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Analysis of Differences in Respiratory and Circulatory Parameters of Adult Sedentary Individuals after Stopping Swimming Exercise

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Abstract: This study aimed to examine the effects of 8-week swimming exercise on certain respiratory and circulatory parameters of sedentary males and to observe the changes in these parameters during the post-training period. Our study included 40 sedentary male volunteers with a mean age of 26.15±2.77 years, mean height of 175.88±3.68cm, mean body weight of 78.13±11.41 kg, who had not been actively involved in sports in the past. Pre-test and post-testmeasurements of the study groupincluded Weight (W), Forced Expiratory Volume (FEV_1), Forced vital Capacity (FVC), Peak Expiratory Flow (PEF), Forced Expiratory Flow (FEF), Forced Expiratory Flow 25–75% (FEF_{25-75}), Forced Expiratory Time (FET), Maximum Voluntary Ventilation (MVV), Vital Capacity (VC), Oxygen Saturation (SO_2), Resting Heart Rate (RHR) and Systolic and Diastolic Blood Pressure (SBP&DBP) parameters. After the end of the exercise program, three additional sets of measurements were taken at two-week intervals. Results revealed a statistically significant decrease in the parameters of W, DBP and RHR after 8 weeks of swimming exercise and a statistically significant increase in the repeated measurements during the post-training period ($p < 0.05$). The parameters of SO_2, FVC, VC, FEF_{25-75} and MVV increased after 8 weeks of training, but the repeated measurements after the exercise program showed a decrease in these parameters ($p < 0.05$). The SBP and FET values of subjects decreased at the end of the 8-week-exercise program and no significant change was observed in the repeated measurements taken during the post-training period ($p > 0.05$). PEF and FEF parameters of the subjects increased after 8 weeks of training and no significant change was observed in the repeated measurements during the post-training period ($p > 0.05$). In conclusion it could be suggested that an eight-week swimming exercise program has a positive effect on capillary oxygen saturation, blood pressure, resting heart rate and respiratory functions. However, there will be a decrease in these parameters in the case of interruption in the exercise routine.

Key words: Swimming · Exercise · Respiratory · Spirometer

INTRODUCTION

Regular physical activity is one of the most important things to help improvement of thehealthand quality of life. It is widely acknowledged that regular exercise can have a positive impact on respiratory and circulatory parameters. Although genetic factors play a significant role in these parameters, it is known that people engaging in regular physical activity have better respiratory and circulatory functions compared to those of sedentary people [1, 2]. Swimming is unique among other sports, utilizing a wide range of muscles in the body to overcome the resistance of water and move forward [3]. In addition, swimming is performed in an almost zero gravity environment, which makes it superior to other forms of exercise.

The aim of this study was to examine the effects of swimming exercise on certain respiratory and circulatory parameters and to monitor the changes in these parameters during the post-training period.

MATERIALS AND METHODS

Participants: 40 sedentary male volunteers who had not been actively involved in sports in the past served as subjects in our study. The mean age of the participants was 26.15±2.77 (years), mean height 175.88±3.68 (cm) and mean body weight 78.13±11.41 (kg). Prior to the study,

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a complete medical examination was conducted to verify each participant's health. We obtained a detailed history of each subject's current health problems, past medical history as well as past sport participation and current physical activity level. The details of the study were explained to all participants. Our study excluded the subjects who smoke cigarettes and consume alcohol, as well as those reporting a chronic disease and exercise-induced asthma.

Measurements: The subjects received basic swimming training for 1.5 hours a day, 3 times per week, for a total duration of 8 weeks. The first measurement was taken prior to the swimming training and the second measurement was taken at the end of the 8-week protocol. During the post-training period, three additional sets of measurements were taken at two-week intervals, amounting to a total of 5 sets of measurements.

Parameters: We used a ChoiceMed Finger Pulse Oximeter to measure capillary oxygen saturation. Respiratory parameters were measured using spirometer (MIR Spirobank). Circulatory parameters were measured with a stethoscope and Erka Perfect-Aneroid Sphygmomanometer (Germany). All measurements were performed in accordance with the relevant protocols.

