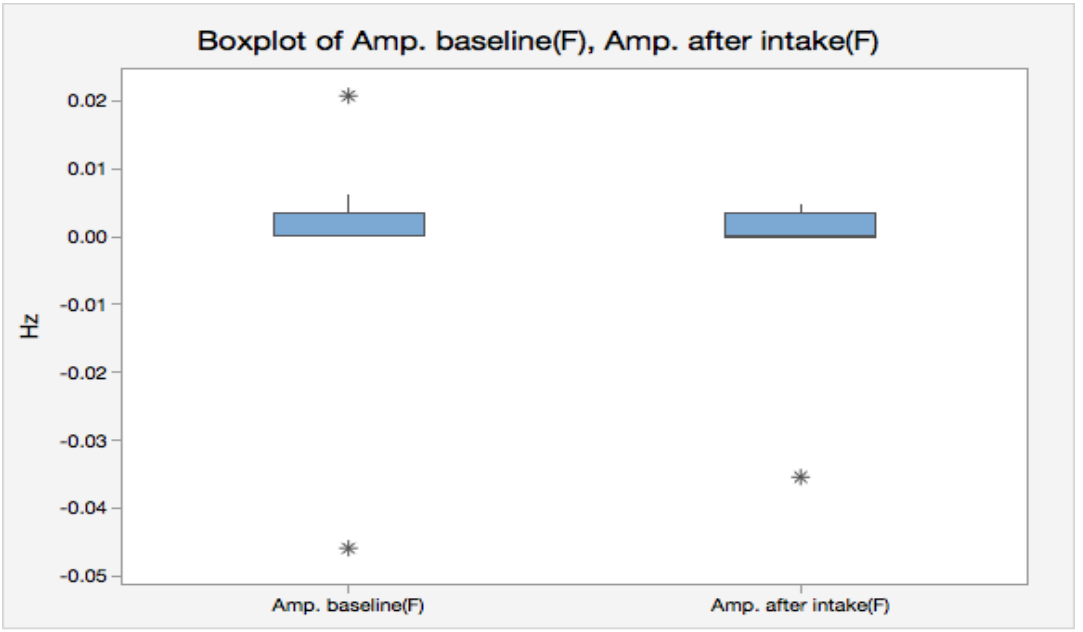
Amp baseline (F) Vs Amp after Intake (F)

Sample	N	Mean	StDev
Amp. baseline(F)	11	-0.001370	0.016027
Amp. after intake(F)	11	-0.002081	0.011206
P value α =0.1	0.7 >0.1	**Insignificant Diffrences**	


Boxplot of Freq. baseline (NF), Freq. after Intake (NF)
Hz
0.06
0.05
0.04
0.03
0.02
0.01
Freq. baseline (NF)
Freq. after Intake (NF)


Boxplot of Amp. baseline(NF), Amp. after intake(NF)
Hz
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
Amp. baseline(NF)
Amp. after intake(NF)


Boxplot of Freq. baseline (F), Freq. after Intake (F)
Hz
0.06
0.05
0.04
0.03
0.02
0.01
Freq. baseline (F)
Freq. after Intake (F)


Boxplot of Amp. baseline(F), Amp. after intake(F)
Hz
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
Amp. baseline(F)
Amp. after intake(F)

Discussion

- From researches subject who consumed fluid have lower frequency and amplitude
- Amount and type of consumed intake can effect the frequency (not enough calories to increase frequency significantly
- Number of electrode used not enough for accurate measuring
- Number of subjects
- Signals get interfaces with by respiration signals and cardio signals.

Analysis of ECG signal amplitude and frequency changes after exercise.

Null Hypothesis	Alternative Hypothesis
No significant differences in amplitude and frequency before and after intake in fasting and non fasting subjects	There is significant differences in amplitude and frequency before and after intake in fasting and non fasting subjects

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 30)	Paired sample T-Test / Two-sampled T-Test

