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To Assess the Effect of Body Mass Index on Cardiac Efficiency in Adolescent Boys and Girls

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Abstract:
Background: *Obesity a major modifiable risk factor for cardiovascular disease is a pandemic among young individuals. The best way to help is by improving physical fitness levels by taking regular exercise and creating awareness of physical fitness in the population.*
Aim: *To compare the physical fitness in individuals with different Body Mass Index (BMI).*
Materials and methods: *This cross – sectional study is carried out on 90 MBBS students in the age group 18 – 20 years in both sexes in the Research lab, Department of Physiology, Kanyakumari Government Medical College, Asaripallam. Group I BMI < 25 kg/m^2, Group II BMI $\geq$ 25 to < 30 kg/m^2, Group III BMI $\geq$ 30 kg/m^2.After measuring the BMI and resting pulse rate, each subject is asked to ride the bicycle ergometer for 5 minutes and pulse rate is recorded between 1 to 1.5 minutes, 2 to 2.5 minutes and 3 to 3.5 minutes after stopping exercise. Then fitness index is calculated.*
Results: *Subjects of normal BMI possess a higher fitness than overweight or obese. Cardiac efficiency decreases progressively as the BMI increases.*
Conclusion: *This study helps in predicting exercise capacity and cardio vascular fitness of healthy individuals. . Hence fitting regular exercise in daily schedule has the potential to limit the risk of morbidity and mortality and improves cardiac efficiency.*
Keywords: *Body Mass Index (BMI), Exercise, Obesity, Physical fitness, Resting pulse rate.*

I. Introduction

Obesity a major modifiable risk factor is becoming a global epidemic in both young and old.[1] Metabolic Syndrome may be associated with the global epidemic of obesity and diabetes—reported by Zimmet et al as "diabesity".[2] Genetics plays an important role in the development of obesity. Recent research has identified more than 41 sites on the genome as possible links to the development of obesity in a favourable environment. [3] It is important to assess the gene–environment obesity relation because the prevalence of obesity, especially in children, is likely to rise. It is associated with numerous comorbidities such as cardiovascular diseases (CARDIO VASCULAR DISEASES), type 2 diabetes, hypertension, certain cancers, and sleep apnea. Currently overweight and obesity are classified by body mass index (BMI). BMI (weight in kilograms/height^2 in meters) is frequently used as a surrogate measure of fatness in children and adults. In adults, overweight is defined as a BMI of 25.0 to 29.9 kg/m^2; obesity is defined as a BMI $\geq$30.0 kg/m^2. Obesity may affect the heart due to dyslipidemia, hypertension, glucose intolerance, inflammatory markers and is associated with numerous cardiac complications such as coronary heart disease, heart failure, and sudden death.

Another study, after 55 years of follow-up, reported an excess mortality rate among male but not female subjects who were overweight (BMI >75th percentile in the US reference population) in adolescence as compared with those who were lean (BMI 25th to 49th percentiles).[4] A variety of adaptations and alterations in cardiac structure and function occur in the individual as adipose tissue accumulates in excess amounts.[5] The adipose tissue is not simply a passive storehouse for fat but an endocrine organ that is capable of synthesizing and releasing into the bloodstream, important variety of peptides and non-peptide compounds that may play a role in cardiovascular homeostasis. Adipose tissue is a significant source of tumour necrosis factor-α (TNF-α), interleukin-6 (IL-6), plasminogen activator inhibitor-1, resistin, lipoprotein lipase, acylation stimulating protein, cholesteryl-ester transfer protein, retinal binding protein, estrogens (through P450 aromatase activity), leptin, angiotensinogen, adiponectin, insulin-like growth factor-I (IGF-I), insulin-binding protein 3 (IGFBP3), and monobutyrin.[6] Circulating concentrations of plasminogen activator inhibitor-1, angiotensin II, C-reactive protein (CRP), fibrinogen, and TNF-α are all related to BMI. It has been estimated that in vivo, 30% of the total circulating concentrations of IL-6 originate from adipose tissue. [7]

