

Impact of BMI on Erythrocyte Sedimentation Rate and C-Reactive Protein in Patients Without a Rheumatic Autoimmune Disorder: A Medical Record Analysis

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ABSTRACT

Objective: Obesity is an inflammatory condition associated with arthralgias. Erythrocyte Sedimentation Rate (ESR) and C-Reactive Protein (CRP) measure systemic inflammation. Increasing body mass index (BMI) could increase ESR and CRP in patients with nonspecific arthralgias. **Methods:** Medical record analysis of 1,185 clinic encounters was performed. Relationship between BMI with ESR and CRP and differences compared among three groups (Group 1: BMI ≤ 29.9 kg/m², Group 2: BMI ≥ 30.0 kg/m² but ≤ 39.9 kg/m², and Group 3: BMI ≥ 40.0 kg/m²). **Results:** Mean age 56.8 (± 14.1) years with a female predominance (82.2%) and age 50 years (71.2%). Weak positive correlation with ESR ($r = 0.147$, $p < 0.0001$) with no relationship with CRP ($r = 0.042$, $p = 0.151$). Relationship with ESR stronger for age under 50, female gender, and Caucasian ethnicity. Relationship with CRP stronger for age under 50, female gender. Mean ESR higher in Group 3 (37.9 (95% Confidence Interval (CI) 35.4 – 40.5) mm/hr). Mean CRP in Group 3 (2.00 (95% CI 1.82 – 2.19) mg/dL) higher than Group 2 but not Group 1. Group 3 mean ESR higher for age under 50, female gender, Caucasian ethnicity. Group 3 mean CRP higher for female gender. **Conclusion:** Positive correlation between BMI and ESR noted. Mean ESR and CRP higher for Group 3. For ESR, age under 50, female gender, and Caucasian ancestry demonstrated statistically significant differences for Group 3. For CRP, only female gender higher for Group 3.

Keywords: Body Mass Index, Erythrocyte Sedimentation Rate, C-Reactive Protein, Inflammation, BMI: Body Mass Index, ESR: Erythrocyte Sedimentation Rate, CRP: C-Reactive Protein, SLE: Systemic lupus erythematosus, RA: Rheumatoid arthritis, SSc: Systemic sclerosis, CI: Confidence Interval.

INTRODUCTION

The erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) are two established serologic biomarkers that measure levels of inflammation. They measure different acute phase reactants, the ESR indirectly measuring fibrinogen, and CRP measuring the protein directly, as they change in response to infectious or inflammatory events. They can aide the clinician in the diagnosis of various types of inflammatory arthritis but also help monitor various infectious or inflammatory conditions. Rheumatologists rely on these tests to help rule in or potential exclude conditions (such as Polymyalgia Rheumatica) while also using them to measure disease activity and response to medications.[1] Though relatively inexpensive and quick turnaround time are strengths of the ESR and CRP, they lack consistent sensitivity or specificity as their performance will vary with various acute and chronic inflammatory conditions.[2] ESR and CRP

values also vary with age, gender, and ethnicity. It has been established that low-grade CRP elevation is associated with various metabolic stressors such as atherosclerosis, obesity, type 2 diabetes, sedentary lifestyles, an unhealthy diet, and even being unmarried. [3, 4] CRP levels vary with age, sex, and ethnicity, though less so than ESR levels [2]. Obesity is defined as a body mass index (BMI) greater than 30 kg/m². BMI is a measure of body fat based on height and weight, calculated as a person's weight in kilograms divided by the square of their height in meters. In the last 3 decades, the worldwide prevalence of obesity has increased 27.5% for adults.[5] Obesity and pain are common problems affecting the older adult and a possible relationship between the two is considered.[6] Cross-sectional studies have revealed a high correlation between pain and obesity and a few longitudinal studies implicate obesity as a risk factor for the development of pain and the associated reduction in quality of life.[6] Obesity related pain arises from mechanical stress as well as metabolic disruptions, and mitigating obesity may help reduce the risk of developing pain and improve recovery from pain.[6, 7]