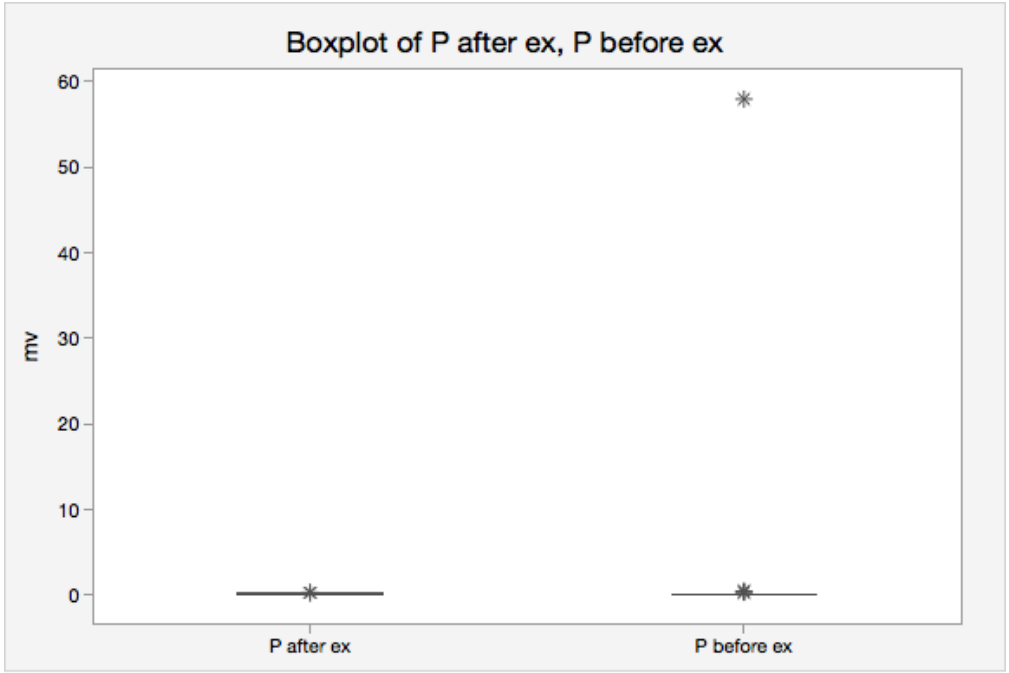
Result

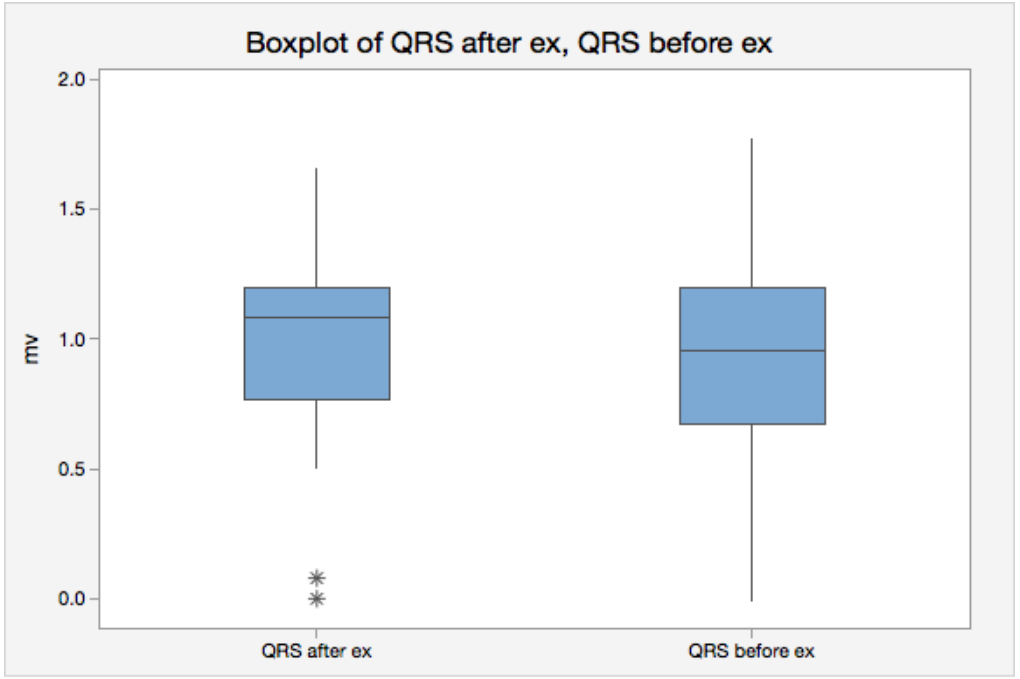
Descriptive Statistics for ECG Amplitude P,QRS and T waves before and after exercise		
Sample	Mean	StDev
P before ex	2.210	10.928
P after ex	0.158	0.061
QRS before ex	0.90255	0.41014
QRS after ex	0.98873	0.37609
T before ex	0.20281	0.09203
T after ex	0.19261	0.08369
Descriptive Statistics for ECG Frequency P,QRS and T waves before and after exercise		
Sample	Mean	StDev
P before	0.1512	0.7789
P after	0.0139	0.0125
QRS before	0.5564	3.0424
QRS after	0.0144	0.0139
T before	0.2713	1.4709
T after	0.0123	0.0213

