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Correlation of Serum Interleukin-6 Levels with Atisthoulya (Obesity): An Integrative Approach between Ayurveda and Modern Biomedicine

Sudipa Saha[1], Mahesh Vyas[2], Anil Kumar[3]

Department of Samhita & Siddhanta, Prakash Institute of Ayurvedic Medical Sciences & Research, Uttar Pradesh, India

Department of Samhita & Siddhanta, All India Institute of Ayurveda, New Delhi, India

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ABSTRACT

Background: Obesity (Atisthoulya) is both a biomedical and Ayurvedic concern, linked with metabolic disorders and chronic low-grade inflammation (metaflammation). Interleukin-6 (IL-6) is a key biomarker in this process. Objective: To assess serum IL-6 levels in individuals with varying BMI and correlate findings with Ayurvedic descriptions of Atisthoulya. Methods: A cross-sectional study on 174 adults (20–60 years) was conducted. Participants were categorized by BMI, and serum IL-6 was measured using ELISA. Statistical analysis included ANOVA and regression models. Results: IL-6 levels increased significantly with BMI ($p < 0.001$), from 26.35 pg/mL in normal weight to 167.32 pg/mL in Obese III. Higher age also correlated with elevated IL-6, whereas gender differences were non-significant. Conclusion: Elevated IL-6 supports the Ayurvedic view of Atisthoulya as a systemic disorder with inflammatory and degenerative consequences. IL-6 may serve as a biomarker linking traditional concepts of Ama with modern inflammation biology, emphasizing the need for integrative management.

Keywords- Atisthoulya, Obesity, Ayurveda, IL-6, Metaflammation

INTRODUCTION

In the present era, obesity has emerged as one of the most pressing global health challenges, associated with metabolic, cardiovascular, and psychosocial disturbances. Obesity is an abnormal growth of adipose tissue due to an enlargement of fat cell size or an increase in fat cell number or a combination of both. A crude population measure of Obesity is Body Mass index (BMI). Obesity is the BMI of 30kg/m^2 or more for either sex. [1]

As per World Health statistics 2012 one in six adults is obese. Some recent WHO global estimates shows that world-wide obesity has nearly tripled since 1975 and overall, about 13% of the world's population (11% of men and 15% of women) were obese in 2016.[2] Recent studies have reported that globally, more than 1.9 billion adults are overweight and 650 million are obese. Approximately 2.8 million deaths are reported as a result of being overweight or obese.[3]Due to the consumption of energy dense food (i.e. unhealthy food habits), sedentary life style, lack of health care services and financial support, the developing countries are facing high risk of obesity and their adverse consequences like diabetes, ischemic heart disease, etc. In India, more than 135 million individuals were affected by obesity. The prevalence of obesity in India varies due to age, gender, geographical environment, socio-economic status, etc.[4]. According to ICMR-INDIAB study 2015, prevalence rate of obesity and central obesity are varied from 11.8% to 31.3% and 16.9%-36.3% respectively. In India, abdominal obesity is one of the major risk factors for cardiovascular disease (CVDs). Various studies have shown that the prevalence of obesity among women were significantly higher as compared to men.[4] Obesity is one of the main medical and financial burdens for the government also.

Ayurveda identifies Atisthoulya not merely as an increase in body weight but as an abnormal and disproportionate accumulation of Meda Dhatu that disturbs the functional harmony of the body and mind. This leads to impaired vitality, reduced longevity, and diminished quality of life. Modern research also highlights that individuals with higher grades of obesity are at increased risk of multiple comorbidities and compromised well-being.

Atisthoulya (obesity) is described in Ayurveda as one of the Ashtaunindita Purusha, a condition associated with multiple systemic impairments and reduced life expectancy. Acharyas have further elaborated the Ashta Doshakara Bhavas (eight adverse consequences) of Sthoulya, which include conditions such as 1)Ayusha hrasha i.e deficiency in longevity due to over nourishment of only meda dhatu and the other dhatu onwards remain famished which leads to manifestation of various disease related to Asthi kshaya, Majja kshyaya and Sukra kshaya,2) Jaba uparodha that is premature aging,3) Kricchavyavayata which indicates the difficulty with indulgence in intercourse as well as altered sperm quantity and quality and also the synthesis of sex hormones get affected,4)Dourbalya means unable to tolerate minimum exhaustion or physically not active,5)Dourgandhya or bad odour from the body,6)Sweda Abadha i.e excessive sweating,7)Ati khsudha & 8) Ati pipasa i.e excessive appetite and thirst. These adverse consequences reflect not only the physical burden of obesity but also its impact on metabolic, respiratory, and psychosocial well-being.