Rheumatic autoimmune diseases such as systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), and systemic sclerosis (SSc) are illnesses characterized by systemic inflammation. A host of genetic and environmental factors over time lead to dysregulation of the immune system and subsequent inflammation and damage of target organs. Tissues such as cartilage, joint synovium, and skin are most frequently targeted.[8] When considered together, rheumatic autoimmune diseases are estimated to afflict more than 7% of the general population.[9] While rheumatic autoimmune diseases can occur across the lifespan, the typical presentation occurs in mid- or late- adulthood,[8, 10] and these diseases are much more common in women than in men, with approximately 90 % of prevalent cases being female for SLE and SSc, and approximately 75 % for RA.[11]. The variability in the sensitivity and specificity of the ESR and CRP, the impact that obesity has on inflammatory markers such as CRP, and the symptoms of rheumatic autoimmune diseases (and differential impact on women), create a “perfect storm” that significantly impacts the decision making of clinicians across the spectrum of care. As an example, an obese patient presenting to her primary care provider with arthralgias and prolonged morning stiffness could have a rheumatic autoimmune illness, fibromyalgia, pain from the mechanical and metabolic disturbances of her obesity, or a host of other conditions. In the absence of other more sensitivity and/or specific serologic biomarkers, an ESR and CRP likely will be ordered. If these results return mildly elevated, with an ESR of 25 mm/hr and CRP of 1.5 mg/dL, this might prompt concern for a rheumatic autoimmune disease and a referral to Rheumatology for further evaluation and possible treatment. In light of the current (and projected) Rheumatology workforce shortage,[12] initial evaluation may be delayed for months, or even up to a year. The purpose of this study was to explore the relationship between BMI to that of ESR and CRP for patients evaluated at a community hospital rheumatology clinic as well as to identify differences in demographic factors that would distinguish when the ESR and CRP were likely impacted by groups of patients based on their BMI and not an infectious or inflammatory process.

METHODS

A medical records review of patient encounters from a Rheumatologist practicing as an employee in a community hospital system were reviewed from 1 July 2017 to 30 June 2022. The hospital system serves about 250,000 people in a suburban/rural area in the southeast US. The Rheumatology Clinic is a referral only clinic. At each encounter patients underwent a reasonably thorough history and physical examination as well as had vital signs and serologic

or radiographic testing ordered appropriate for their health at the time of the interview. Data collected from these medical encounters for this study included the date of the encounter, patient age, reported gender, reported ethnicity, primary diagnosis for the encounter, secondary and additional diagnoses when available, BMI, ESR, and CRP. ESR and CRP were measured using standard laboratory techniques. Patient could have multiple encounters with the physician at different points in time. The initial data request yielded 14,253 records. These records were then filtered based on diagnosis, with diagnoses of an inflammatory arthritis (such as RA, SLE, Psoriatic Arthritis, infectious arthritis, etc.) or inflammatory condition (such as Polymyalgia Rheumatica) excluded. Primary diagnoses that were accepted included but were not limited to osteoarthritis, positive anti-nuclear antibody or positive rheumatoid factor (not associated with a rheumatic autoimmune disease or other etiology such as infection, malignancy, etc.), and benign joint hypermobility syndrome. After this filter was applied, 6,069 records remained. Next, a filter limiting ESR values to 0 – 150 mm/hr (values such as “<0”, “>150”, or “NULL” were excluded) left 2,845 records for review. Another filter limiting CRP to values between 0 and 28 mg/dL was applied (values such as “NULL” were excluded). This left 1,220 records. The final filter applied was for a recorded BMI. This ultimately left 1,185 records for statistical analysis. A flow chart of this process is detailed in Figure 1.

