ТОЧКА ЗРЕНИЯ

DOI 10.25789/YMJ.2025.92.28

УДК 616-06

I.V. Kononova, S.I. Sofronova, A.N. Romanova

ASSOCIATION OF OBESITY WITH C-REACTIVE PROTEIN LEVELS AND NON-ALCOHOLIC FATTY LIVER DISEASE IN FEMALE RESIDENTS OF SOUTHERN YAKUTIA

A study working women in Southern Yakutia to analyze obesity rates and their association with serum C-reactive protein levels and the prevalence of non-alcoholic fatty liver disease revealed that only 25% of the participants had normal body weight. Obesity, as measured by their body mass index, was found in half of the women, abdominal obesity, as measured by waist circumference, was found in four out of five women, and abdominal obesity. Extreme obesity (class III) is typical for women nearing menopause. Body mass index, waist circumference, and hip circumference are closely correlated with serum C-reactive protein levels, the frequency of elevated C-reactive protein levels, and the incidence of non-alcoholic fatty liver disease. The frequencies of elevated C-reactive protein levels and non-alcoholic fatty liver disease show signs of a complete functional relationship. One-third of the study participants with normal body weight are likely at risk for developing non-alcoholic fatty liver disease and related diseases. The analysis revealed an urgent need for targeted care, including medical assistance, involving clinical specialists in nutrition and physical fitness. The lack of timely and effective healthcare response will exacerbate the progression of obesity and related diseases among working women in Southern Yakutia.

Keywords: body mass index, inflammation, women's health.

For citation: Kononova I.V., Sofronova S.I., Romanova A.N. Association of obesity with C-reactive protein levels and non-alcoholic fatty liver disease in female residents of southern yakutia. Yakut medical journal. 2025; 92(4): 118-121. https://doi.org/10.25789/YMJ.2025.92.28

Introduction. Nowadays Obesity has become a global crisis. The World Health Organization defines obesity as a chronic, complex disease characterized by excess fat deposition, which negatively impacts health. Obesity can lead to an increased risk of type 2 diabetes and cardiovascular disease, affect bone health and reproductive function, and can also increase the risk of certain cancers. Obesity was once considered a problem in high-income countries, but today, some of the highest rates of overweight and obesity are found in middle-income countries [9]. Obesity is most often assessed using the body mass index (BMI) [1]. Other body parameters, particularly waist circumference, also provide additional information to BMI for predicting morbidity and mortality risk [6].

Closely associated with obesity is non-alcoholic fatty liver disease (NAFLD), which is characterized by excess accumulation of fat in the liver and is one of the most common liver diseases worldwide with a global prevalence of approximately 30%. The rising prevalence of obesity is projected to further increase the prevalence of NAFLD, which is the basis of chronic liver diseases, including cirrhosis and hepatocellular carcinoma. NAFLD has multiple clinical phenotypes and is heterogeneous due to the complexity of its pathogenesis and clinical onset conditions. The gold standard for confirming fatty tissue changes is a biopsy, but it has limitations related to its inherent non-safety concerns due to the invasive nature of the procedure. Non-invasive methods, such as computed tomography, ultrasound, and magnetic resonance imaging, are also used to detect fatty changes in the liver. Therefore, data on the incidence and prevalence of NAFLD vary depending on the diagnostic method used. Since NAFLD is characterized by chronic inflammation, inflammatory markers have been studied in patients with NAFLD. It has been established that C-reactive protein (CRP) levels are associated with liver inflammation, and their determination (high-sensitivity CRP) can predict NAFLD progression [2].

In 2022 the Yakut Scientific Center of Complex Medical Problems conducted an expeditionary survey of working-age individuals in Southern Yakutia to analyze their health. Among the results a link was identified between NAFLD and arterial hypertension [8].

The aim of this study was to analyze the relationship between obesity rates and serum CRP levels and the prevalence of NAFLD among women working in enterprises in Southern Yakutia.

Materials and methods. The study contains sample data from an expeditionary survey of working-age individuals in Southern Yakutia [8]. Indicators were selected from women of Russian nationality who underwent anthropometric measurements (height, weight, waist circumference (WC), and hip circumference (HC)), abdominal ultrasound, and serum CRP levels determined using an enzyme-linked immunosorbent assay. Based on these criteria, the total number of study participants was 69, ranging in age from 22 to 66 years.

