Role of VO_2 MAX in Determining the Rest Period during Moderate Work

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Abstract— The ergonomics means fitting the job according to the workers capability. Ergonomically rest period is one of the basic factor in increasing the human comfort and reducing the risk of injuries. VO2 max is an criteria for determining the rest period which is based on the levelling of oxygen intake in the blood due to the increase in work rate, high level of lactic acid in the blood. With the increase of stress level maximal oxygen consumption also increase due to which demand for energy in the body increases and when our body is unable to supply such increasing demands than the condition of fatigue arises which ultimately leads to the musculoskeletal disorders, reduction in working efficiencies and other work related problems. The solution to such situation is providing the rest period. The aim of present study is to calculate the maximum oxygen consumption and the heart rate so to determine the optimum rest period in order to perform the task comfortably and efficiently.

Key words: Maximal oxygen consumption, VO_2 Max, Maximum Heart Rate, Rest Period and peak oxygen consumption

I. INTRODUCTION

VO_2 max is generally accepted as best measure of functional limit of cardiovascular system [1]. VO_2 max is one of the primary descriptive variable in determining the rest period like as height weight and age. Metabolic rate is the amount of energy utilized (released) in the body. The total daily energy expenditure is usually expressed per unit of time in kJ / 24 h (1 h, 1 min) or kcal/ 24 h (1 h, 1 min). The individual body organs and tissues use this energy for different metabolic activities. The lowest energy rate required by the body during the rest condition is known as basal metabolism and as the work activity of body increases this energy requirement also increases and finally increasing the intake of oxygen. Ageing can also be used to determine both oxygen consumption as well as maximum heart rate. [2]

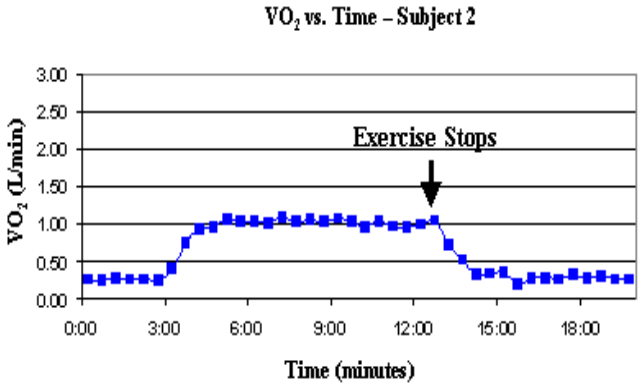

Fig 1: Increase of VO_2 max after exercise

If we combine the parameters between ageing, physical activity on VO_2 max and heart rate response than it seems that a positive relationship appears between the VO_2 max and ratio between heart rate max to heart rate at the rest. [3] Calculations based on the Fick principle and incorporating literature data for maximum to rest ratio for the heart rate, stroke volume and arterio-venous O_2 difference, respectively suggest that mass-specific VO_2 maximum may be estimated by multiplying ratio of heart rate maximum to the heart rate at rest by a factor of about 1.5. Relationship between VO_2 max and the ratio between HR max and HR rest is given the equation-

Mass- Specific VO_2 max = (15.0 ml. $min.^{-1}$ kg^{-1}) (HR_{max} / HR_{rest}).

II. RELATION BETWEEN VO_2 MAX AND HEART RATE

The aim of this study was to determine the relationship between %HRR vs %VO_2 and %HRR vs VO_2 max during the moderate work activity. The ability to accurately prescribe the work to the worker is a fundamental, with ergonomists which were used frequently relying upon multiple methods to establish target workloads, including percentages of maximal heart rate (%HR_{max}), heart rate reserve (%HRR), and maximal oxygen uptake (%VO_2max). [4]. The secondary purpose of the present study was to better understand the influence of exercise mode on the relationship between %HRR vs. %VO_2R and %HRR vs. %VO_2max during the work activity [5].

This can be estimated from the study that the not only type of work but working style also determined the fatigue and VO_2 relationship with the heart rate. [6].

