Does the Increase of Body Mass Index (BMI) or Waist to Hip Ratio (WHR) Affect Left Ventricular Myocardial Performance Index (MPI) in Normal Men?

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هل تؤثر زيادة مؤشر كتلة الجسم أو نسبة الخصر إلى الورك على مؤشر كفاءة البطين الأيسر في الرجال الطبيعيين؟

الخلاصة:

خلفية الدراسة: على الرغم من استعمال مؤشر كفاءة البطين الأيسر كقياس حساس لمعرفة كفاءة البطين الأيسر،القليل من المعلومات متوفرة فيما إذا كان هذا المؤشر يتأثر بزيادة مؤشر كتلة الجسم أو زيادة نسبة الخصر إلى الورك.

الهدف من الدراسة: تحرّت الدراسة الحالية عن تأثير الدرجات المختلفة لمؤشر كتلة الجسم ونسبة الخصر إلى الورك على مؤشر كفاءة البطين الأيسر في الرجال الطبيعيين.

الطريقة: الدراسة تضمنت ٨٢ متبرع من الذكور الطبيعيين، قسّموا حسب دليل كتلة الجسم إلى مجموعتين، مجموعة ١أ (مؤشر كتلة الجسم ٢٠-٢٤,٩، العدد=٣٤، متوسط العمر=٣٢,٣١٥±١٠,١٧٩) ومجموعة ٢أ (مؤشر كتلة الجسم أكثر من ٢٤,٩، العدد= ٤٤، متوسط العمر=٣٨,١٨١±١١,٥٠١). كذلك قسموا إلى مجموعتين حسب نسبة الخصر إلى الورك، مجموعة ١ب (نسبة الخصر إلى الورك= اقل من ٠,٨ إلى ٠,٩، العدد=٤٥، متوسط العمر=٣١,٨±٨,٩١) و مجموعة ٢ب (نسبة الخصر إلى الورك= اكثرمن٠,٩، العدد=٣٧، متوسط العمر=٣٩,٩١٨±١٢,٢٣٩).

النتائج: إحصائيا لا توجد هناك اختلافات معنوية بين مؤشر كفاءة البطين الأيسر مع زيادة مؤشر كتلة الجسم أو نسبة الورك إلى الخصر. كذلك لاتوجد هناك علاقة خطية بين مؤشر كفاءة البطين الأيسر مع مؤشر كتلة الجسم أو نسبة الورك إلى الخصر.

الاستنتاج: مؤشر كفاءة القلب أداة بسيطة ودقيقة للتقييم الكمي لوظائف البطين الأيسر،وبسبب التطبيق السهل لهذا المؤشر لذا يمكن استخدامه في دراسات جهاز الدوران الشاملة خصوصا أولئك الذين لديهم زيادة في مؤشر كتلة الجسم أو نسبة الورك إلى الخصر حيث إن هذه الزيادة لا تؤثر بشكل ملحوظ عليه.

Abstract:

***Background*:** Despite its clinical use as a sensitive measure of left ventricular performance, little is known about whether MPI is influenced by increasing BMI or WHR.

***Aim*:** The present study is targeted at investigating the impact of different grades of BMI and WHR on left ventricular myocardial performance index in normal men.

***Method*:** 82 normal male subjects were involved in this study. The subjects were divided as per BMI groups into group Ia (BMI= 20-24.9, n=34, mean age 32.315±10.179 as a control group) and group IIa (BMI= >24.9, n=44, mean age 38.181±11.501); as well as, by dividing the subjects in to two groups according to Waist-Hip ratio, group Ib (WHR <0.8-0.9, n=45, mean age 31.8±8.91) and group IIb (WHR >0.9, n=37, age 39.918±12.239). MPI was determined in all these subjects using the formula proposed by Tie as MPI=IVCT+IVRT/ET.

***Results*:** There were statistically no significant variations in MPI with increased BMI (p>0.05) or WHR (p>0.05). There was no linear correlation between MPI and BMI (*r*= 0.0023), and MPI and WHR (*r*=0.0007).

***Conclusion*:** MPI is a simple and accurate tool for quantitative assessment of left ventricular functions and because of easy application, cost effectiveness, and reproducibility; it could be regarded as an important measurement in a comprehensive hemodynamic study, especially in those with increased BMI or WHR, in whom the increased BMI or WHR was found to have no effect on MPI.

