

Research Article

Immunological and Cytokine Profiles in the Pathogenesis of Uterine Leiomyomas Among Nigerian Women: A Case-control Study

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Abstract

Uterine leiomyomas (fibroids) are the most common benign tumors of the female reproductive tract, with a notably high prevalence among women of African descent. While traditionally linked to hormonal factors, recent evidence implicates immune dysregulation and chronic inflammation in their pathogenesis. This case-control study assessed serum cytokine and immunoglobulin profiles in 400 Nigerian women aged 20-50 years, including 300 with ultrasound-confirmed fibroids and 100 age-matched controls. Serum levels of IL-1 α (interleukin-1 α), IL-1 β (interleukin-1 β), IL-6 (interleukin-6), TNF- α (tumor necrosis factor- α), IgA (immunoglobulin A), IgG (immunoglobulin G), and IgM (immunoglobulin M) were measured using enzyme-linked immunosorbent assay and nephelometry, analyzed in relation to BMI, parity, and ethnicity. Data were analyzed by SPSS (IBM version 26.0) with significance set at $p < 0.05$. Results showed significantly elevated IL-1 β and IL-6 ($P < 0.01$ and $P < 0.001$) and significantly reduced IL-1 α and TNF- α ($P < 0.01$ and $P < 0.001$) among women with fibroids, indicating a cytokine environment conducive to inflammation and fibrosis. IgM levels were significantly reduced ($P < 0.005$), suggesting impaired humoral immunity, while IgG, was mildly elevated. Ethnic subgroup analysis revealed higher IgA levels among Isoko women ($P < 0.001$). Body mass index (BMI) and parity showed no significant effects, although some non-significant trends were observed. The findings support the role of immune dysregulation in fibroid development and highlight potential biomarkers and immune-based therapeutic targets, especially relevant for African populations disproportionately affected by fibroids.

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Keywords

Uterine Fibroids, Cytokines, Immunoglobulins, Chronic Inflammation, Immune Dysregulation, Ethnic Variation

1. Introduction

Uterine leiomyomas (UL), or fibroids, are the most common benign tumors of the female reproductive tract, affecting up to 70% of women during their reproductive years [1, 2]. Histologically, these tumors are composed of interlacing bundles of smooth muscle cells embedded within a collagen-rich extracellular matrix (ECM), contributing to their fibrotic and proliferative nature [3]. Clinically, fibroids present a wide spectrum of manifestations, from being asymptomatic to causing significant morbidity through menorrhagia, pelvic discomfort, infertility, and recurrent pregnancy loss [4, 5].

While the role of estrogen and progesterone in the etiology of fibroids is well-established [4], recent research has highlighted the importance of immune system components and chronic inflammation in their pathogenesis [6, 7]. Cytokines and immunoglobulins—central mediators of immune regulation—are believed to influence critical processes such as extracellular matrix (ECM) remodeling, angiogenesis, and smooth muscle proliferation, all of which are hallmarks of fibroid development [8, 6]. Notably, pro-inflammatory cytokines like interleukin-1 alpha (IL-1 α), interleukin-1 beta (IL-1 β), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF- α) have been found to be elevated in fibroid tissue, potentially fostering a localized micro-inflammatory environment conducive to tumor growth [9, 10].

Additionally, alterations in serum levels of immunoglobulins—IgA, IgG, and IgM—may represent either a response to fibroid-associated inflammation or an underlying immune dysregulation contributing to tumorigenesis [11]. Chronic stimuli, including infection and oxidative stress, may further perpetuate a cytokine cascade that promotes fibroblast activation and ECM accumulation, consistent with the fibrotic phenotype of leiomyomas [7].

Epidemiologically, women of African descent exhibit a higher incidence, larger fibroid volumes, earlier age of onset, and more severe symptoms than other populations [12, 13]. Despite the significant burden of fibroids among Nigerian women, immunological research in this population remains limited. This study aims to evaluate serum cytokine and immunoglobulin profiles in women with sonographically confirmed uterine leiomyomas in Warri, Delta State, Nigeria. By elucidating the immunoinflammatory landscape of fibroid pathophysiology, this research seeks to identify potential biomarkers for early diagnosis and new targets for non-hormonal therapeutic intervention.

2. Materials and Methods

2.1. Study Design and Location

This was an analytical case-control study conducted at selected diagnostic and clinical laboratories in Warri, Delta State, Nigeria. Warri is a major commercial city in southern Nigeria with a multi-ethnic population and a high rate of spontaneous clinic attendance for gynecologic ultrasonography.