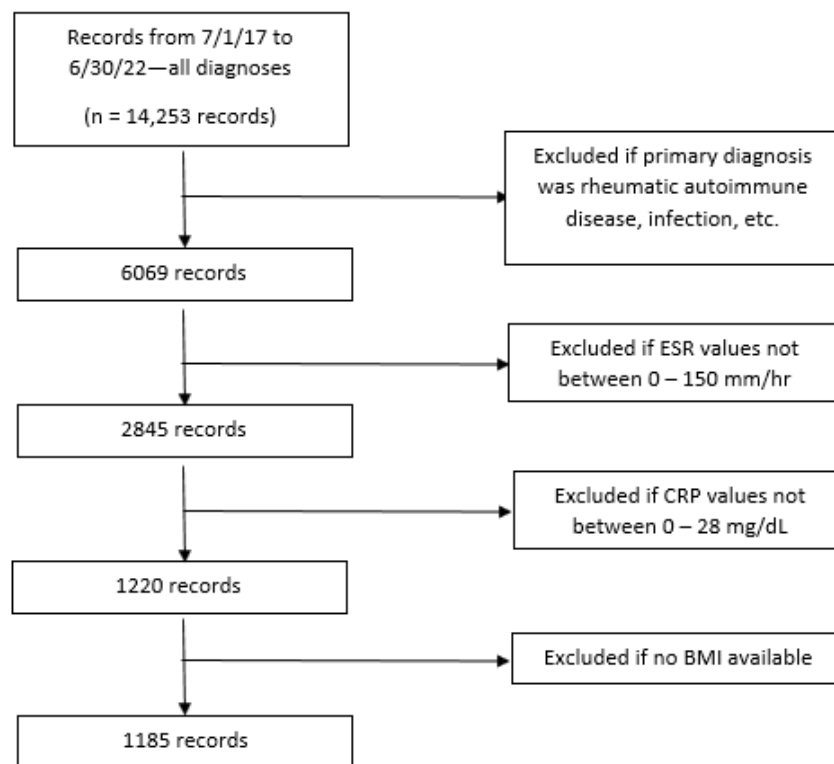


Figure 1: Flow Chart of record exclusion

Key: BMI = Body Mass Index; ESR = Erythrocyte Sedimentation Rate, CRP = C-Reactive Protein

The hypothesis of this study was that a (positive) relationship would be identified between BMI and ESR and CRP but that there would be differences among different groups of BMI based on various demographic categorization. Thus, this study had two endpoints. First, assess the strength of the relationship between BMI with ESR and/or CRP. As noted, a positive relationship was expected as this has been described elsewhere.[1] Second, after dividing the

data into 3 groups based on BMI, identify differences in the mean ESR and CRP when further stratified based on demographic data. The groups created by the divisions in the BMI are noted below:

- (1) Group 1: BMI ≤ 29.9 kg/m²,
- (2) Group 2: BMI ≥ 30.0 kg/m² but ≤ 39.9 kg/m² (obese), and
- (3) Group 3: BMI ≥ 40.0 kg/m² (extreme obesity)

In this study Group 1 would have been a control group as it reflects normal or overweight patients, and the intent was to look at the trends for obese (BMI ≥ 30 kg/m²) or extremely obese patients. The categories in demographic data that were studied are noted below:

- (1) Age (< 50 y/o and ≥ 50 y/o)
- (2) Gender (male and female)
- (3) Ethnicity (African American and Caucasian)

The data were entered into SPSS Version 26.0. The demographic variables included age, ethnicity, and gender. The research variables included BMI, ESR and CRP. The statistics included Pearson Product Moment Correlations between BMI and ESR and between BMI and CRP. One-way Analysis of Variance (ANOVA) techniques with Scheffe post hoc procedures were conducted. Separate analyses were executed for the demographic categories of age, gender, and ethnicity. The probability level for statistical significance was set at $p < 0.05$. The data in this protocol was considered exempt as no personal identifiable information was utilized. Ethical approval was deemed not necessary by the author's institution review board as all information for this study did not require personally identifiable information.

RESULTS

Of the 1,185 patients studied, the average age was 56.8 (± 14.1) years, with a range from 18 to 92 years and 28.8% under the age of 50 and 71.2% age 50 years or older. Females comprised 974 (82.2%) of the patients and males 211 (17.8%).

Table 1: Cohort Demographics (n = 1185)

		Number (%)
Gender	Male	211 (17.8%)
	Female	974 (82.2%)
Age	Age < 50 y/o	341 (28.8%)
	Age ≥ 50 y/o	844 (71.2%)
Ethnicity	Native American	3 (0.3%)
	Asian	12 (1.0%)
	African American	288 (24.3%)
	Caucasian	818 (69.0%)
	Native Hawaiian	1 (0.1%)
	Other	37 (3.1%)
	Refused or Unknown	26 (2.2%)
BMI	< 30 kg/m ²	396 (33.4%)
	≥ 30 kg/m ² to 39.9	478 (40.3%)
	≥ 40 kg/m ²	301 (25.4%)

