Association of body mass index and waist circumference with severity of knee osteoarthritis

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ACTA REUMATOL PORT. 2016;41:226-231

ABSTRACT

Aim: The aim of the present study was to investigate the association of the body mass index (BMI) and waist circumference (WC) with the radiographic severity of knee osteoarthritis (rKOA)

Methods: A cross-sectional study had been applied during this research which included 150 patients diagnosed at the General Hospital in Užice and Health Center in Arilje (Serbia). The study included patients over the age of 50, diagnosed with OA according to The European League Against Rheumatism (EULAR) criteria. Data on social-demographic characteristics, health habits, and personal and family histories of the participants were collected through a specific questionnaire designated for this research. The severity of the disease was assessed pursuant to radiological changes using the Kellgren-Lawrence grading scale (K-L). The state of nourishment was assessed according to the BMI and WC.

Results: According to multivariate logistic regression analyses, after adjustment for age, sex, marital status, formal education, present occupation, smoking, alcohol consumption and physical activity; higher grades of rKOA (grade III and grade IV) were significantly related to BMI ($p = 0.038$) and WC ($p < 0.001$). The association was much stronger for obesity defined as BMI ≥30 kg/m^2 ($p = 0.002$) and for abdominal obesity – WC > 102 cm in men and > 88 cm in women ($p = 0.009$).

Conclusion: This study showed that obesity defined as BMI ≥30 kg/m^2 and abdominal obesity are strongly related to K-L of rKOA, with the associations being of very similar extent.

Keywords: Knee osteoarthritis; Obesity; K-L scale.

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INTRODUCTION

Osteoarthritis (OA) is the third most widespread disease in the older population, with OA of the knees being most common[1].

The epidemiologic studies performed in the European and American populations showed that the prevalence of radiologically proven knee OA in adult population ≥ 45 years old ranged from 19.2%[2] to 27.8%[3] depending on the type of the study and the examined population. The frequency of OA increases with age, and both symptomatic and radiographic OA are more common in women than in men. The frequency of arthritis in females increases during menopause and after the surgical removal of ovaries[4,5]. In comparison with men women demonstrate significantly higher K-L 3 and 4 (12.9% vs. 6.5%)[4].

The knee OA occurrence is connected to numerous factors. Along with age and gender, the other factors are obesity, knee injuries, repetition of joint movements, reduced bone density and muscle weakness[6]. Primary knee OA is influenced by work which requires more demanding physical labor with frequent kneeling and squatting positions. OA is more common in people engaged in agriculture, forestry, fish farming, transportation and construction[7,8]. According to the findings of Spector *et al.*[9], overloading, excessive exercising and abnormal use of the joint creates risks for the occurrence of OA among long distance runners and professional football players. Newton and associates, however, did not find such connection[10]. OA was also more common in married people and in people with less for-

mal education or low income[11].

Some studies have found that smoking acts as a protective factor for severe cases of knee OA because of nicotine, which promotes proliferation and collagen synthesis within the chondrocytes[12]. The research findings relating to alcohol consumption and OA are contradictory[13].

According to epidemiological researches, obesity presents the most important individual risk factor for the occurrence of primary knee OA[14], and numerous studies have shown that obesity also presents an OA progression predictor[14]. Obesity prior to the age of 40 substantially increases the risk of subsequent symptomatic knee OA in females[15].

Davis et al. followed the distribution of fat tissue in those suffering from OA and concluded that the BMI is in relation with the knee OA but that the body distribution of the fat tissue is not in correlation with the OA of the knees, hips and hands[16]. Abbate *et al.* performed a study covering 779 women and concluded that BMI was in tight connection with the severity of the disease according to the K-L and that the fat distribution was not in correlation with the severity of the disease[17]. However, according to the prospective cohort study carried out in Melbourne, BMI and waist circumference increase the risk of knee endoprosthesis implant rather than hip implant in those with primary OA[18].

Since the results of the association between progression of knee OA and obesity, especially abdominal obesity, have been not consistent, the aim of the present study was to investigate the association of the BMI and WC with the severity of rKOA.

MATERIAL AND METHODS

A cross-sectional study had been applied during the research which included 150 patients diagnosed at the General Hospital in Užice and Health Center in Arilje (Serbia).

The study included patients over the age of 50 with knee OA according to The European League Against Rheumatism (EULAR) criteria[19]: three symptoms (pain on use, brief morning joint stiffness (< 30 minutes), limited joint function) and one of the following three signs (crepitation, limited movement or joint enlargement); erythrocyte sedimentation[20] and radiographic knee joint findings of some of the OA signs (presence of osteophyte, narrowed joint space, subchondral bone sclerosis or joint deformation). The severity of the disease was assessed pursuant to the radiological changes according to the K-L grading scale[20].