From a modern perspective, obesity is now understood as a state of chronic low-grade inflammation, or metaflammation. Metaflammation is a term that combines “metabolic” and “inflammation”. It refers to a chronic, low-grade systemic inflammation that arises due to metabolic disturbances, typically associated with obesity, insulin resistance, type 2 diabetes, cardiovascular disease, and other metabolic disorders.[5,6] Among the inflammatory biomarkers, Interleukin-6 (IL-6) plays a crucial role as it is predominantly secreted by adipocytes and macrophages within adipose tissue.[7]Elevated IL-6 levels contribute to insulin resistance, endothelial dysfunction, atherogenesis, and overall systemic inflammation.[8]Thus, IL-6 serves as an important biomarker linking obesity with its long-term health consequences.

Testing IL-6 levels in subjects with Atisthoulya provides an opportunity to scientifically correlate the Ayurvedic description of Ashta Doshakara Bhavas with the modern understanding of inflammatory and metabolic dysfunctions. Early detection of elevated IL-6 may help identify individuals at risk of developing these adverse outcomes, thereby supporting preventive and integrative strategies in obesity management.

Therefore, this study emphasizes the importance of assessing IL-6 levels in Atisthoulya subjects to validate the Ayurvedic principle of Ashta Doshakara Bhavas in Sthoulya and to bridge traditional wisdom with modern biomedical evidence for early detection and comprehensive health management.

MATERIALS AND METHODS

A Cross-sectional Study has been carried out to evaluate the impact of BMI on circulating level of serum IL-6. The study has enrolled total 174 adults, age ranged between 20-60 years. The distribution of the subjects was as follows-

Overweight (BMI 25.0–29.9 kg/m²): 38 subjects (10 males, 28 females)

Class I Obesity (BMI 30.0–34.9 kg/m²): 25 subjects (9 males, 16 females)

Class II Obesity (BMI 35.0–39.9 kg/m²): 37 subjects (10 males, 27 females)

Class III Obesity (BMI ≥40 kg/m²): 31 subjects (11 males, 20 females)

Normal weight controls (BMI 18.5–24.9 kg/m²): 43 subjects (21 males, 22 females)

Selection Criteria

For all the participants, a detailed medical history was obtained including comorbid conditions and concomitant medications. A thorough clinical examination was performed. Body mass index was calculated as weight(kg) divided by the square of height(m),kg/m2. None of the subjects with overweight and obesity and controls were on a special diet when they were enrolled into the study.

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The subjects for this study were selected based on clinical presentation, anthropometric measurements, and final diagnosis. Allocation into respective groups was done according to the Body Mass Index (BMI) as per the WHO International Classification of Nutritional Status. Initially, subjects were screened on the basis of the classical features of Sthoulya and Swasthya described in the Caraka Saṃhita. Further assessment included anthropometric measurements such as waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), waist-to-stature ratio (WSR), and skinfold thickness.

Inclusion & Exclusion Criteria

Subjects between 20 to 60 years of age, irrespective of sex, religion, or caste, were included in the study. Individuals with acute infectious diseases or acute medical conditions such as bronchial asthma exacerbation and myocardial infarction, cancer patients, pregnant or lactating women, those with secondary causes of obesity, and subjects with chronic major systemic diseases involving the liver, kidney, or cardiovascular system were excluded. Additionally, those taking medications such as antihypertensive or hypolipidemic agents were not considered for the study. For the control group, healthy non-obese subjects were included after obtaining a detailed medical history and performing a thorough clinical examination to rule out systemic or metabolic disorders. Following investigations were performed for the final selection of the subjects for IL-6 investigation -HbA1C, Random blood sugar, Lipid profile.

Table 1 Baseline Anthropometric Characteristics of Study Participants by BMI group

BMI Group	Age (years)	Weight (kg)	Height (cm)	BMI (kg/m²)	WC (cm)
Normal	32.5 ± 8.1	60.2 ± 7.5	164.3 ± 8.2	22.4 ± 1.7	78.6 ± 6.4
Pre-obese	35.8 ± 9.4	72.1 ± 8.9	163.8 ± 7.6	27.1 ± 1.9	88.9 ± 7.8
Obese I	39.3 ± 7.8	82.6 ± 9.2	162.5 ± 8.0	31.2 ± 2.1	96.3 ± 8.1
Obese II	41.7 ± 8.6	92.4 ± 10.1	161.8 ± 7.3	35.5 ± 2.3	103.7 ± 9.2
Obese III	44.2 ± 9.1	102.8 ± 12.4	160.7 ± 7.8	40.2 ± 3.1	112.4 ± 10.5

Estimation of Circulating level of serum Interleukin-6

Serum IL-6 concentrations were measured by ELISA using a commercial human IL-6 kit(Kit 96 wells Make-Vector Best Russia) purchased from Immunconcept India p.v.t. LTD, New Delhi, India with a Cat No. A-876. First Blood Samples were collected as per standard protocol. Then the samples have been centrifuged, transferred supernatant to clean tubes and stored at −80 °C. Samples and standards were run in duplicate and the assay was performed according to the manufacturer's protocol. Optical density was read at 450 nm and concentrations were determined using a 4-parameter logistic standard curve. The intra- and inter-assay coefficients of variation were X% and Y% respectively (report your observed values). The assay detection limit was Z pg/mL. The samples were handled as potentially infectious material, following institutional biosafety guidelines and obtained ethics approval for human sample use.