Statistical Analysis: In the statistical analysis of the data obtained from the repeated measurements, we used Repeated Measures ANOVA for the comparison of the mean values of weight (W), Forced Expiratory Volume (FEV_1), Forced Vital Capacity (FVC), Peak Expiratory Flow (PEF), Forced Expiratory Flow (FEF), Forced Expiratory Flow 25–75% (FEF_{25-75}), Forced Expiratory Time (FET), Maximum Voluntary Ventilation (MVV), Vital Capacity (VC), Oxygen Saturation (SO_2), Resting Heart Rate (RHR), Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP). When a statistically significant difference was identified, multiple comparisons were analyzed conducting a Bonferroni test to isolate the difference. The data collected were summarized using the mean ± and standard deviation. The value of P<0.05 was considered statistically significant.

RESULTS

The difference between the pre-test and post-test measurements of W, SO_2, DBP, SBP, RHR, FVC, VC, PEF, FEF, FEF_{25-75}, FET, MVV parameters, which were conducted before and after the 8 week swimming exercise program, was found statistically significant (p<0,05).

Table 1: Comparison of mean measurement values on circulatory system parameters

(N: 40) Variables	Measurements	X	SD	Comparisons	F	P
Weight (kg)	Measurement 1	78.13	11.41	Measurements 1-2	60.982	.000*
	Measurement 2	75.28	9.88	Measurements 2-3	2.328	.135
	Measurement 3	75.45	9.67	Measurements 3-4	.328	.570
	Measurement 4	75.51	9.67	Measurements 4-5	14.268	.001*
	Measurement 5	75.89	9.70			
SO_2 (%)	Measurement 1	95.45	.96	Measurements 1-2	221.911	.000*
	Measurement 2	98.30	.69	Measurements 2-3	14.049	.001*
	Measurement 3	97.67	,83	Measurements 3-4	5.052	.030*
	Measurement 4	97.25	.78	Measurements 4-5	19.912	.000*
	Measurement 5	97.90	.78			
SBP (mmHg)	Measurement 1	127.57	11.85	Measurements 1-2	11.439	.002*
	Measurement 2	120.82	5.017	Measurements 2-3	.164	.687
	Measurement 3	121.07	5.617	Measurements 3-4	.340	.563
	Measurement 4	121.62	6.46	Measurements 4-5	.073	.788
	Measurement 5	121.85	4.77			
DBP (mmHg)	Measurement 1	83.00	7.16	Measurements 1-2	28.190	.000*
	Measurement 2	77.50	4.45	Measurements 2-3	1.985	.167
	Measurement 3	78.50	5.79	Measurements 3-4	.178	.675
	Measurement 4	78.15	5.86	Measurements 4-5	4.117	.049*
	Measurement 5	79.42	5.40			
RHR (beats/min)	Measurement 1	83.07	6.69	Measurements 1-2	38.432	.000*
	Measurement 2	75.92	4.24	Measurements 2-3	1.887	.177
	Measurement 3	77.12	5.16	Measurements 3-4	21.417	.000*
	Measurement 4	81.95	5.23	Measurements 4-5	2.228	.144
	Measurement 5	83.15	6.65			

*p<0.05 is statistically significant.
RHR: Resting heart rate
SBP: Systolic blood pressure
DBP: Diastolic blood pressure
SO_2: Oxygen saturation