III. MUSCLES EXERTED DURING THE FILLING OPERATION

The shoulder is made up of the three bones which are connected by the muscles, ligaments and the tendons. The tendons connect bones to the muscles. There are some muscles present which help in stabilization of the arm and others help to give movements to it. The rhomboid and trapezius are some muscles which help in the stabilizing.

A long time working without the proper rest period can cause the tendonitis in the rotator cuff which means microscopic tears in the tendons which become the source of pain and inflammation. This rotator cuff as a result of overuse of muscles, mechanical impingement. Sometimes it is an age related disorder also.

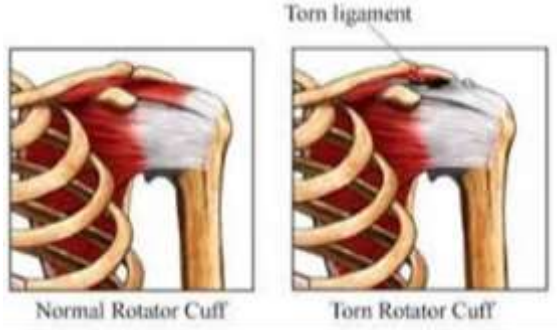

Fig 2: Muscles condition before and after work.

IV. EXPERIMENTAL SET UP

The methodology of study is based on the experiment of the moderate work such as filling operation. The experimental

work is done on the surface filling of moderate work and on various subjects. For the experimental work various parameters are considered such as age, heart rate and maximal oxygen consumption ($VO_{2\ max}$). The main objective of work was to introduce the human exertion levels in the moderate work with ergonomic efforts to obtain optimum rest period. The main aim of study is to examine the physiological behaviour of various age groups during moderate activity of filling work

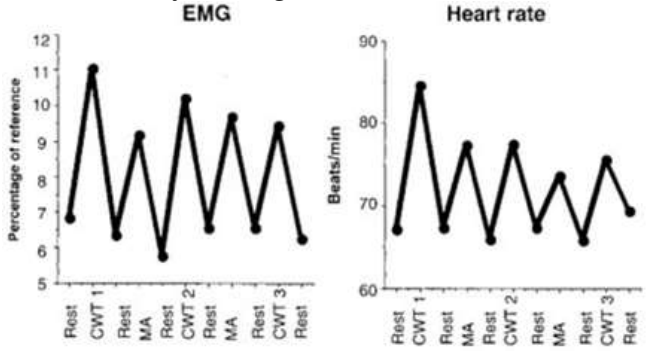

Fig. 3: Trapezius muscles activity during filling operation

V. ANTHROPOMETRIC DETAILS

The data of four age groups of persons has been recorded during the filing operation. The age group of candidates ranges between the 18 – 45 years. These candidates were declared physically and mentally fit during the operation. The anthropometric details of these persons were given below-

Subject	Age	Height	Weight
A	18	5'8"	60
B	18	5'1"	45
C	20	5'7"	71
D	21	5'0"	52
E	24	5'5"	42
F	25	5'0"	50
G	27	5'2"	55
H	28	5'9"	78
I	30	6'0"	75
J	31	6'3"	78
L	34	5'7"	64
M	35	6'1"	75
N	35	5'5"	68
O	37	5'6"	70
P	38	5'7"	69
Q	39	5'7"	64
R	40	5'7"	63
S	43	5'4"	64
T	43	5'5"	53
U	45	5'6"	65

Table 1: Anthropometric details

VI. VARIATION OF HEART RATE WITH TIME OF VARIOUS AGE GROUPS

The heart of various age groups has been recorded the different time intervals. After the heart rate reaches its peak value that ranges between the 95- 100 pulse rate or heart rate the work is stopped and now heart rate is again measured till it reaches the normal value. The average value of these age groups is calculated at various time intervals and shown in the table.