The following were calculated: BMI in kg/m^2 using the generally accepted formula [1], waist-to-weight ratio (WTR) using the formula WTR=WC (cm)/weight (kg), and waist-to-hip ratio (WHR) using the formula WHR=WC (cm)/HC (cm).

In accordance with the classification of obesity in BMI values for the Caucasian population as outlined in the Russian National Recommendations [1], five comparison groups were formed. Group I - 17 women with normal body weight

KONONOVA Irina Vasilievna – Candidate of Medical Sciences, Senior Researcher-Head of the Laboratory of the YSC of CMP, Yakutsk, SPIN code: 3282-7170, ORCID: 0000-0002-9243-6623, irinakon.07@mail.ru; **SOFRONOVA Sargylana Ivanovna** – Candidate of Medical Sciences, Chief Researcher-Head of the Department of the YSC of CMP, Yakutsk, ORCID: 0000-0003-0010-9850, sara2208@mail.ru; **ROMANOVA Anna Nikolaevna** – Doctor of Medical Sciences, Director of the YSC of CMP, ORCID: 0000-0002-4817-5315, ranik@mail.ru.

(NormW) with a BMI of 18.5-24.9 kg/m2, group II - 19 women with overweight (OvW) with a BMI of 25.0-29.9 kg/m2, group III - 18 women with Class I obesity (Ob1) with a BMI of 30,0-34,9 kg/m2, group IV - 9 women with Class II obesity (Ob2) with a BMI of 35,0-39,9 kg/m2 and group V - 6 women with Class III obesity (Ob3) with a BMI> 40,0 kg/m2.

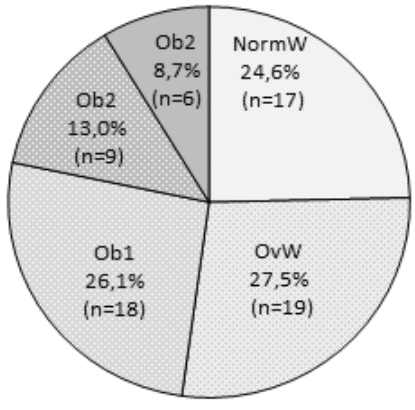
The Shapiro-Wilk test was used to test the normality of variable distribution. A one-way analysis of variance was used to identify differences between indicators in five or two samples with normally distributed data. If the distribution was not normal, the Kruskal-Wallis test was used to determine differences between data in five samples, and the Mann-Whitney test was used between two samples. The mean (M) and standard deviation (SD) were calculated. Quantitative and qualitative data were also described as relative variables (%). Spearman's correlation coefficient (*rho*) was used to identify pairwise relationships. Differences and *rho* were considered statistically significant at $p < 0,05$.

The study was conducted in accordance with the ethical principles of the Helsinki Declaration of the World Medical Association (2008) and approved by the Protocol of the Bioethics Committee of the Yakut Scientific Center of Complex Medical Problems.

Results and discussion. The distribution of the participants in this study by body weight type depending on their calculated BMI, presented in Figure 1, showed obesity to varying Classes had half of them, approximately a quarter were overweight, and only the remaining quarter had normal body weight. Signs of abdominal obesity - WC values above 80 cm and/or WHR values above 0,85 [9] were detected in 79% of cases (54 of 69 people) and in 48% of cases (33 of 69 people), respectively. The combination of BMI above 25 kg/m2 and WC above 80 cm was detected in 49% of cases (47 of 69 people). The prevalence of obesity among the participants of this study significantly exceeds the results of the ESSE-RF epidemiological study, which showed the presence of obesity in a third of cases among all Russian women [1].

A between-group analysis was performed to determine the differences in age, anthropometry, and serum CRP levels according to body mass type, the results of which are shown in Table 1. The study participants' anthropometric parameters, including weight, WC, HC, WTR, and WHR, differed statistically significantly between the groups. Their mean values across the comparison groups increased with increasing BMI, so it was expected that they would have a complete functional relationship with the group' mean BMI values (*rho*=1, *p*=0,000).