***Key Words*:** Myocardial performance index, Doppler echocardiography, obesity, overweight.

Abbreviations: MPI: Myocardial performance index, BMI: Body mass index, WHR: Waist to hip ratio, LV: Left ventricle, IVCT: Isovolumic contraction time, IVRT: Isovolumic relaxation time, ET: Ejection time.

Introduction:

Body Mass Index (BMI) is defined as the ratio between the weight (in kg) and the height (in m^2)[1]. The BMI allows the establishment of normality, overweight and obesity criteria. BMI provided a simple numeric measure of a person's "fatness" or "thinness", allowing health professionals to discuss over- and under-weight problems more objectively with their patients.[2]

However, BMI has become controversial because many people, including physicians, have come to rely on its apparent numerical authority for medical diagnosis. A frequent use of the BMI is to assess how much an individual's body weight departs from what is normal or desirable for a person of his or her height. The weight excess or deficiency may, in part, be accounted for by body fat (adipose tissue) although other factors such as muscularity also affect BMI significantly[3]. The WHO regard a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI greater than 25 is considered overweight and above 30 is considered obese[4]. These ranges of BMI values are valid only as statistical categories when applied to adults, and do not predict health.

Obesity is a chronic and progressive disease that predisposes to an increase in the mortality rate, as demonstrated by several population studies[5]. Its importance becomes even greater when it is observed that its prevalence has been increasing drastically, in developed as well as in developing countries. It represents an independent risk factor for cardiovascular disease, defined as the incidence of coronary disease, sudden death and congestive cardiac failure [6]. The association between obesity and cardiovascular disease is independent from the levels of arterial pressure, cholesterol levels, smoking, presence of left ventricular hypertrophy or glucose intolerance, although there is an important association between excess weight and left ventricular hypertrophy[7]. In the heart of the obese individual, the left ventricular filling pressure and volume increase, shifting the Frank-Starling curve to the left, and inducing chamber dilation. The volume of the dilated chamber also inappropriately increases the left ventricular wall stress, and the ventricle adapts by inducing an augment of the contractile elements and myocardial mass. The final product of this adaptation is the hypertrophy, normally of the eccentric type [8, 9]. The excess fat mass associated with obesity is known to increase metabolic demand and thus, both cardiac output and total blood volume are elevated in obesity. These circulatory changes cause left ventricular geometric remodelling in the form of cavity dilatation, a structural change commonly seen in obesity, which is then thought to lead to a compensatory left ventricular hypertrophic response in response to increased wall stress[8]. In addition to this, advances in the understanding of hormonal changes in obesity have highlighted several alternative mechanisms. Increased visceral and subcutaneous adiposity is known to cause higher levels of serum leptin, the hallmark of human obesity, and hyperinsulinaemia, both of which have been linked to ventricular hypertrophy in humans and in animal models [10]

Furthermore, a simple calculation of the measurements of the waist girth divided by the hip girth, Waist to Hip Ratio (WHR) = Gw / Gh, where Gw = waist girth, Gh = hip girth.. This measure is often used to determine the coronary artery disease risk factor associated with obesity [11]. The basis of this measure as a coronary disease risk factor is the assumption is that fat stored around the waist posses a greater risk to health than fat stored elsewhere in the body [12.]. If the result is over 1.0, it would be considered to be at higher risk for heart disease and other health problems. Researchers have called having a high WHR the “apple” shapes because weight is centered in the abdomen. People who are apple shaped are at higher risk than those with their weight centered in their hips (also known as “pear” shaped). The following table gives general guidelines for acceptable levels for hip to waist ratio:

Table (1) acceptable levels for hip to waist ratio.[13]

	acceptable		unacceptable		
	excellent	good	average	high	extreme
male	< 0.85	0.85 - 0.90	0.90- 0.95	0.95 - 1.00	> 1.00
female	< 0.75	0.75 - 0.80	0.80- 0.85	0.85 - 0.90	> 0.90

The Doppler-derived myocardial performance index (MPI, also denoted the Tei Doppler index), a fairly new index of combined systolic and diastolic function, is defined as the sum of isovolumic contraction time and isovolumic relaxation time divided by the ejection time[14]. MPI has previously been shown to be a sensitive indicator for symptomatic heart failure in a cross-sectional study [15]. But whether MPI predicts future development of heart failure independently of other echocardiographic measurements is still to be examined.

