What Does an Elevated Erythrocyte Sedimentation Rate (ESR) Indicate About the Body's Inflammatory Process, And How Can This Be Used to Diagnose Various Disorders?

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ABSTRACT

Through this study, I aim to understand the implications of an elevated erythrocyte sedimentation rate and how it can be used to aid the diagnosis of several disorders. By conducting a comprehensive analysis of 75 blood reports collected in Pune, India of individuals of various ages, genders, and health statuses I found out the trend in erythrocyte sedimentation rates and how they are different in Pune specifically.

Introduction

Erythrocyte sedimentation rate (ESR) is a blood test conducted to measure how quickly erythrocytes, also known as blood cells, separate from a blood sample which has been treated to prevent blood clots. The ESR value is derived through measuring the rate at which red blood cells settle towards the bottom of the tube, in which blood is placed, after one hour. Erythrocytes are red blood cells (RBC). RBC's are the functional component of blood responsible for the transportation of different gasses as well as nutrients throughout the human body (1). ESR tests are often used along with other tests to help diagnose conditions which cause inflammation. Additionally, ESR tests can be used to monitor certain health conditions. Some examples of conditions which cause inflammation include arthritis, infection, vasculitis, and inflammatory bowel disease (IBD).

In normal conditions, red blood cells usually sink slowly. However, inflammation can cause RBCs to stick together in clumps. These clumps of cells are heavier than individual cells, therefore sink faster. If an ESR test indicates that your red blood cells are sinking faster than normal, it can signal that you have a medical condition which is causing such inflammation. High ESR levels indicate that RBCs are falling faster than expected. This usually occurs when RBCs contain more protein in them, causing them to stick together (2). ESR can be used for supportive evidence in several cases. The rate can increase with inflections, inflammatory conditions, and even chronic diseases. An elevated ESR level is often a very useful clue in medical investigations as it can signal underlying conditions or issues.

I will take a sample of individuals currently residing in Pune, India from ages 21 to 50. The sample not only includes a range of ages, but also both genders. I will be measuring each person's ESR rate and looking at any indicators or outliers to generate a trend between ESR levels and different conditions. The sample consists of 75 individuals.

Purpose

Though ESR's are commonly measured in regular blood tests, their data is often not focused on or utilized. I hope to find out a trend or understand the complex relationship between ESR levels and different inflammatory

diseases. By gaining a deeper understanding of this relationship and various medical conditions, I could potentially add to more precise clinical decision making and open up a new avenue for therapeutic interventions. Through my research I can understand how we can use ESR data as a screening tool, a way to monitor disease activity, and guide further investigation. Additionally, I could connect my findings to pathophysiology and integrate it with other biomarkers.

Review of Literature

Erythrocytes are mature red blood cells. The unique shape of RBCs along with their composition allows these specialized cells to carry out several essential functions. RBC's are continuously produced in our bone marrow and their primary function is to deliver oxygen to tissues in our body (3). A mature red blood cell is known as an erythrocyte. Most vertebrates possess red blood cells which remain nucleated. Generally in males there are 4.7 to 6.1 million cells per microliter (cells/mcL) while in females there are 4.2 to 5.4 million cells/mcL (Mount Sinai).

The ESR test, also known as the "sed rate" test, measures the rate at which RBCs fall in a tall thin tube over a period of time (usually one hour). The test reflects the degree of inflammation in the body (4). Firstly, blood is collected and then mixed with an anticoagulant like sodium citrate to prevent clogging. The anticoagulated blood is placed into a test tube and measures the rate at which the blood cells settle. Due to gravity, blood cells will sink to the bottom and the plasma will remain at the top. The distance the cells have fallen is measured in mm/hr. Several factors can affect ESR, these include proteins such as fibrinogen that can cause RBCs to clump up together and changes in the shape, number, or abnormalities.