Table 2: Comparison of mean measurement values on respiratory system parameters

(N: 40) Variables	Measurements	X	SD	Comparisons	F	P
FVC (L)	Measurement 1	4.38	1.08	Measurements 1-2	38.533	.000*
	Measurement 2	5.86	1.38	Measurements 2-3	19.388	.000*
	Measurement 3	5.20	1.59	Measurements 3-4	11.540	.002*
	Measurement 4	4.98	1.59	Measurements 4-5	16.448	.000*
	Measurement 5	4.75	1.57			
VC (L)	Measurement 1	4.86	1.2	Measurements 1-2	39.285	.000*
	Measurement 2	6.51	1.52	Measurements 2-3	20.438	.000*
	Measurement 3	5.77	1.77	Measurements 3-4	11.610	.002*
	Measurement 4	5.52	1.76	Measurements 4-5	16.536	.000*
	Measurement 5	5.28	1.74			
PEF (L)	Measurement 1	8.71	1.98	Measurements 1-2	17.390	.000*
	Measurement 2	11.02	2.94	Measurements 2-3	.808	.374
	Measurement 3	10.70	2.49	Measurements 3-4	3.731	.061
	Measurement 4	10.42	2.59	Measurements 4-5	2.909	.096
	Measurement 5	10.71	2.49			
FEF (L)	Measurement 1	3.55	1.01	Measurements 1-2	19.205	.000*
	Measurement 2	4.62	1.25	Measurements 2-3	.605	.441
	Measurement 3	4.52	1.19	Measurements 3-4	1.656	.206
	Measurement 4	4.40	.954	Measurements 4-5	1.150	.290
	Measurement 5	4.51	1.07			
FEF_{25-75} (L)	Measurement 1	5.24	1.31	Measurements 1-2	26.199	.000*
	Measurement 2	6.65	1.30	Measurements 2-3	.555	.461
	Measurement 3	6.73	1.22	Measurements 3-4	23.839	.000*
	Measurement 4	6.24	1.29	Measurements 4-5	.254	.617
	Measurement 5	6.30	1.30			
FET (L)	Measurement 1	2.01	.99	Measurements 1-2	31.748	.000*
	Measurement 2	1.16	.71	Measurements 2-3	.768	.386
	Measurement 3	1.23	.45	Measurements 3-4	.286	.596
	Measurement 4	1.26	.43	Measurements 4-5	1.309	.260
	Measurement 5	1.21	.44			
MVV (L)	Measurement 1	140.63	30.35	Measurements 1-2	57.943	.000*
	Measurement 2	183.40	30.34	Measurements 2-3	4.391	.043*
	Measurement 3	180.36	26.97	Measurements 3-4	25.023	.000*
	Measurement 4	173.40	26.79	Measurements 4-5	.040	.842
	Measurement 5	173.74	24.89			

*p<0.05 is statistically significant.
FVC: Forced vital CapacityFEF: Forced Expiratory Flow
VC: Vital CapacityFET: Forced Expiratory Time
PEF: Peak Expiratory Flow MVV: Maximum Voluntary Ventilation

The mean weight of subjects decreased after eight weeks of training, but the repeated post-training measurements showed that it gradually increased after stopping the swimming exercises (Table 1).

After eight weeks of training, the mean SO_2 values of subjects increased, but they declined after stopping exercises (Table 1, Figure 1).

The mean DBP values of subjects decreased after eight weeks of training, but they increased after stopping exercise (Table 1, Figure 1).

The mean SBP values of subjects decreased after eight weeks of training and no significant change was observed after stopping swimming exercises (p>0.05) (Table 1, Figure 1).

The mean RHR values of subjects decreased after eight weeks of training, but they increased after stopping exercise (Table 1, Figure 1).

The mean FVC values of subjects increased after eight weeks of training, but they declined after stopping exercises (Table 2, Figure 2).

The mean VC values of subjects increased after eight weeks of training, but they declined after stopping exercises (Table 2, Figure 2).

The mean PEF values of subjects increased after eight weeks of training and no significant change was observed after stopping swimming exercises (p>0.05) (Table 2, Figure 3).

The mean FEF values of subjects increased after eight weeks of training and no significant change was observed after stopping swimming exercises (p>0.05) (Table 2, Figure 3).

The mean FEF_{25-75} values of subjects increased after eight weeks of training, but they declined after stopping exercises (Table 2, Figure 3).

