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Relation between Heart Rate Recovery, Level of Fatigue and VO2 max in Swimmers - An Observational Study

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ABSTRACT

Background: Swimming is an exercise modality that is highly suitable for health promotion, disease prevention, and is one the most popular, practiced as well as most recommended form of physical activity. The heart rate recovery is said to be an important predictor of cardiovascular diseases in diseased and general population. Likewise, the Direct measurement of whole-body maximal oxygen (VO2 max) is considered as gold standard when assessing cardiorespiratory fitness. Treadmill based Bruce protocol test is valid and reliable for assessing body's aerobic capacity. Borg RPE scale is used to monitor perceived exertion during specific stages of exercises.
Method: In this Observational study 47 well-trained freestyle male swimmers between the age group of 18-30 were selected by using simple random sampling technique. After noting the baseline data, the participants were asked to perform Treadmill test according to Bruce Protocol. After cessation of the test, the HRR in the first 30 seconds, Fatigue using Borg based RPE scale and VO2 max of the participants were noted.
Result: The results show that the correlation between HRR and Fatigue was recorded as -0.773 and the correlation between HRR and VO2max was recorded as 0.949 which is statically significant with non-linear and linear association between them respectively.
Conclusion: This concludes that there is indirect relationship between HRR and Fatigue, and direct relationship between HRR and VO2 max.

Keywords: Swimmers, Heart rate recovery, fatigue, VO2 max, Bruce Protocol

INTRODUCTION

Swimming is an exercise modality that is highly suitable for health promotion, disease prevention, and is one the most popular, practiced and most recommended form of physical activity [1]. Recreational swimming can provide you with a low-impact workout and it's also a good way to relax and feel good [1]. Swimming is a great workout because you need to move your whole body against the resistance of the water [1].

Fatigue can refer to a subjective symptom of malaise and aversion to activity or to objectively impaired performance. It has both physical and mental aspects. The symptom of fatigue can be defined as a poorly defined feeling, and careful inquiry is needed to inquire about complaints of fatigue, tiredness, or exhaustion and to distinguish lack of energy from loss of motivation or sleepiness, which may be pointers to specific diagnoses [2]. Fatigue can also be defined as loss of capacity to develop force in response to a load, and is

reversible after rest. Failure at the NMJ or within the muscle is called peripheral fatigue [3].

Heart rate recovery after exercise depends upon several factors: the intensity of exercise, the cardio-respiratory fitness, cardiac ANS modulations, hormonal changes and baroreflex sensitivity [4]. Previous study on Heart rate recovery after exercise and neural regulation of heart rate variability in 30–40-year-old female marathon runners showed that when compared with untrained controls, the female marathon runners showed the following results-1) a higher aerobic capacity; 2) a higher blood pressure after exercise; 3) a higher percent decrease of blood pressure after exercise; 4) a faster HR recovery after exercise; 5) higher HRV parameters and lower LF/HF ratio at rest [4]. These results suggests that endurance training increases cardiorespiratory function and accelerates HR recovery after exercise. It also suggests that different degrees of exercise training intensities would result in diverse types of HR recovery. Studies have suggested that after light exercise, the HR follows an exponential decline to resting level and after moderate or heavy exercise, however, the recovery pattern is characterized by two distinct phases, an initial exponential drop followed by a slower decline to resting level [4]. The increase in heart rate that accompanies exercise is due to reduction in vagal tone. Recovery of the heart rate immediately after exercise is a function of vagal reactivation and decrease in vagal activity is known to be a risk factor for death [5].

Exercise training at a variety of intensities increases maximum oxygen uptake (VO2 Max), it is also the strongest predictor of cardiovascular and all- cause mortality [6]. Direct measurement of whole-body maximal oxygen consumption (VO2 max test) is considered the gold standard when assessing cardiorespiratory fitness [7]. Reliability of Vo2 max as way of measuring person's individual aerobic capacity is 0.93 [8]. Treadmill based Bruce protocol is a valid and reliable method of testing V02max in diseased population as well as in general population [8].