Obesity produces an increment in total blood volume and cardiac output that is caused in part by the increased metabolic demand induced by excess body weight. Thus at any given level of activity, the cardiac workload is greater for obese subjects. [8] The increased cardiac output is attributable mostly to increased stroke volume because heart rate increases. [9] Weight loss through diet and exercise is recommended in the

management of obesity, but it is important to recognize that obesity is associated with persistence of elevated cardiac filling pressures during exercise. [10] Intentional weight loss in obese patients can improve or prevent many of the obesity-related risk factors for Coronary Heart Disease. [11] Current therapies available for weight management that cause weight loss by inducing a negative energy balance include dietary intervention, physical activity, pharmacotherapy and surgery. Behaviour modification to enhance dietary and activity compliance is an important component of all of these treatments [11]. Sympathetic mechanisms have been implicated in the development of left ventricular hypertrophy and weight reduction in obese subjects reduces the indices of sympathetic activity such as plasma norepinephrine levels and urinary norepinephrine excretion.[12] The renin-angiotensin system may also be involved in the pathogenesis of left ventricular hypertrophy, and weight reduction may decrease plasma renin activity and aldosterone levels. [13] Physical fitness is a .general state of health and well-being and, more specifically, the ability to perform aspects of sports or occupations. Physical fitness is generally achieved through correct nutrition, moderate to vigorous physical activity, exercise and rest.[14] The study adjusted basic confounders with moderate to vigorous physical activity and the relation with cardio vascular disease mortality displayed physical activity being associated with a lower risk of cardio vascular diseases mortality that was independent of traditional metabolic risk factors. [15]

The present study indicates the importance of regular exercise in improving the cardiac efficiency i.e., physical fitness and the prerequisites that need to be followed while exercising by maintaining the target heart rate. An ideal exercise program does not over stress the individual but does ensure that the intensity of the exercise increases slowly and steadily so that there is very little stress on the heart. So this study is done to determine the physical fitness of individuals with different body mass index using bicycle ergometer. The response of the cardiovascular system to standardized exercise is the single and best test for assessing the efficiency of heart. This test is known as "Cardiac efficiency test" or "Exercise Tolerance Test". This test helps to assess maximum heart rate, target heart rate and how the heart responds during rest and exercise. It assists in designing an effective exercise program. It also indicates cardiac inefficiency if present and to help in correcting the condition in the initial stage.

II. Materials & Methods

This cross – sectional study is carried out on 90 MBBS students in the age group 18 – 20 years in both sexes in the Research lab – Department of Physiology, Kanyakumari Government Medical College, Asaripallam. Healthy adolescents who volunteered to participate in the study were included. Subjects with locomotor disturbances, musculo-skeletal dysfunction, those who are on medications or drugs, any chronic disease, any previous surgeries, any medical or surgical condition were excluded and the following parameters were assessed-body mass index, heart rate response and fitness index. The divided groups were as follows:

Group I - Individuals with BMI < 25 kg/m^2
Group II - Individuals with BMI > 25 to < 30 kg/m^2
Group III - Individuals with BMI > 30 kg/m^2

2.1 Bicycle Ergometer

The bicycle ergometer is a stationary one-wheeled cycle used to measure a person's work output under controlled conditions. The resistance (and therefore work output) is controlled usually by one of the four main methods: varying mechanical resistance (by tightening or loosening a flywheel), electrical resistance (by changing the strength of the magnetic field through which an electrical conductor moves), air resistance (produced by fan blades displacing air as the wheel turns), or hydraulic fluid resistance. A cycle ergometer supports the upper body, keeping it relatively immobile. It also makes the cycle ergometer a good device for measuring physiological responses to a standard rate of work output (power output) in people whose weights have changed. Because much of the body weight is supported by the cycle, resistance is relatively independent of body weight (compared to treadmill).

2.2 Methods

The standing height and weight of the subjects were measured by using standard methodology with the help of inch tape in centimetres and weighing machine.

Body mass index was calculated : BMI = Weight in kg / Height in m^2 (1)

The bicycle ergometer is well maintained and calibrated. The room is well ventilated and bright. The test is explained to the subject and the subject is examined if his/her present physical condition is good. The test is done 2 hours after noon meals. The subject is asked to stop the test if he/she feels fainting, dizzy or short of breath. The subject is free to stop the test for any reason. The seat height is adjusted so that the knee is almost straight 5^o in bottom stroke with ankle in neutral position, so that the pedalling position is comfortable for the subject. A light warm up is done prior to actual exercise to decrease the oxygen deficit by increasing the blood flow and nutrients to the working muscles.