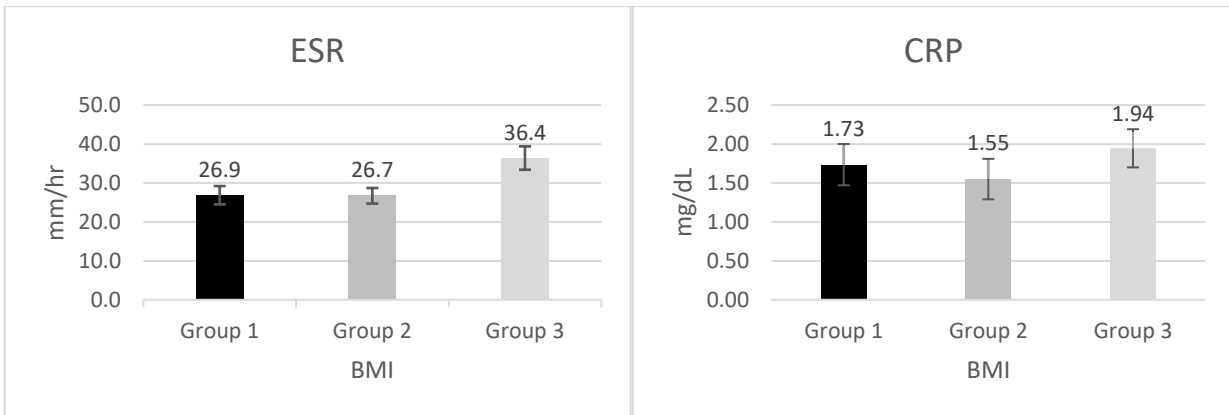
The most frequently reported ethnicity was Caucasian with 818 (69.0%) patients, with African Americans the second largest at 288 (24.3%) patients. Average BMI was 34.9 ($\pm$ 9.6) kg/m² with 396 (33.7%) having a BMI in Group 1, 478 (40.3%) in Group 2, and 301 (25.4%) in Group 3. The average ESR was 32.7 ($\pm$ 22.8) mm/hr and the average CRP was 1.75 ($\pm$ 2.07) mg/dL. This information is summarized in Table 1.

Assessing the relationship between the BMI with the ESR and CRP, a weak positive correlation was noted between the BMI with ESR ($r = 0.147$, $p < 0.0001$) and essentially no relationship between the BMI with CRP ($r = 0.042$, $p = 0.151$) was noted. The relationship between the BMI with ESR was stronger (but still weak) for age under 50 ($r = 0.247$, $p < 0.0001$), female gender ($r = 0.188$, $p < 0.0001$), and Caucasian ethnicity ($r = 0.178$, $p < 0.0001$). Age 50 and over demonstrated a relationship that was weaker than the overall relationship of BMI with ESR ($r = 0.100$, $p < 0.004$). The relationship between BMI and CRP was stronger (but again still weak) for age under 50 ($r = 0.100$, $p = 0.04$) and female gender ($r = 0.110$, $p = 0.043$). This information is summarized in Table 2. The relationship between the ESR with CRP was moderately weak ($r = 0.395$, $p < 0.0001$).

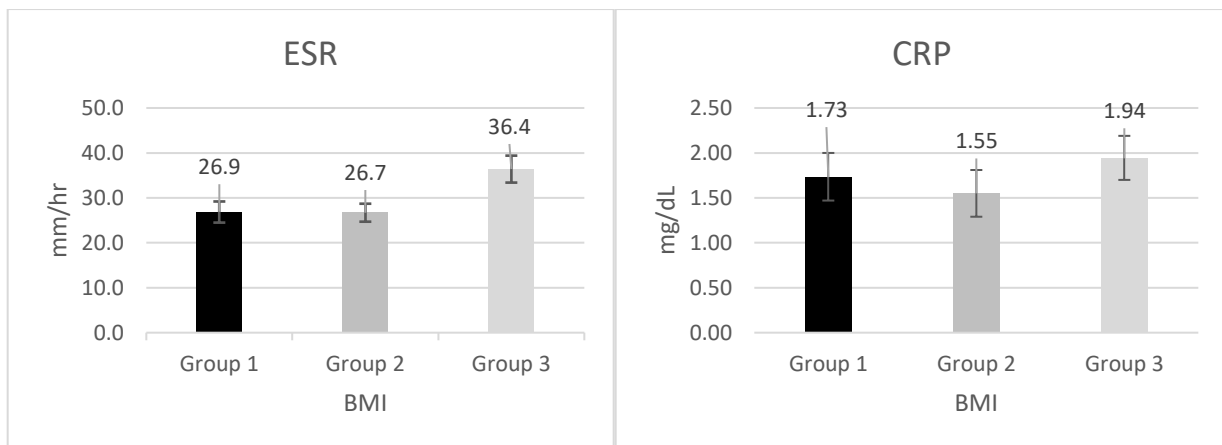
Table 2: Pearson correlation coefficients for BMI with ESR and CRP

