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The inter-relationship between obesity and symptomatology of knee osteoarthritis in older women: a cross-sectional study

La interrelación entre la obesidad y los síntomas de la artrosis de rodilla en mujeres mayores: un estudio transversal

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Abstract. Objective: To define a cut-off point of osteoarthritis (OA) symptomatology that becomes serious in older women. Methodology: the cross-sectional study with a quantitative and comparative approach, in which the data were collected by structured interview, informing age, body mass, height, and the filling out the Western Ontario and McMaster Universities questionnaire (WOMAC). The found results were sub-grouped by general WOMAC index (< 39 and ≥ 39 points) and by classification of body mass index - BMI [eutrophic (E); overweight (O); and obese (OB)] for post-comparisons. Inferential statistics: the independent t-test, analysis of variance (ANOVA-one way), a Receiver Operator Characteristic Curve (Curve ROC), and the Youden test for robustness were used, considering a $p < 0.05$. Results: The participants of the study were 79 older women distributed by BMI classification (E = 24; O = 28 and OB = 27 participants) with a mean age of (E = 67.1 ± 6.4; O = 68.4 ± 5.8; OB = 68.5 ± 5.3 years old). When analyzed by WOMAC index subgroups, the ≥ 39 WOMAC subgroup showed a BMI bigger than the < 39 WOMAC subgroup ($p < 0.05$). At last, when analyzing the robustness of variations described by the Youden test, the cut-off point was 29.78 kg/m². Conclusion: The development of osteoarthritis is positively associated with the BMI index in older people, and the cut-off point detected by the Youden test can be a relevant indicator of increased risk for the development of osteoarthritis.
Keywords: Aging; Osteoarthritis; Obesity; Inflammation; Cartilaginous Tissue.

Resumen. El objetivo del estudio fue definir un punto de corte para los síntomas de la osteoartritis (OA) que se agrava en mujeres de edad avanzada. Se trata de un estudio transversal, con enfoque cuantitativo y comparativo, en el que se recolectaron datos a través de entrevistas estructuradas, informando: edad, masa corporal, talla y cumplimentación del cuestionario de las Universidades Occidentales de Ontario y McMaster (WOMAC). Los datos obtenidos se subdividieron según el índice general WOMAC (<39 y ≥39 puntos) y la clasificación del índice de masa corporal (IMC) [Eutrófico (E); Sobrepeso (O) y Obeso (OB)] para posteriores comparaciones. Considerando la significancia de $p < 0,05$. Se utilizó la prueba t, análisis de varianza (ANOVA-one way); Curva de Roc y prueba de Youden para la robustez de los datos. Participaron del estudio 79 mujeres distribuidas en grupos según IMC (E = 24; O = 28 y OB = 27 participantes) con las siguientes edades promedio (E = 67,1 ± 6,4; O = 68,4 ± 5,8; OB = 68,5 ± 5,3 años). Cuando se analizó utilizando el índice WOMAC, el subgrupo ≥ 3 9 demostró un IMC más alto que el subgrupo WOMAC <39 ($p < 0,05$). Además, cuando se realizó la robustez de los datos mediante la prueba de Youden, el punto de corte fue 29,78 kg/m². Por tanto, el desarrollo de artrosis se asocia positivamente con el IMC en personas mayores, y el punto de corte detectado por el test de Youden puede ser un indicador relevante del mayor riesgo de padecer artrosis.
Palabras clave: Envejecimiento; Osteoartritis; Obesidad; Inflamación; Tejido cartilaginoso.

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Introduction

Osteoarthritis (OA) is a degenerative illness that hits a significant part of the world population summarily (Pacca et al., 2018; Swain et al., 2020; Vina & Kwoh, 2018). The knee joint is the most frequently developed pathology between the main body joints (Hussain et al., 2016). Furthermore, the main symptoms of OA in the knee are related to the progressive reduction of functionality, the evolution of pain, and joint stiffness (Thomas et al., 2017). This disorder complex develops with different generalized factors, such as age, sex, obesity, and family history (Hussain et al., 2016; Landsmeer et al., 2019).

