ORIGINAL RESEARCH ARTICLE

Effect of Aerobic Exercise and Pranayama on Heart Rate Variability and Maximal Oxygen Consumption (VO2 Max) in Sedentary Middle Aged Males.

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Received Date: 2-2-2024 Revised Date: 14-3-2024 Accepted Date: 15-04-2024

Abstract:

VO2 max is the maximum rate of oxygen consumption attainable during physical exertion and widely used as an indicator of cardio-respiratory fitness. In this study, the benefits of pranayama on VO2 max, physical endurance and cardio-respiratory parameters are explored. We have screened 350 people by their age, physical activity, systemic illness, smoking and other habits following which 78 people included for this study. Subjects are apparently healthy, sedentary middle aged males in the age group 40-60 years. The subjects are divided into two groups i.e. Group A and Group B. Group A (n=39) receive aerobic exercise, Group B (n=39) receive structured pranayama practice 30 minutes a day for 5 days in a week for 12 weeks. VO2 max and HRV are measured at the end of 12 weeks. It is concluded that both aerobic exercise and pranayama is effective in raising the VO2 max value but comparison pranayama is the most effective in increasing the VO2 max value. Both aerobic exercise and pranayama is effective in improving the frequency domain indices but on comparison, pranayama is more effective in improving the frequency domain values.

Keywords: ***Maximum Rate Of Oxygen Consumption, Heart Rate.***

Introduction:

VO2 max is the maximum rate of oxygen consumption attainable during physical exertion and widely used as an indicator of cardio-respiratory fitness. It is expressed either as an absolute rate in litres of oxygen per minute (L/min) or as a relative rate in millilitres of oxygen per kilogram of body mass per minute (mL/kg·min). Aerobic refers to the use of oxygen to meet energy demands during exercise via aerobic metabolism adequately. Aerobic exercise is performed by repeating sequences of light-to-moderate intensity activities for extended periods of time. Memelink RG et al. evaluated the additional effect of aerobic exercise to hypocaloric diet on body weight, body composition, glycaemic control and cardio-respiratory fitness in adults with overweight or obesity and type 2 diabetes [1].

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How to cite this article:
Hariprasad R, Prabhu N & Karishma S. Effect of Aerobic Exercise and Pranayama on Heart Rate Variability and Maximal Oxygen Consumption (VO2 Max) in Sedentary Middle Aged Males. *International Journal of Current Medical and Applied sciences; 2024, 42(2), 20--25.*

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Subject:
Medical Sciences

Aerobic exercise may be better referred to as "solely aerobic", as it is designed to be low-intensity enough that all carbohydrates are aerobically turned into energy via mitochondrial ATP production. Mitochondria are organelles that rely on oxygen for the metabolism of carbs, proteins, and fats. Aerobic exercise comprises of walking, rowing, swimming, cycling, running and jumping rope. Pranayama involves manipulation of the breath, which is a dynamic bridge between body and mind. After 12 weeks of pranayama and aerobic exercise, we observed significant improvement in mean values of FVC, FEV1, PEFR, but effects of pranayama were more pronounced as compared to aerobic exercise [2]. Pranayama consists of three phases: Puraka (inhalation) kumbhaka (retention) and rechaka (exhalation) that can be either fast or slow. Slow pranayama like nadishudhisavitri and pranav pranayama have been shown to decrease heart rate, systolic blood pressure and diastolic blood pressure. Fast pranayamas like kapalbhati and bhastrika when practiced alone, increased the sympathetic activity [3]. The daily practice of Bhastrika pranayama helps to keep lungs more efficient [4]. Breathing exercise (pranayama) for a minimum of 3 weeks is reported to influence cardiorespiratory and autonomic functions. Bhavanani AB et al. stated that suryanamaskara increases strength of respiratory muscles contributing to improvement in pulmonary functions [5]. Few studies have shown the benefits of pranayama on physical endurance. Vedala SR et al. suggests that short-term yoga exercise improves respiratory breathing capacity by increasing chest wall expansion and forced expiratory lung volumes [6]. In this study, the benefits of pranayama on VO2 max, physical endurance and cardio-respiratory parameters are explored.

