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Prevalence and Impact of high body mass index in coronary artery disease patients in cyprus

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Abstract

Aim: High body mass index (BMI) is a precursor to coronary artery disease (CAD) and an aggravator of other coexisting CAD risk factors. Therefore, the aim of this study is to calculate the prevalence of overweight BMI and obesity in known CAD patients in correlation with diabetes, hypertension, exercise, diet and smoking.

Methods: The study retrospectively included 362 consecutive patients (88% male; mean age 67 years) with a history of CAD (MI, PCI or CABG), who visited the cardiology clinics of a public hospital of Cyprus (Nicosia General Hospital) from 2011 to 2014.

Results: The study showed a prevalence of 49.2% in overweight CAD patients and 32.9% in obese CAD patients. The prevalence of diabetes and of hypertension in overweight CAD patients was 47.3% and 49.8%, respectively; compared to 42% and 37.6% in obese CAD patients. Regarding the lifestyle risk factors, 46.7% of overweight CAD patients did not exercise regularly, compared to 40.9% in obese CAD patients. The prevalence of overweight patients who did not follow a diet was 42.9%, compared to 42.4% in obese patients. Moreover, the prevalence of smoking in overweight CAD patients was 52.2% compared to 36.3% in obese CAD patients.

Conclusion: Overweight and obese patients make up a large percentage of the CAD population, exceeding 80% of the study group. Despite BMI being a modifiable risk factor, not adhering to a diet or exercise was observed amongst above-normal BMI groups of CAD patients.

Lay summary: Having more body fat increases one's risk of developing another heart attack in patients who previously experienced one. Other factors that increase that risk are smoking, history of high blood pressure and/or high blood sugar, physical inactivity and poor diet. This study looks at how common these risk factors are amongst patients who experienced a heart attack in the past and whether there is an association between the risk factors and having more body fat (i.e. being overweight or obese). These were the findings:

- Nearly half of the patients in this study were overweight, most of the other half were obese. Having high blood pressure, high blood sugar, being physical inactive, not following a diet and smoking were all found to be more common amongst overweight and obese patients than in patients with body fat within the normal range.
- There were two associations found: 1) between high body fat and high blood sugar and 2) between high body fat and not exercising nor following a diet

Keywords: Coronary artery disease, high BMI, obesity, overweight, CAD risk factors, secondary prevention.

Introduction

Cardiovascular disease (CVD) remains to be the leading cause of deaths worldwide; it is responsible for taking approximately 17.9 million lives annually, translating to around 32% of all deaths [1]. Unfortunately this number is still on the rise and it is expected to increase to 23.3 million by 2030 [2]. Coronary artery disease (CAD) and stroke account for 85% of those deaths [1]. Therefore, identification of high risk individuals is essential to prevent recurrent episodes and premature deaths.

Modifiable cardiovascular risk factors, such as physical inactivity and poor, diet lead to higher body mass index (BMI) i.e. overweight and obesity. The contribution of these factors together increases the risk of developing CAD as well as aggravating other coexisting CAD risk factors such as hypertension and diabetes mellitus [3]. The prevalence of obesity is on the rise globally; it is estimated to reach 18% in males and 21% in females by 2025 [5]. Due to both its acceleration and modifiability, it is important to consider BMI when developing secondary prevention strategies for CAD.

A wide variety of physiological changes stem from obesity disrupting the body's homeostasis. Haemodynamic changes caused by obesity include increased cardiac output (CO) and systemic vascular resistance (SVR) which result in hypertension [5]. Obesity also raises the levels of free fatty acids, decreasing glucose uptake and glycogen synthesis, therefore muscles predominantly use up lipids instead of glucose [6]. Consequently, glucose accumulates in the bloodstream causing insulin resistance to develop. Moreover, chronic hyperglycemia and hypertension both induce endothelial dysfunction, a hallmark in CAD, triggering vascular damage-associated processes via the secretion of proinflammatory cytokines and angiogenic regulatory factors leading to inflammation and fibrosis. The vessels become more permeable reinforcing vascular lipid uptake. The combination of free fatty acids, inflammation and fibrosis lead to the formation of atheroma and later atherosclerosis which on the long term develops into clinically significant CAD [7,8].

