

The relation between body mass index and waist–hip ratio in knee osteoarthritis

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Background: The best measure of body habitus as a risk factor for chronic disease is not well defined. Our intent was to examine the relation between waist–hip ratio (WHR) and body mass index (BMI) as a measurement of body habitus in patients with end-stage knee osteoarthritis (OA).

Methods: We reviewed the data of 200 consecutive patients in our registry undergoing knee replacement surgery for demographic data of age, sex, BMI and WHR. We performed a stratified analysis by sex and calculated the risk ratios (RRs) to describe the risk of being classified as obese by WHR for those considered obese by the BMI criteria.

Results: A similar percentage of male and female patients were classified as obese by the BMI criteria (38% v. 42%, respectively). Men were classified as obese more often than women by WHR (92% v. 82%). The RR of being obese as determined by WHR if classified as obese by the BMI criteria was 1.04 (95% confidence interval [CI] 0.91–1.18) for men and 1.23 (95% CI 1.03–1.46) for women.

Conclusion: Among patients with knee OA, the overlap between BMI and WHR is greater in women than men. This difference has implications for defining the prevalence of metabolic syndrome in this population.

Contexte : La meilleure mesure du phénotype corporel comme facteur de risque de maladie chronique n'est pas bien définie. Nous voulions étudier le lien entre le rapport taille-hanches (RTH) et l'indice de masse corporelle (IMC) comme mesure du phénotype corporel chez les patients qui ont une arthrose du genou (AG) au stade ultime.

Méthodes : Nous avons étudié les dossiers de 200 patients consécutifs inscrits dans notre registre qui ont subi une arthroplastie du genou pour dégager des données démographiques sur l'âge, le sexe, l'IMC et le RTH. Nous avons effectué une analyse stratifiée selon le sexe et calculé le risque relatif (RR) afin de décrire le risque d'être classifié comme obèse en fonction du RTH chez les personnes considérées comme obèses selon les critères de l'IMC.

Résultats : Un pourcentage semblable de patients des deux sexes ont été classifiés comme obèses en fonction des critères de l'IMC (38 % c. 42 %, respectivement). Les hommes ont été classés obèses plus souvent que les femmes selon le RTH (92 % c. 82 %). Le RR d'être obèse selon le RTH des personnes classées comme obèses selon les critères de l'IMC s'est établi à 1,04 (intervalle de confiance [IC] à 95 %, 0,91–1,18) chez les hommes et à 1,23 (IC à 95 %, 1,03–1,46) chez les femmes.

Conclusion : Chez les patients atteints d'arthrose du genou, le chevauchement entre l'IMC et le RTH est plus important chez les femmes que chez les hommes. Cette différence a des répercussions sur la définition de la prévalence du syndrome métabolique dans cette population.

Metabolic syndrome (MetS) is cluster of the following comorbidities: obesity, elevated fasting glucose, high blood pressure and dyslipidemia.^{1,2} Patients with MetS have a systemic proinflammatory and prothrombotic state, which increases their risk for cardiovascular disease and stroke.² In the orthopedic literature, MetS has been linked to an elevated risk of deep vein thrombosis³ and pulmonary embolus⁴ after joint replacement surgery.

The individual comorbid factors of diabetes, hypertension and hypercholesterolemia have independent relations with degenerative joint disease.^{5–7}

Similarly, obesity is an independent risk factor for the incidence and progression of hip and knee osteoarthritis (OA).⁸⁻¹¹ However, the World Health Organization (WHO) criteria for diagnosing obesity in MetS patients suggests that it may be defined by elevated body mass index (BMI) or waist-hip ratio (WHR).¹² These 2 measures describe body habitus in different ways: BMI accounts for both lean muscle mass and total body fat, whereas WHR represents predominantly truncal obesity.

The WHR suggests that truncal obesity is the greatest contributor to the relation between body habitus and chronic disease. Truncal adipocytes are believed to be a metabolically active exocrine organ that secretes inflammatory mediators into the systemic circulation.^{13,14} Large epidemiologic studies have shown that WHR is the strongest predictor of the risk for myocardial infarction, independent of BMI.¹⁵ Similarly, WHR has been shown to be a stronger predictor than BMI for the risk of ischemic stroke, diverticular disease and overall mortality.¹⁶⁻¹⁸ Few data comparing BMI and WHR for predicting incident OA exist.¹⁹ All studies examining the relation between body habitus and orthopedic surgical outcomes use BMI, whereas none have used WHR.

The estimated prevalence of MetS may be different depending on whether WHR or BMI is used to define obesity. We sought to examine the relation between WHR and BMI as a measurement of body habitus in patients with end-stage knee OA. We believed that there would be poor overlap between these 2 measures for both men and women.

METHODS

In our university hospital, we recruit patients to participate in a total joint replacement registry while on a waiting list for primary knee replacement surgery. All patients give informed consent to participate in the registry. In this study, we included patients aged 18 years and older with a diagnosis of primary knee OA. The study protocol was approved by the Human Subject Review Committee at our institution.

We reviewed a consecutive series of 200 white patients on the waiting list for primary knee arthroplasty in 2007. All data were collected by an independent assessor (D.T.) not involved in the medical care of the patients.