Material and Methods:

350 people are screened by their age, physical activity, systemic illness, smoking and other habits following which and 78 people included for this study. Subjects are apparently healthy, sedentary middle aged males in the age group 40-60 years. Height and weight are measured for all subjects. The height in centimeters was measured with subjects standing without their shoes. The weight in kilograms was recorded using a standardized weighing machine. Body mass index was calculated. Resting heart rate, Blood pressure and VO2 max were measured. VO2 max is measured by 6 minutes walk test (MWT) and the test was administered following the American Thoracic Society guidelines as closely as possible. A corridor, where every 1 meter was marked, served as the walking course. Participants, in comfortable clothing and shoes, were instructed to walk as fast as possible for 6 minutes between two cones spaced 20 m apart. Standardized verbal encouragements were provided. The total distance covered in meters was also recorded. To estimate VO2 max, we utilized the following formula: VO2 max (mL•kg-1 •min-1) = 70.161 + (0.023 × 6MWT distance [m]) – (0.276 × weight [kg] – (6.79 × sex, where m=0, f=1) – (0.193 × resting HR [beats per minute]) – (0.191 × age [years]).

HRV is recorded using using Powerlab 8/30 ML 870 data acquisition system with Lab chart pro software. From the RR tachogram both frequency domain and time domain measures were computed using HRV analysis software (Kuboi's HRV, version 1.1 Finland). Power spectral analysis was done by FFT and the frequency domain indices computed were VLF, LF and HF; both in absolute powers given as ms2 and in normalized unit (nu). The ratio of LF/HF in ms2 was given as LF-HF ratio. The time domain measures included the various statistical measures from RR interval (ms), SDNN (ms), RMSSD (ms) NN50, pNN50.

Then subjects are divided into two groups i.e. Group A and Group B. Group A (n=39) receive aerobic exercise in the brisk walking for 30 minutes and Group B (n=39) receive pranayama practice 30 minutes a day for 5 days in a week for 12 weeks. Blood pressure, heart rate and VO2 max were repeated after 12 weeks.

Observation & Results:

We have screened 350 people by their age, physical activity, systemic illness, smoking and other habits following which 78 people included for this study. Subjects are apparently healthy, sedentary middle aged males in the age group 40-60 years.

The subjects are divided into two groups i.e. Group A and Group B. Group A (n=39) receive aerobic exercise, Group B (n=39) receive structured pranayama practice 30 minutes a day for 5 days in a week for 12 weeks. VO2 max and HRV are measured at the end of 12 weeks.

Data of both group A and group B were compared within before and after intervention and then the comparison was done between the groups.

Table 1: Comparison of data (post 12 weeks values) between Group A and Group B.

	Group A	Group B	p-Value
Age	43.33 ± 6.73	45.11 ± 5.82	0.2154
Height	164.02 ± 5.34	162.19 ± 8.53	0.2597
Weight	61.02 ± 7.43	59.74 ± 6.73	0.4277
BMI	22.78 ± 3.92	23.16 ± 4.83	0.7039

The age and the anthropometric data of Group A and Group B were compared by using t-test and there was no significant difference between the two groups.

Table 2: Overall comparison of VO2 max values in both Group A and Group B before and after 12 weeks.

	Group A	Group B
Baseline	22.8 ± 4.6	23.2 ± 5.7
After 12 weeks	24.5 ± 3.9	25.1 ± 4.8

The VO2 max baseline value of Group A with VO2 max value after 12 weeks of the same Group A and there is significant difference between the baseline value and the value after 12 weeks. The VO2 max baseline value of Group B with VO2 max value after 12 weeks of the same Group B and there is significant difference between the baseline value and the value after 12 weeks.

Table 2 compares the VO2 max value before and after 12 weeks of aerobics in Group A and the VO2 max value before and after 12 weeks of pranayama in Group B. It is observed that from baseline there is increase in VO2 max value after 12 weeks of aerobic exercise in Group A and also there is increase in VO2 max value from baseline after 12 weeks of pranayama in Group B. Both aerobic exercise and pranayama is effective in raising the VO2 max value but comparison pranayama is the most effective in increasing the VO2 max value.

Table 3: Comparison of frequency domain values in group A before and after 12 weeks.