The Borg rating of perceived exertion (RPE) scale was developed to make simple, reliable, and valid interpretations of exercise intensity. It is widely accepted as a method of quantifying aerobic exercise intensities. Perceived exertion has been used only infrequently in resistance exercise prescription. The Borg RPE scale is based on the idea that a measure of perceived exertion is the level of strain and/or heaviness that is experienced during physical effort, as estimated by a specific rating method. The primary use of Borg RPE scale in exercise science is primarily to monitor exercise intensity and is most often used as a method to quantify exercise intensities during aerobic training. It is commonly utilized to monitor perceived exertion during specific stages of exercises [9].

Previous studies have been done on well trained and elite cyclists to use Heart rate recovery as a guide to monitor fatigue and predict changes in performance parameters which concluded that the measurement of HRR has the potential to be a useful tool for monitoring fatigue and prescribing training load in well-trained and elite cyclists [10]. Another study on heart rate recovery on heavy smokers concluded that HRRI was found to be lower in the 1st, 2nd, 3rd, and 5th minutes in heavy smokers [11]. The reliability of HRR is 0.91.

The aim of the study was to find the relation between HRR, level of Fatigue and VO2 max in well-trained male swimmers between the age group 18-25. The objective of the study includes finding the relation between the three variables i.e., HRR, level of Fatigue and VO2 max.

MATERIALS & METHODS

Ethical clearance was obtained from the Institutional Ethical Committee (ICE), College of Physiotherapy, Wanless Hospital, Miraj. Screening of the participants was done according to the

inclusion and exclusion criteria. 47 male well- trained freestyle swimmers between the age of 18-30 years with minimum 2 years of training were selected and participants who consumed caffeine, smoked, alcohol 3 hours before the test; with Musculoskeletal and neurological disorders; history or presence of any cardiovascular or respiratory disorder; and Uncooperative participants were excluded from the study. Written consent was taken from the participants and the procedure was explained. Baseline assessment that is height, weight, BMI, resting heart rate was taken. Participants were asked to perform the treadmill test (Bruce protocol). After the treadmill test the heart rate recovery, fatigue and VO2 max of the participants were calculated.

Procedure for Bruce protocol-

- The basic assessment i.e., ht., wt., age, BMI of the participant was recorded.
- Before starting the stress test, resting HR was noted.
- Max HR was calculated (220-age).
- Termination of the test was done when the participant complains of symptoms like fatigue, exhaustion, dyspnea.
- VO2max was calculated.
- RPE levels of fatigue was monitored at every stage.
- After reaching max HR, HRR in first 30secs was noted.

Assessment of Heart Rate Recovery Index-

The heart rate recovery index is the reduction in the heart rate from the rate at peak exercise to the rate 1st minute (HRR1), 2ND minute (HRR2), 3RD minute (HRR3), and 5th minute (HRR5) after the cessation of exercise stress testing. (r = 0.91)

HRR in 1 min

>52 beats per minute	Extremely Rapid
42-51 beats per minute	Very Rapid
32-42 beats per minute	Rapid
22-31 beats per minute	Average
12-21 beats per minute	Slow
<12 beats per minute	Extremely slow

Assessment of VO2max -

The maximum or optimum rate at which the heart, lung and muscles can effectively use oxygen during exercise is used as way of measuring a person's aerobic capacity.

Reliability of VO2 max is 0.93

VO2 max is calculated by using the following formula :

VO_2 max = 14.8 - (1.379 × T) + (0.451 × T^2) - (0.012 × T^3).