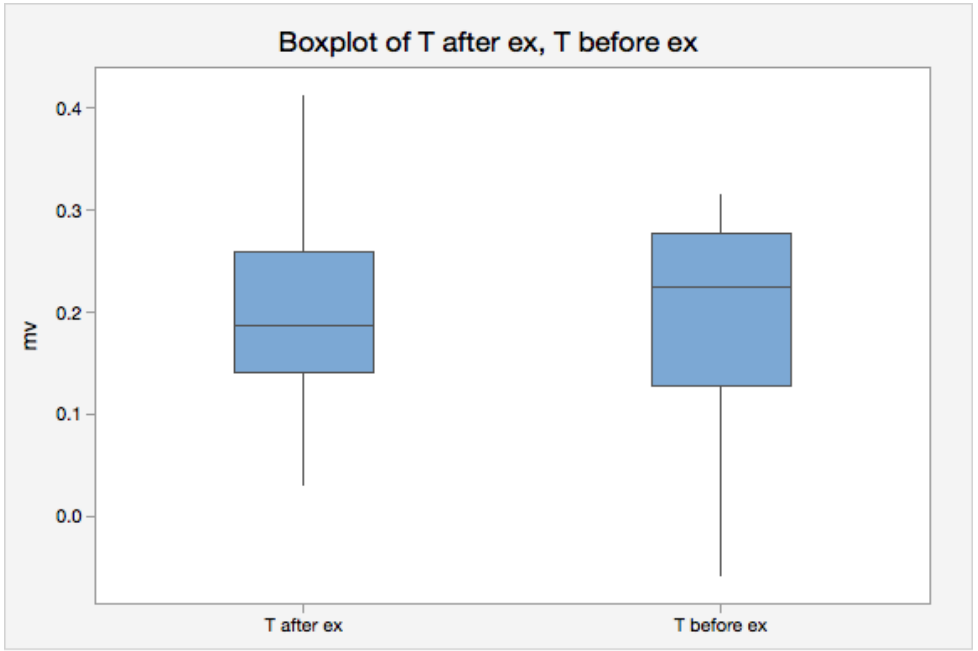
Result

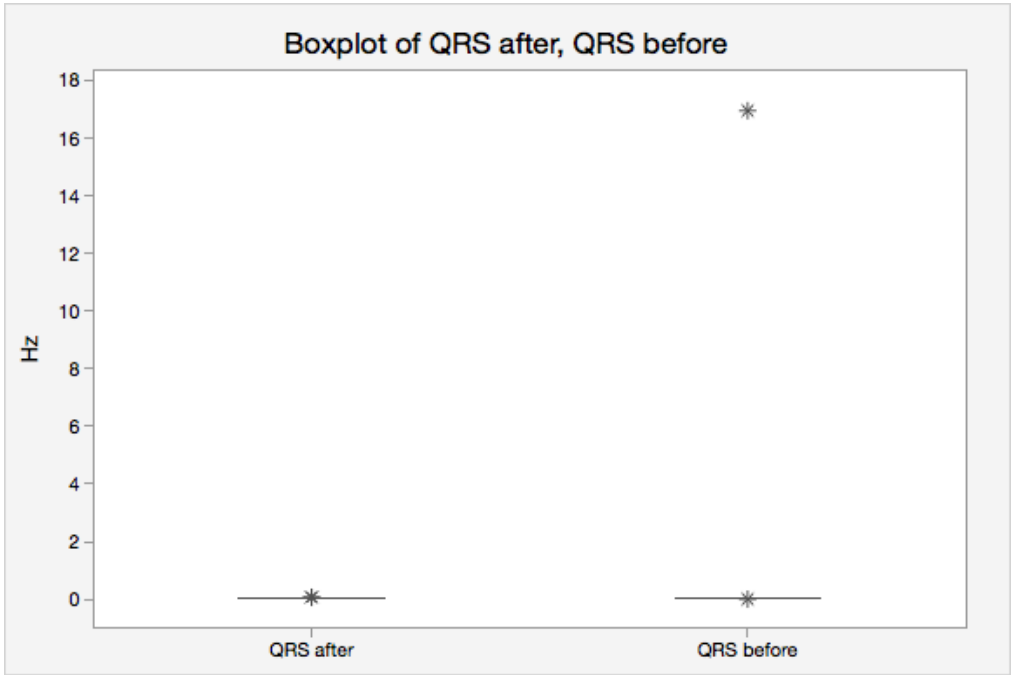
Frequency		
P before vs P after	P=0.3	Insignificant
QRS Before vs QRS after	P=0.3	Insignificant
T before vs after	P=0.3	Insignificant

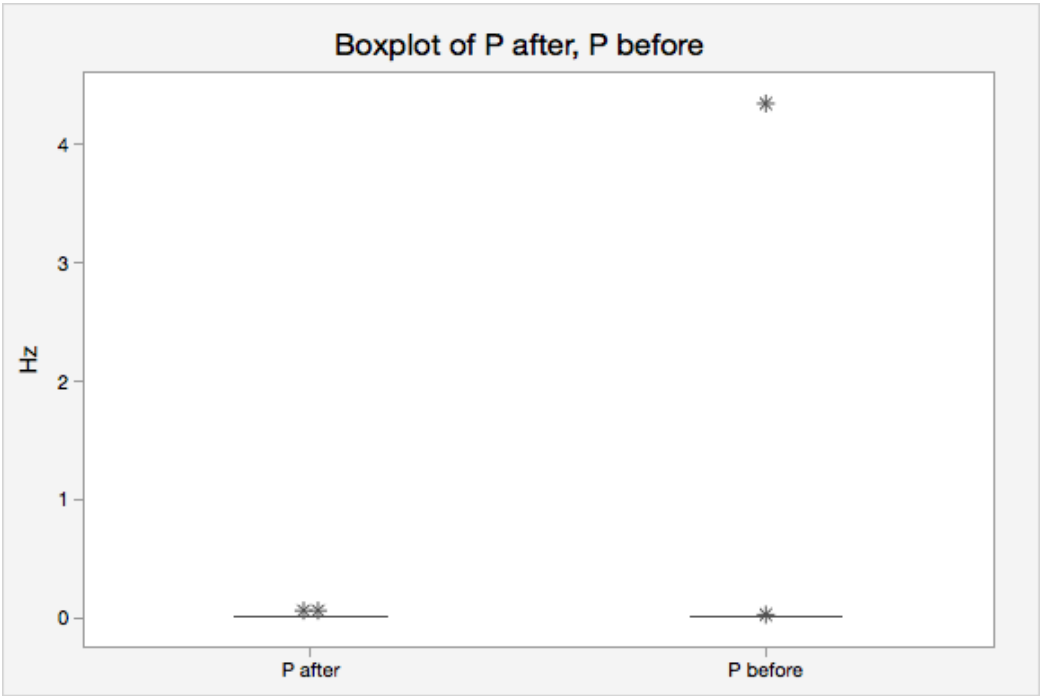
Amplitude		
P before vs P after	P=0.3	Insignificant
QRS Before vs QRS after	P=0.4	Insignificant
T before vs after	P=0.6	Insignificant