Frequency Domain Indices	Group A		
	Before	After	p-value
TP	1231.65 ± 98.24	1299.45 ± 87.36	0.0019
LF	669.85 ± 35.01	471.78 ± 24.07	<0.0001
HF	430.15 ± 15.01	568.22 ± 14.07	<0.0001
LF-HF ratio	1.65 ± 1.4	0.83 ± 1.54	0.0161

Table 3 compares frequency domain values such as TP, LF, HF, LF-HF ratio before and after 12 weeks of aerobic exercise in Group A and occurs significant increase in TP, decrease in LF, increase in HF and decrease in LF-HF ratio after 12 weeks compared to the baseline value in Group A.

Table 4: Comparison of frequency domain values in group B before and after twelve weeks.

Frequency Domain Indices	Group B		
	Before	After	p-value
TP	1167.35 ± 89.34	1237.45 ±87.26	0.0008
LF	597.58 ± 38.21	434.87 ± 34.27	<0.0001
HF	324.15 ± 26.41	526.72 ± 18.57	<0.0001
LF-HF ratio	1.84 ±1.6	0.82 ± 1.33	0.0030

Table 4 compares frequency domain values such as TP, LF, HF, LF-HF ratio before and after 12 weeks of aerobic exercise in Group B and occurs significant increase in TP, decrease in LF, increase in HF and decrease in LF-HF ratio after 12 weeks compared to the baseline value in Group B.

Table 5: Overall comparison of frequency domain values in both group A and group B before and after 12 weeks.

Frequency Domain Indices	Group A			Group B		
	Before	After	p-value	Before	After	p-value
TP	1231.65 ± 98.24	1299.45 ± 87.36	0.0019	1167.35 ± 89.34	1237.45 ±87.26	0.0008
LF	669.85 ± 35.01	471.78 ± 24.07	<0.0001	597.58 ± 38.21	434.87 ± 34.27	<0.0001
HF	430.15 ± 15.01	568.22 ± 14.07	<0.0001	324.15 ± 26.41	526.72 ± 18.57	<0.0001
LF-HF ratio	1.65 ± 1.4	0.83 ± 1.54	0.0161	1.84 ±1.6	0.82 ± 1.33	0.0030

Table 5 compares the frequency domain values before and after 12 weeks of aerobics in Group A and frequency domain values before and after 12 weeks of pranayama in Group B. it is observed that from the baseline, there is increase in TP and HF and decrease in LF and LF-HF ratio after 12 weeks of aerobic exercise in Group A and also from the baseline, there is increase in TP and HF and decrease in LF and LF-HF ratio after 12 weeks of aerobic exercise in Group B.

Both aerobic exercise and pranayama is effective in improving the frequency domain indices but on comparison, pranayama is more effective in improving the frequency domain values.

Table 6: Comparison of Time domain values in group A before and after twelve weeks.

Time Domain Indices	Before	After	p-value
Mean RR (s)	877.57 ± 85.05	843.84 ± 96.06	0.1048
SDNN (ms)	43.76 ± 24.04	39.49 ± 11.47	0.3199
RMSSD (ms)	23.32 ± 7.21	24.43 ± 5.71	0.4534
NN50	14.65 ± 13.77	17.35 ± 12.24	0.3630
p NN50	4.68 ± 2.51	6.90 ± 3.45	0.0017

Table 6 compares the time domain values such as Mean RR(s), SDNN(ms), RMSSD(ms), NN50 and PNN50 before and after 12 weeks of aerobic exercise in Group A and there occurs decrease in Mean RR(s), SDNN(ms) and increase in RMSSD(ms), NN50 and PNN50 values after 12 weeks compared to the baseline values.

Table 7: Comparison of Time domain values in group B before and after twelve weeks.

	Group B		
Time Domain Indices	Before	After	p-value
Mean RR (s)	834.42 ± 76.15	793.64 ± 58.97	0.0099
SDNN (ms)	47.68 ± 18.73	41.58 ± 12.35	0.0936
RMSSD (ms)	28.61 ± 6.87	26.52 ± 4.62	0.1191
NN50	15.43 ± 11.47	18.56 ± 10.94	0.2213
p NN50	5.08 ± 1.97	7.21 ± 2.06	<0.0001

Table 7 compares the time domain values such as Mean RR(s), SDNN(ms), RMSSD(ms), NN50 and PNN50 before and after 12 weeks of pranayama in Group B and there occurs decrease in Mean RR(s), SDNN(ms) and RMSSD(ms) and increase in NN50 and PNN50 values after 12 weeks compared to the baseline values.