Despite the obesity epidemic being a notable health concern and a threat to the cardiovascular system, according to the obesity paradox hypothesis, there is an inverse relationship between BMI and negative CAD outcomes [5]. Around 17,800 participants took the US national and nutritional examination survey (NHANES III) which assessed their health and nutritional status. It was calculated that the adjusted risk ratio of obese and non-obese participants with and

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without CVD was 0.79 and 1.30 respectively. This aligns with the obesity paradox hypothesis indicating that obesity might be a protective factor as well as a risk factor [9]. There are multiple explanations for this hypothesis. The extra adipose tissue insulates the body from the accumulation of harmful lipophilic chemicals in addition to neutralising bacterial toxins and circulating cytokines caused by excessive levels of serum lipoproteins; all of which enhance survival [8,10]. Protection of the cardiovascular system in obese patients is further secured by the decreased production of thromboxane, a platelet activation marker, reducing cardiovascular mortality [11]. Furthermore, CAD is usually diagnosed earlier in obese compared to non-obese patients and it is associated with higher chances of survival. The results of percutaneous coronary interventions (PCIs), appear to be better in obese patients because their blood vessels tend to be larger [8].

Survivors of a first CAD event are at a higher risk of recurrence or death compared to the general population, thus increasing the importance placed on secondary prevention of CAD, which is crucial in reducing mortality and recurrent events. A meta-analysis evaluating several lifestyle modification programs over a follow-up period ranging from one to five years showed a 34% reduced mortality whilst cardiac re-incidence and readmissions went down by 35% [12]. In order to ameliorate secondary prevention programs, a solid understanding of the burden of disease is needed. Therefore, the aim of this study is to calculate the prevalence of overweight and obesity among CAD patients and assess the interrelationship between high BMI and the other CAD risk factors.

Methods

The aim of the present study is primarily focusing on secondary prevention of CAD and more specifically it studies the prevalence of overweight and obesity in patients with known CAD by calculating the BMI among these patients. BMI is derived from weight and height to give a calculated estimate of one's body fat. It is usually classified into four categories with the following BMI ranges: underweight (< 18.5), normal (18.5 - 24.9), overweight (25 - 29.9) and obese (30+).

An observational study was carried out to measure the prevalence of overweight and obesity in known CAD patients i.e. patients who had history of myocardial infarction (MI), percutaneous coronary intervention (PCI) or/and coronary artery bypass graft surgery (CABG). The study is a retrospective one, extracting patient information from the Cyprus Survey of Coronary Artery Disease and it included consecutive patients who were examined in the Cardiology Clinics of Nicosia General Hospital between the years 2011 and 2014. The data included age, gender, date of MI, date of PCI or CABG surgery, past medical history of diabetes and history of hypertension, in addition to whether or not patients followed a healthy diet (e.g. Mediterranean diet which encourages higher consumption of whole grains, vegetables and fruits), exercised (walking at least 30 minutes a day) and smoked (including those who used to in the past and those who still do).

The study population consisted of 362 patients, 88% were male with a mean age of 67 years. Overall prevalence of every BMI category (normal, overweight and obese) was calculated and compared across both genders (females and males). The study population was subdivided further and the prevalence within the above-normal BMI groups was then analysed according to their risk factors: hypertensive vs non-hypertensive, diabetic vs non-diabetic, exercise vs no-exercise and healthy diet vs unhealthy diet. For every BMI group, the number of CAD patients with the specified risk factor was counted and divided by the total number of patients with and without that risk factor.