The height and age indicators of the study participants did not show statistically significant group differences, although for differences between mean age values, the obtained p-level (0,167) still suggests a greater than 80% probability of their presence. Moreover, the average age of women with stage III obesity was statistically significantly higher than that of women with normal body weight (*p*=0,014 for paired one-way analysis of variance). To confirm the presence of statistically significant differences in age depending on body mass type, whereby older age corresponds to a higher BMI, a larger number of study participants is needed. However, an increasing BMI with age in some ethnic groups has been confirmed [10]. Similar to other recent scientific studies [4], this study revealed statistically significant differences in serum CRP levels varies by body mass type. Herewith, mean values in the comparison groups as well as anthropometric parameters (except height) are increasing with increasing BMI. Accordingly, the mean values of serum CRP and BMI showed a close functional relationship (*rho*=1, *p*=0,000), calculated for the study participants' groups.



Distribution of the number of study participants by their body weight type (abbreviations here and below are presented in the text of the article).

Elevated serum CRP levels (>5 IU/ml) were detected in 65% of the study participants (45 of 69 people) and found in all groups: in women with normal body weight - in 36% of cases (6 of 17 people), with overweight - in 53% of cases (10 of 19 people), with Class I obesity - in 73%

Table 1

Age. anthropometry. and serum CRP levels in female patients by body mass type

Body mass type		BMI	Age (years)	Height (cm.)	Weight (kg.)	WC (cm.)	WWR	HC	WHR	CRP (mg/l)
Normal body mass (n=17)	M	22.56	40.70	162.94	59.88	73.41	9.48	93.52	0.78	4.97
	SD	0.85	11.13	7.38	5.08	8.02	0.88	3.29	0.07	5.13
	P^1	0.107	0.439	0.776	0.197	0.268	0.101	0.699	0.074	0.002^
Overweight body mass (n=19)	M	27.57	44.11	162.95	73.31	85.47	9.99	104	0.82	7.03
	SD	1.58	12.28	6.99	7.41	6.78	0.68	3.94	0.06	6.68
	P^1	0.144	0.787	0.579	0. 871	0. 530	0. 854	0.632	0.365	0.003^
Class 1 Obesity (n=18)	M	31.81	42.89	163.28	85.00	94.83	10.29	109.83	0.86	9.07
	SD	1.53	10.44	5.10	8.04	9.41	0.75	7.12	0.06	5.41
	P^1	0.175	0.691	0.797	0. 368	0. 447	0. 648	0.005^	0.995	0.331
Class 2 Obesity (n=9)	M	36.98	42.33	163.00	98.33	109.78	11.08	118.88	0.92	12.22
	SD	1.40	10.25	8.00	8.89	8.01	0.70	6.31	0.08	5.57
	P^1	0.605	0.072	0.538	0. 904	0. 740	0. 213	1	0.230	0.126
Class 3 Obesity (n=6)	M	41.26	53.83	160.17	106.00	116.00	11.28	127	0.91	15.22
	SD	0.77	10.80	8.21	9.96	7.10	0.55	3.28	0.04	3.35
	P^1	0.555	0.218	0.919	0. 744	0. 854	0. 978	0.890	0.955	0.093
P^2		0.000*	0.167	0.902	0.000*	0.000*	0.000*	N/A	0.000*	N/A
p^3		N/A	N/A	N/A	N/A	N/A	N/A	0.000*	N/A	0.000*

Note: M - the mean value, SD - the standard deviation; p1 - the significance level of the Shapiro-Wilk test, ^ - the distribution is not normal; p2 - the significance level of the multiple one-way analysis of variance; p3 - significance level of the Kruskal-Wallis test, * - the differences in the indicators have reached the required significance level; N/A - not applicable.

of cases (13 of 18 people), with Class II obesity - in 67% of cases (6 of 9 people) and with Class III obesity - in 100% (all 6 people). These data had a statistically significant strong positive relationship with the average BMI value calculated for the groups of study participants (*rho*=0,9, *p*=0,037).

NAFLD, detected using an abdominal ultrasound, was observed in 26% of women (18 of 69 people) and also occurred in all groups: in women with normal body weight in 6% of cases (1 of 17 people), with overweight - in 16% (3 of 19 people), with Class I obesity - in 39% (7 of 18 people), with Class II obesity - in 23% (2 of 9 people) and with Class III obesity - in 84% (5 of 6 people). The prevalence of NAFLD, as well as the above-mentioned prevalence of elevated serum CRP levels, showed a statistically significant strong positive association with the mean BMI value calculated across the study all participants (*rho*=0,9, *p*=0,037).