BMI with ESR				
		n	r	'p' value
	Overall	1185	0.147	< 0.0001
Age	Under 50 years	341	0.247	< 0.0001
	50 years and older	844	0.100	0.004
Gender	Female	974	0.188	< 0.0001
	Male	211	-0.124	NS
Ethnicity	Native American	3	-0.222	NS
	Asian	12	-0.601	0.039
	African American	288	-0.013	NS
	Caucasian	818	0.178	< 0.0001
	Native Hawaiian	1	-	-
	Other	37	-0.200	NS
	Refused or Unknown	26	0.161	NS
BMI with CRP				
		n	r	'p' value
	Overall	1185	0.042	NS
Age	Under 50 years	341	0.110	0.043
	50 years and older	844	0.015	NS
Gender	Female	974	0.098	0.002
	Male	211	-0.076	NS
Ethnicity	Native American	3	0.181	NS
	Asian	12	-0.181	NS
	African American	288	0.088	NS
	Caucasian	818	0.024	NS
	Native Hawaiian	1	-	-
	Other	37	-0.285	NS
	Refused or Unknown	26	0.071	NS
Key: BMI—Body Mass Index (measured in kg/m ²), ESR—Erythrocyte Sedimentation Rate, CRP—C-Reactive Protein				

Assessing the differences based on BMI when divided into 3 groups (as described earlier), the ESR and CRP demonstrated statistically significant trends. For the overall ESR, Group 3 was statistically higher, with an average ESR of 37.9 (95% Confidence Interval (CI) 35.4 – 40.5) mm/hr as compared to Group 1 with an average ESR of 30.4 (95% CI 28.1 – 32.8) mm/hr and Group 2 with an average ESR of 31.4 (95% CI 29.4 – 33.3) mm/hr. For the overall CRP, Group 3 was statistically higher than Group 2, with an average CRP of 2.00 (95% CI 1.82 – 2.19) mg/dL vs. Group 2 of 1.58 (95% CI 1.39 – 1.77) mg/dL. No statistically significant difference was observed with Group 1 with an average CRP of 1.78 (95% CI 1.55 – 2.01) mg/dL. This information is summarized Table 3 and graphically in Figure 2.