VO2 Max Norms for Men

AGE	VERY POOR	POOR	FAIR	GOOD	EXCELLENT	SUPERIOR
13-19	<35.0	35.0 - 38.3	38.4 - 45.1	45.2 - 50.9	51.0 - 55.9	>55.9
20-29	<33.0	33.0 - 36.4	36.5 - 42.4	42.5 - 46.4	46.5 - 52.4	>52.4
30-39	<31.5	31.5 - 35.4	35.5 - 40.9	41.0 - 44.9	45.0 - 49.4	>49.4
40-49	<30.2	30.2 - 33.5	33.6 - 38.9	39.0 - 43.7	43.8 - 48.0	>48.0
50-59	<26.1	26.1 - 30.9	31.0 - 35.7	35.8 - 40.9	41.0 - 45.3	>45.3
60+	<20.5	20.5 - 26.0	26.1 - 32.2	32.3 - 36.4	36.5 - 44.2	>44.2

Assessment of Fatigue -

Rate of perceived exertion of the participants was measured by asking them about their level of fatigue using BORG scale. Reliability of BORG scale is 0.88

Rating	Perceived Exertion
6	No exertion
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Statistical Analysis

Statistical analysis was done using SPSS Software. The basic data was analyzed using frequency analysis and the relation between the variables was analyzed using Karl Pearson's correlation test.

RESULT

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) Version 20. The basic data was analysed using frequency analysis and the relation between the three variables i.e., HRR, Fatigue and VO2 max was analysed using Karl Pearson's Correlation test. 47 male swimmers between the age group of 18-30 years were assessed. Using Bruce Protocol HRR, Fatigue, and VO2 max was calculated.

Table No. 1.: Shows the frequency and percentage of the male swimmers.

Age	Frequency	Percent
18.00	4	8.5
19.00	5	10.6
20.00	5	10.6
21.00	6	12.8
22.00	4	8.5
23.00	4	8.5
24.00	6	12.8
25.00	5	10.6
26.00	5	10.6
27.00	3	6.4
Total	47	100.0

Descriptive Statistics

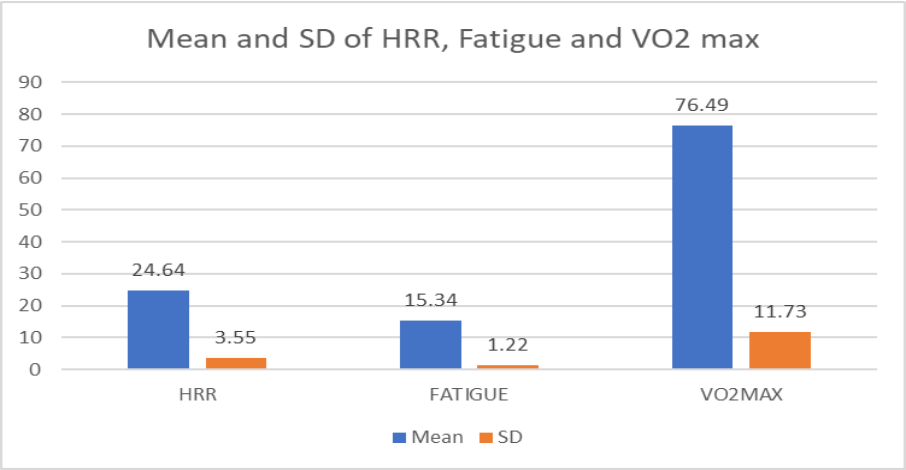
Table No. 2. Shows the Mean and Standard deviation.

	Minimum	Maximum	Mean	SD
AGE	18.00	27.00	22.40	2.78

- Table No.1 and 2 shows the frequency and percentage, and Mean and Standard deviation respectively i.e., 47, 100% and 22.40, 2.78 respectively.

Table No. 3.: Shows Mean and Standard deviation of HRR, Fatigue and VO2 max.