2.1.1. Study Population and Ethical Approval

Four hundred (400) women were recruited into this study. Three hundred (300) women with ultrasound-guided confirmed cases of uterine leiomyomas were recruited as study subjects, while 100 women who were confirmed via ultrasound without uterine leiomyoma were recruited as control subjects. These women with fibroid were drawn from women attending Gynaecology clinic in Government Hospital Ekpam and Central Hospital, Warri, both in Delta State, Nigeria. In this study, the controls were drawn from healthy general public without leiomyoma in Ekpam and Warri. Ethical approval was obtained from the Ethics Committee of Government Hospital, Ekpam and Central Hospital Warri, Delta State with reference number and EMZ/GHE/ETN/VOL./1/5, 29/6/2016 and CHW/ECCVOL 1/ 129, 25/5/2017 respectively.

2.1.2. Sample Size Calculation

The technique used for the sample size determination was the formula by (Naing *et al.*, 2006) [14]. This is as shown below:

$$n = \frac{Z^2 \times P(1-P)}{d^2}$$

Where; n= required sample size.

Z=Value of normal distribution at confidence level at 95% (standard value of 1.96).

P=Estimated prevalence of patient with uterine leiomyomas 18% [15].

d=Margin of error at 5% (standard value of 0.05).

Substituting into the above formula; we have

$$\frac{1.96^2 \times 0.18(1-0.18)}{0.05^2} = \frac{0.5670202}{0.0025} = 226.8 \approx 227.0$$

The minimum size calculated was 227, but for the purpose

of this study, the size was increased to 300 women due to attritions and 100 controls subjects were enrolled from among the same communities.

Inclusion criteria were women of reproductive age (20-50 years), not pregnant, not on hormonal therapy, and without chronic diseases such as autoimmune disorders or cancer. Exclusion criteria included recent infections (within four weeks), immunosuppressive drug use, or prior surgical treatment for fibroids.

2.2. Sample Collection and Laboratory Analysis

Approximately 10 mL of venous blood was collected from each participant under aseptic conditions. Blood was centrifuged at 3,000 rpm for 10 minutes, and the serum was aliquoted into cryovials and stored at -20 °C until analysis.

- 1) Cytokine Assay: Quantification of IL-1 α , IL-1 β , IL-6, and TNF- α was performed using enzyme-linked immunosorbent assay (ELISA) kits (Elastance Biotechnology Co. Ltd. China, 2017), following manufacturer's instructions. Absorbance was read at 450 nm using a microplate reader.
- 2) Immunoglobulin Assay: Serum levels of IgA, IgG, and IgM were measured by nephelometry using the Minineph™ Plus system (Binding Site, UK).

2.2.1. Determination of IL-1 α , IL-1 β , IL-6, TNF- α

Exactly 0.10 ml of patient serum, reference standard and controls were added to microplate's wells in duplicate and incubated at 37 °C for 90 mins. The liquid content was removed after the 90 mins incubation and 0.10 ml of Biotinylated detection antibody added to the microplate's well and incubated at 37 °C for 1 hour. At the end of the incubation, 350 μ l of buffer solution was aspirated into the wells and washed 5 times and the well blotted. In wells 0.10 ml of substrate is added to each well and allow to stand for 20 min at 37 °C after which 0.50 mls of stop solution was added which colour changes and read immediately spectrophotometrically at 450 nm.

2.2.2. Determination of IgA, IgG and IgM

The Immunoglobulin IgA, IgG and IgM were tested using serum samples. Exactly 2 μ l of serum samples/ calibrator was added to 250 μ l of buffer and was mixed properly and incubated at 37 °C for 5 minutes and absorbance read as A1. In the second stage, 50 μ l of antibody reagent was added to the mixture of serum and buffer from stage one and incubated again for another 5 minutes at 37 °C and absorbance read spectrophotometrically at 340 nm as A2. The different absorbance values A= A2- A1 were plotted against the immunoglobulin IgA, IgG and IgM concentration of each calibrator dilution. IgA, IgG, and IgM concentration in the sample was calculated by extrapolating it's (A) value in the calibration curve.

2.3. Ultrasonographic Diagnosis

Transabdominal pelvic ultrasonography was performed using a GE LOGIQ e Ultrasound Machine with a 3.5 MHz convex probe. Fibroids were classified based on location: submucosal, intramural, and subserosal. Fibroid size and number were also documented.