Though an ESR level indicates inflammation in the body, where exactly it is and what exactly is its cause isn't known. ESR levels are most commonly high in people with cases of arthritis, systemic lupus erythematosus, different infections, and certain cancers (5). On the other hand, conditions like sickle cell anemia, extreme leukocytosis, or polycythemia can reduce the ESR. Additionally factors like age and gender can affect ESR as values can be high in the elderly as well as menstruating or pregnant women (6).

The ESR test is usually used in conjunction with other tests and clinical evaluation (7). Researchers or doctors often use it as a general marker for inflammation, monitoring disease activity, and even gauging the effectiveness of on-going treatments. Through analyzing 75 ESR values, I plan to better understand how ESR values behave under different conditions over time.

Expected Findings

Through my research I expect to find individuals with significantly elevated ESR rates to have or be diagnosed with inflammatory diseases. I also expect to see different inflammatory disorders to exhibit varying degrees of ESR elevation.

My aim is to create a trend out of the data I see and understand what are the average ESR values for individuals residing in Pune, India. This will be helpful for me to understand if external factors like location, age, and gender also affect ESR values and if so, then to what extent.

Methods

The most feasible way for me to collect data is through asking individuals for their recent blood reports. I reached out to 100 individuals to provide me with their blood reports taken in the past year which includes data about their ESR value. Out of these 100, 75 were able to provide me with their blood test. All the individuals in the sample have a similar job where they work a 9-5 in an office setting. After collecting this data I organized

all the candidate's age, gender, ESR number, ESR unit, as well as ESR range. I ensured all the people I asked lived in Pune, India as well to make my data more specific. All the ESR values collected below were through the modified westergren method.

Once receiving the blood reports, I organized the ESR levels specifically into a spreadsheet. With columns including age, sex, ESR number, ESR unit, and ESR range. After organizing this table, I highlighted outliers, or individuals which had elevated ESR values.

Results

Raw Data

Table 1. 75 ESR Values and Background Information

Age	Sex	ESR Number (mm/1hr) Range (0-15)	Age	Sex	ESR Number (mm/1hr) Range (0-15)
26	M	5	28	M	9
26	M	15	28	M	9
25	M	18	28	M	4
42	M	4	28	M	6
28	M	8	28	M	7
28	M	6	28	M	9
26	M	5	29	M	4
35	M	4	29	M	15
26	M	7	29	M	5
32	M	15	29	M	4
21	F	4	30	M	3
21	M	10	30	M	6
22	M	4	30	M	6
22	M	8	30	M	3
22	M	6	30	M	2
23	M	1	30	F	29
24	M	4	30	M	9
24	M	3	31	M	20
24	M	5	31	M	2
24	M	41	31	M	2

24	M	2	32	M	17
25	M	4	34	M	4
25	F	8	34	M	6
26	M	12	35	F	18
26	M	2	35	F	8
26	M	27	37	M	24
26	M	3	37	F	14
26	M	1	37	M	4
27	M	5	38	M	12
27	F	5	39	M	5
27	M	8	43	F	33
27	M	4	44	M	13
27	M	5	45	F	56
27	M	5	50	M	4
27	M	2	32	F	13
20	F	10	43	F	20

From this data we can understand that the average ESR for males is 9.30 mm/1 hr, while the average ESR for women is 9.68 mm/1 hr out of a range of 0-15. Furthermore, out of a sample of 75, 10 individuals have an elevated ESR value. Additionally, 6 males have an elevated ESR level, while in females there are only 4. Overall this is a ratio of 1:7.5, so every 15 people 2 will have an elevated ESR level.