	Minimum	Maximum	Mean	SD
HRR	17.00	32.00	24.64	3.55
FATIGUE	13.00	17.00	15.34	1.22
VO2MAX	54.70	103.40	76.49	11.73



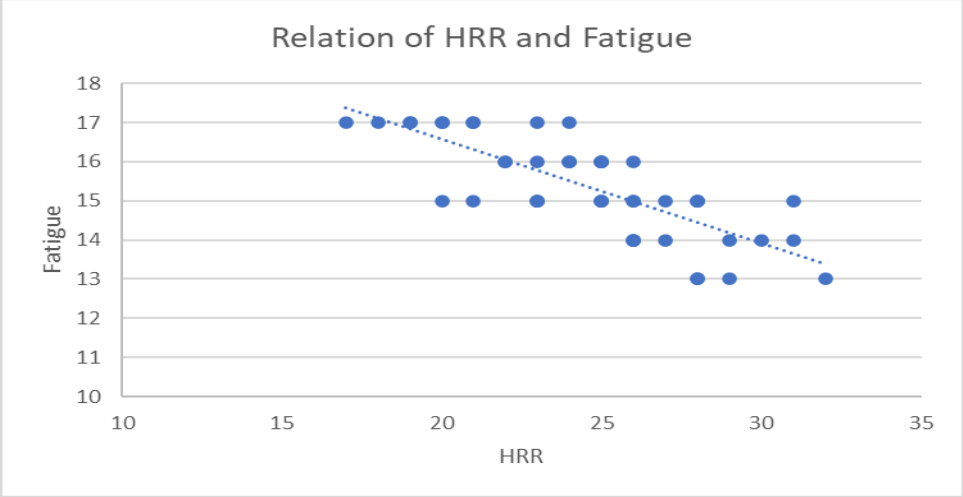
Graph no.1.: Shows Mean and SD of HRR, Fatigue and VO2 max.

Correlation analysis

Table No. 4.: Shows Correlation and Significance of HRR with Fatigue and VO2 max.

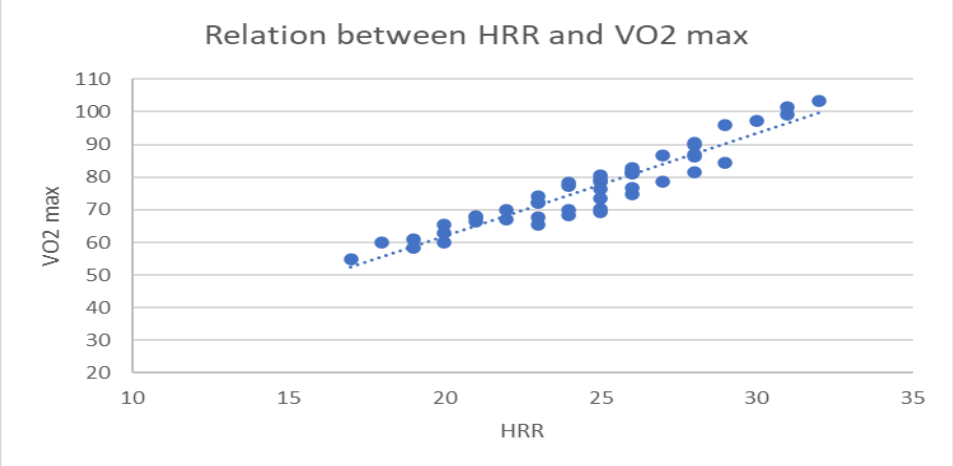
Variable X	Variable Y	r-value	p-value	Result
HRR	FATIGUE	-0.773	0.001*	Significant at 5% Non-Linear association
	VO2MAX	0.949	0.001*	Significant at 5% Linear association

The correlation between HRR and Fatigue has been recorded as -0.773 which is statistically significant at 5% level with non-linear association. It means both the variables are moving in the opposite direction at the time association with each other. It is also called as indirect relationship between the variables



Graph no.2.: Shows relation of HRR and Fatigue

The correlation between HRR and VO2max has been recorded as 0.949 which is statistically significant at 5% level with linear association. It means both the variables are moving in the same direction at the time association with each other. It is also called as direct relationship between the variables.