The physiological causes of OA development were not well defined in the literature, but three main ways are highlighted in the process: consequence problems of joint aging and traumas that increase the functionality; the quantity of extracellular matrix; and the changes in bone and vascular composition that can reduce the joint functionality (Rahmati et al., 2017). To analyze the cellular aging process, the literature presents that local stress events can promote the early aging of joint structures as chondrocytes (Komori, 2016; Leong & Sun, 2011; Rahmati et al., 2017). Trauma can promote the micro-development of an inflammatory state in the region, increasing the secretion of inflammatory cytokines, vascular endothelial growth factors, and catabolic enzymes, starting the OA grades (Thomas et al., 2017).

Based on current population data, demographic problems such as obesity and aging have significantly increased in recent years (Brasil, 2023). Studies have shown that over the previous thirty years, obesity has been one of the factors that, besides increasing, aggravates the clinical grade of older people (Batsis & Villareal, 2018; Kulkarni et al., 2016). Also, in the United States, the prevalence of OA is more extensive in older people at 65 years old or older (33.6%), and women showed a more considerable number of cases compared to men (42.1% *vs.* 31.2%) (Lespasio et al., 2017). Furthermore, when evaluating the risk factors in 407 women with frequent pain in knee joints, age, BMI, difficulty to upstairs, and joint stiffness were the most prevalent factors for OA development (Landsmeer et al., 2019).

The behavioral parameters involved directly in the process of OA development and how much each one impacts pathology development are not to be elucidated in the literature. Thus, OA development is multifactorial, and the relationship between genetic and epigenetic factors may influence the independence of the population's general characteristics (Garzón Mosquera & Aragón Vargas, 2021; Rice et al., 2020). Therefore, the objective of the present study was to define a cut-off point of the symptomatology of OA that becomes serious in older women.

Methodology

Experimental Design

The study presents a cross-sectional design with a quantitative and comparative approach following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Cuschieri, 2019).

Sample

The present study sample was comprised of 79 older women in Maringá City – Paraná, Brazil (southern region of Brazil). As criteria of inclusion were accepted participants with the following characteristics: 1) female sex; 2) older than 60 years; 3) showed historic of overweight or obesity (Pelaez et al., 2001); 4) stiffness in at least one joint in the morning; 5) self-reported arthritis in at least two joints; 6) visual deformation of the joint. Exclusion criteria: were not accepted: 1) women with age inferior to 60 years old; 2) older people with any cognitive disorders or degenerative central system disorders 3) people without self-reports of osteoarthritis. The recruitment and sorting of participants followed all specifications shown in the Ministry of Health 466/2012 resolution. All participants filled in the ethical consentient terms. The Ethics Committee approved the study in research on humans of Unicesumar under number 2.596.181. The present study was conducted in the University facilities.

Inquiry

The participants were evaluated and instructed to answer about personal, sociodemographic, behavioral, and anthropometric information. The recent study participants pervaded for consultation and were questioned for age, sex, and scholarship. Also, weight and height were measured. All participants filled in the Western Ontario and McMaster Universities (WOMAC) answered by Google Forms Instrument (Google, USA) made available on the Interdisciplinary Laboratory of Intervention in Health Promotion of the University computers.

Evaluate the specific quality of life of osteoarthritis (WOMAC)

The specific osteoarthritis questionnaire WOMAC is an instrument that evaluates the participant in three different domains (pain, stiffness, physical incapacity) considered in five intensities, variating from 0 to 5, on which 0 represents nothing of discomfort (0 points), and 5 represents very intense discomfort (4 points). The three domains are pain, evaluated in 5 questions (total of 0 to 20 points); stiffness, with two questions (0 to 8 points); physical incapacity, composed of 17 questions (0 to 68 points); the total score is obtained through by sum of items in each domain, when the higher score, the greater the involvement of scale in osteoarthritis development (Fernandes, 2002).

Classification of general WOMAC index

Based on Hawker et al. (2000), the cut-off point equal to or above 39 points in the general WOMAC index is classified as severe osteoarthritis, and individuals with a score of 39 or more were indicated for cartilage degeneration. In addition, considering a score varying from 39 to 96 points in the WOMAC index, the present sample was subgrouped into scores <39 points and ≥ 39 points.