The conducted correlation analysis revealed a complete functional relationship between the frequency of elevated levels of serum CRP and the occurrence of NAFLD (*rho*=1, *p*=0,000).

A paired correlation analysis among all study participants (69 individuals), regardless of body weight, revealed statistically significant positive relationships between serum CRP levels and BMI, weight, WC, HC, WTR, and WHR. The results of which are shown in Table 2. Although the *rho* values for these relationships did not reach the values required for medical research (*rho* should be at least 0,7), but moderate positive correlation was found between serum CRP levels and WC and between CRP and HC.

It is known that the values of the WC and related indices can reflect the amount of abdominal fat [6]. Abdominal fat acts as an endocrine organ, secreting inflammatory cytokines such as IL-6 and TNF-α. The constant release of IL-6 signals the liver to secrete CRP and leads to low-grade systemic inflammation throughout the body, which maintains elevated levels of serum CRP [5]. Systemic inflammation contributes to the development of NAFLD and is present in the chain of its pathogenesis, in which also includes lipid metabolism disorder, apoptosis, fibrogenesis in the liver, etc. [2].

We were interested in the relatively high prevalence of elevated serum CRP in normal-weight study participants—almost a third of them (36% of cases, as noted above). Of course, elevated serum CRP levels are associated not only with abdominal obesity and NAFLD, but are also present in many infectious and immune-inflammatory diseases. However, research has shown that elevated serum CRP levels can predict the development of NAFLD in non-obese individuals [3]. Therefore, to identify differences between their anthropometric parameters depending on the level of serum CRP, the parameters of the study participants with normal body weight were divided into two subgroups: with normal (11 people) and with elevated levels (6 people) of serum CRP (Table 3). Although the analysis revealed no statistically significant differences, the mean values of anthropometric parameters—BMI, weight, WC, HC, WTR, and WHR —were still lower in the subgroup with normal serum CRP levels than in the subgroup with elevated levels. For differences between the mean BMI and weight values in the subgroups, the obtained p-value (0,120 and 0,183, respectively) suggests a greater than 80% probability of their presence. Of course, to confirm the hypothesis of statistically significant differences in BMI and other anthropometric parameters depending on serum CRP levels in women with normal body weight, a larger number of study participants is needed.

Thus, it was found that only 25% of the participants in this study had a normal body weight. Obesity, as measured by BMI, was found in half of the women, abdominal obesity, as measured by WC, was found in four out of five women, and abdominal obesity, as measured by WHR, was found in half of the study participants. Extreme obesity (Stage III) is typical for women nearing menopause.

I this study along with the increase in BMI, WC, HC and their indices, there is a parallel increase in such indicators as the mean of serum CRP, the frequency of its elevated values and the prevalence of NAFLD. The frequencies of elevated serum CRP levels and the prevalence of NAFLD show signs of a complete functional relationship. One-third of the women with normal body weight are likely at risk of developing NAFLD and related diseases [7].

Conclusion. The results demonstrate that women in Southern Yakutia are not immune to the global obesity crisis, which poses a health threat. Although obesity and NAFLD are known to be lifestyle-related, primarily to diet and physical activity, the significantly increased prevalence of obesity and NAFLD in the examined women and the high potential risks of developing them in women with normal body weight highlight the urgent need for targeted care, including medical interventions, involving clinical specialists in nutrition and

Table 2

Spearman's rank correlation coefficients (*rho*) between CRP values and age and anthropometric parameter in all female patients

	Patients (n=69)	
	rho	*p*
Age	0.082	0.504
Height	-0.017	0.888
Weight	0.474*	0.000
WC	0.503*	0.000
HC	0.527*	0.000
WWR	0.441*	0.000
WHR	0.367*	0.002
BMI	0.496*	0.000

Note: * - differences in indicators have reached the required level of significance

Table 3

Age and anthropometric parameters in normal-weight female patients depending on CRP levels