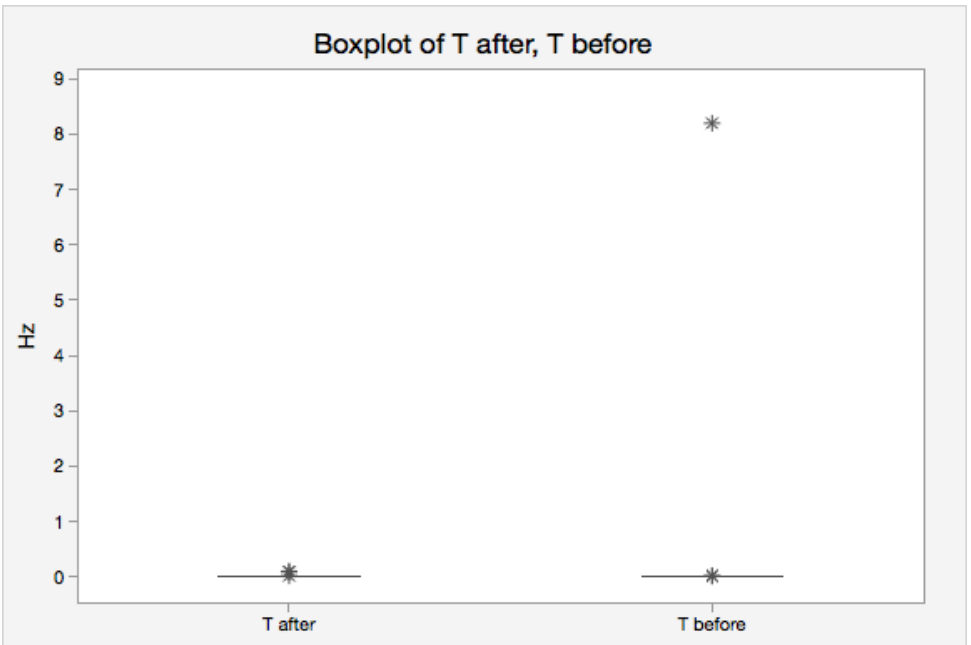

Boxplot of P after ex, P before ex
mv
60
50
40
30
20
10
0
P after ex
P before ex


Boxplot of QRS after ex, QRS before ex
mv
2.0
1.5
1.0
0.5
0.0
QRS after ex
QRS before ex


Boxplot of T after ex, T before ex
mv
0.4
0.3
0.2
0.1
0.0
T after ex
T before ex


Boxplot of QRS after, QRS before
Hz
18
16
14
12
10
8
6
4
2
0
QRS after
QRS before


Boxplot of P after, P before
Hz
4
3
2
1
0
P after
P before


Boxplot of T after, T before
Hz
9
8
7
6
5
4
3
2
1
0
T after
T before

Discussion

- heart rate increases linearly with exercise intensity up to the maximum heart rate T-test results showed insignificant changes in frequency and amplitude before and after exercise that confirm the null hypothesis
- Exercises performed in lab was not enough to make significant change in the heart rate readings
- To study ECG signal post exercise it is better to add S-T segment changes and Q-T intervals
- Identification of a P wave may be difficult at high heart rates during exercise because the P wave may be superimposed on the T wave of consecutive beats.

Respiratory rate and heart rate during and after moderate exercise. Explain the physiological basis of the observed changes.

Null Hypothesis	Alternative Hypothesis
No significant differences in Respiratory rate during and after moderate exercise	There is significant differences in Respiratory rate during and after moderate exercise
No significant differences in Heart rate during and after moderate exercise	There is significant differences in Herat rate during and after moderate exercise

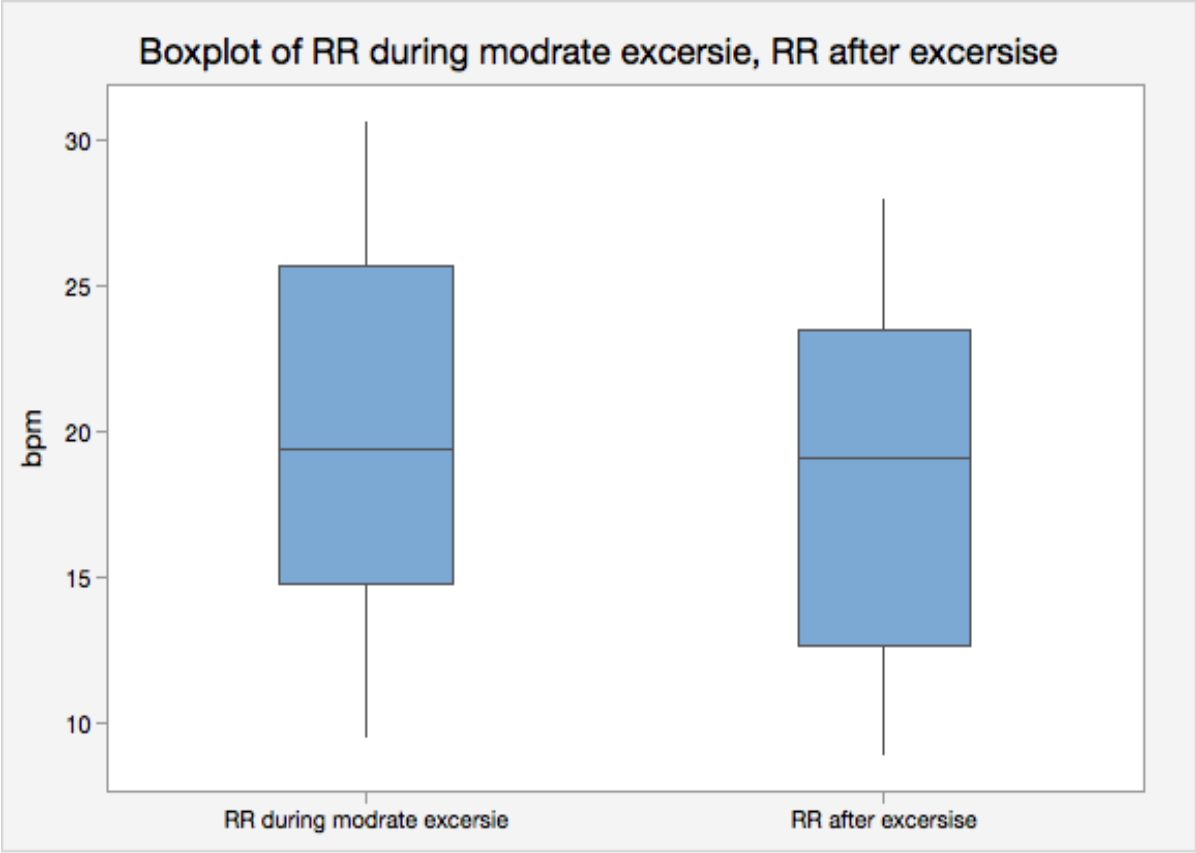
Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 30)	Paired sample T-Test / Two-sampled T-Test