The criteria for exclusion of patients from the research were as follows: patients < 50 years of age, erythrocyte sedimentation values exceeding 20, the presence of secondary knee OA (as a result of inflammatory rheumatic diseases: idiopathic arthritis, infectious arthritis, metabolic arthropathy or injuries), presence of malignant diseases and the presence of mutual endoprosthesis of the knee joint. The study did not include hemodialysis patients, immobile or fairly mobile patients (hemiplegia, paraplegia),

All information regarding the patients' social-demographic characteristics, health habits, and personal and family histories were collected by means of a specific questionnaire designed for this research. The patients were classified into the following categories: current and former smokers and non-smokers and current and former alcohol consumers and non-drinkers. As for physical activities (any non-professional physical activity with duration of over 30 minutes daily) the patients were classified into the following 3 groups:

– Patients who do not conduct physical exercises at all or perform it not more than 4 times a month
– Patients who perform physical activities 5 to 8 times a month, and
– Patients who perform physical activities 9 or more times a month

Patients were considered physically active if their physical activities were more frequent than 4 times a month.

Body weight and height, measured by standard procedures, were used to calculate the BMI as weight (Kg) divided by height (m^2). The BMI was categorized according to the World Health Organization criteria[21] and those with BMI ≥ 30 Kg/ m^2 were considered obese. Abdominal obesity was determined according to the WC values, where male with the WC exceeding 102 cm and females with WC exceeding 88 m were classified as a group of patients with abdominal obesity[21].

ETHICAL APPROVAL

The clinical research and patients' written consent for the study participation was approved by the Ethical Committee of the Užice Medical Centre.

STATISTICAL ANALYSIS

Categorical variables were presented by counts and percentages and continuous variables were described

as means ± standard deviation (SD). ANOVA was used to compare patients with different grades of rKOA with adjustment on age.

Four separate multivariate logistic regression analyses were performed in order to find out whether severity of disease was related with BMI and WC as continuous variables, and with obesity defined as BMI ≥30 kg/m^2 and with abdominal obesity defined as WC > 102 cm in men and > 88 cm in women. Because patients with rKOA grades I and II were similar in their characteristics as well as patients with rKOA grades III and IV, in multivariate logistic regression analysis severity of disease was represented with only two categories (rKOA grade I and II vs. rKOA grade III and IV). In multivariate analyses adjustment was made on variables which are according to literature data possible confounders for association between BMI and WC with severity of rKOA: age, sex, marital status, formal education, present occupation, smoking, alcohol consumption and physical activity.

The data were analyzed using SPSS software version 15.0 (SPSS Inc., Chicago IL) with two-tailed significance level set at 0.05.

RESULTS

In the study were included 150 patients with rKOA, 47 men (31.3%) and 103 women (68.7%). According to K-L, grade I was present in 35 patients (23.3%), grade II in 36 (24.0%), grade III in 28 (18.7%) and grade IV in 51 patients (34.0%) (Table I). As the groups

TABLE I. SOCIO-DEMOGRAPHIC AND LIFE-STYLE CHARACTERISTICS OF PATIENTS WITH RADIOGRAPHIC KNEE OSTEOARTHRITIS (RKOA) BY KELLGREN- LAWRENCE SCALE