While this data shows us that elevated ESR levels aren't very common, there are certain values which are extremely above the normal range. These specific cases should be further looked into.
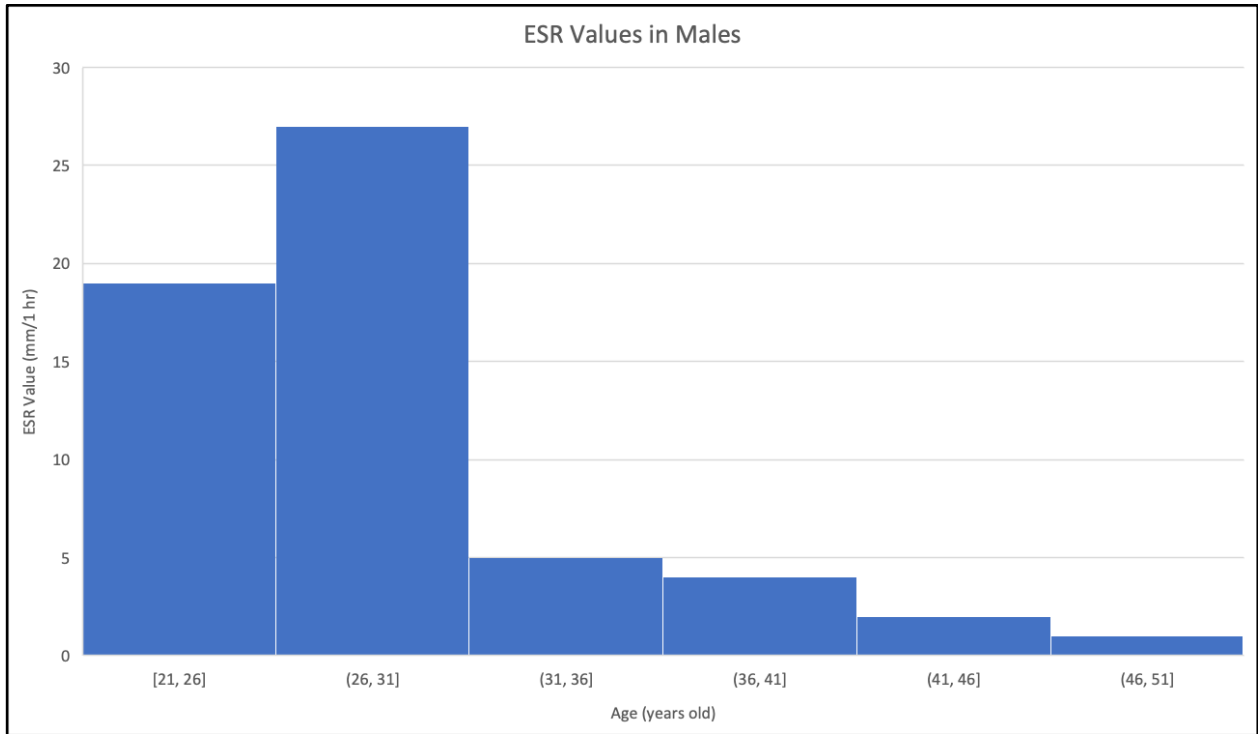
Figure 1. ESR Values in Males

       Through this histogram we can further understand the data specific to males. We see the most common ESR values to be between 25-30 mm/1 hr which is quite above the normal range of 0-15 mm/1 hr. We see the ages with such values are males from 26-31 years old. Additionally, we see that males from ages 21-26 have the second highest ESR with values slightly higher than the range.