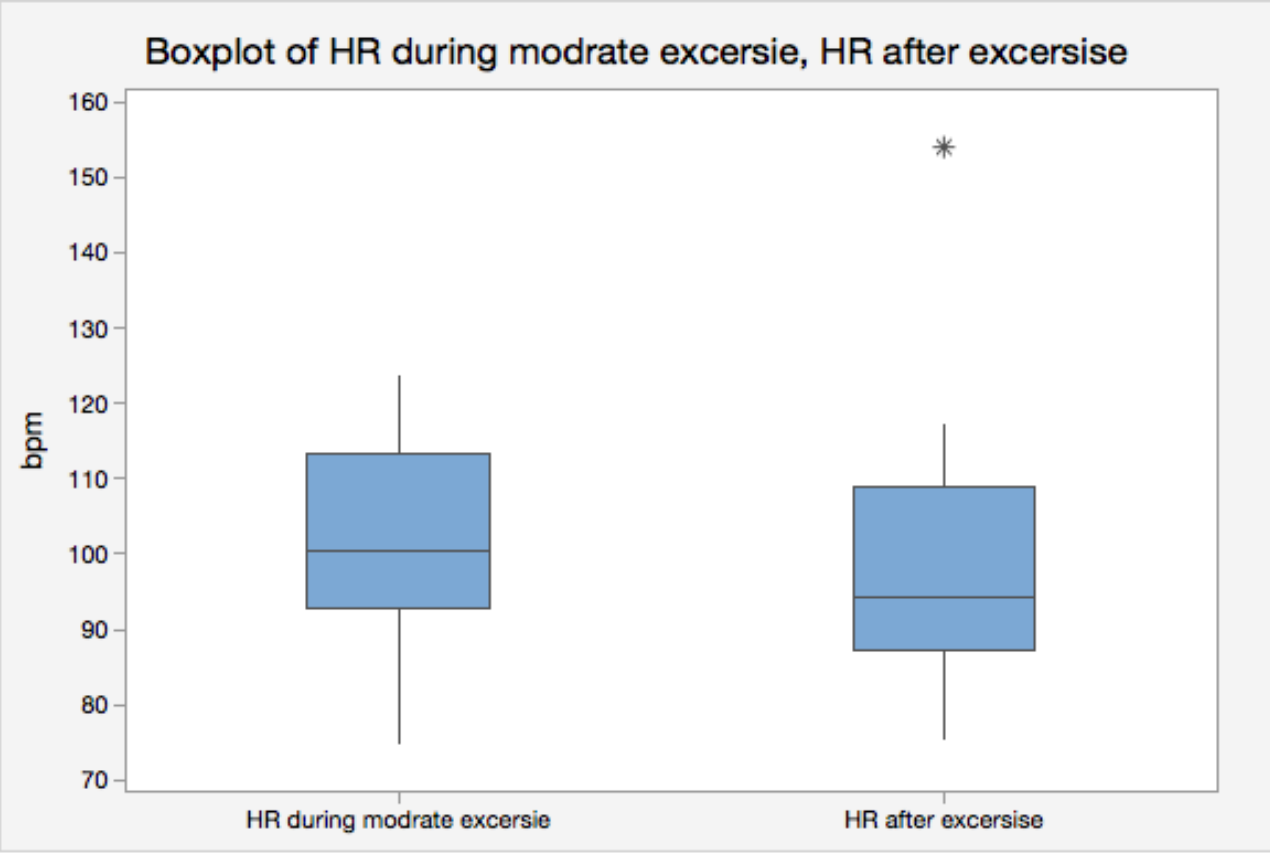
Heart Rate during and after moderate exercise Descriptive Statistics		
Sample	Mean	StDev
HR during moderate exercise	101.160	13.223
HR after exercise	98.925	16.973

Heart Rate during and after moderate exercise Descriptive Statistics		
Sample	Mean	StDev
RR during moderate exercise	20.323	6.255
RR after exercise	18.043	6.253

T-test results		
Respiration Rate during exercise vs after exercise	P=0.007	significant
Heart Rate during exercise vs after exercise	P=0.58	Insignificant

Result


Boxplot of RR during modrate excersie, RR after excersise
bpm
30
25
20
15
10
RR during modrate excersie
RR after excersise


Boxplot of HR during modrate excersie, HR after excersise
bpm
160
150
140
130
120
110
100
90
80
70
HR during modrate excersie
HR after excersise

Discussion

- Alternative hypothesis confirmed for respiratory rate
- Null hypothesis confirmed for heart rate
- During exercise heart rate and respiratory rate mean increases due to work load
- Mean shows that the heart rate and respiratory related
- Increasing workload will increase the consumption of oxygen where it will increase the heart rate.