Overall trends



Age over 50 years

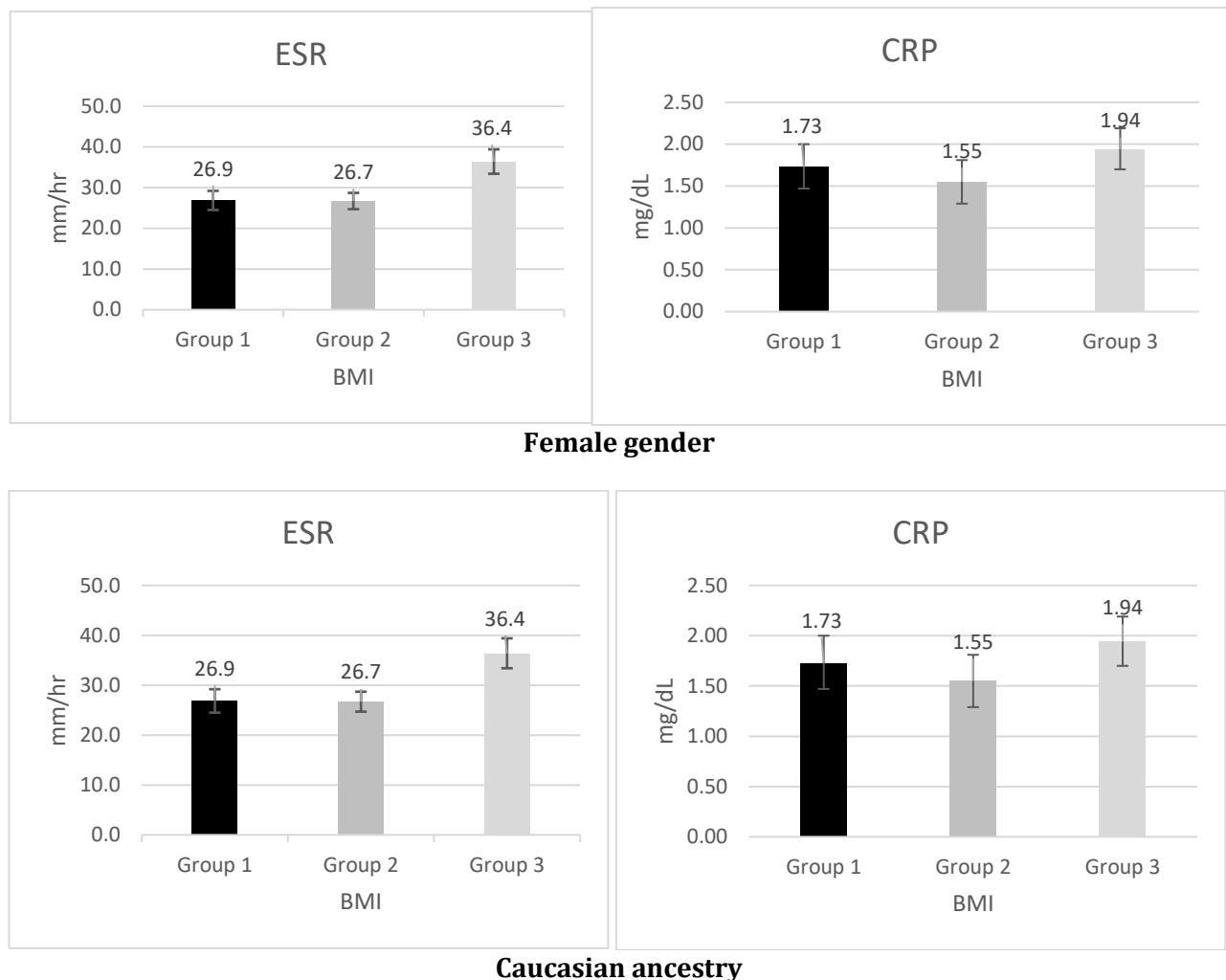


Figure 2: Differences between the three groups of BMI for ESR and CRP

Key: ESR: Erythrocyte Sedimentation Rate; CRP: C-Reactive Protein; * - $p < 0.0001$ and for Group 3 compared to Groups 1 & 2; † - $p = 0.021$ for Group 3 compared to Group 2 only

Further analyzing the data based on demographics, statistically significant differences were noted for Group 3 ($\text{BMI} \geq 40 \text{ kg/m}^2$) as compared to the other two groups. For the ESR, Group 3 was statistically significantly higher compared to the other two groups when analyzed for age under 50 years (40.4 [95% CI 36.3 – 44.4] mm/hr), female gender (38.9 [95% CI 36.2 – 41.5] mm/hr), and Caucasian ancestry (36.4 [33.4 – 39.4] mm/hr). Other demographic factors did not demonstrate statistically significant changes amongst the three groups, although each group generally had mean ESR values over 20 mm/hr. Numerically of interest, but not reaching statistical significance, for African Americans the average ESR was highest for Group 1 and decreased to Group 3. For the CRP, Group 3 was statistically significantly higher compared to the other two groups when analyzed for female gender (1.97 [95% CI 1.80 – 2.15] mg/dL). No other demographic factors demonstrated statistically significant differences amongst Groups 1 – 3 when analyzing CRP. Table 3 provides a summary of the mean values, the 95% CI, and 'p' values for the ESR and CRP for all of the demographics analyzed, and Figure 2 illustrates the aforementioned trends.

Table 3: Differences in ESR and CRP based on divisions in BMI

ESR (mm/hr)					
		n	Group 1 Mean (95% CI) n	Group 2 Mean (95% CI) n	Group 3 Mean (95% CI) n
	Overall	1175	30.4 (28.1 – 32.8) n = 396	31.4 (29.4 – 33.3) n = 478	37.9* (35.4 – 40.5) n = 301
Age	Under 50 years	337	27.9 (22.7 – 33.1) n = 72	29.3 (25.6 – 33.0) n = 136	40.4* (36.3 – 44.4) n = 129
	50 years and older	838	31.0 (28.4 – 33.6) n = 324	32.2 (29.9 – 34.7) n = 342	36.2 (32.9 – 39.4) n = 172
Gender	Female	966	29.2 (26.7 – 31.8) n = 292	32.1 (30.0 – 34.2) n = 398	38.9* (36.2 – 41.5) n = 276
	Male	209	33.8 (28.6 – 39.1) n = 104	27.8 (22.3 – 33.3) n = 80	28.2 (19.4 – 37.1) n = 25
Ethnicity	African American	287	47.0 (39.2 – 54.9) n = 58	43.0 (38.5 – 47.4) n = 136	42.5 (37.4 – 47.6) n = 93
	Caucasian	810	26.9 (24.5 – 29.2) n = 310	26.7 (24.7 – 28.7) n = 306	36.4* (33.4 – 39.4) n = 194
CRP (mg/dL)					
		n	Group 1 Mean (95% CI) n	Group 2 Mean (95% CI) n	Group 3 Mean (95% CI) n
	Overall	1175	1.78 (1.55 – 2.01) n = 396	1.58 (1.39 – 1.77) n = 478	2.00† (1.82 – 2.19) n = 301
Age	Under 50 years	337	1.68 (1.16 – 2.20) n = 72	1.62 (1.29 – 1.95) n = 136	2.00 (1.74 – 2.26) n = 129
	50 years and older	838	1.81 (1.55 – 2.06) n = 324	1.57 (1.34 – 1.79) n = 342	2.01 (1.75 – 2.27) n = 172
Gender	Female	966	1.57 (1.33 – 1.82) n = 292	1.52 (1.35 – 1.69) n = 398	1.97‡ (1.80 – 2.15) n = 276
	Male	209	2.37 (1.82 – 2.90) n = 104	1.87 (1.11 – 2.63) n = 80	2.33 (1.19 – 3.46) n = 25
Ethnicity	African American	287	1.93 (1.30 – 2.56) n = 58	1.72 (1.41 – 2.03) n = 136	2.21 (1.93 – 2.49) n = 93
	Caucasian	810	1.73 (1.47 – 2.00) n = 310	1.55 (1.29 – 1.81) n = 306	1.94 (1.69 – 2.19) n = 194