Additionally, to assess whether the difference `in the calculated prevalence of the BMI categories is statistically significant or due to chance, the Two-Proportion Z-test was applied. This statistical test was chosen because the sample consisted of more than 30 participants following a normal distribution. The statistical significance between the following groups was tested: 1) prevalence of having vs not having each risk factor in both overweight and obese patients independently (i.e. diabetes mellitus vs no diabetes mellitus, hypertension vs no hypertension, exercise vs no exercise, diet vs no diet and smoking vs no smoking), and 2) prevalence of overweight vs obesity in the presence and absence of each risk factor. Correspondingly, it was hypothesized, 1) the risk factors that showed a higher prevalence amongst obese and overweight CAD patients were, diabetes, hypertension, no exercise, no diet and smoking, and 2) obese CAD patients showed a higher prevalence than overweight CAD patients as there were more obese patients who had diabetes and hypertension as well as no exercise and no healthy diet.

The following equation was used and the result was compared to the Z alpha/2 score with a confidence level of 95% found in a z table:

$$\square = \frac{(\square 1 - \square 2) - 0}{\sqrt{(\square)(1-\square)(\frac{1}{\square 1} + \frac{1}{\square 2})}}$$

(p1 = proportion of the first group who either exercised or followed a diet, p2 = proportion of the second group who did not, p = overall sample proportion , n1 = sample size of the first group, n2 = sample size of the second group; the proportions were calculated by extracting the number of patients within the chosen BMI category from the table below and divided over the total sample size for the specified risk factor).

The Z alpha/2 score with a confidence level of 95% is 1.96. If our z-results are greater than 1.96 then our hypotheses are verified, which means our results are statistically significant. If our z-results are less than 1.96 then the null hypothesis which states that there is no relationship between the risk factors and a higher prevalence of overweight and obesity is to be confirmed, meaning the difference is due to chance.

Results

The study population was made up largely of overweight CAD patients with a prevalence of 49.2%, followed by obese patients who had a prevalence of 32.9%. There was an overall similarity in the prevalence of every BMI category across both genders shown in figure 1. With respect to CAD comorbidities, the prevalence of overweight BMI was 47.3% and 49.8% amongst diabetic and hypertensive CAD patients, respectively, compared to 42% and 37.6% in obese CAD patients. On the other hand, 51% of overweight CAD patients had both diabetes and hypertension, compared to 38.5% in obese patients (figure 2).

Furthermore, there was a prominent gap between the prevalence of the presence of each lifestyle risk factor amongst CAD patients with above-normal BMI and their absence. Overweight CAD patients who reported exercising had a prevalence of 51.6% compared to 25.3% in obese CAD patients. The prevalence of overweight and obese CAD patients who reported following a healthy diet was 57.3% and 20.4%, respectively. Amongst CAD patients who did not exercise, the prevalence of overweight patients was 46.7% compared to 40.9% in obese patients. Amongst CAD patients who did not follow a healthy diet, the prevalence of overweight and obese patients was 42.9% and 42.4% respectively. As for smoking, the prevalence of overweight patients who did smoke was 52.2% compared to 45.3% in those who never smoked. The prevalence of obesity in CAD patients who smoked was 36.3% compared to 31.9% in obese CAD patients who never smoked (figure 3). Among overweight CAD patients, the z-result comparing the prevalence of those with diabetes to those without diabetes was