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (mean $\pm$ SEM) were used to summarize participant characteristics. Independent t-tests compared mean values between groups. A p-value < 0.05 was considered statistically significant.

3. Results

Table 1 shows comparative analysis of the immunoglobulins (IgA, IgG, and IgM) profile of the individuals investigated in this study. The level of IgM was significantly lower in subjects with fibroid compared to apparently healthy subjects ($p < 0.005$) while IgA and IgG showed no significant difference between subjects with fibroid and apparently healthy participants ($p > 0.05$).

Table 1. Comparative Analysis of the Immunoglobulins (IgA, IgG, and IgM) profile of the individuals investigated in this study.

PARAMETERS	CONTROL $\bar{x} \pm SE$ (min-max) N=100	SUBJECTS $\bar{x} \pm SE$ (min-max) N=300	P-VALUE
IgM (mg/dl)	180.18 $\pm$ 17.46 (25.50-1703.0)	130.14 $\pm$ 6.717 (17.30-1703.0)	0.001
IgA (mg/dl)	340.88 $\pm$ 63.14 (112.0-6338.0)	330.22 $\pm$ 21.03 (109.0-6338.0)	0.836
IgG (mg/dl)	1290.6 $\pm$ 129.05 (58.60-136.0)	1322.3 $\pm$ 77.65 (80.0-121.0)	0.837

IgM=Immunoglobulin M, IgA=Immunoglobulin A, IgG= Immunoglobulin G, $\bar{x}$ = Mean, SE=Standard Error, N =Number of participants, Min-max =Minimum-Maximum, $P > 0.05$ = No Significance Difference, $P < 0.05$ = Significance Difference

Table 2 shows comparison of immunoglobulin parameters (IgA, IgG and IgM) in women with leiomyomas based on body mass index. The mean IgA IgG decrease with increasing body mass index among study participants except for IgM which rises

again at BMI of 35.0-39.9 kg/m². The difference was statistically not significant (P>0.05).

Table 2. Comparison of Immunoglobulin parameters (IgA, IgG and IgM) in women with leiomyomas based on Body Mass Index.

PARAMETERS	18.5-24.9 kg/m ² $\bar{x} \pm SE$ (min-max) N=78	25.0-29.9 kg/m ² $\bar{x} \pm SE$ (min-max) N=160	30.0-34.9 kg/m ² $\bar{x} \pm SE$ (min-max) N=61	35.0-39.9 kg/m ² $\bar{x} \pm SE$ (min-max) N=1	P-VALUE
IgM (mg/dl)	143.32 $\pm$ 8.516 (63.00-400.0)	136.9 $\pm$ 11.56 (17.30-1703.0)	96.19 $\pm$ 3.221 (59.00-204.00)	100 $\pm$ 13.00 (87.00-113.00)	0.079
IgA (mg/dl)	389.3 $\pm$ 80.17 (132.0-6338.0)	312.44 $\pm$ 9.591 (109.00-1219.00)	304.98 $\pm$ 8.463 (109.0-460.0)	282.5 $\pm$ 63.50 (219.00-346.00)	0.441
IgG (mg/dl)	1515.6 $\pm$ 186.42 (500.00-12100.00)	1321.4 $\pm$ 113.14 (80.00-12100.00)	1088.5 $\pm$ 27.27 (106.00-1360.00)	1061.5 $\pm$ 101.5 (960.00-1163.00)	0.327

P> 0.05 = No Significant Difference, IgM=Immunoglobulin M, IgA=Immunoglobulin, IgG= Immunoglobulin G, $\bar{x}$ =Mean, SE=Standard Error. Min-max=Minimum-Maximum, N=Number of participants

Table 3 shows comparison of immunoglobulins (IgM, IgA, IgG) in women with leiomyomas based on parity. The mean IgM and IgG levels mg/dl were higher in those without babies than those with babies, Moreso, the mean of IgA with babies were higher than those without babies. The difference in the means levels of immunoglobulins based on parity among the study group were not statistically significant (P>0.05).

Table 3. Comparison of Immunoglobulins (IgM, IgA, IgG) in women with leiomyomas based on Parity.