Key: * - $p < 0.0001$ when compared to other Groups

Group 1: BMI ≤ 29.9 kg/m², Group 2: BMI ≥ 30.0 kg/m² but ≤ 39.9 kg/m² (obese), and Group 3: BMI ≥ 40.0 kg/m² (extreme obesity)

BMI – Body Mass Index, ESR – Erythrocyte Sedimentation Rate, CRP = C-Reactive Protein

Due to small numbers, statistical analysis of other ethnicities failed to reveal any trends and thus were not included in this table.

DISCUSSION

The serologic markers ESR and CRP are routinely ordered in clinical practice with the intent to detect and monitor systemic inflammation, however, their results do not exactly correlate with the presence or absence of a rheumatic autoimmune disease.[1] While previous studies have explored the relationship between BMI with ESR and CRP in select groups of patients with a specific inflammatory diseases, such as Rheumatoid Arthritis,[13] less is known about these relationships in a general adult populations with no apparent rheumatic autoimmune disease. This is important to understand as obesity is a growing public health challenge and a source of chronic inflammation, with the ESR and CRP routinely ordered among blood screening tests for obese[14] individuals who are asymptomatic, mildly symptomatic, or with unspecific clinical manifestations.[15] Additionally, exploring the relationship between BMI with ESR and CRP in the obese general population is important for understanding the relevance of reference values.[15] This study was performed to enhance the understanding of the impact that elevations in the BMI may have on the ESR and CRP in a general adult population. The demographics of this study represent a typical cross section of patients who could be referred to a rheumatology clinic at a suburban-rural community hospital, but perhaps with an above average representation of Caucasian patients and under representation of African American patients, with fewer patients of other ethnicities (such as Hispanic) in this cohort. In Mississippi 56.4% of the population is Caucasian, 37.5% is African American, 0.99% is Asian, and 0.43% is Native American.[16] The average BMI in this study was in the obese range, which would be expected for the practical location from which the data was obtained, as Mississippi has an obesity prevalence of 39.1%.[17] The average age and predominance of female gender of this cohort would be expected as eliminating rheumatic autoimmune diagnoses from the study group, with their onset typically during the reproductive years, and retaining disorders such as osteoarthritis, where weight would likely cause pain from both a mechanical and metabolic standpoint, would favor this trend. The relationship of BMI with ESR was weak but statistically significant, and no meaningful relationship was identified of the BMI with the CRP. A weak moderate relationship was noted between the ESR with the CRP, and the Pearson correlation coefficient obtained in this study was similar to that reported in another study which assessed trends in ESR and CRP in patients with no known inflammatory condition ($r = 0.391$).[15] The relationship between BMI with ESR was stronger when evaluated among female patients, age under 50, and Caucasian ethnicity. Differences in BMI also demonstrated that these demographic factors were associated with elevations in ESR, statistically significantly higher in those with a BMI over 40 kg/m². The relationship between BMI with CRP was stronger when evaluated among female patients and age under 50, but the strength of the relationship was still weak. Differences in BMI demonstrated that female gender was associated with a higher CRP when over 40 kg/m². This trend supporting ESR as compared to CRP in relationship to BMI seems somewhat counterintuitive given the relationship between adipokines, interleukin-6, and CRP secretion, [15, 18] but has been observed elsewhere.[19] Every study has inherent strengths and limitations. For this study, strengths include the size of the cohort, which even