Appendix A

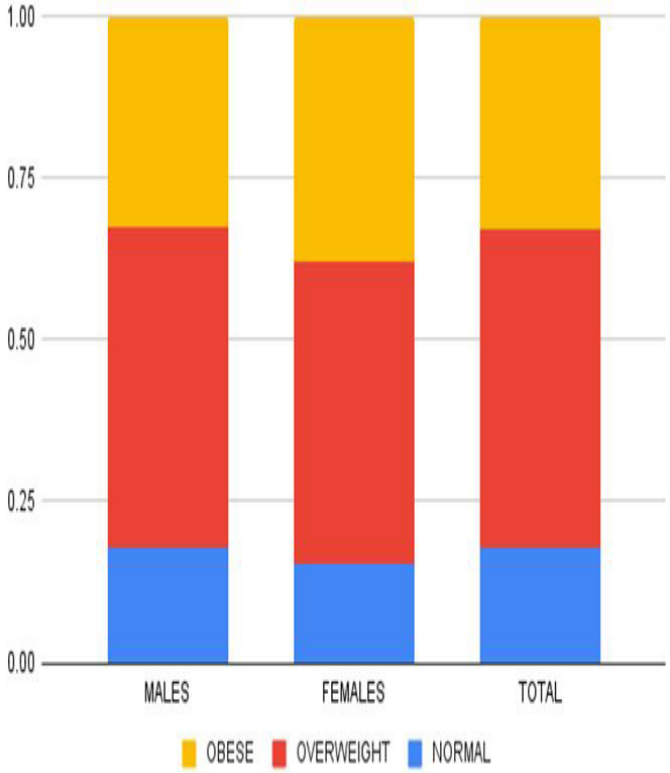

***Figure 1**: Comparing the prevalence of every BMI category (normal, overweight and obese) between males, females and total study population. There was a similar distribution of normal, overweight and obese BMI across males (normal BMI = 18%, overweight = 49.5%, obese = 32.2%), females (normal BMI = 15.5%, overweight = 46.7%, obese = 37.8%) and the total population (normal BMI = 17.7%, overweight = 49.2%, obese = 32.9%).*

Appendix B

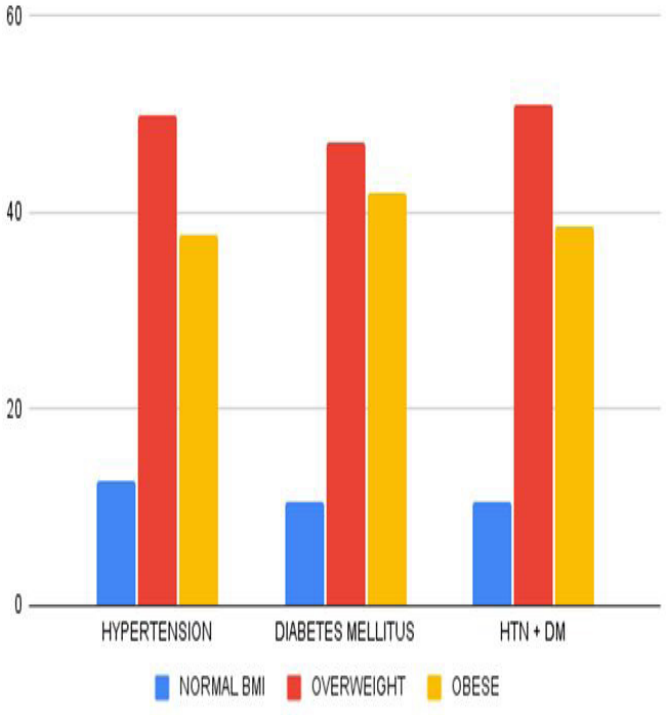

***Figure 2**: Comparing the prevalence of high BMI (overweight and obese) to normal BMI in relation to co-exisiting CAD comorbidities (hypertension, diabetes mellitus and both of them together). The BMI prevalence of each group was the following: hypertension (normal BMI = 12.7%, overweight = 49.8%, obese = 37.6%), diabetes mellitus (normal BMI = 10.6%, overweight = 47%, obese = 42%) and hypertension + diabetes (normal BMI = 10.4%, overweight = 51%, obese = 38.5%).*