It has been used as a sensitive measure of LV performance. As this index combines systolic and diastolic parameters, it may be more useful for the diagnosis of global cardiac dysfunction than indices of systolic or diastolic performance alone. The Tei index has shown clinical usefulness for assessing LV function and outcomes in a wide range of clinical conditions including congestive heart failure, myocardial infarction, cardiac transplant, and amyloidosis. [16-22]

The available reports that studied the effect on MPI of increased BMI and WHR in normal individuals are lacking, most of the investigators were confined to study pediatric age groups and morbid obesity in confounding diseases. Fatima et. al., 2009 [23] demonstrated significant correlation between BMI and MPI in men with type 2 DM, Sarita et. al., 2010 [24] showed the obese subjects (children and adolescent) had significantly high MPI, Ertürk et. al., 2005[25] showed high MPI in normotensive and hypertensive obese children.

Aim:

The purpose of this study is to investigate the impact of increasing BMI and / or WHR on LV myocardial performance index in normal male subjects.

Subjects and Methods:

A total of 82 normal male individuals recruited in this study, after having their verbal and written consent and approval from the ethical local committee at Kufa College of medicine. The study started from the 9th of November 2010 and ended by the 4th of May 2011. In order to exclude conditions that might influence the results, the following criteria are required:

- **a)** No previous history or clinical evidence of hypertension, diabetes mellitus, coronary artery disease, heart failure, or cardiac valve disease, abnormal ECG, respiratory disease.
- **b)** Not taking any drugs that could affect the heart.
- **c)** And not involved in competitive sports.

All participants provided information on age, family history, personal habits (alcohol intake, tobacco consumption, type and level of physical exercise, drug ingestion, known pathological conditions). A detailed physical examination is conducted to exclude endocrine and cardiac co-morbidities. The subjects were divided as per BMI groups into group Ia (BMI= 20-24.9, n=34, mean age 32.315±10.179 as a control group) and group IIa (BMI=>24.9, n=44, mean age 38.181±11.501); as well as by dividing the subjects into two groups according to Waist-Hip ratio: groupIb (WHR <0.8-0.9, n=45,mean age 31.8±8.91) and group IIb (WHR >0.9, n=37, age 39.918±12.239). Height in cm and weight in kg are measured in light clothing, using measuring tape and digital scale respectively. Body Mass Index is calculated using the following equation: Weight (kg) / Height (m) ^{2}. Waist circumference (inch) is measured in all individuals by measuring the distance around waist just above the belly button; for hip circumference (inch) we measured the distance around the largest area of hips at the widest part of the buttocks. Measurement around waist then divided by the measurement around hips to yield waist hip ratio.

All participants were subjected for Echo-Doppler study(figure 1, 2), using Philips Sonos 7500 equipment with 2-4 MHz transducer and tissue harmony facility, made in USA. MPI was calculated by placing Doppler sample volume to record both mitral inflow and LV outflow; IVCT can be measured from end of A wave (under guidance of simultaneous ECG recording) to commencement of AV opening. ET can be measured from opening of AV to closure of AV. IVRT was measured from closure of AV to commencement of E wave [26]. A noteworthy, measuring IVCT is rather difficult without using synchronized ECG tracing, as in many instances the end of A wave is not so clear.

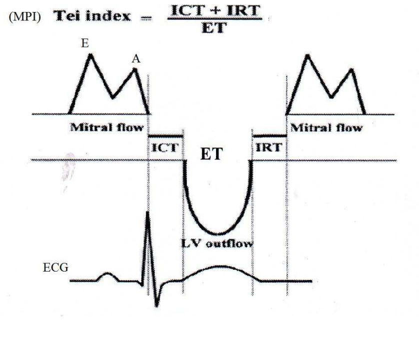

Figure (1) simultaneous recording of MPI from left ventricle out flow tract

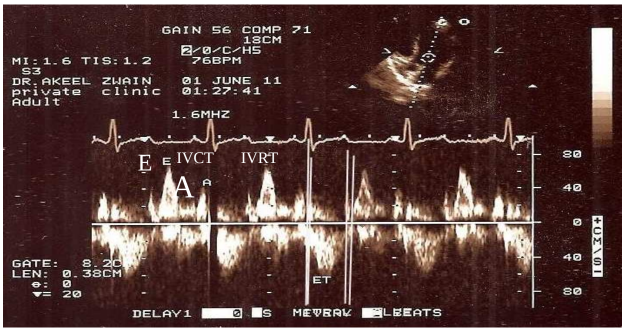

Figure (2) simultaneous recording of MPI from left ventricle out flow tract, in 5 chamber view.