RESULTS & OBSERVATIONS

Table 2 Descriptive Statistics of IL-6 across BMI categories

BMI Group	N	Mean IL-6 (pg/mL)	SD	SE	95% CI (Lower–Upper)	Min	Max
Normal	43	26.35	22.45	3.42	19.44 – 33.25	0.60	85.70
Pre-Obese	38	89.80	40.29	6.54	76.55 – 103.04	13.78	192.10
Obese I	25	148.40	87.51	17.50	112.28 – 184.52	59.00	431.10
Obese II	37	145.53	68.05	11.19	122.85 – 168.22	67.70	327.30
Obese III	31	167.32	82.83	14.88	136.94 – 197.70	24.90	469.20
Total	174	108.20	81.13	6.15	96.06 – 120.34	0.60	469.20

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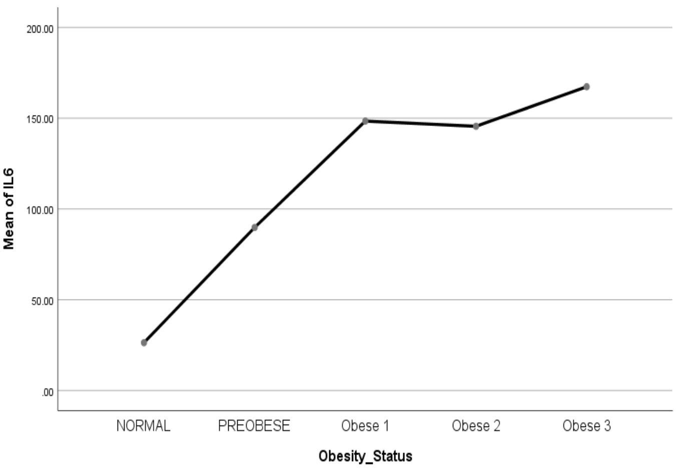

Fig. 1 Showing the association of BMI and IL-6 level

BMI & Serum IL-6

The descriptive statistics of serum IL-6 levels across BMI categories are summarized in Table 1. The mean IL-6 values demonstrated a clear rising trend with increasing BMI. Normal weight individuals had the lowest mean IL-6 levels (26.35 ± 22.45 pg/mL), while Obese III individuals exhibited the highest (167.32 ± 82.83 pg/mL). One-way ANOVA confirmed that these differences were statistically significant ($p < 0.001$) and the association is presented in a graph (Figure Higher BMI was strongly associated with elevated IL-6, suggesting an obesity-induced inflammatory state.

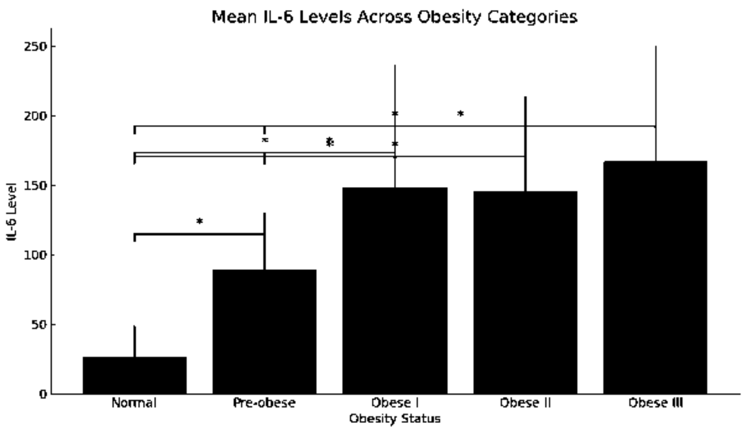

Fig. 2 Showing IL-6 across obesity categories

BMI Categories & IL-6

A Bonferroni post hoc test was done for the multiple comparison of different categories of BMI on the basis of their IL-6 levels and it confirms that the differences in IL-6 levels between most obesity categories are statistically significant. Normal vs. all obese groups (Pre-obese, Obese I, II, III): Highly significant differences were observed ($p < 0.001$), with IL-6 levels increasing sharply with obesity. Pre-obese vs. Obese I, II, III: These comparisons also showed statistically significant differences (all $p < 0.005$), indicating a steady inflammatory rise even within higher BMI categories. Obese I vs. Obese II & III and Obese II vs. Obese III: These differences were not statistically significant ($p = 1.000$), suggesting a plateau effect in IL-6 levels at severe stages of obesity. The bar graph(Fig. 2) illustrates the mean IL-6 levels across different obesity categories. Error bars represent standard deviations, and asterisks (*) denote statistically significant differences ($p < 0.05$). Significant increases in IL-6 were observed between normal/pre-obese and all higher obesity classes, indicating progressive systemic inflammation.