       While it is expected for older individuals to have higher ESR values, the opposite is shown through this histogram. Most males from ages 21-31 have elevated erythrocyte levels, while males from 31-51 have low ESR values or values within the normal range.
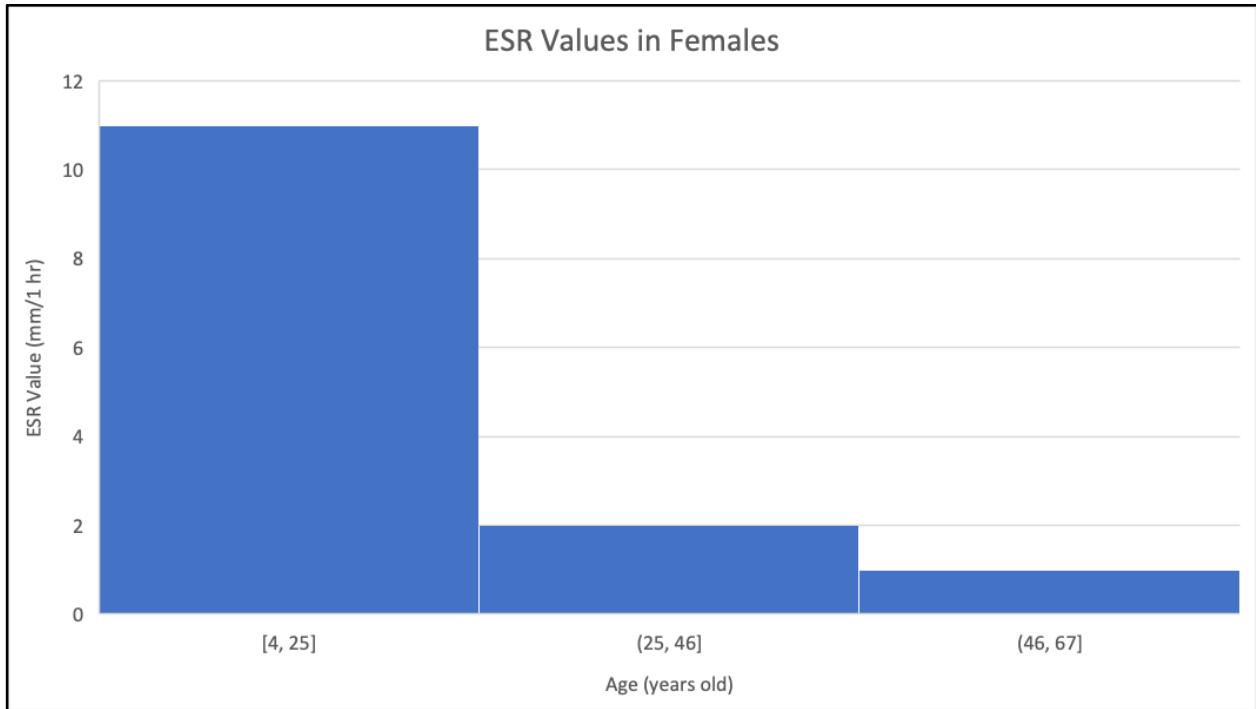
Figure 2. ESR Values in Females

In this histogram it can be once again observed that females with the highest ESR values are 4 to 25 years old. While the lowest age I collected my data from was 20, and the highest was 50, this histogram has extrapolated my data.

Similar to males, we see younger females having higher ESR values. Though on average most females have ESR values within the range, when looking back at my raw data there are few women in particular who have an ESR value above the normal range. This histogram shows that as women age, their ESR value tends to decrease. This is represented by the downward sloping trend of the graph.

Analysing Elevated ESR Levels

Table 2. Extreme ESR Values and Medical Diagnosis

Age	Sex	ESR Number (mm/1hr) Range (0-15)	Medical Background/Diagnosis
25	M	18	Asthma
24	M	41	Type 2 Diabetes
26	M	27	Inflammatory Bowel Disease
30	F	29	Type 2 Diabetes
31	M	20	Type 2 Diabetes
32	M	17	Rheumatoid Arthritis

37	M	24	Breast Cancer Remission
43	F	33	None
45	F	56	Type 2 Diabetes
43	F	20	Endometriosis

As mentioned before, out of my sample of 75 individuals 10 had an elevated ESR level. There are more males which have higher ESR levels than females. Additionally, males on average tend to have higher ESR levels than females, proved by the averages mentioned above. The highest male ESR level is 41 of a 24 year old and highest female ESR level is 56 of a 45 year old. While both these values are extremely high and alarming, having a value of 41 at 24 years old is quite uncommon.

To better understand why these individuals had an elevated ESR level, I analyzed their blood reports along with medical history. I saw a strong correlation and most common correlation of those with type 2 diabetes having elevated ESR levels. The woman with the highest ESR value has type 2 diabetes. Similarly, the male with the highest ESR value is diagnosed with type 2 diabetes as well. Other medical conditions like endometriosis, cancer, inflammatory bowel diseases (IBD), asthma, and rheumatoid arthritis were also linked with elevated ESR values. One woman, though having an elevated ESR level, had no medical history of any condition nor did she have any reported medical issues/troubles.