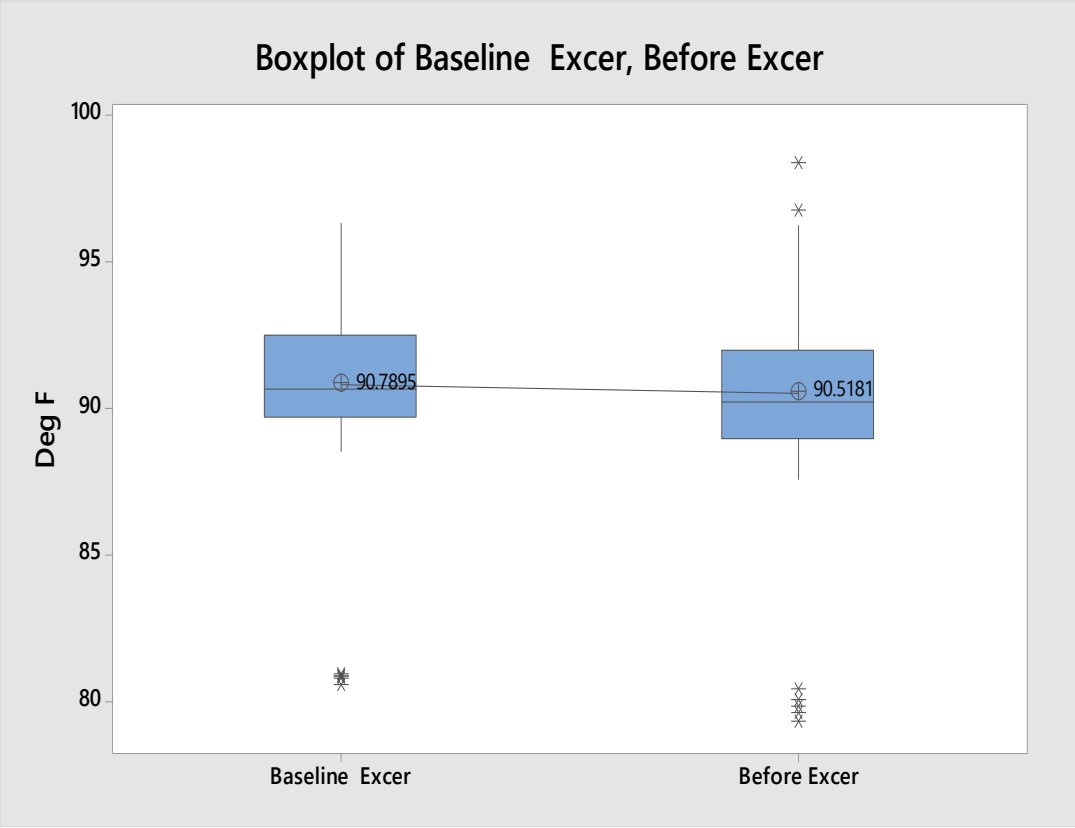
Skin temperature before, during and after exercise

Null Hypothesis	Alternative Hypothesis
No Significant difference in mean value of temperature between baseline and before exercise. No Significant difference in mean value of temperature between baseline and during exercise. No Significant difference in mean value of temperature between baseline and after exercise.	Significant difference in mean value of temperature between baseline and before exercise. Significant difference in mean value of temperature between baseline and during exercise. Significant difference in mean value of temperature between baseline and after exercise.

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed	Paired sample T-Test / Two-sampled T-Test

Result

Parameters	Values
P-value	0.138
μ Baseline (Deg F)	90.789
μ Before Exercise (Deg F)	90.518
σ Baseline	2.824
σ Before Exercise	3.330