PARAMETERS	MULTIPAROUS $\bar{x} \pm SE$ (min-max) N=95	NULLIPAROUS $\bar{x} \pm SE$ (min-max) n=205	P-VALUE
IgM (mg/dl)	129.2 $\pm$ 7.002 (20.0-405.0)	133.91 $\pm$ 9.278 (17.30-1703.0)	0.410
IgA (mg/dl)	377.76 $\pm$ 64.85 (109.0-6338.0)	308.19 $\pm$ 6.543 (109.0-785.0)	0.124
IgG (mg/dl)	1276.3 $\pm$ 109.86 (117.0-112.0)	1343.6 $\pm$ 101.73 (80.0-121.0)	0.688

P> 0.05 = No Significant Difference, IgM=Immunoglobulin M, IgA=Immunoglobulin A., IgG= Immunoglobulin G, $\bar{x}$ =Mean, SE=Standard Error. N=Number of participants, Min-max=Minimum-Maximum

Table 4. Comparison of Immunoglobulins (IgA, IgG, and IgM) parameters in women with leiomyomas based on Ethnicity.

PARAMETERS	URHOBO $\bar{x} \pm SE$ (min-max) n= 196	ISOKO $\bar{x} \pm SE$ (min-max) n= 9	IJAW $\bar{x} \pm SE$ (min-max) n= 29	IGBO $\bar{x} \pm SE$ (min-max) n=11	ITSHEKIRI $\bar{x} \pm SE$ (min-max) n= 22	ETHNICITY IN OTHER STATES $\bar{x} \pm SE$ (min-max) n= 33	P-VALUE
IgM (mg/dl)	127.65 $\pm$ 9.299 (17.30-1703.00)	165.22 $\pm$ 26.71 (90.00- 306.00)	118.75 $\pm$ 16.16 (60.00-400.00)	137.55 $\pm$ 21.73 (72.00-305.00)	136.98 $\pm$ 16.80 (73.00-310.00)	137.77 $\pm$ 15.95 (60.00-405.00)	0.921
IgA (mg/dl)	313.41 $\pm$ 7.042 ^b (132.00-785.00)	1018.2 $\pm$ 666.03 ^a (273.00-6338.00)	292.68 $\pm$ 11.22 ^b (109.00-422.00)	379.45 $\pm$ 84.94 ^b (197.00-1219.00)	298.64 $\pm$ 27.49 ^b (157.00-785.50)	280.97 $\pm$ 10.37 ^b (109.00-382.00)	0.000
IgG (mg/dl)	1185.6 $\pm$ 51.01 (80.00-10300.00)	1313.6 $\pm$ 100.369 (970.50-1800.50)	1539.8 $\pm$ 394.082 (219.00-12100.00)	1178.1 $\pm$ 113.507 (145.50-1660.00)	2005.9 $\pm$ 671.678 (660.50-11300.00)	1551.4 $\pm$ 311.587 (988.00-12100.00)	0.095

P> 0.05 = no significant difference, P< 0.001 = very high significant difference IgM=Immunoglobulin M, IgA=Immunoglobulin A, IgG= Immunoglobulin G $\bar{x}$ =Mean, SE=Standard Error, *SIG= Level of Significant, N=Number of participants Min-max=Minimum-Maximum

Table 4 shows comparison of immunoglobulins (IgA, IgG, and IgM) parameters in women with leiomyomas based on ethnicity. The mean of IgA mg/dl value was higher among the Isoko than the rest ethnic groups. The difference was statistically significant ($P < 0.001$). Other parameters in this group were not statistically significant ($P > 0.05$).

Table 5 shows comparative analysis of interleukins (IL-1 α ,

IL-1 β , IL6 and TNF- α) profile of the individuals investigated in this study. The mean levels of IL-1 β ($P < 0.01$) and IL-6 ($P < 0.001$) were statistically significantly higher among women with leiomyomas subjects compared with control subjects while IL-1 α ($P < 0.01$) and TNF- α ($P < 0.001$) were significantly lower among women with leiomyomas than controls.

Table 5. Comparative Analysis of Interleukins (IL-1 α , IL-1 β , IL6 and TNF- α) profile of the individuals investigated in this study.

PARAMETERS	CONTROL $\bar{x} \pm SE$ (min-max) N=100	Women leiomyomas $\bar{x} \pm SE$ (min-max) N=300	P-VALUE
IL-1 α (Pg/ml)	51.47 $\pm$ 5.993 (1.00-420.0)	34.64 $\pm$ 2.406 (3.70-420.0)	0.002
IL-1 β (Pg/ml)	222.85 $\pm$ 10.94 (40.50-485.0)	290.24 $\pm$ 12.97 (35.50-3750.0)	0.004
TNF- α Pg/ml	150.32 $\pm$ 10.82 (7.60-365.0)	61.56 $\pm$ 3.869 (5.00-750.0)	0.000
IL6 Pg/ml	124.7 $\pm$ 9.866 (20.40-710.50)	231.24 $\pm$ 7.862 (20.40-850.0)	0.000

$P < 0.01$ = High Significant Difference, $P < 0.01$ = Very High Significant Difference

IL-1 α = Interleukin 1 alpha, IL-1 β = Interleukin 1 Beta

sTNF- α = Tumour Necrosis Factor alpha, IL6 = Interleukin 6

$\bar{x}$ = Mean, SE =Standard Error.