Appendix C

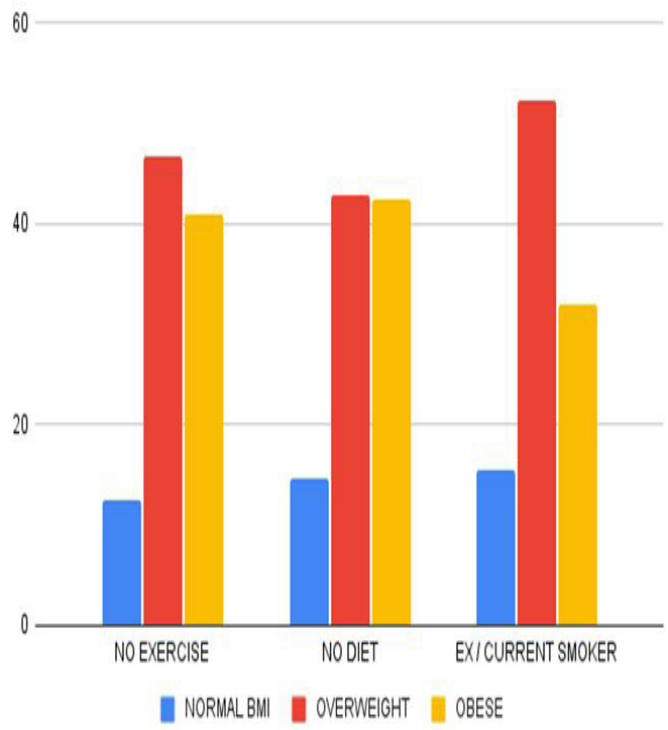

***Figure 1**: Comparing the prevalence of high BMI (overweight and obese) in relation with the lifestyle risk factors i.e. no exercise, no diet and smoking (ex-smoker and current smokers). The BMI prevalence among these lifestyle risk groups are as follows: no exercise (normal BMI = 12.5%, overweight = 46.7%, obese = 40.9%), no diet (normal BMI = 14.6%, overweight = 42.9%, obese = 42.4%) and ex/current smoking (normal BMI = 15.4% , overweight = 52.2%, obese = 31.9%).*

0.46 and the z-result of those who were hypertensive compared to those who were normotensive was 0.39. When the prevalence of overweight CAD patients who exercised was compared to those who did not exercise, the z-result was 0.95 whereas when the prevalence of overweight CAD patients who followed a diet was compared to those who did not follow a diet, the z-result was 2.72. Lastly, the z-result was 1.32 amongst overweight CAD patients who smoked and those who did not smoke. On the other hand, amongst obese CAD patients, the z-result of the diabetics vs non-diabetics was 2.51 whilst the z-result of those who were hypertensive vs those who were normotensive was 1.72. The z-result of obese CAD patients who exercised and those who did not exercise was 3.16 in comparison to 4.42 in obese patients who followed and did not follow a diet. As for the z-result of those who smoked and those who did not smoke amongst obese CAD patients, it was 1.32. Moreover, when comparing the prevalence of overweight to obese CAD patients in the presence and absence of all risk factors, the z-results were 1.76, 0.88, 2.43, 4.07 and 1.16 in diabetes mellitus, hypertension, exercise, diet and smoking respectively.

Discussion

The highest prevalence observed in the study was 49.2% amongst overweight CAD patients which made up 49.5% of males and 46.7% of females. The second highest prevalence was 32.9% amongst obese CAD patients which made up 32.2% of males and 37.8% of females. These results were replicated by the EUROASPIRE IV (conducted in 2015) as both studies followed a similar pattern of BMI prevalence showing no discrepancy in prevalence across both genders [13]. Additionally, two previous studies were also carried out in Cyprus and it was noted that the prevalence of obesity in CAD patients increased from 36% (between the years 2003 and 2006) to 42% (between 2007 and 2008) [14,15].