	rKOA (Kellgren-Lawrence scale)					
Variable	I (n=35) mean ± SD/%	II (n=36) mean ± SD/%	III (n=28) mean ± SD/%	IV (n=51) mean ± SD/%	Total mean ± SD/%	P*
Age (years)	60.8±10.80	63.4±9.58	69.4±9.32	71.2±7.84	66.6±10.17	0.000
Sex						0.705
Males	13 (37.1)	11 (30.6)	11 (39.3)	12 (23.5)	47 (31.3)	
Females	22 (62.9)	25 (69.4)	17 (60.7)	39 (76.5)	103 (68.7)	
Marital status						0.753
With partner	31 (88.6)	32 (88.9)	22 (78.6)	38 (74.5)	123 (82.0)	
Without partner	4 (11.4)	4 (11.1)	6 (21.4)	13 (25.5)	27 (18.0)	
Years of school						0.879
≤ 8	32 (91.4)	34 (94.4)	28 (100.0)	48 (94.1)	142 (94.7)	
> 8	3 (8.6)	2 (5.6)	0 (0.0)	3 (5.9)	8 (5.3)	
Present occupation						0.178
Employed	15 (42.9)	9 (25.0)	6 (21.4)	3 (5.9)	33 (22.0)	
Retired	12 (34.3)	13 (36.1)	13 (46.4)	25 (49.0)	63 (42.0)	
Unemployed	8 (22.9)	14 (38.9)	9 (32.1)	23 (45.1)	54 (36.0)	
Smoking						0.110
Yes	1 (2.9)	4 (11.1)	5 (17.9)	4 (7.8)	14 (9.3)	
No	34 (97.1)	32 (88.9)	23 (82.1)	47 (92.2)	136 (90.7)	
Alcohol consumption						0.291
Yes	3 (8.6)	3 (8.3)	4 (14.3)	4 (7.8)	14 (9.3)	
No	32 (91.4)	33 (91.7)	24 (85.7)	47 (92.2)	136 (90.7)	
Physical activity						0.710
0-4	4 (11.4)	4 (11.1)	5 (17.9)	4 (7.8)	17 (11.3)	
5-8	9 (25.7)	10 (27.8)	11 (39.3)	16 (31.4)	46 (30.7)	
9-13	13 (37.1)	14 (38.9)	11 (39.3)	21 (41.2)	59 (39.3)	
>14	9 (25.7)	8 (22.2)	1 (3.6)	10 (19.6)	28 (18.7)	

SD – standard deviation; *ANOVA with adjustment on age

TABLE II. WEIGHT, HEIGHT, BODY MASS INDEX (BMI) AND WAIST CIRCUMFERENCE (WC) IN PATIENTS WITH RADIOGRAPHIC KNEE OSTEOARTHRITIS (RKOA) BY KELLGREN-LAWRENCE SCALE

	rKOA (Kellgren-Lawrence scale)					
Variable	I (n=35) mean ± SD/%	II (n=36) mean ± SD/%	III (n=28) mean ± SD/%	IV (n=51) mean ± SD/%	Total mean ± SD/%	P*
Weight	76.77±15.19	81.26±17.06	84.00±12.96	85.35±15.73	81.85±15.35	0.131
Height	169.24±10.45	169.71±9.02	170.78±8.06	170.44±10.25	170.04±9.59	0.932
BMI	26.87±4.31	28.29±5.13	29.44±4.36	29.27±4.84	28.39±4.70	0.175
BMI ≥30 kg/m^2						0.004
Yes	8 (22.9)	10 (27.8)	13 (46.4)	24 (47.1)	55 (36.7)	
No	27 (77.1)	26 (72.2)	15 (53.6)	27 (52.9)	95 (63.3)	
WC	94.79±15.14	96.62±17.95	104.49±14.63	107.48±13.50	100.85±15.61	0.001
Abdominal obesity**						0.012
Yes	22 (62.9)	22 (61.1)	19 (67.9)	43 (84.3)	106 (70.7)	
No	13 (37.1)	14 (38.9)	9 (32.1)	8 (15.7)	44 (29.3)	

* – ANOVA with adjustment on age; ** WC > 102 cm in men and > 88 cm in women

of patients defined according to K-L significantly differed by age ($p < 0.001$), all further comparisons between them were age-adjusted. Compared groups did not significantly differ by sex, marital status, formal education, present occupation, smoking, alcohol consumption and physical activity (Table I).

Patients with various severities of rKOA did not significantly differ in BMI when it was analyzed as continuous variable (Table II). WC, as an indicator of abdominal obesity, increased with increasing grade of rKOA ($p = 0.001$). Obesity defined as BMI ≥30 kg/m^2 and abdominal obesity defined as WC > 102 cm in men and > 88 cm in women, were significantly more frequent in patients with rKOA grades III and IV in comparison with patients who had rKOA grades I and II ($p = 0.004$ and $p = 0.012$ respectively).

According to multivariate logistic regression analyses (Table III), after adjustment on age, sex, marital status, formal education, present occupation, smoking, alcohol consumption and physical activity, higher grades of rKOA (grade III and grade IV) were significantly related to BMI ($p = 0.038$) and WC ($p < 0.001$). Association was much stronger for obesity defined as BMI ≥30 kg/m^2 ($p = 0.002$) and to abdominal obesity ($p = 0.009$).

Because of the high correlation between BMI and WC ($r = 0.687$, $p < 0.001$), it was not possible to find out whether these two parameters were independently from each other related to K-L of rKOA.