after it was parred down, yielded information about 1,185 patients. Data was obtained from a sizeable patient population in a suburban-rural area with a robust Rheumatology practice that evaluates and treats 25 – 28 patients a day and accepts consults for all patients regardless of type of insurance (indemnity, government, or commercial). It was performed in a location of the United States where the prevalence of obesity is high and similar to that of multiple states within a several hundred mile radius.[17] The trends in the ESR and CRP values that were observed based on the three groups for BMI highlight demographic factors that seem intuitive with the known effects of BMI (and specifically adiposity) on these labs, but provide additional clarity that some subsets of patients being referred for arthralgias and “elevated” inflammatory markers may actually have an age, gender, and habitus appropriate test results. The current literature suggests that the upper limit of normal for an age and gender adjusted ESR is 30 mm/hr for women over 50,[20] however these upper limits were identified at a time when obesity was not the public health issue that it is today. This study yields some insight that while a thorough history and physical examination is warranted for any patient with an elevated ESR and/or CRP, levels over 30 mm/hr, and potentially even over 40 mm/hr, might be age, gender, and habitus appropriate. Weaker trends were identified for the effect of BMI on CRP, but it is possible that women with a BMI over 40 kg/m² may have a CRP around 2.00 mg/dL and this might be gender and habitus appropriate, so long as other causes of inflammation have been appropriately screened for and ruled out.

There are some limitations that may affect the generalizability of the results obtained in this study. The data obtained in this study are from a single center and from a single provider. This potentially overestimates the relationships or the effects of differences observed, however some of the trends identified were similar to those of other studies. For example, as described earlier, the strength of the relationship of the ESR with the CRP obtained in this study is very close to that from another study assessing a similar relationship of obesity with ESR and CRP.[15] A medical records review study design also has inherent limitations. Results in a medical records review study suggest an association but not causality. A prospective trial in the future could better define the relationships and differences between BMI with ESR and CRP. The current study could also be affected by misclassification bias as data was collected from one clinician at one site. A geographic bias may be present as the prevalence of obesity is higher in the location where the study data was collected as compared to other parts of the United States (such as West Coast, California and Washington, or in the Northeast).[17] Control groups in a medical records review study are prone to a selection bias as they are recruited by convenience sampling. Thus, the control group, which in this study was Group 1 (BMI ≤ 29.9 kg/m², representing normal and overweight patients), may not truly reflect the general US population. The strength of the Pearson correlation coefficients were not as strong as other studies,[15, 19] but this might be a function of the population studied and potentially the study design, although one study was retrospective as well.[15] It is unclear why the relationship between BMI and CRP was almost non-existent as sufficient evidence elsewhere supports obesity as a low grade chronic inflammatory condition and adiposity has known inflammatory effects.[21] Additionally, the study design and filtering process could have still retained patients with other chronic inflammatory disorders such as diabetes or chronic kidney disease which could have skewed study results.[22] While the BMI does not directly measure body adiposity, it is moderately correlated with more direct measures that do and has been found to strongly correlate with adverse health outcomes.[17] It is also a quick screening tool with parameters that are easy to obtain in routine clinical practice, so even though it is not perfectly

correlation with adiposity, it has a well-studied relationship to health outcomes, and thus can be used to relate inflammation and inflammatory markers such as ESR and CRP to outcomes based on weight.

In conclusion, this study was undertaken to assess the relationship between BMI with ESR and CRP, two routinely used serologic markers of inflammation, to identify any new changes in the relationships between these markers but also to look for any differences relating changes in the ESR and/or CRP to 3 different groups of BMI. A positive relationship between BMI and ESR was noted but was weak whereas the relationship between BMI and CRP was almost non-existent. When looking at differences between the three groups of BMI, overall values for the ESR and CRP were higher in the group with a BMI ≥ 40 kg/m², as compared to the other 2 groups. For the ESR, age under 50, female gender, and reported Caucasian ancestry demonstrated statistically significant differences for the group with a BMI ≥ 40 kg/m². For the CRP, only female gender was statistically significantly higher for the group with a BMI ≥ 40 kg/m². In the context of the strengths and weaknesses of this study, given the growing public health issue of obesity, elevations in ESR (over 30 mm/hr) and CRP (up to 2.00 mg/dL) could be encountered, but it is important that a thorough history, physical examination, and appropriate serologic and radiographic testing is undertaken to exclude rheumatic autoimmune disorders or other infectious/inflammatory processes.

ACKNOWLEDGEMENTS

I am indebted to Dr. Susan R. Carroll, PhD (no relationship to author) for her help designing the study and performing the biostatistical analysis of the data.

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