Anthropometric assessment

The anthropometric data were composed of height (H) measured with a stadiometer (Filizola®) and body weight (BW) measured with digital weight balance (Filizola®). The formula calculated the body mass index (BMI): BMI = BW (kg) / height² (m²). Based on the results found in the BMI of participants, a sub-classification was realized by BMI classification for the older people: as eutrophic (> 23 to ≤ 28 kg/m²); overweight (> 28 to < 30 kg/m²); obese (≥ 30 kg/m²) (PAHO, 2001).

Statistical Analysis

In order to evaluate the inference of collected data, the software GraphPad Prism (San Diego, USA) was used for descriptive and inferential statistical analysis. The descriptive statistics used the mean, standard deviation, confidence interval, absolute frequencies, and relative frequencies (%). With the intention of comparing selected groups classified by the WOMAC index, the independent t-test and ANOVA were used. The Pearson Correlation was utilized for the association between variables after the analysis of the receiver operating characteristics curve (ROC curve), and last, the robustness test of Youden, how to agree to evaluate the robustness of the analytical method, as also serialize the impact of each one variation in final results, indicating the influence of each one variation, the greater the robustness of the method, the greater its confidence. The sample size was estimated by software G*Power (Dusseldorf, Germany), and the number of participants was established at 64 people for this study ($1\text{-}\beta = 0.80$; $\alpha = 0.05$). The characterization of threshold sensibility of osteoarthritis was developed by the Sturges formula to determine the number and size of class intervals adopted for each category. The values were determined based on the amplitude of informed responses in the instrument. The significance adopted for tests was $p < 0.05$.

Results

When analyzing the results, the power of sample size (1-β error probabilistic) was 0.94. The participants were classified into subgroups by BMI classification: 24 presented eutrophic characteristics, 28 were classified as overweight, and 27 were classified as obese. Thus, it can be observed that the participants classified as obese showed a tendency towards a higher general WOMAC index, as well as when the pain, stiffness, and physical incapacity domains were evaluated, but without significant difference (Table 1).

Analyzing this retrospective, the present study sample was classified by the general WOMAC index in a group score < 39, totaling 67 older women, and a group score ≥ 39, totaling 12 older women.

To verify the significance of the tendency of cartilaginous degeneration in the older people, the BMI of the participants was compared by the subcategories of score < 39 and score ≥ 39 of osteoarthritis sensitization measured by the WOMAC index, and it was observed that those with a score ≥ 39 points had a higher BMI *vs.* score < 39 points ($p < 0.05$).

In addition, an association between BMI and individual scores was analyzed, verifying that BMI was positively associated with the WOMAC index ($r^2 = 0.367$; $p < 0.01$; Figure 1), suggesting an average effect size between the two variables studied. A sensitivity and specificity analysis determined by the ROC curve (1-specificity) was performed, verifying that there was a good accuracy of the test (AUC = 0.732, $p < 0.05$). The Youden robustness test was performed to order the influence of each of the variations on the final result, identifying the Youden index (J) of 48.390 for the value of the respective cut-off point of 29.78 kg/m² for BMI.

Finally, a descriptive analysis of the frequency of cases can be analyzed, and it was observed that a large part of the sample, regardless of BMI classification, showed low sensitization to osteoarthritis. However, the subgroups classified as overweight and obese had a higher number of occurrences in the eutrophic group, and only in the obese subgroup did the retraction of high-intensity sensitization in all domains investigated by the WOMAC instrument.

On the other hand, when comparing the age of the participants by the score levels ≥ 39 and < 39, it can be observed that there was no significant difference. Likewise, the non-association between BMI and age was verified (Figure 1).

Table 1 presents the descriptive and inferential distribution of general characteristics of subgroups and general values of domains in Western WOMAC categorized by subclassification of BMI

Table 2 presents the frequency distribution between the BMI index classification and study participants' pain, stiffness, and physical incapacity domains.

Figure 1 presents the statistical analysis of participants' data.

Table 1.
Descriptive and inferential distribution of general characteristics of subgroups and general values of domains in Western Ontario and McMaster Universities Index categorized by sub-classification of body mass index.