To eliminate inter observer and intra observer errors, and to insure accuracy of measurements of these intervals with Doppler technique, requires repeating the measurements 5 to 7times [27]; in our study, the average of at least 5 Doppler waveform intervals was undertaken.

Statistical analysis:

Data was analyzed as per BMI groups(BMI= 20-24.9 and BMI= >24.9), as well as, by dividing the subjects in to two groups according to Waist-Hip ratio (WHR ratio <0.8-0.9 and WHR ratio >0.9). Mean and standard deviations were calculated. Independent T test and correlation regression test (using SPSS version 18) were applied to compare the study groups. Correlation coefficient (r) was obtained to study the correlation of BMI and Waist-Hip ratio with LV Tie index. Probability value P of less than 0.05 was considered statistically significant (α=0.05).

Results:

The mean values by BMI and WHR for the MPI are shown in Tables 2 and 3; figures 2 and 3). There was statistically no significant variation in MPI with increased BMI or WHR, using unpaired (independent) T test. When fitted to a linear relationship, neither increased BMI(r =0.0023) nor WHR(r=0.0007) had a significant correlation with MPI:

Table (2) mean values for MPI in group Ia and group IIa

Sample	MPI (M± SD)	N	Age M±SD
Group Ia (Control	0.384±0.0683	38	32.315±10.179
Group IIa (increased BMI)	0.399±0.0541	37	39.918±12.239

The calculated t value was -1.09, From percentile of t distribution table (t(1- α/2), df=80) t value was =±1.99. MPI is not different for the two groups (p>0.05).
Results of the impact of increased WHR on MPI are shown in table 3.

Table (3) mean values for MPI in group Ib and group IIb

Sample	MPI (M± SD)	N	Age M±SD
Group Ib (Control)	0.387±0.061	45	31.8±8.91
Group IIb (increased WHR)	0.398±0.06	37	39.918±12.239

The calculated t value was -0.82, From percentile of t distribution table (t(1- α/2), df=80) t value was =±1.99. MPI is not statistically different for the two groups(p>0.05).