Definition of obesity

We used the WHO definitions that are part of their guidelines for the diagnosis of MetS.¹² Those with a BMI of 30 or higher and a WHR of 0.9 or higher (men) and 0.85 or higher (women) were considered obese.¹²

We collected data about BMI through patient self-report. For WHR, hip circumference was measured at the widest diameter of the buttocks over thin clothing, and waist circumference was measured over the bare skin of the abdomen at the narrowest diameter between the iliac crest and costal margin.^{20,21} All measurements were made by a single person (H.D.) using a stiff measuring tape and taken in duplicate and averaged together for the final values.

Statistical analysis

We performed a stratified analysis by sex because the definition of obesity for WHR varies by sex. We constructed 2 x 2 tables examining the association between being defined as obese by BMI and by WHR criteria for men (Table 1) and women (Table 2). We report the risk ratios (RRs) and 95% confidence intervals (CIs), defined as the risk of being classified as obese by WHR for those considered obese by the BMI criteria. An RR with a 95% CI that does not include 1 indicates that there is significant relation between the risk of being classified as obese by both criteria.

RESULTS

Of the 200 patients included, we had complete data on 191 patients. The other 9 patients had not provided a BMI. There were 107 (56%) women and 84 (44%) men in our cohort. The mean age of the patients was 65.9 (standard deviation [SD] 10.1) years.

The overall mean BMI was 29.2 (SD 5.5), and the mean WHR was 0.93 (SD 0.07). The mean BMI among men was 29.0 (SD 4.3), compared with 29.3 (SD 6.2) among women. The mean WHR among men was 0.97 (SD 0.05), compared with 0.90 (SD 0.07) among women.

Based on the WHR criteria, 77 (92%) men were obese, compared with 32 (38%) who were obese by the BMI criteria. Similarly, 87 (82%) women were obese by the WHR

Table 1. Risk of being classified as obese by waist-hip ratio and body mass index for men

BMI	Waist-hip ratio	
	Obese	Not obese
Obese	30	2
Not obese	47	5

BMI = body mass index.

Table 2. Risk of being classified as obese by waist-hip ratio and body mass index for women

BMI	Waist-hip ratio	
	Obese	Not obese
Obese	41	4
Not obese	46	16

BMI = body mass index.

criteria, compared with 45 (42%) who were obese by the BMI criteria. Among men, the RR for being classified as obese by the WHR criteria if obese by the BMI criteria was 1.04 (95% CI 0.91–1.18). Among women, the RR of being defined as obese by the WHR criteria if obese by the BMI criteria was 1.23 (95% CI 1.03–1.46).

DISCUSSION

Metabolic syndrome is well established as a risk factor for myocardial infarction, stroke and dementia.^{2,22,23} In the orthopedic literature, MetS has been linked to an increased risk of deep vein thrombosis,³ pulmonary embolism⁴ and incident OA.²⁴ The WHO definition of MetS suggests that obesity may be defined by BMI or WHR; however, our study shows that the prevalence of obesity would potentially vary greatly depending on which definition is used, especially among men.

The impact of obesity on the risk for hip and knee OA has been shown in many studies; however, recent literature suggests this effect may be mediated through a systemic metabolic effect rather than just a mechanical effect. In addition to the inflammatory mediators released, truncal and visceral adipocytes release the hormone leptin, which has been shown to have a direct damaging effect on joint chondrocytes.^{25–27} This argument is supported by the relation between obesity and OA in non-weight-bearing joints, such as those in the hand.^{28–30}

Our finding that BMI and WHR have greater overlap in women than in men may be explained by the fact that women carry their fat more in their lower extremities, whereas men carry their adipose tissue at the abdominal level.^{31–33} In our study, a similar percentage of men and women were obese as defined by the BMI criteria (38% v. 42%, respectively), whereas men were defined as obese more often than women by the WHR criteria (92% v. 82%). Abdominal and visceral adipocytes are considered the most metabolically active, whereas fat centered around the hips and thighs is metabolically protective through improved glucose tolerance and better serum lipid profiles.^{2,21}

Strengths and limitations

Our study has several strengths. First, we included a large, homogenous sample of consecutive patients, which limits any selection bias in this study. Second, all body measurements for WHR were taken by the same person to limit the variability in the data.

The primary limitation of our study is that we included only white patients; thus, our conclusions are only generalizable to this ethnic group. Some have shown that other ethnic groups, such as Asian people, have a greater proportion of body fat and a lesser proportion of lean muscle mass as compared with white people of the same BMI.^{34,35} This relation between BMI and WHR should be explored in

other ethnic groups in future studies. Although we used self-reported BMI, others have shown that it is reliable and is highly correlated with objective measurements of BMI.^{36,37} Some have suggested that self-reported BMI may range from 0.29 to 1.0 less than objective measures.^{38,39} In our study, we collapsed BMI into 2 categories (obese or not obese); thus, even if these differences did exist, they would not have changed our conclusions.

CONCLUSION

We found that, among patients with knee OA, there is greater agreement between BMI and WHR in women than in men. This difference has implications for the prevalence of MetS in this population. The best measure of body habitus, whether BMI, WHR or some other measure, as a risk factor for incident OA, surgical outcomes and complications (such as infection) warrants further study.

Competing interests: None declared.

Contributors: Drs. Gandhi and Mahomed designed the study. Drs. Gandhi and Dhotar and Mr. Tsvetkov acquired the data, which all the authors analyzed. Drs. Gandhi and Dhotar wrote the article, which Drs. Gandhi and Mahomed and Mr. Tsvetkov reviewed. All authors approved the article that was submitted for publication.

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