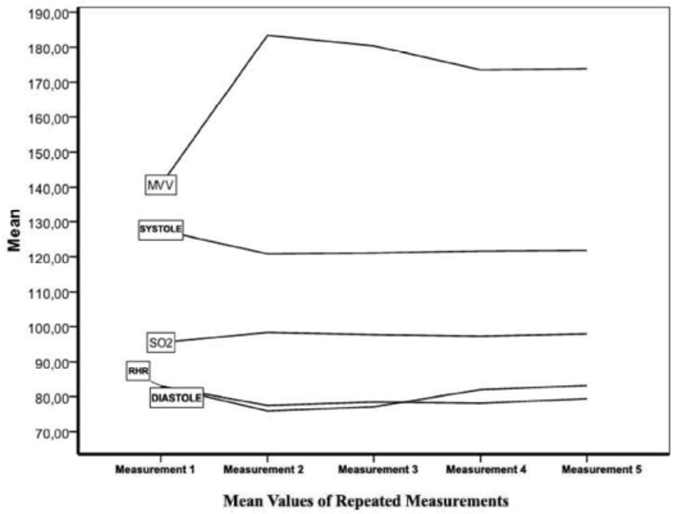

Fig. 1: Mean values of repeated measurements on MVV, SBP, DBP, SO_2, RHR

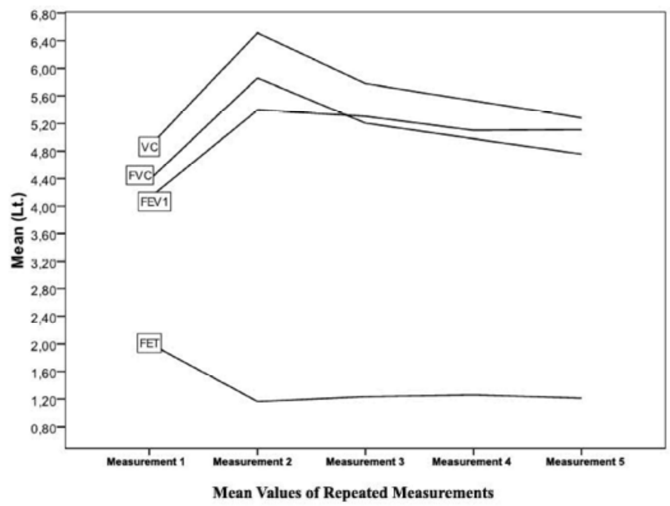

Fig. 2: Mean values of repeated measurements on VC, FVC, FEV_1, FET

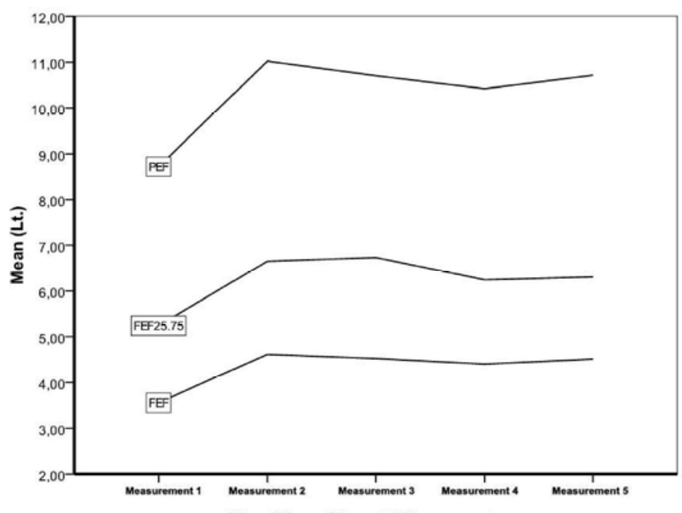

Fig. 3: Mean values of repeated measurements on PEF, FEF, $FEF_{25\text{-}75}$

The mean FET values of subjects decreased after eight weeks of training and no significant change was observed after stopping swimming exercises ($p>0.05$) (Table 2, Figure 1).

The mean MVV values of subjects increased after eight weeks of training, but they declined after stopping exercises (Table 2, Figure 3).

DISCUSSION

We found that there is statistically significant difference between the pre-test and post-test measurements of W, SO_2, DBP, SBP, RHR, FVC, VC, PEF, FEF, FEF_{25-75}, FET, MVV parameters, which were conducted before and after the 8-week swimming exercise program ($p<05$).