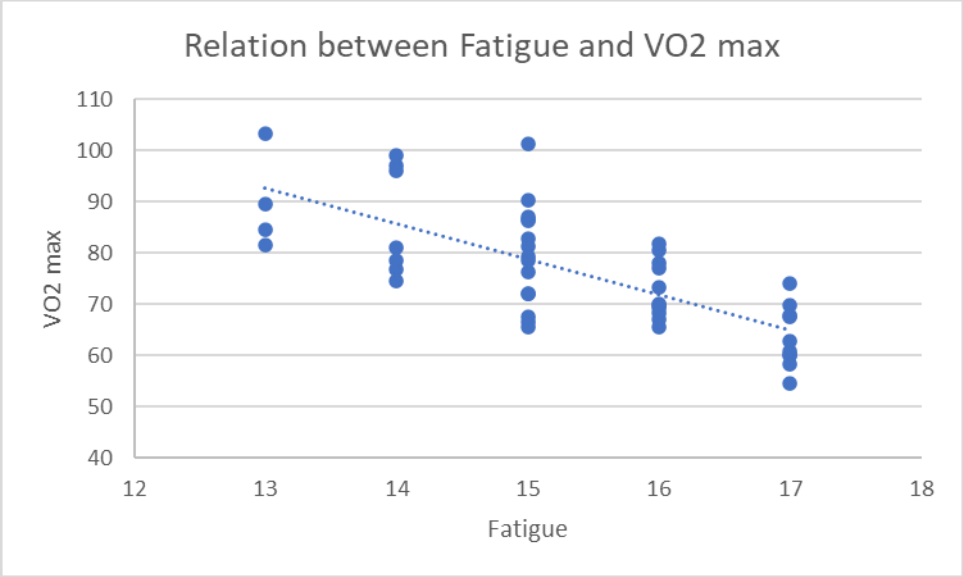


Graph no.3.: Shows relation between HRR and VO2 max

Correlation analysis

Table No. 5.: Shows Correlation and Significance of Fatigue and VO2 max.

Variable X	Variable Y	r-value	p-value	Result
FATIGUE	VO2MAX	-0.716	0.001*	Significant at 5% Non-Linear association



Graph no.4.: Shows relation between VO2 max and Fatigue

The correlation between fatigue and VO2max has been recorded as -0.716 which is statistically significant at 5% level with non-linear association. It means both the variables are moving in the opposite direction at the time association with each other. It is also called as indirect relationship between the variables.

DISCUSSION

In the present study the main objective was to find the relation between HRR, Fatigue and VO2 max in well trained male swimmers between the age group of 18-30 years. Table no. 4 and Graph no. 2 shows the relation between HRR and Fatigue, which concludes that as the two variables are going in opposite directions there is indirect relation between them. The Table no. 4 and Graph no. 3 shows the relation between HRR and VO2 max which shows that these two variables have a direct relation with each other as both are going in the same direction. Similarly in Table no. 5 and Graph no 4. the relation between Fatigue and VO2 max is shown which concludes that these two variables have an indirect relation with each other. From the results of the study, it was found that as the HRR increases there is decrease in Fatigue and increase in VO2 max.

Previously a study by R. P. Lamberts et al. on Heart rate recovery as a guide to monitor fatigue and predict changes in performance parameters in well-trained and elite male cyclists concluded that a decrease in HRR can possibly predict an inability to cope with the training load and the accumulation of fatigue. Therefore, the measurement of HRR after a standardized warm-up has the potential to play an important role in monitoring cycling performance and optimizing training program [10].