Discussion:

The maximum rate of oxygen consumption attainable during physical exertion is the VO2 max and it is widely used as an indicator of cardio-respiratory fitness. It is expressed either as an absolute rate in litres of oxygen per minute (L/min) or as a relative rate in millilitres of oxygen per kilogram of body mass per minute (mL/kg·min).

Aerobic exercise refers to the use of oxygen to meet energy demands during exercise via aerobic metabolism adequately. Aerobic exercise is performed by repeating sequences of light-to-moderate intensity activities for extended periods of time. Aerobic exercise may be better referred to as "solely aerobic", as it is designed to be low-intensity enough that all carbohydrates are aerobically turned into energy via mitochondrial ATP production. Mitochondria are organelles that rely on oxygen for the metabolism of carbs, proteins, and fats.

Aerobic exercise comprises of walking, rowing, swimming, cycling, running and jumping rope. Pranayama involves manipulation of the breath, which is a dynamic bridge between body and mind. Pranayama consists of three phases: Puraka (inhalation) kumbhaka (retention) and rechaka (exhalation) that can be either fast or slow. Slow pranayama like nadishudhisavitri and pranav pranayama have been shown to decrease heart rate, systolic blood pressure and diastolic blood pressure. Fast pranayamas like kapalbhati and bhastrika when practiced alone, increased the sympathetic activity [7,8]. Breathing exercise (pranayama) for a minimum of 3 weeks is reported to influence cardiorespiratory and autonomic functions. Some studies have found that there is no effect for fast pranayama after 12 weeks of practice. Few studies have shown the benefits of pranayama on physical endurance. There were not many studies in literature which investigate the beneficial effects of pranayama on cardio-respiratory parameters and physical endurance. In this study, we are exploring the benefits of pranayama on VO2 max, physical endurance and cardio-respiratory parameters.

We have screened 350 people by their age, physical activity, systemic illness, smoking and other habits following which 78 people included for this study. Subjects are apparently healthy, sedentary middle aged males in the age group 40-60 years.

The subjects are divided into two groups i.e. Group A and Group B. Group A (n=39) receive aerobic exercise, Group B (n=39) receive structured pranayama practice 30 minutes a day for 5 days in a week for 12 weeks. VO2 max and HRV are measured at the end of 12 weeks.

Data of both group A and group B were compared within before and after intervention and then the comparison was done between the groups.

Effect of aerobics and pranayama on VO2 max in both Group A & Group B:

VO2 max : The maximum rate of oxygen consumption attainable during physical exertion is the VO2 max and it is widely used as an indicator of cardio-respiratory fitness. It is expressed either as an absolute rate in litres of oxygen per minute (L/min) or as a relative rate in millilitres of oxygen per kilogram of body mass per minute (mL/kg·min).

The VO2 max baseline value of Group A with VO2 max value after 12 weeks of the same Group A and there is significant difference between the baseline value and the value after 12 weeks

The VO2 max baseline value of Group B with VO2 max value after 12 weeks of the same Group B and there is

significant difference between the baseline value and the value after 12 weeks

Table 2 compares the VO2 max value before and after 12 weeks of aerobics in Group A and the VO2 max value before and after 12 weeks of pranayama in Group B. It is observed that from baseline there is increase in VO2 max value after 12 weeks of aerobic exercise in Group A and also there is increase in VO2 max value from baseline after 12 weeks of pranayama in Group B.

Both aerobic exercise and pranayama is effective in raising the VO2 max value but comparison pranayama is the most effective in increasing the VO2 max value.

Effect of aerobics and pranayama on Frequency domain values in both Group A & Group B:

HF: The HF component is caused by vagal activity during the respiratory cycle. the HF component of HRV indicates the cardiac vagal drive of the individual. Increased HF power represents increased vagal drive and decreased Hf power represents decreased vagal drive to the heart. Increased vagal drive is considered to be a good indicator of cardiovascular stability.