Variables	Eutrophic (n=24)		Overweight (n=28)		Obese (n=27)		
	Mean	±SD	Mean	±SD	Mean	±SD	P-value
Body mass (kg)	58.5*	10.8	71.6*	6.7	86.3*	12.4	<0.01
Height (m)	1.57	0.07	1.60	0.06	1.56	0.06	0.17
Age (years old)	67.1	6.4	68.4	5.8	68.5	5.3	0.07
BMI (kg/m²)	23.6*	3.7	27.6*	1.4	35.1*	4.4	<0.01
Variables	WOMAC Index						
	Mean	CI95%	Mean	CI95%	Mean	CI95%	P-value
Pain domain	3.3	0.9 – 5.7	2.2	0.6 – 3.7	5.0	3.4 – 6.6	0.06
Stiffness domain	1.4	0.5 – 2.3	0.7	0.2- 1.2	1.6	0.8 – 2.4	0.32
Physical Inc. domain	9.7	3.3 – 16.0	4.5	0.8 – 8.2	17.4	11.4 – 23.4	0.06
Total	8.8	0.5 – 17.1	18.8	11.2 – 26.5	22.4	14.5 – 30.2	0.06

Note: the data were expressed in mean ± standard deviation (±SD) and confidence interval (CI95%). Inc. = incapacity; *= statistical significance between groups (P<0.05).

Table 2.
Frequency distribution between the body mass index classification and study participants' pain, stiffness, and physical incapacity domains.

BMI index Classification	Eutrophic	Overweight	Obese
Pain domain			
Small	13 (76.5%)	21 (87.5%)	26 (68.4%)
Medium	4 (23.5%)	3 (12.5%)	9 (23.7%)
High	0 (0%)	0 (0%)	3 (7.9%)
Stiffness domain			
Small	12 (70.6%)	22 (91.7%)	30 (79%)
Medium	5 (29.4%)	2 (8.3%)	4 (10.5%)
High	0 (0%)	0 (0%)	4 (10.5%)
Physical Incapacity domain			
Small	14 (70.6%)	22 (91.7%)	24 (63.2%)
Medium	3 (29.4%)	2 (8.3%)	10 (26.3%)
High	0 (0%)	0 (0%)	4 (10.5%)

Note: the data were presented with absolute and relative frequencies; BMI = body mass index.

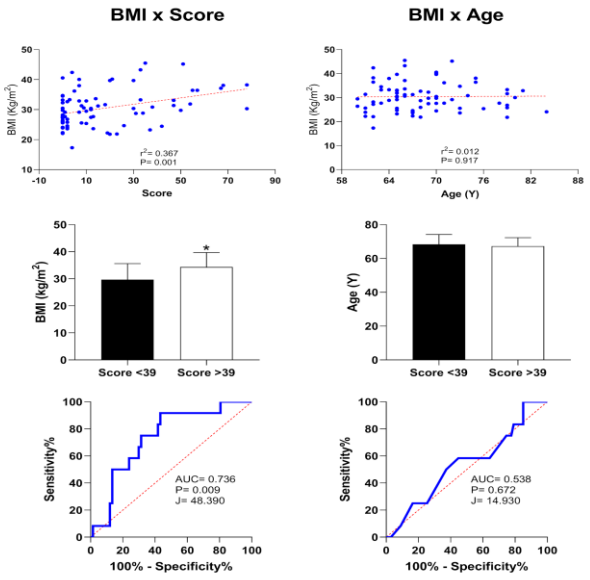

Figure 1. Statistical analysis of participants' data. Note: association between BMI *vs.* Score (panel A), BMI *vs.* Age (panel B). Analysis of scores < 39 *vs.* ≥ 39 in comparison with BMI (panel C) and age (panel D). ROC curve for BMI vs. Score (panel E) and BMI vs. Age (panel F). r^2= level of association between variables; AUC = area under curve; J = representative value of Youden test; BMI = body mass index; ROC = receiver operating characteristics curve; * = significant difference between groups ($p < 0.05$).

Discussion

The present study aimed to assess the impact of age and obesity on the development of osteoarthritis in older women with pre-established symptoms. Based on the results found, it can be observed that the obese older women had a higher average of the general WOMAC index, and the participants who presented an index equal to or greater than 39 also showed a significantly higher BMI and were positively associated with the BMI with the WOMAC index, characterizing body mass as a sensitizing factor for the development of this pathology.