A study by Na Du et al. on Heart Rate Recovery After Exercise and Neural Regulation of Heart Rate variability in 30-40 years old Female Marathon Runners concluded that when compared with untrained controls, female marathon runners had a higher aerobic capacity; a higher blood pressure after exercise; a higher percent decrease of blood pressure after exercise; a faster HR recovery after exercise and a higher HRV parameters and lower LF/HF ratio at rest suggesting that endurance training increases cardiorespiratory function and accelerated HR recovery after exercise [4]. Many studies have also suggested that the findings of a blunted HR elevation during progressive exercise i.e., chronotropic incompetence and attenuated HR decline during recovery are important surrogates for an underlying autonomic dysfunction associated with increased cardiovascular morbidity and

mortality [15]. Hence a high resting HR (HR rest) and abnormal HR responses during or after exercise may precede manifestations of cardiovascular disease and may contribute to the early identification of persons at high risk.

Another study by George Papathanasiou et al. on Effects of Smoking on Heart Rate at Rest and During Exercise, and on Heart Rate Recovery, in Young Adults concluded that Smokers had significantly higher resting HR values than non-smokers. Both female and male smokers showed a significantly decline HR increase during exercise. Female smokers failed to reach their age-predicted maximum HR and during recovery and the HR decline was significantly attenuated in females [15].

With the cessation of exercise, the decrease in HR immediately after exercise is mainly thought to be a function of a reactivation of the parasympathetic nervous system [4]. Studies have suggested that a delayed decrease in HR after exercise would be a powerful and independent predictor of all-cause mortality in patients or in general population [4].

Treadmill tests for maximal oxygen uptake (VO2 max) have traditionally used at set speed and incline increments regardless of participants training or exercise background. A study by Michael J. Hamlin et al. on Determination of Maximal Oxygen Uptake Using the Bruce or a Novel Athlete-Led Protocol in a Mixed Population concluded that these two tests were highly correlated with VO2 max; and the Bruce and ALP protocols were unaffected by fitness levels of participants, suggesting the two tests are both valid protocols for measuring aerobic capacity. Studies have also suggested that Exercise training at a variety of intensities increases maximal oxygen uptake (VO2max) and it is also the strongest predictor of cardiovascular and all-cause mortality [8].

Due to these conclusions, it is necessary to address the importance of alterations in HRR, VO2 max and Fatigue in every population. As proper assessment of these variables can help in diagnosing cardiovascular disease and may contribute in the early identification of persons at high risk. This study alerts the physical therapists about the importance of proper assessment of HRR, VO2 max and Fatigue, as well as help in setting proper treatment protocols using the findings of the assessment done.

CONCLUSION

The result of the study shows that the correlation between HRR and Fatigue was recorded as -0.773 which is statistically significant at 5% level with non-linear association. Also, the correlation between HRR and VO2 max was recorded as 0.949 which is statistically significant at 5% level with linear association. This concludes that there is indirect relationship between HRR and Fatigue, and direct relationship between HRR and VO2 max. Meaning, as the HRR increases there is decrease in Fatigue and increase in VO2 max. On correlating the two variables i.e., Fatigue and VO2 max, it was concluded that correlation between them was recorded as -0.716 which is statistically significant at 5% level with non-linear association. This concludes that there is indirect relationship between Fatigue and VO2 max. As maximal oxygen capacity (VO2 max) is a strong predictor of adverse health outcomes such as cardiovascular disease and all-cause mortality, a decrease in VO2 max can indicate poor cardiovascular condition and may predispose the individual towards adverse health conditions. Similar to VO2 max, HRR following maximal exercise is also a good marker of cardiac autonomic control and it is directly related with a higher risk of cardiovascular disease. The findings of the current study can help in proper assessment, diagnosis and planning proper rehabilitation protocols for Swimmers and help in improving their cardio-vascular fitness as well as general well-being.

Limitation: The sample size of the study was small and only male swimmers were included in the study.

Suggestion

- The same study can be conducted in adolescent swimmers,
- Female swimmers can also be included in the study.

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Ethical Approval: Approved

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