LF: The LF component of HRV is charecterised by an oscillatory pattern with a period of 10 seconds. This rhythm originated from self-oscillation in the vasomotor part (sympathetic component) of the baroreceptor loop.

The LF component of HRV mainly indicates the cardiacsympathetic drive of the individual. Increased LF power represents increased sympathetic drive while decreased LF power represents the decreased sympathetic drive.

LF-HF ratio: The sympathovagal balance is assessed by the LF-HF ratio. Increased LF-HF ratio reflects increased sympathetic activity, while decreased LF-HF ratio indicates increased parasympathetic activity and decreased sympathetic activity.

TP: Total power of HRV indicated the magnitude of heart rate variability. Decreased TP (decreased overall cardiac vagal modulation) has been implicated with future adverse cardiovascular morbidities and mortalities.

Table 3 compares frequency domain values such as TP, LF, HF, LF-HF ratio before and after 12 weeks of aerobic exercise in Group A and occurs significant increase in TP, decrease in LF, increase in HF and decrease in LF-HF ratio after 12 weeks compared to the baseline value in Group A.

Table 4 compares frequency domain values such as TP, LF, HF, LF-HF ratio before and after 12 weeks of aerobic exercise in Group B and occurs significant increase in TP, decrease in LF, increase in HF and decrease in LF-HF ratio after 12 weeks compared to the baseline value in Group B

Table 5 compares the frequency domain values before and after 12 weeks of aerobics in Group A and frequency domain values before and after 12 weeks of pranayama in Group B. it is observed that from the baseline, there is increase in TP and HF and decrease in LF and LF-HF ratio after 12 weeks of aerobic exercise in Group A and also from the baseline, there is increase in TP and HF and decrease in LF and LF-HF ratio after 12 weeks of aerobic exercise in Group B.

Both aerobic exercise and pranayama is effective in improving the frequency domain indices but on comparison, pranayama is more effective in improving the frequency domain values.

Effect of aerobics and pranayama on Time Domain values in both Group A & Group B:

Time domain indices: The variation in heart rate may be evaluated by a number of methods. Perhaps the simplest to perform are the time domain measures.

In these methods, either the heart rate at any point in time or the intervals between successive normal complexes are determined.

In a continous ECG record, each QRS complex is detected, and the so called normal to normal (N-N) intervals are determined.

SDNN: standard deviation of all N-N intervals.

RMSSD: the square root of the mean of the sum of the squares of the differences between adjacent N-N intervals.

NN50: number of pairs of adjacent N-N intervals differing by more than 50ms in the entire recording.

pNN50: NN50 count divided by the total number of all N-N intervals.

Table 6 compares the time domain values such as Mean RR(s), SDNN(ms), RMSSD(ms), NN50 and PNN50 before and after 12 weeks of aerobic exercise in Group A and there occurs decrease zin Mean RR(s), SDNN(ms) and increase in RMSSD(ms), NN50 and PNN50 values after 12 weeks compared to the baseline values.

Table 7 compares the time domain values such as Mean RR(s), SDNN(ms), RMSSD(ms), NN50 and PNN50 before and after 12 weeks of pranayama in Group B and there occurs decrease in Mean RR(s), SDNN(ms) and RMSSD(ms) and increase in NN50 and PNN50 values after 12 weeks compared to the baseline values.

The time domain values before and after 12 weeks of aerobics in group A and time domain values before and after 12 weeks of pranayama in group B. it is observed that there occur no improvement in both the groups after 12 weeks except for RMSSD (ms), NN50, pNN50 in group A and NN50, pNN50 in group B were there is some improvement.

Conclusion:

It is concluded that both aerobic exercise and pranayama is effective in raising the VO2 max value but comparison pranayama is the most effective in increasing the VO2 max value. Both aerobic exercise and pranayama is effective in improving the frequency domain indices but on comparison, pranayama is more effective in improving the frequency domain values. It is observed that there

occur no improvement of time domain indices of HRV in both the groups after 12 weeks except for RMSSD (ms), NN50, PNN50 in group A and NN50, PNN50 in group B were there is some improvement.

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Conflict of interest: *None declared*
Source of funding: *None declared*