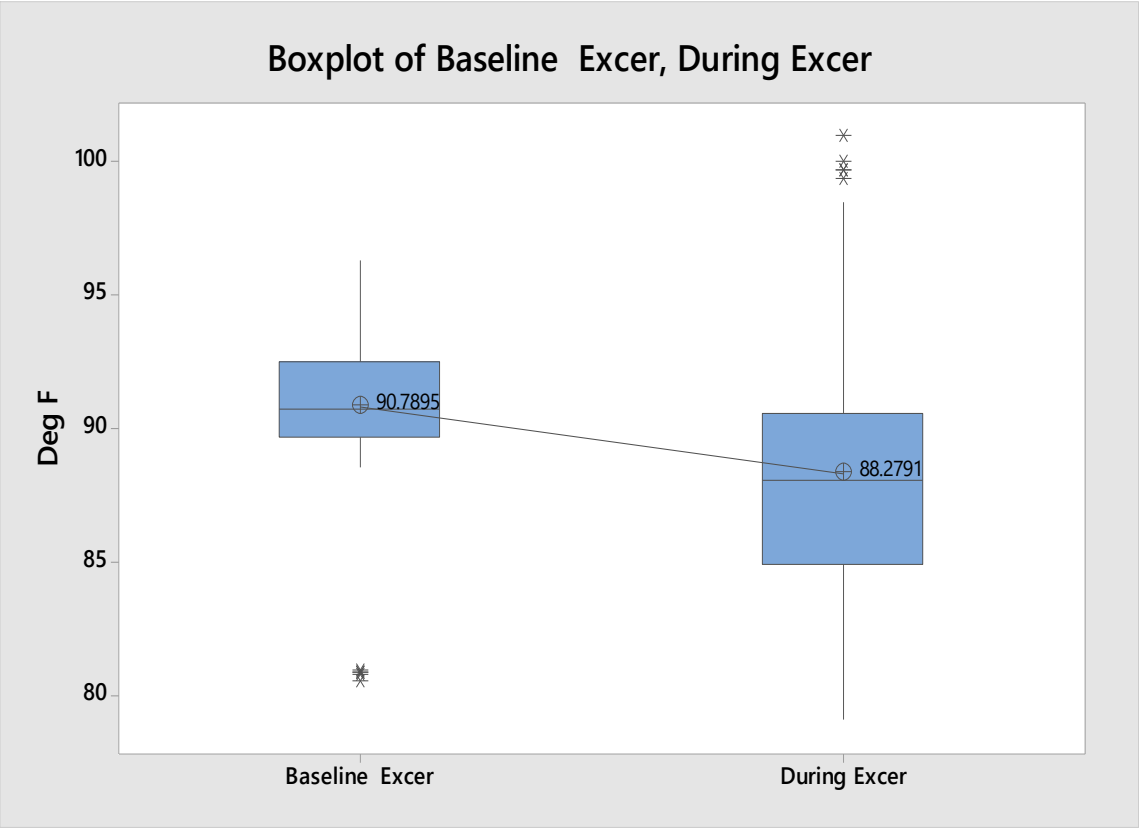


NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

Result

Parameters	Values
P-value	0.000
μ Baseline (Deg F)	90.789
μ During Exercise (Deg F)	88.279
σ Baseline	2.824
σ During Exercise	4.782

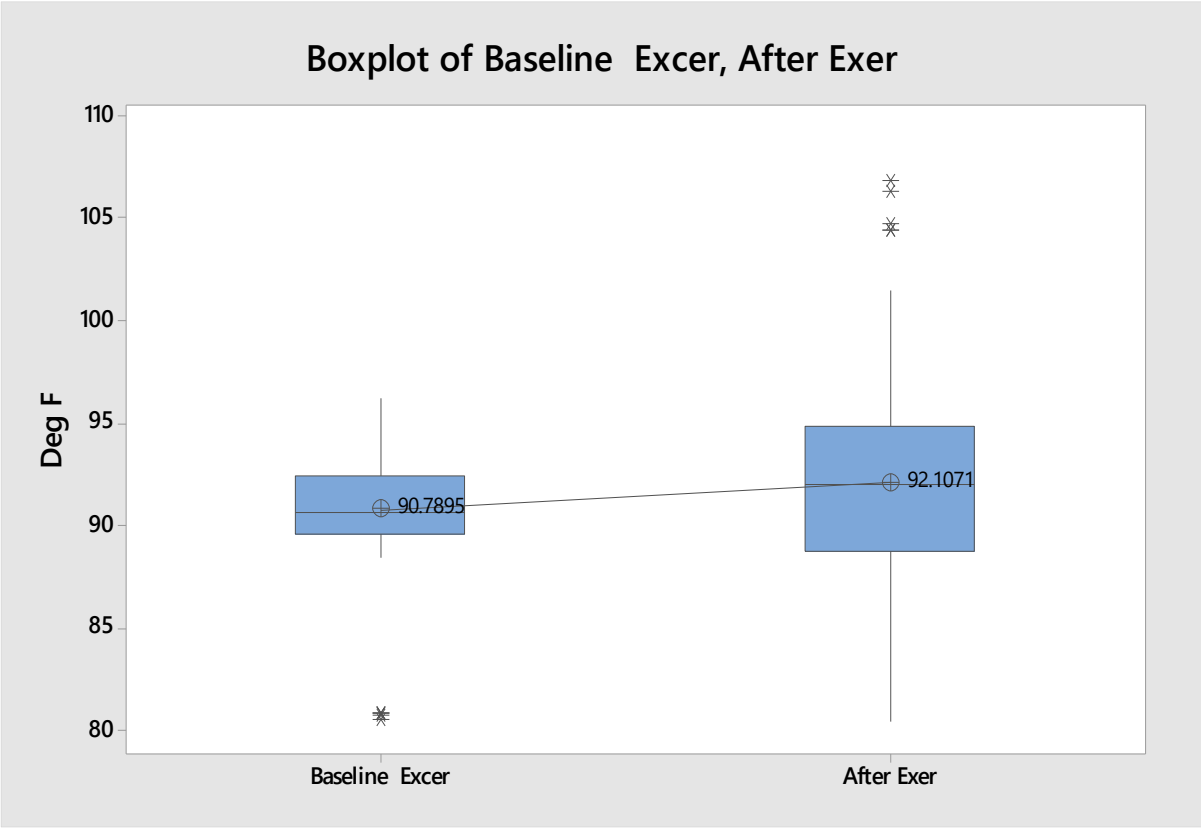


SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

Result

Parameters	Values
P-value	0.138
μ Baseline (Deg F)	90.789
μ After Exercise (Deg F)	92.107
σ Baseline	2.824
σ After Exercise	5.481



NOT SIGNIFICANT

Reject Alternative Hypothesis in favor of Null Hypothesis

DISCUSSION

- During exercise, increase in heart rate increase blood flow to skin and cools through sweat.
- Due to chemical reactions involve in burning carbohydrates, fats increases body temperature after exercise.
- The thermoregulation is based on time taken by body to loose heat.

Systolic and diastolic ECG signal responses to exercise.