Discussion

Through the data above we can see that while elevated ESR levels are not extremely common in the sample I have chosen, they are still present. This could be due to a variety of reasons. I have explained the potential reasons below.

My data highlights that males and females of ages on average from 20 to 30 have higher ESR levels than people of older ages. This is quite interesting as most research indicates that individuals of older ages have a tendency to have higher ESR levels. In fact, for people aged 50 or above, their ESR range is increased from 0 to 20 mm/1 hr. This is due to several reasons including older women experiencing menopause and both females and males undergoing hormonal changes. Additionally, most elderly individuals have inflammatory diseases like arthritis or diabetes. In general, ESR is expected to rise with age.

While my data highlights the opposite, I would like to understand why. It is commonly known that high ESR levels are caused by inflammatory diseases and inflections, however it is not common for individuals of ages 20 to 30 to have such conditions. Anemia is another reason behind elevated ESR levels. Anemia is extremely common in women with approximately 30% of them aged 15 to 49 having it. In Pune specifically, 51.9% of women are anemic. Women with anemia are also rising as in India iron, B-12, and folate deficiencies are extremely common. This is due to improper diets which lack high amounts of iron, vitamin B-12, or folate.

Another reason behind such results could be environmental factors. If there is a specific environmental exposure in Pune, it could lead to increased inflammation and ESR levels in the particular demographic I got my data from. In a study conducted in 2020, it was found that microbial isolates such as *S. aureus*, *P. aeruginosa*, and *Aspergillus sp* were discovered indoors. Additionally, it was reported that the dominantly found microbes exhibited elevated production of proinflammatory mediators. Such data could indicate why ESR levels were so high in the young population of Pune, India.

Furthermore, diet and lifestyle can contribute significantly to ESR data. Specific dietary habits, obesity, and lifestyle factors can cause ESR values to be elevated. In the general population, not specifically in Pune, consumption patterns have changed. Often people of younger ages tend to have a rather unhealthy lifestyle which involves excessive consumption of alcohol, sedentary jobs/lifestyles, lack of exercise, as well as

improper eating patterns. The sample of people which I have gotten my data from all work in the same company therefore have similar lifestyles. They all work in an office setting which is usually sedentary for extended hours. This can lead to inflammatory conditions or diseases, which in turn lead to a higher ESR value.

Conclusion

In conclusion, my research regarding "What does an elevated erythrocyte sedimentation rate (ESR) indicate about the body's inflammatory process, and how can this be used to diagnose various disorders?" found different trends of ESR values. As my data was specific to Pune, India I found that a combination of factors lead to younger populations having higher ESR values compared to the elderly population.

Limitations

There are several limitations associated with my data. Firstly, my sample size was quite small. Just 75 participants is too small to generalize my findings to the whole of India's population or even Pune's. Additionally, within my sample there was a lack of diversity. All the individuals which I received data from had similar socio-economic backgrounds, lifestyle habits, and health conditions. Therefore, my data is not representative of Pune or India's population. Additionally, the cross-sectional nature of my study could be seen as a limitation. Since my study analyzes the ESR value at a single point in time, I cannot determine the casualty or progression of any condition which could have caused the elevated ESR value. There was no control group which had normal ESR values from a different geographical location. This made it challenging to draw comparative conclusions for my data.

There are several factors unaccounted for in my research. For instance I do not know any of the individual's lifestyles. Nor do I know information about factors such as diet, exercise, smoking/alcohol consumption, or medication use. All these factors can influence ESR values and therefore I would need to have such data to make a valid and accurate conclusion. Furthermore, ESR can vary due to transient factors, and if the data is not collected at consistent times or under consistent conditions, the data can have variability. Variations in the methodology or instruments used for collecting or measuring ESR data can introduce inconsistencies. While all the participants used the modified westergren method to collect ESR data, each blood test was collected at a different location and at different hospitals. Lastly, without comprehensive medical history or follow-ups, elevated ESR value interpretations could be speculative

Acknowledgments

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