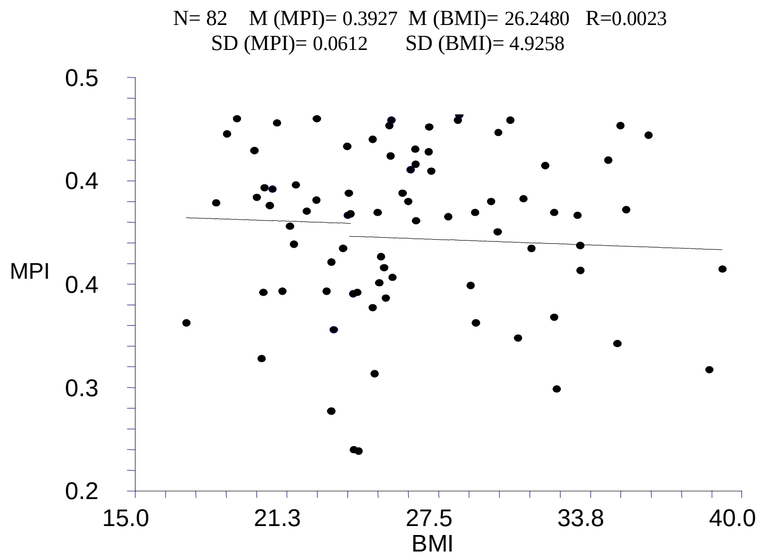

Figure (2) linear correlation plot of MPI&BMI

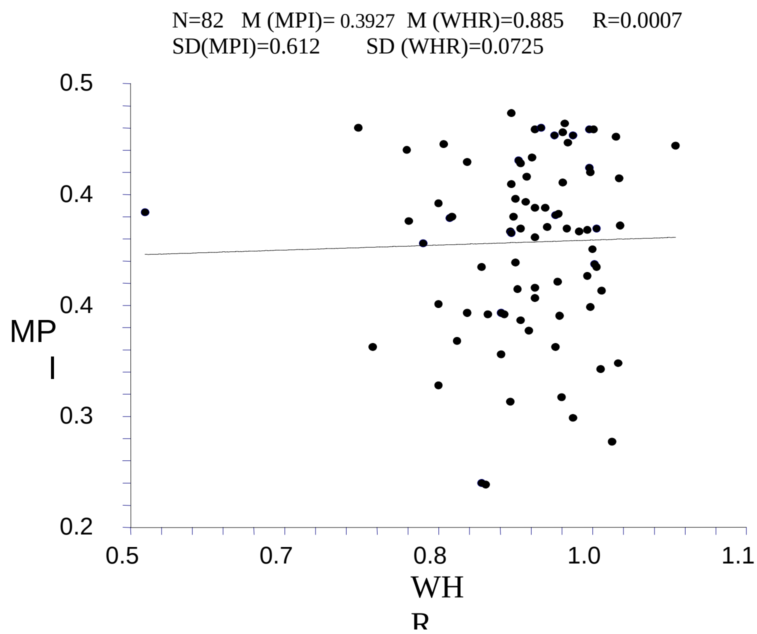

Figure (3) linear correlation plot of MPI&WHR

DISCUSSION

Despite diversity of the clinical use of MPI in cardiology, little is known about whether MPI (Tei index) is influenced by changing of BMI or WHR. In our study, MPI has been shown to have no statistical significant alteration with increased BMI or WHR; however, as demonstrated in figure (3), a slight increase of MPI was noticed with increased WHR.

Our findings are identical with those of previous reports who demonstrated that MPI was not changed in 57 patients with morbid obesity, who had undergone gastric bypass surgery and echocardiography before and after surgery(Carolina et. al.,2010)[(28)]. Our results contradict with that of Fatima et. al., 2009[(23)] who demonstrated significant correlation between BMI and MPI in men with type 2 DM; however, in this study, no data regarding control groups was furnished. Other studies like that provided by Sarita et. al., 2010[(24)], showed the obese subjects (children and adolescent) had significantly high MPI; adults and middle age groups were not included. In another study, Ertürk et. al. 2005[(25)] showed high MPI in normotensive and hypertensive obese children. The non unanimity of our study with the above cited reports resides in the fact that previous studies focused on the impact of morbid obesity on MPI, in diseased children or adults, whereas, our study investigated the impact of increased BMI (including mild to moderate obesity) on MPI in healthy adult men only.

Of particular noteworthy, a study by Pascual et. al., 2003[(29)], using ejection fraction and fractional shortening as contractility indices has demonstrated a higher systolic function and predicted that systolic function might be affected only with severe obesity; these findings would add further backup to our study in which morbid obesity was not included. Our results are consistent with that of (Rajesh et. al., 2010, Kanoupakis et. al., 2001, Ferraro et. al., 1996, Crisostomo et. al., 2001, Crisostomo et. al., 1999, Seto et. al., 1998, Mureddu et. al., 1996, Berkalp et. al., 1995 and Chakko et. al., 1991)[(30-38)] who showed that no significant change of systolic function with increase of BMI or WHR, they proposed that such findings were due to a possible compensation by structural changes that might have occurred in the heart; systolic function impairment might be affected with still higher BMI.

No significant alteration of MPI with increased BMI or WHR found, though, a slight increase of MPI was noticed with increased WHR, as inferred from figure 3; a finding that could be attributed to the slight increase of IVRT with increased WHR. When analyzing WHR interrelationship with MPI components, of the 82 subjects, 16 were of WHR of a mean of 0.94(range 0.9-1.03) and their IVRT was of a mean of 96.1ms (range: 85.6-120.8).

The current observation is close to that demonstrated by Rajesh et. al., 2010[(30)] who showed no linear association between BMI or WHR ratio and diastolic function, although Diastolic function showed decline even with mild increase of BMI from normal to overweight and the decline was also seen in obese. They hypothesized that cardiac adaptation to chronic volume overload in obese might be associated with eccentric hypertrophy and abnormalities of diastolic function from the initial stages. As stated earlier, it was proposed that increased visceral and subcutaneous adiposity is known to cause higher levels of serum leptin which have been linked to ventricular hypertrophy in humans and in animal models [(10)].

In conclusion, this investigation demonstrated that MPI (Tei index) not varies significantly with BMI or WHR, taking in to account that morbid obesity was not included in this study.

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