4. Discussion

This study provides strong evidence that uterine leiomyomas (fibroids) are significantly associated with immune dysregulation, particularly through elevated proinflammatory cytokines and alterations in humoral immunity. Among the cytokines evaluated, interleukin-6 (IL-6) was notably elevated in women with fibroids. This finding underscores its role in inflammatory signaling, extracellular matrix (ECM) remodeling, and cellular proliferation within the uterine microenvironment, in agreement with Chegini (2010) and Yun & Daniel (2005) [6, 10]. Elevated interleukin-1 beta (IL-1 β) levels also supported this inflammatory profile, consistent with the work of Inagaki et al. (2003) [9], who noted IL-1 β 's contribution to chronic inflammation and fibroid cell proliferation.

The study also revealed a significant reduction in interleukin-1 alpha (IL-1 α) and tumor necrosis factor-alpha (TNF- α) among women with fibroids. This inverse trend suggests an immunosuppressive or anti-apoptotic adaptation within fibroid tissue, consistent with observations by Makinen *et al.* (2004) and Laughlin-Tommaso *et al.* (2019) [16, 17]. These cytokines are typically involved in apoptotic signaling and immune surveillance; thus, their downregulation may promote fibroid persistence by limiting immune-mediated cell clearance.

Immunoglobulin profiling revealed a selective dysregulation of humoral immunity. Although IgG was mildly elevated

and IgA unchanged, IgM was significantly reduced ($p < 0.005$), pointing to compromised primary immune defense. IgM plays a pivotal role in complement activation and the clearance of abnormal cells [18], and its reduction may permit unchecked smooth muscle cell proliferation characteristic of leiomyomas. This aligns with earlier findings by Dele-Ochie et al. (2016) [11], who also observed decreased IgM levels in chronic inflammatory conditions.

Mechanistically, the reduced IgM may result from either suppressed B-cell production or increased consumption due to chronic inflammation. The proinflammatory environment, notably elevated IL-6, may drive immunoglobulin class-switch recombination from IgM to IgG or IgA, thereby reducing circulating IgM. Tumor immunology studies have shown IgM to have antiproliferative and cytostatic effects [19], reinforcing its potential role in suppressing fibroid development.

Interestingly, chronic exposure to immune stimuli—such as infections or oxidative stress—can lead to immune complex formation and enhanced IgM consumption. These mechanisms might partly explain the immunoglobulin patterns seen in this study, especially within a population experiencing high pathogen exposure. The significantly reduced IgM may thus serve as a biomarker for aggressive fibroid phenotypes and a candidate for therapeutic modulation.

When stratified by BMI, immunoglobulin trends revealed additional complexity. IgA and IgG levels declined as BMI increased, while IgM levels rose in the highest BMI category (35-39.9 kg/m²), although these differences were not statistically significant ($p > 0.05$). This is contrary to many reports in

general populations, where obesity correlates with higher IgA and IgG due to chronic low-grade inflammation [20]. However, some studies suggest that IgM may remain stable or even decrease with obesity, supporting its unique immunological behavior.

The rise in IgM at high BMI in this study may indicate a threshold at which obesity transitions from metabolic to immunologically active, potentially triggering B-cell subsets that enhance IgM production. This phenomenon has been observed in obesity-related metabolic disorders such as type 2 diabetes, where IgM increases in response to microbiota-derived stress. Despite statistical insignificance, these findings highlight the potential for BMI to subtly influence immune status in fibroid patients, echoing [21], who describe a nonlinear relationship between adiposity and fibroid risk.

Parity-related analysis of immunoglobulin levels showed that IgG and IgM were higher among nulliparous women, while IgA was elevated among parous participants. However, none of these differences were statistically significant ($p > 0.05$), suggesting only modest or transient parity effects on humoral immunity. During pregnancy, there are known changes in immunoglobulin levels—such as IgG hemodilution and altered IgA/IgM profiles—yet these usually normalize postpartum [22]. Similar trends were reported by Ojeka & Zabbey (2021) [23] in a Nigerian cohort, where parity showed no significant effect on serum immunoglobulin concentrations.