		BMI	Age (years)	Height (cm.)	Weight (kg.)	WC (cm.)	HC	WWR	WHR
Normal CRP levels (n=11)	M	22.10	40.91	162.82	58.54	71.90	92.90	9.38	0.77
	SD	1.77	8.61	5.84	5.04	8.65	3.78	0.81	0.07
	P^1	0.547	0.629	0.234	0.558	0.374	0.887	0.223	0.248
Elevated CRP levels (n=6)	M	23.39	40.33	163.16	62.33	76.16	94.66	9.66	0.80
	SD	0.92	13.41	8.56	5.88	7.93	1.96	0.96	0.08
	P^1	0.517	0.563	0.981	0.741	0.314	0.659	0.728	0.549
P^2		0.120	0.915	0.922	0.183	0.335	0.309	0.541	0.459

Note: M - the mean value, SD - the standard deviation; p1 - the significance of the Shapiro-Wilk test; p2 - the significance of the one-way analysis of variance.

physical fitness. The lack of timely and effective healthcare responses will exacerbate the progression of obesity and related diseases among working women in Southern Yakutia.

The authors declare no conflict of interest.

References

1. Boytsov S.A., et al. Kardiovaskulyarnaya profilaktika 2022. Rossijskie nacional'nye rekomendacii [Cardiovascular prevention 2022. Russian national guidelines]. Rossijskij kardiologicheskij zhurnal [Russian journal of cardiology. 2023. Vol. 28, No. 5. P. 119-249 (In Russ.).] DOI:10.15829/1560-4071-2023-5452

2. Sofronova S.I., Romanova A.N. Vzaimosvyaz' nealkogol'noj zhirovoj bolezni pecheni u bol'nyh arterial'noj gipertenziej s nekotorymi kardiometabolicheskimi faktorami riska [Relationship of non-alcoholic fatty liver disease in patients with arterial hypertension to certain cardio-metabolic risk factors.]. Yakutskij medicinskij zhurnal [Yakut Medical Journal. 2024. No. 4 (88). P. 118-121 (in Russ.).] DOI: 10.25789/YMJ.2024.88.28

3. Chen C, Gong J, Li M et al. High sensitivity C-reactive protein may be a significant predictor of non-alcoholic fatty liver disease in non-obese adults: A four-year retrospective study, Nutrition, Metabolism and Cardiovascular Diseases. 2025. 104224. https://doi.org/10.1016/j.numecd.2025.104224.

4. Kesavadev J, Krishnan G, Basanth A. et al. Association of Elevated C-reactive Protein with Body Mass Index and Gender in Individuals with Diabetes: A Cross-sectional Analysis. International Journal of Diabetes and Technology.2025. No 4(1). P. 5-10. doi: 10.4103/ijdt.ijdt_3_25

5. Kumar R, Porwal YC, Dev N et al. Association of high-sensitivity C-reactive protein (hs-CRP) with non-alcoholic fatty liver disease (NAFLD) in Asian Indians: A cross-sectional study. J Family Med Prim Care. 2020. No 28;9(1). P.390-394. doi: 10.4103/jfmpc.jfmpc_887_19.

6. Ross R, Neeland IJ, Yamashita S et al. Waist circumference as a vital sign in clinical practice: a Consensus Statement from the IAS and ICCR Working Group on Visceral Obesity. Nat Rev Endocrinol. 2020. No16(3). P.177-189. doi: 10.1038/s41574-019-0310-7.

7. Rubino F, Cummings DE, Eckel RH et al. Definition and diagnostic criteria of clinical obesity. Lancet Diabetes Endocrinol. 2025;13(3):221-262. doi: 10.1016/S2213-8587(24)00316-4.

8. Sofronova SI, Romanova AN. Relationship of non-alcoholic fatty liver disease in patients with arterial hypertension to certain cardio-metabolic risk factors. Yakut Medical Journal. 2024. № 4 (88). C. 118-121. DOI: 10.25789/YMJ.2024.88.28

9. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

10. Yang YC, Walsh CE, Johnson MP, Belsky DW et al. Life-course trajectories of body mass index from adolescence to old age: Racial and educational disparities. Proc. Natl. Acad. Sci. U.S.A. 2021. No118(17). e2020167118. https://doi.org/10.1073/pnas.2020167118 (2021).