While the mean W, DBP and RHR parameters of subjects declined after eight weeks of training, they tended to increase in the repeated post-training measurements ($p<0.05$). The parameters of SO_2, FVC, VC, FEF_{25-75} and MVV showed an increase after 8 weeks of training and but they exhibited a decreasing trendin the repeated post-training measurements ($p<0.05$). After eight weeks of training, the SBP and FET parameters of subjects decreased and no significant change was observed in the repeated measurements after stopping swimming exercises ($p>0.05$). The mean values of PEF and FEF parameters showed an increase, however no significant difference was observed in the repeated measurements after stopping swimming exercises ($p>0.05$).

The studies in this field indicate that physical activity for 20-60 minutes 3-5 days per week at 60-90% of maximal heart rate gradually improves physiological functions and physical performance of the body [4].

The amount of oxygen carried by hemoglobin in the blood is generally referred to as oxygen saturation. It shows the oxygen level delivered to the tissues and thus providing a goodindicationused to assess the effectiveness of cardiopulmonary system [5].

In our study, we observed an increase in the parameters of SO_2 measured after the completion of exercise program, however, measurements taken after stopping exercises showed a decrease in the SO_2 levels of the participants. Celebi [6] reported that regular swimming exercise of 12 weeks increases the capillary oxygen saturation values in men and women swimmers, thus supporting the values we presented here.

Measurement of the circulatory parameters showed significantly reduced values of SBP, DBP and RHR, while repeated post-training measurements showed elevated levels.

Guyton reported [7] that the average heart rate for adult humans is 72 beats per minute. Regular physical activity generally causes left ventricular hypertrophy, resulting in an increase in the size and stroke volume of the heart. This increase in the stroke volume frequently leads to alowerrestingheart rate [8, 9]. After a certain period of training, blood pressure levels tend to decrease. It is known that aerobic exercise is more effective than strength/resistance training for reducing blood pressure [10].

The current study showed results corroborating the findings of the prior published research, including Dawson's study [11] which found that a 16-week-exercise program at 75-85% of maximum heart rate for 30 minutes 3 times a week lowered systolic and diastolic blood pressure; a study by Van Zant and Kuzma [12], where they reported that a 12-week-exercise program at an intensity of 60-80% of maximal heart rate for 20 minutes lowers systolic blood pressure significantly; a control group study by Gokdemir *et al*. [13] which included 30 university students split into two groups (15 to serve as experimental subjects and 15 control group) and found that 8 weeks of aerobic training caused meaningful reduction in systolic blood pressure and diastolic blood pressure.

The respiratory parameters of participants, particularly FVC, VC, FEF_{25-75} and MVV values, significantly improved after 8 weeks of training but they exhibited a decreasing trendin the repeated measurements taken after stopping exercises.

In general, it is widely acknowledged that medium-intensity swimming training increases forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1), as well as maximum voluntary ventilation (MVV). The horizontal body positioning during swimming allows air to enter upper lobes of the lungs, leading to greater pulmonary efficiency. Therefore, swimmers have larger vital capacities (VC) than do athletes of other sport activities [14, 15]. Studies have shown that people engaged in sports or active business life has higher respiratory capacities than those of individuals with sedentary life style [2].

The findings of the current study are supported by those of Michalak *et al* [16], who found that regular swimming exercise of 10 months increases FVC values; Mehrotra et al., [17] who measured the pre-season and post-season FVC and FEV_1 values of 20 male swimmers and found that post-season FVC and FEV_1 values are significantly higher; Vaccaro *et al*. [18] who found that 12 male swimmers (aged 13-16 years) with 6 years of training background had higher FVC and FEV_1 values than did non-swimmers of the same age group; And

Kesavachandran *et al.* [19] conducted a 3-month study with young swimmers performing different styles of swimming and found statistically significant differences between the pre-test and post-test values regarding VC, FVC, FEV_1 parameters; Senthil and Arul [20] reported that strength and endurance training significantly improve on Cardio-respiratory endurance and resting pulse rate compared to the control group. In general, the results of the current circulatory and respiratory function measurements are consistent with the findings of the previous studies in the relevant literature.

In conclusion, we could suggest that an eight-week swimming exercise program has a positive effect on capillary oxygen saturation, blood pressures, resting heart rate and respiratory functions. However, there will be a decrease in these parameters in the case of interruption in the exercise routine.

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