The clinical diagnosis of osteoarthritis can be determined by thoroughly analyzing images, symptoms, thresholding, and location of pain to determine the pathology picture and the level of cartilage tissue deterioration (Fernandes et al., 2019; Wu et al., 2005). The WOMAC questionnaire index improves the diagnostic process by assessing the evaluated 'patients' sensitization (Wu et al., 2005). However, the literature has shown that despite having different classification domains that can increase the probability of identifying factors related to pathological development, the index is not widely explored in clinical interventions investigating osteoarthritis development (Copsey et al., 2019).

In the present study, in addition to dimensioning the proposed domains of the WOMAC index, the average of the domains was verified, and the different sub-classifications of the BMI of the older women who participated in the research were compared. An increasing tendency ($p = 0.06$) for the sensitization of pain and physical activity domains in obese subgroups. In such a way, appearances are only an indicator of high sensitization in the individuals classified as obese. It can be complemented by the association between BMI and the general WOMAC index and the significant increase when considering the subgroup with a score ≥ 39.

In a robust study conducted by Clement et al. (2018), it was found in 2559 patients after knee arthroplasty that a variation of 10 points in the total score of the index can be a good indicator of considerable changes in the patient's clinical condition. Despite not finding significant changes in the BMI subclasses, it can be observed that the eutrophic group, compared to the other groups, presented values below 10 points in the total score (eutrophic *vs.* overweight and *vs.* obese), characterizing the possible clinical differences between the subgroups.

In addition to the mechanical stress generated by excess weight that can cause joint degeneration to develop, some studies have shown that inflamed chondrocytes, osteoblasts, and synovium all contribute to the production of various pro-inflammatory cytokines (IL-1b, IL- 6, IL-8, TNF-α) that imply a critical catabolic process, contributing to the degradation of cartilage tissue (Hussain et al., 2016; Rice et al., 2020; Wang & He, 2018). Likewise, obese individuals present altered secretion of pro-inflammatory cytokines (Wang & He, 2018), and infrapatellar fat deposits have metabolic properties of adipose tissue, contributing in parallel to the inflammatory process in synovial membrane activity (Jang et al., 2021).

It is also known that with joint aging, epigenetic and behavioral factors, polymorphisms associated with inflammatory processes of aging develop; this, added to the accumulation of fat caused by obesity, directly impacts the etymology, functionality, and severity of the development of osteoarthritis (Duclos, 2016; Landsmeer et al., 2019; Wang & He, 2018). Differently from other instruments, the general WOMAC index has shown a close relationship positively associated with the inflammatory process of patients with osteoarthritis; however, it is less specific for pain characteristics, stiffness, and functionality (Fernandes et al., 2019; Simone et al., 2008).

On the other hand, another study described the predictive factor of the general WOMAC index as more significant when the body pain burden is also increased, reaching more than one body region (Clement et al., 2018; Riddle et al., 2020). Therefore, the extent of pain the patient feels should be considered when evaluating the questionnaire (Riddle et al., 2020). Also, when assessing the relationship between the WOMAC index and the Hip or Knee Disability And Osteoarthritis Score (HOOS/KOOS, JR), it was found that both general index, as the three WOMAC domains, has a high association with the scores of the HOOS and KOOS, JR (Fleisher et al., 2022). In addition, The WOMAC scores are described to reflect the X-ray measurement of the knee joint and the significant correlation between the tibial angle and joint gap angle on anteroposterior X-ray (Ma et al., 2012).

One of the characteristics of the inflammatory process, the symptoms, and the development of osteoarthritis have been reported mainly in places such as knee joints and shoulders, and there is a higher prevalence in women (Prieto-Alhambra et al., 2014; Xueshan et al., 2019). In the present study, an exclusive approach was carried out in older women with different levels of pre-established symptoms. Considering the association between the WOMAC index and the BMI, there was also a reasonable specificity for the association (ROC curve) complemented by the Youden test, finding the most critical point for the BMI of 29.78 kg/m² in the study participants. Because of this, the BMI cut-off zone may indicate the sensitization, symptomatology, and development of osteoarthritis in older women.

Following the proposal of Fluss et al. (2005) describe that the Youden test was classified as an excellent method for verifying the cut-off points, suggesting a sample size greater than 50 participants, in which 79 older women were evaluated in a cross-sectional study, and the sample size estimated for this design in 64 participants, being a critical point indicative of pathological development.