TABLE III. RELATIONSHIP OF BODY MASS INDEX (BMI) AND WAIST CIRCUMFERENCE WITH SEVERE FORM OF RADIOGRAPHIC KNEE OSTEOARTHRITIS (GRADES III AND IV OF KELLGREN-LAWRENCE SCALE) ACCORDING TO MULTIVARIATE LOGISTIC REGRESSION ANALYSIS*

Variable	Odds ratio (95% confidence interval)	P value
Body mass index	1.091 (1.005-1.184)	0.038
BMI ≥ 30 kg/m^2	3.655 (1.594-8.378)	0.002
Waist circumference	1.052 (1.024-1.081)	0.000
Abdominal obesity**	3.524 (1.367-9.081)	0.009

*Four separate multivariate analyses were performed, one for each weight parametar.
In all analyses adjustment was mad on age, sex, marital status, formal education, present occupation, smoking, alcohol consumption and physical activity.
** WC > 102 cm in men and > 88 cm in women

DISCUSSION

In the present study, obesity, presented by BMI or WC, was significantly related to higher K-L of rKOA independently from age, sex, marital status, formal education, present occupation, smoking, alcohol consumption and physical activity.

Even though the studies on the relation between the degree of nourishment and OA differ, Grazio and Balen suggest that 27% percent of cases of hip arthroplasty and 69% f knee arthroplasty may be attributed to obesity[14]. Obesity is considered a risk factor for the occurrence and progress of osteoarthritis[22]. Each new 5 kg of gained body weight increases the risk of knee OA by 36%[22].

Along with numerous evidence that central, abdominal obesity presents a strong factor relating to health problems and mortality, the issue is raised about its impact on the locomotor's system. A study conducted by Muramato *et al.* on 217 females, ages 60 to 79, demonstrated that central obesity is substantially connected to changes on the locomotor's system and that waist circumference may present a beneficial parameter for risk assessment with regards to locomotor's system damage in elderly women[23].

Since central obesity is a key factor in metabolic syndrome (MetS), relationship between OA and MetS or its components have been evaluated in several investigations. In a study conducted by Engström *et al.*[24] MetS was associated with increased incidence of knee OA in a Western population, after adjustment on age, sex and social factors. In a study by Gandhi *et al.*[25] MetS was found to be the risk factor for OA in Asian population. However in a study conducted in Korean subjects[26] knee OA was associated only with WC in female, but not with MetS or any of its components. Monira *et al.* studied the association of the components of the metabolic syndrome, both individual and cumulative, with severe forms of knee and hip OA. The association of these diseases with obesity was also followed through BMI[27]. After adjustment for age, sex, education, physical activity and BMI, central obesity and hypertension presented only risk factors for knee OA but not hip OA. The risk increased with the increase of the number of components of the metabolic syndrome. It was found that the metabolic syndrome was associated with the increased risk of severe knee OA, regardless of the BMI and that there was no connection with severe forms of hip OA[27]. These results point out that the pathogenesis of the knee and hip OA differs and that metabolic syndrome therapy may reduce risk for knee OA[27].

In a cross-sectional study performed by Sanghi *et al.* on 180 patients, with the disease severity shown according to the K-L, the triceps-skinfold thickness (peripheral fat) in males and the waist-hip ratio (central fat) in females were more strongly associated with rKOA than BMI[28].

The relation between obesity and knee OA may be explained in two ways. One is biomechanical and the other is metabolic[29]. There is a growing number of evidence on the impact of metabolic factors with regards to arthrosis development. The fat tissue, once thought to have a function of a passive energy reservoir in the body, activates proinflammatory cytokines (IL -6, IL-1, IL -8, IL -18, TNF-alfa). Adipocytes also secrete specific cytokines – adipokines which lead to synovial inflammations, cartilage deformations and remodeling of the bone matrix which may be an incentive or predictor for the development and severity of OA[30] . It is suggested that OA is a disease that has a variety of phenotypes and epidemiological and biological studies support the concept of metabolic OA[31] he shared mechanisms of inflammation, oxidative stress, common metabolites and endothelial dysfunction that characterize the etiology of OA and MetS, nominated OA as the fifth component of MetS[32].

The main limitations of this study are its cross-sectional design and a relatively small number of patients.

The cross-sectional design makes it difficult to judge causal relations, association between obesity and KOA being usually used as a scholar example of the principal drawback of this type of studies.

This study showed that obesity defined as BMI ≥30 kg/m^2 and abdominal obesity (WC > 102 cm in men and > 88 cm in women) are strongly related to K-L of rKOA, the associations being of very similar extent.

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