Physiologically, pregnancy induces expansion of IgA-secreting plasma cells and reshaping of IgG subclasses [24], though these effects tend to be transient. Studies in animal models have shown parity-related increases in IgA and IgG within colostrum, but not necessarily in maternal serum [25]. Therefore, any variation seen in this study likely represents residual or mild immunological remodeling rather than sustained changes in humoral immunity.

Ethnicity appeared to play a more pronounced role in immunoglobulin variation. Women from the Isoko ethnic group exhibited significantly higher serum IgA levels ($p < 0.001$), while IgG and IgM remained similar across ethnic lines. This observation supports previous research indicating that individuals of African descent tend to have higher baseline IgA levels [26, 27]. These differences may stem from genetic polymorphisms affecting immunoglobulin production, mucosal immunity, or exposure to environmental antigens and pathogens.

Greater diversity in genes regulating immune responses—such as immunoglobulin class switching—has been documented in populations of African ancestry [28]. Regional differences in dietary intake, microbiota composition, and pathogen burden may further shape systemic IgA expression. The current findings agree with those of Oyeyemi (2018) [29], who reported ethnic variability in IgA levels across Nigerian communities.

Elevated IgA may have clinical relevance in fibroid biology. As a key player in mucosal immunity and systemic antigen

clearance, IgA has been implicated in autoimmune and inflammatory conditions like IgA nephropathy. Whether increased IgA confers protective benefits or exacerbates fibroid pathology through immune activation remains uncertain. Nonetheless, the convergence of evidence across ethnic studies highlights IgA's sensitivity to both genetic and environmental modulation.

Finally, the cytokine profile observed in this study—characterized by elevated IL-1 β and IL-6 with reduced IL-1 α and TNF- α —further reinforces the concept of immune imbalance in fibroid development. IL-6 is known to stimulate fibroblast proliferation and ECM deposition, which are central to fibroid growth [30]. IL-1 β contributes to creating a supportive microenvironment for fibroid expansion [31].

In contrast, TNF- α and IL-1 α typically mediate apoptosis and immune regulation. Their suppression may allow fibroid cells to evade immune clearance and sustain abnormal proliferation. This pattern was similarly observed by Makinen *et al.* (2004) [16], who reported low TNF- α activity in fibroid tissues, and by Laughlin-Tommaso *et al.* (2019) [17], who highlighted altered cytokine signatures in affected individuals.

This study provides novel insights into the immunopathogenesis of uterine fibroids among Nigerian women. The findings demonstrate that fibroid development is influenced not only by hormonal and genetic factors but also by a dysregulated immune system characterized by elevated pro-inflammatory cytokines and selective humoral immune alterations. IgM deficiency, in particular, may serve as a biomarker for aggressive disease and a potential target for immunotherapeutic strategies. Ethnicity- and BMI-related immunoglobulin variations also highlight the need for personalized approaches in fibroid research and management.

5. Conclusion

This study provides compelling evidence that immune dysregulation is a central feature of uterine leiomyoma pathogenesis. Elevated IL-6 and IL-1 β levels suggest a pro-inflammatory microenvironment conducive to extracellular matrix remodeling and smooth muscle proliferation, whereas the suppression of TNF- α and IL-1 α points to a loss of key immunoregulatory and apoptotic controls. The concurrent reduction in IgM, despite increased IgG levels, indicates a dysregulated humoral immune response, possibly undermining the body's ability to identify and eliminate fibroid tissue. These immunologic shifts, coupled with significant ethnic variation in IgA levels, underscore the complexity and multifactorial nature of fibroid biology, particularly in African populations.

6. Recommendation

Future research should consider longitudinal studies to explore cytokine fluctuations during fibroid progression and

post-treatment states, as well as interventional trials using anti-inflammatory or immunomodulatory agents in fibroid management.

Abbreviations

IL-1 α	Interleukin-1 α
IL-1 β	Interleukin-1 β
IL-6	Interleukin-6
TNF- α	Tumor Necrosis Factor- α
IgA	Immunoglobulin A
IgG	Immunoglobulin G
IgM	Immunoglobulin M
ECM	Extracellular Matrix
SEM	Standard Error of Mean
SPSS	Statistical Package for Social Science
$\bar{x}$	Mean

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Data Availability Statement

The data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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