The reference indices are an important indicator of clinical causes and help in the prognosis and monitoring of diseases. When performing the present analysis, an indicator

of the development of osteoarthritis was found, which can be used as a parameter for new complementary experimental designs or clinical applicability. Cut-off points can create parameters to identify patterns such as the difference between sexes, age, level of physical activity, and pain intensity (Hawker et al., 2000). Thus, using the cut-off point of 29.78 kg/m² can be an essential parameter to add to the risk factors for developing osteoarthritis and include it in the preventive process (Garcia et al., 2023), thus inhibiting the generation of health costs and surgical needs.

The present study has some limitations, such as the need for inference in a larger group of older women diagnosed with osteoarthritis, the inclusion in future studies with the same procedure for older men, the premises of parameters of body composition such as body fat percentage, muscle mass, and mineral content and, finally, accurate analysis of images and the pain sensitivity of patients after surgical intervention (arthroplasty) for a pain threshold analysis. It can be a new design for further research.

Conclusion

It can be concluded that older women evaluated with a general WOMAC index equal to or greater than 39 points have a higher BMI than older women with a lower index, and the WOMAC index is positively associated with the participant's BMI. Finally, for the present investigated population, it was found that a BMI of 29.78 kg/m² is more robust for the possible development of knee osteoarthritis in women aged 60 years or older.

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Conflict of interests

All authors report no competing interests.

References

Batsis, J. A., & Villareal, D. T. (2018). Sarcopenic obesity in older adults: aetiology, epidemiology and treatment strategies. *Nature Reviews Endocrinology*, *14*(9), 513–537. https://doi.org/10.1038/s41574-018-0062-9

Brasil. Ministério da Saúde. Secretaria de Vigilância em Saúde. VIGITEL 2023. *Vigilância de Fatores de Risco e Proteção para Doenças Crônicas em Inquérito Telefônico. Brasília: Ministério da Saúde; 2023.* https://www.gov.br/saude/pt-br/centrais-de-conteudo/publicacoes/svsa/vigitel/vigitel-brasil-2023-vigilancia-de-fatores-de-risco-e-protecao-para-doencas-cronicas-por-inquerito-telefonico/view#:~:text=O%20Vigitel%202023%20atualiza%20a,relativos%20ao%20ano%20de%202023.

Clement, N. D., Bardgett, M., Weir, D., Holland, J., Gerrand, C., & Deehan, D. J. (2018). What is the minimum clinically important difference for the womac index after TKA?.*Clinical Orthopaedics and Related Research*, *476*(10), 2005–2014. https://doi.org/10.1097/CORR.0000000000000444

Copsey, B., Thompson, J. Y., Vadher, K., Ali, U., Dutton, S. J., Fitzpatrick, R., Lamb, S. E., & Cook, J. A. (2019). Problems persist in reporting of methods and results for the WOMAC measure in hip and knee osteoarthritis trials. *Quality of Life Research*, *28*(2), 335–343. https://doi.org/10.1007/s11136-018-1978-1

Cuschieri, S. (2019). The STROBE guidelines. *Saudi Journal of Anaesthesia*, *13*(5), S31–S34. https://doi.org/10.4103/sja.SJA_543_18

Duclos M. (2016). *Science Direct Osteoarthritis , obesity and type 2 diabetes: The weight of waist circumference*. Ann Phys Rehabil Med. 2016,59(3):157–60. https://doi.org/10.1016/j.rehab.2016.04.002

Hawker, G. A., Wright, J. G., Coyte, P. C., Williams, J. I., Harvey, B., Glazier, R., Badley, E. M. (2000). Differences between men and women in the rate of use of hip and knee arthroplasty. *N Engl J Med*, *342*(14), 1017–22. https://10.1056/NEJM200004063421405

Fernandes, M. I. (2002). Translation and validation of the specific quality of life questionnaire for osteoarthritis WOMAC (Western Ontario and McMaster Universities) for portuguese language. *Escola Paulista de Medicina*, 101. http://repositorio.unifesp.br/bitstream/handle/11600/19401/Tese-7891.pdf;jsessionid=F71B188BDB5F24C7257B254678F9CB66?sequence=1