Null Hypothesis	Alternative Hypothesis
No significant difference in SYSTOLE at Rest and After Exercise No significant difference in DIASTOLE at Rest and After Exercise	Significant difference in SYSTOLE at Rest and After Exercise Significant difference in DIASTOLE at Rest and After Exercise

Significance level	Assumption	Test performed
10% (0.10)	The data is normally distributed (sample size = 28)	Paired sample T-Test

Results

SYSTOLE AT REST VS AFTER EXERCISE

Parameters	Values
P-value	0.003
μ SYSTOLE REST (ms)	276.9
μ SYSTOLE AFTER EXERCISE (ms)	234.8
σ SYSTOLE REST	43.4
σ SYSTOLE AFTER EXERCISE	70.0

SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

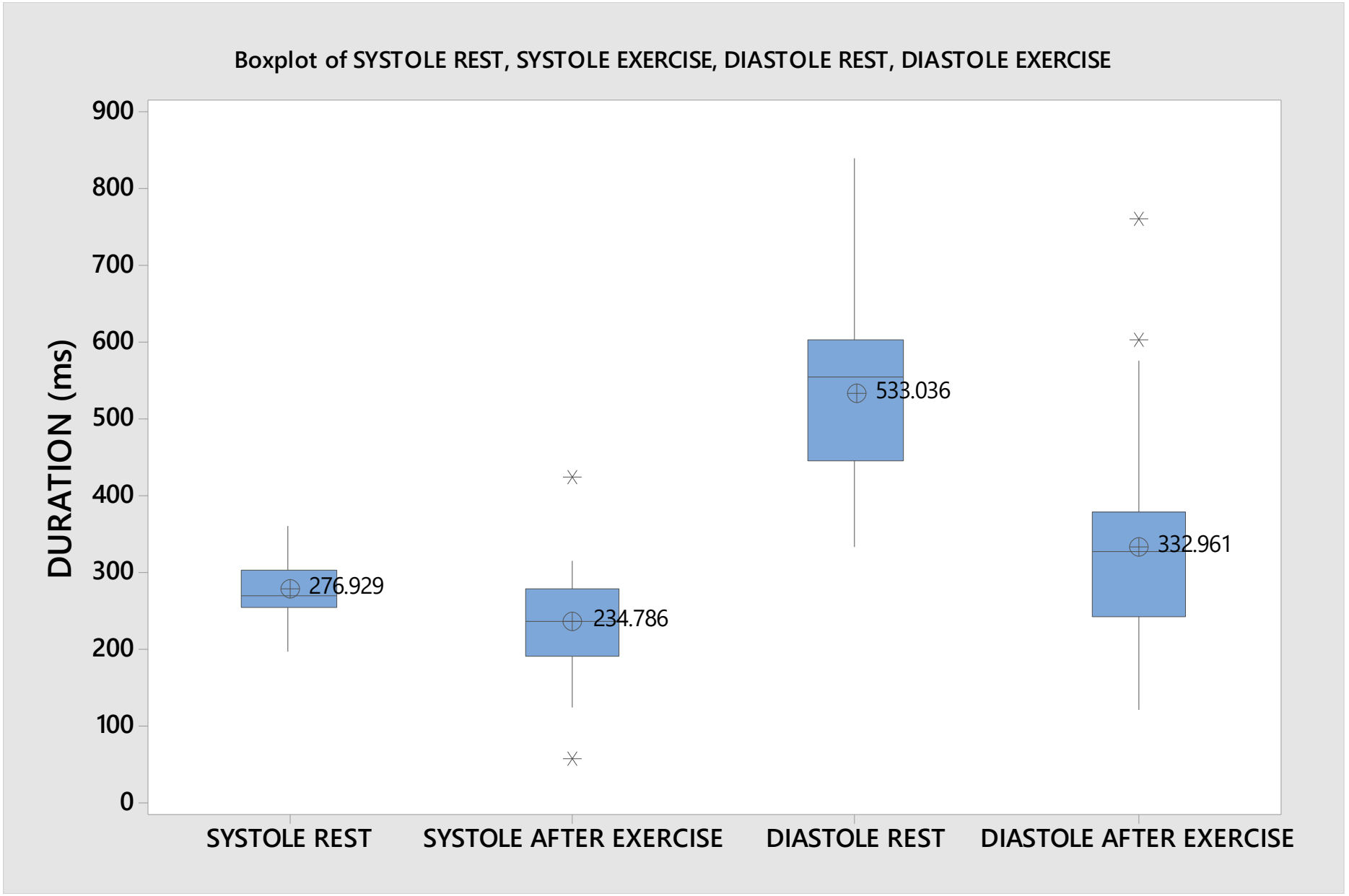
SYSTOLE AT REST VS AFTER EXERCISE

Parameters	Values
P-value	0.000
μ SYSTOLE REST (ms)	533.0
μ SYSTOLE AFTER EXERCISE (ms)	333.0
σ SYSTOLE REST	114.6
σ SYSTOLE AFTER EXERCISE	137.3

SIGNIFICANT

Reject Null Hypothesis in favor of Alternative Hypothesis

BOX PLOT OF SYSTOLE REST, SYSTOLE EXERCISE, DIASTOLE REST, DIASTOLE EXERCISE



Discussion

- There is a significant decrease in Systole After exercise when compared with the Resting state. During systole, the heart muscles takes to contract. After exercise body needs for oxygen increases which make the heart to beat faster which is possible when the muscles contracts faster. So Systolic duration decreases.
- There is a significant decreases in Diastole After exercise when compared with the Resting state. This is the similar case as above. Systole and Diastole is a rhythmic process where Diastole is the time the heart muscles takes to relax. As after exercise body needs more oxygen, blood flow need to be increased which is possible when heart muscle beats faster. So Diastolic duration decreases too.

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