After measuring the resting pulse rate, each subject is asked to ride the bicycle ergometer for 5 minutes with the tension adjusted at 2kg and in a speed of 15 to 18 km/min. The recovery pulse rate is recorded immediately between 1 to 1.5 minutes, 2 to 2.5 minutes and 3 to 3.5 minutes after stopping exercise. Then fitness index is calculated by the following formula:

$$Fitness\ index = (\text{Duration of exercise in seconds x100}) / (2 \text{ x sum of recovery pulse rate counts}) \quad (2)$$

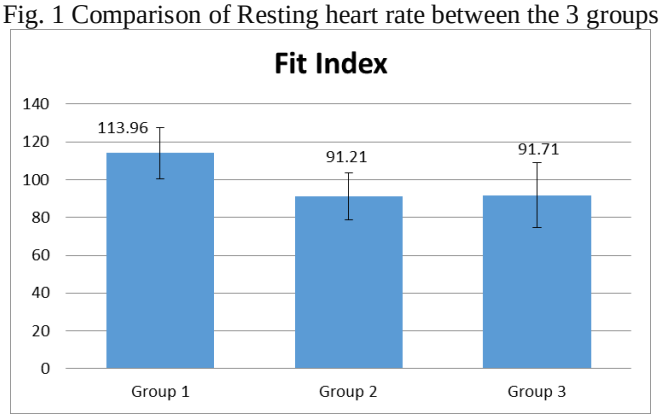
The Fitness Index is graded on the basis of Heart rate recovery as: (< 50) Poor, (50 – 80) Average, (80 – 90) Good and (>90) Excellent.

III. Results

TABLE 1 Comparison of variables between the 3 groups

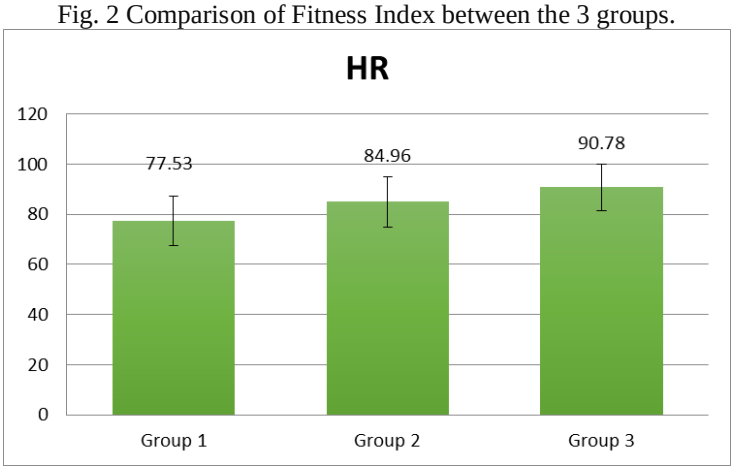
	Resting Heart Rate		Fitness Index	
	Mean	Standard Deviation (±)	Mean	Standard Deviation (±)
Group I	77.53	9.85	113.96	13.37
Group II	84.96	10.02	91.21	12.46
Group III	90.78	9.27	91.71	17.07
P value	<0.0001		<0.0001	

Fig. 1 Comparison of Resting heart rate between the 3 groups



From the graph depicted, it is obvious that the resting heart rate progressively increases as the BMI increases. P value is significant.

Fig. 2 Comparison of Fitness Index between the 3 groups.



IV. Discussion

According to the present study resting heart rate progressively increases as the BMI increases and there is a high negative correlation (correlation coefficient -0.655) with significance between fitness index and heart rate. Fitness index of individuals of group II and III is significantly lower than group I and there is a moderate negative correlation coefficient -0.358 with significance between BMI and fitness index. These observations suggest that the cardiac efficiency of subjects will differ from one another in various BMI categories, with the

subjects of normal BMI possessing a higher fitness than overweight or obese. Fitness capacity therefore decreases progressively as the BMI increases.

The importance of fitness over fatness has recently been addressed by church et al.[16] There was a negative correlation between BMI and aerobic fitness (chen et al., 2002). [17] A negative significant – correlation was observed between percent of body fat and aerobic fitness (Nikbakht, 1991; Hoseini, 1998).[18] The correlation between percent of body fat and abdominal muscle endurance was negative and significant (Afarinesh, 1991).[19] The relationship between waist circumference and physical fitness was negative (Delaux et al., 1999).[20] These findings are in accordance with the present study and corroborate the deleterious impact of excess body weight and physical inactivity on cardiac efficiency

V. Conclusion

Man's ability to perform exercise is normally limited by the capacity of cardiovascular system to increase the transport of oxygen to active muscles. The beneficial effect of exercise on the cardiovascular system is well documented. There is a direct relation between physical inactivity and cardiovascular mortality. Physical exercise is important for maintaining physical fitness and is performed for strengthening muscles and the cardiovascular system, honing athletic skills and weight loss or maintenance. This study helps in predicting exercise capacity and cardio vascular fitness of healthy individuals. The heart's efficiency is not exactly stellar, but it can be improved during exercise. Hence fitting regular exercise in daily schedule has the potential to limit the risk of morbidity and mortality and improves cardiac efficiency.

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