Fernandes, M. T. P., Fernandes, K. B. P., Anibal, F. F., Shimoya-Bittencourt, W., Santos, V. M., de Oliveira Perrucini, P. D., & Poli-Frederico, R. C. (2019). Functional status and severity of osteoarthritis in elderly is associated to the polymorphism of TNFA gene. *Advances in Rheumatology (London, England)*, *59*(1), 25. https://doi.org/10.1186/s42358-019-0068-6

Fleisher, I. T., Thompson, M. C., Mensah, C. J., Joseph, A. D., McLawhorn, A. S., Padgett, D. E., & Lyman, S. (2022). Development and Validation of Crosswalks Between the Western Ontario & McMaster Universities Osteoarthritis Index and Hip Disability and Osteoarthritis Outcome Score Joint Replacement/Knee Injury and Osteoarthritis Outcome Score Joint Replacement. *Journal of Arthroplasty*, *37*(6), 1034-1039.e3. https://doi.org/10.1016/j.arth.2021.11.009

Garcia, R. C., Oliveira, P. S., Quevedo, N., Cristina, N., Vargas, D. O., Henrique, B., Branco, M., Maria, S., & Gomes, M. (2023). *Efectos de ejercicios basados en el método Pilates practicados en equipos portátiles por ancianas con lumbalgia crónica: un ensayo clínico aleatorizado (Effects of exercises based on the Pilates method practiced on portable equipment by elderly women with*. Retos, *48*, 791–799. https://doi.org/10.47197/retos.v48.93865

Garzón Mosquera, J. C., & Aragón Vargas, L. F. (2021). Sedentarismo, actividad física y salud: una revision narrativa (Sedentary lifestyle, physical activity and health: a narrative review). *Retos*, *42*, 478–499. https://doi.org/10.47197/retos.v42i0.82644

Hussain, S. M., Neilly, D. W., Baliga, S., Patil, S., & Meek, R. M. D. (2016). Knee osteoarthritis: A review of management options. *Scottish Medical Journal*, *61*(1), 7–16. https://doi.org/10.1177/0036933015619588

Jang, S., Lee, K., & Ju, J. H. (2021). Recent updates of diagnosis, pathophysiology, and treatment on osteoarthritis of the knee.

International Journal of Molecular Sciences, *22*(5), 1–15. https://doi.org/10.3390/ijms22052619

Komori, T. (2016). Cell death in Chondrocytes, osteoblasts, and osteocytes. *International Journal of Molecular Sciences*, *17*(12). https://doi.org/10.3390/ijms17122045

Kulkarni, K., Karssiens, T., Kumar, V., & Pandit, H. (2016). Obesity and osteoarthritis. *Maturitas*, *89*, 22–28. https://doi.org/10.1016/j.maturitas.2016.04.006

Landsmeer, M. L. A., Runhaar, J., van Middelkoop, M., Oei, E. H. G., Schiphof, D., Bindels, P. J. E., & Bierma-Zeinstra, S. M. A. (2019). Predicting knee pain and knee osteoarthritis among overweight women. *Journal of the American Board of Family Medicine*, *32*(4), 575–584. https://doi.org/10.3122/jabfm.2019.04.180302

Leong, D. J., & Sun, H. B. (2011). Events in articular chondrocytes with aging. *Current Osteoporosis Reports*, *9*(4), 196–201. https://doi.org/10.1007/s11914-011-0070-3

Lespasio, M. J., Piuzzi, N. S., Husni, M. E., Muschler, G. F., Guarino, A., & Mont, M. A. (2017). Knee Osteoarthritis: A Primer. In *The Permanente journal* (Vol. 21). https://doi.org/10.7812/TPP/16-183

Ma Y, Wang Q, Chen Z, Du C, Li J, Huang H, et al (2012). Multiple linear regression analysis of X-ray measurement and WOMAC scores of Knee osteoarthritis. Zhongguo Gu Shang, 25(5), 373–6.