	Time (secs)						
AGE	0	4	8	12	16	20	24
18-24	0	80	82	98	97	85	83
25-32	80	83	90	95	93	87	81
33-38	78	81	90	98	96	88	79
39-45	77	83	91	98	95	87	77

Table 2: Heart Rate Variation with Time

VII. EXPERIMENTAL PROCEDURE

- Step 1: The maximal heart rate is calculated by the online software [7].
- Step 2: With the help of heart rate VO_2 max is calculated by the formula
  VO_2 max = 15x maximum heart rate/ heart rate at rest ($ml.min^{-1}. Kg^{-1}$) [8].
- Step 3: With the help of these calculated values the rest period is calculated for the different age groups with the help of the formula-

  Trp= (Ec/4-1) of resting time. [9]

The increase in heart rate with respect to time of various age groups is shown in the form of graph below-

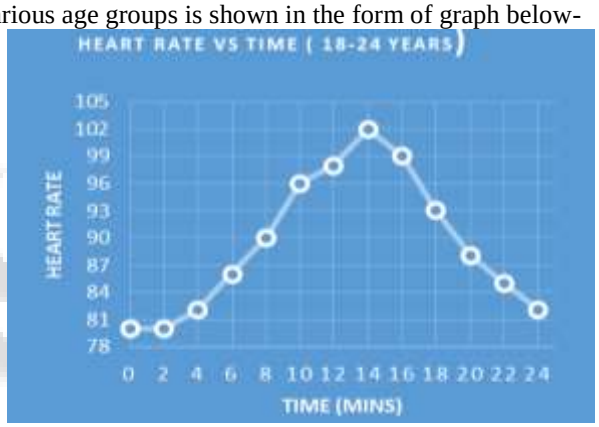

Fig. 4: heart rate VS TIME (18-24YEARS)

Fig. 5: heart rate VS TIME (25-32YEARS)

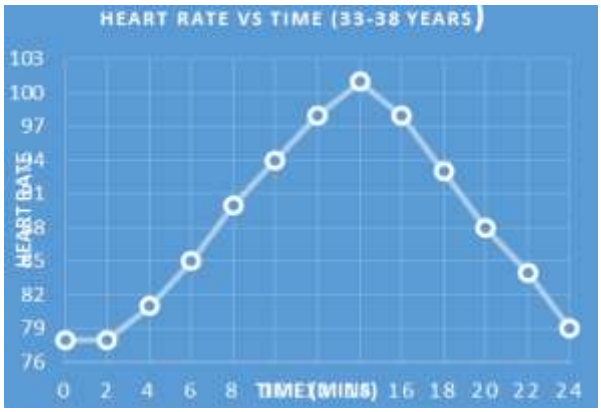

Fig. 6: heart rate VS TIME (33-38YEARS)

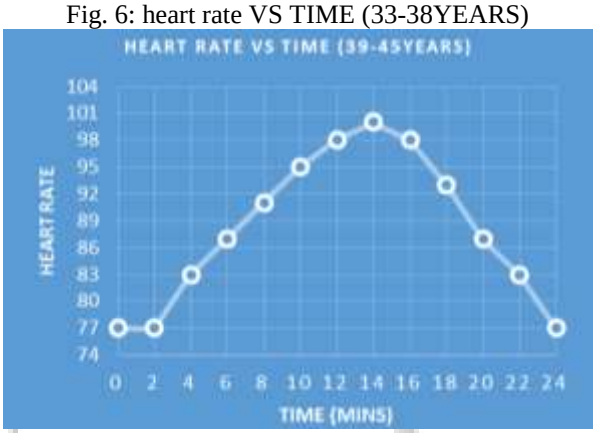

Fig. 7: heart rate VS TIME (39-45YEARS)

VIII. Conclusion

As the physical activity of the human body increases its demand for energy also increases, this increased demand can be measured in the terms of maximum oxygen consumed by the body. When body is unable to meet this required demand of the oxygen than the feeling of fatigue occur which may lead to the many physical and mental disorders [10]. The various results have been derived from the above analysis-

- The analysis of optimal calculation of rest period for the moderate work (filling) also establishes a relation between heart rates before and after the activity.
- As the maximal oxygen consumption increases the heart rate also increases this increased heart rate is shown graphically in the figure.
- There is a period of 10- 12 minutes given to the worker to make its heart beat normal.

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