Nonetheless, our study and EUROASPIRE IV countered each other in regards to prevalence of overweight amongst diabetic and non-diabetic patients. In the present study, the prevalence of overweight non-diabetic CAD patients was higher than overweight diabetic CAD patients whereas in EUROASPIRE IV the prevalence of both overweight and obesity was higher in diabetic CAD patients than in non-diabetics [16]. The z-result comparing the prevalence of diabetic and non-diabetic overweight patients was not statistically significant which means the increase in prevalence of non-diabetic overweight CAD patients in this study could had been due to chance. Contrarily, the z-result comparing the prevalence of diabetic and non-diabetic obese patients demonstrated statistical significance, suggesting an association between diabetes mellitus and higher prevalence of obese CAD patients.

One possible explanation for the increased prevalence of above-normal BMI diabetic CAD patients is the lack of weight loss due to physical inactivity and poor diet, predisposing patients to a recurrent CAD event. These results revealed that the difference between the prevalence of obese CAD patients who exercised and followed a healthy diet and those who did not exercise nor followed a healthy diet were statistically significant, implying that higher prevalence of obesity is associated with lack of exercise and diet. Another gap observed in the results, was between the prevalence of overweight and the prevalence of obese CAD patients who exercise and followed a healthy diet.

There was a higher proportion of overweight patients who exercised and followed a healthy diet compared to obese patients, nearly double and triple respectively, supporting that the higher the BMI, the higher the risk of experiencing a CAD event. This in turn negates the obesity paradox hypothesis as it fails to reflect a true survival advantage when the confounders such as smoking and other comorbidities are adjusted for the risk of negative outcomes among overweight and obese CAD patients increases instead of decreases [5].

This study established an association between higher prevalence of overweight and obesity and the presence of CAD risk factors, physical inactivity and poor diet in particular. Therefore exercising and following a healthy diet is important to incorporate when planning lifestyle modifications for above-normal BMI CAD patients. Nonetheless, further research needs to be conducted to explore the causation of these associations. Furthermore, the present study population was not representative enough; not only was the distribution of genders not similar, but also using hospital records to estimate population prevalence implies selection bias. One way this bias can be eliminated is by selecting patients randomly or having a more evenly distributed study population to be more representative of the general population. Another setback in our study is the inability to establish whether high BMI led to the CAD event or the CAD event took place before the patient's BMI increased. The same concept applies to whether the patient started exercising and following a diet post-CAD-event or pre-event which is also unknown. However, temporality is hard to establish in a retrospective study.

This study is important as it helps assess the burden of CAD on the healthcare system and guide management plans to prevent recurrence and mortality. In a secondary prevention trial, it was recommended to consume a Mediterranean-type diet (e.g. fish, chicken, fruits, vegetables and grains) as it reduced recurrence and mortality by 72% over a 4-year follow-up. Moreover, the recommended daily exercise for CAD patients is a 30-minute brisk walk which reduces the symptoms and lowers mortality after the first event by 30 to 50%. According to the European Society of Cardiology (ESC) guidelines, it is recommended to lower blood pressure to <140/90 mmHg and HbA1c to < 7% in patients with established CAD to minimise the CAD risk [17].

The Cyprus Society of Cardiology (CSC) has made several efforts towards secondary prevention of CVD including campaign launches e.g. "world heart day", "world hypertension day" and "world diabetes day". All these, help educate the public as well as raise awareness amongst CAD patients regarding their risk factors. Another way to better secondary prevention of CAD in Cyprus is by setting up cardiac rehabilitation programs. CAD patients will be supported with physical activity training, nutritional counselling, psychosocial interventions and further management of risk factors e.g. obesity; thus minimising their risk of recurrence and mortality [18].

Conclusion

In conclusion, the CAD population is predominantly made up of overweight and obese patients. There is an association between CAD patients with a higher BMI and lifestyle CAD risk factors such as physical inactivity and poor diet. The combination of patients with higher BMI and diabetes mellitus is also found frequently amongst the CAD population. Therefore, secondary prevention of CAD should tackle the lifestyle risk factors as well as glucose level control in order to halt the pathophysiological effects of high BMI involved in CAD and stop it

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