Pacca, D. M., De-Campos, G. C., Zorzi, A. R., Chaim, E. A., & De-Miranda, J. B. (2018). Prevalence of joint pain and osteoarthritis in obese Brazilian population. *Arquivos Brasileiros de Cirurgia Digestiva*, *31*(1), 1–4. https://doi.org/10.1590/0102-672020180001e1344

Pan American Health Organization (2001). Encuesta multicéntrica salud bienestar y envejecimiento (SABE) en América Latina: informe preliminar. 19 p. (CIAS 36/2001.5). https://iris.paho.org/handle/10665.2/45890?locale-attribute=pt

Pelaez, M., Palloni, A., Arias, E., Pinto, G. (2001). XXX Reunión del Comité Asesor de Investigaciones en Salud. *Boletín de La Oficina Sanitaria Panamericana. Pan American Sanitary Bureau*, *119*(6), 538–546. https://doi.org/10.1590/s1020-49891997000600016

Prieto-Alhambra, D., Judge A., Javaid M. K., Cooper, C., Diez-Perez, A., Arden, N. K. (2014). *Incidence and risk factors for clinically diagnosed knee, hip and hand osteoarthritis*.https:/ 10.1136/annrheumdis-2013-203355 /

Rahmati, M., Nalesso, G., Mobasheri, A., & Mozafari, M. (2017). Aging and osteoarthritis: Central role of the extracellular matrix. In *Ageing Research Reviews* (Vol. 40, pp. 20–30). https://doi.org/10.1016/j.arr.2017.07.004

Rice, S. J., Beier, F., Young, D. A., & Loughlin, J. (2020). Interplay between genetics and epigenetics in osteoarthritis. *Nature Reviews Rheumatology*, *16*(5), 268–281. https://doi.org/10.1038/s41584-020-0407-3

Riddle, D. L., Perera, R. A., Riddle, D. L., & Perera, R. A. (2020). TITLE: The WOMAC Pain Scale and Cross Talk From Co-occurring Pain Sites in People With. *Phys Ther.*, *100*(10), 1872–1881. https://academic.oup.com/ptj/advance-article-abstract/doi/10.1093/ptj/pzaa098/5842103

Simone, K., Vasconcelos, D. S., Marcos, J., Dias, D., Dias, R. C., & Zenite, R. (2008). Impacto do grau de obesidade nos sintomas e na capacidade funcional de mulheres com osteoartrite de joelhos Impact of the degree of obesity on symptoms and functional capacity of women with knee osteoarthritis. *Fisioterapia e Pesquisa*, *15*(2), 125–130. https://doi.org/10.1590/S1809-29502008000200003

Swain, S., Sarmanova, A., Mallen, C., Kuo, C. F., Coupland, C., Doherty, M., & Zhang, W. (2020). Trends in incidence and prevalence of osteoarthritis in the United Kingdom: findings from the Clinical Practice Research Datalink (CPRD). In *Osteoarthritis and Cartilage* (Vol. 28, Issue 6, pp. 792–801). https://doi.org/10.1016/j.joca.2020.03.004

Thomas, A. C., Hubbard-Turner, T., Wikstrom, E. A., & Palmieri-Smith, R. M. (2017). Epidemiology of posttraumatic osteoarthritis. *Journal of Athletic Training*, *52*(6), 491–496. https://doi.org/10.4085/1062-6050-51.5.08

Vina, E. R., & Kwoh, C. K. (2018). Epidemiology of osteoarthritis: Literature update. *Current Opinion in Rheumatology*, *30*(2), 160–167. https://doi.org/10.1097/BOR.0000000000000479

Wang, T., & He, C. (2018). Pro-inflammatory cytokines: The link between obesity and osteoarthritis. In *Cytokine and Growth Factor Reviews* (Vol. 44, pp. 38–50). https://doi.org/10.1016/j.cytogfr.2018.10.002

Wu, C. W., Morrell, M. R., Heinze, E., Concoff, A. L., Wollaston, S. J., Arnold, E. L., Singh, R., Charles, C., Skovrun, M. L., Fitzgerald, J. D., Moreland, L. W., & Kalunian, K. C. (2005). Validation of American College of Rheumatology classification criteria for knee osteoarthritis using arthroscopically defined cartilage damage scores. *Seminars in Arthritis and Rheumatism*, *35*(3), 197–201. https://doi.org/10.1016/j.semarthrit.2005.06.002

Xueshan Sun, Xuemei Zhen, Xiaoqian Hu, Yuanyuan Li, Shuyan Gu, Yuxuan Gu, H. D. (2019). *Osteoarthritis in the Middle Aged and Elderly in China Prevalence and Influencing Factors*. https:// 10.3390/ijerph16234701