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Table 2 Showing Descriptive Statistics of IL-6 across Age group

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
<30 Years	47	59.2355	45.42069	6.62529	45.8995	72.5715	.70	158.20
30-39	53	110.0223	76.52337	10.51129	88.9298	131.1147	.60	322.00
40-49	51	123.1635	74.84892	10.48095	102.1119	144.2151	9.00	431.10
50 & above	23	170.8717	105.46345	21.99065	125.2659	216.4776	35.50	469.20
Total	174	108.1991	81.13478	6.15081	96.0588	120.3394	.60	469.20

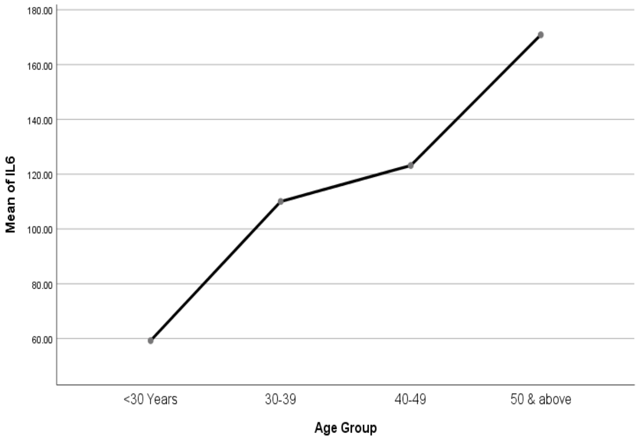
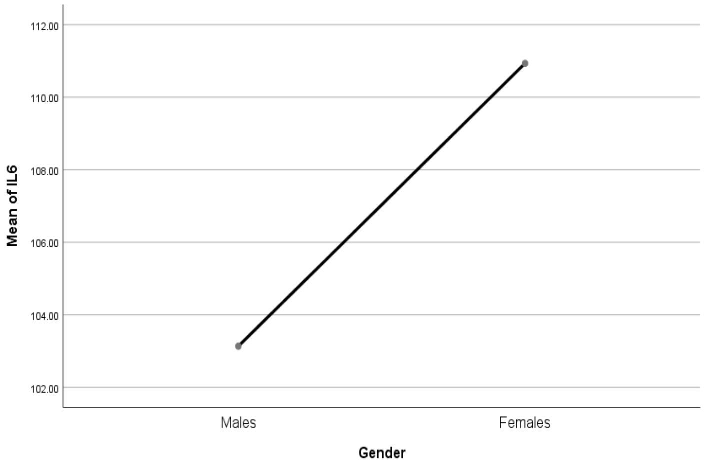


Fig. 2 Showing association between Age group and Serum IL-6 level

Age & IL-6



The distribution of IL-6 by age categories is presented in Table 2. Mean IL-6 levels progressively increased with age, ranging from 59.24 ± 45.42 pg/mL in individuals <30 years to 170.87 ± 105.46 pg/mL in those aged ≥50 years. The variability of IL-6 was also greater in older age groups, reflecting a wider range of inflammatory responses. There was a statistically significant difference in IL-6 levels among different age groups ($p < 0.001$) and the association is presented in a graph (Figure2). Advancing age is associated with higher IL-6 levels, supporting the concept of "inflammaging" where chronic low-grade inflammation rises with age.

Gender & IL-6

The mean IL-6 level in females (110.93 ± 79.61) was slightly higher than in males (103.14 ± 84.33). However, this difference was found to be statistically non-significant based on the ANOVA result ($p = 0.547$). This suggests that gender does not significantly influence IL-6 levels in this sample. The wide standard deviation in both groups reflects considerable inter-individual variation, but the overall inflammatory response appears similar across genders.

IL-6 Levels in Males & Females based on Obesity Status and Age Group

A multiple linear regression was performed to predict IL-6 levels in males based on obesity status and age group and IL-6 levels were significantly predicted by both obesity status ($p < 0.001$) and age group ($p = 0.007$) in males. The model explained 49.5% of the variance in IL-6 levels ($p < 0.001$). A multiple linear regression was performed to predict IL-6 levels in females based on obesity status and age group and it shows that both obesity status ($p < 0.001$) and age group ($p = 0.005$) were significant predictors of IL-6 levels in females. The model explained 41.1% of the variance in IL-6 ($p < 0.001$). Significant variation in IL-6 levels were significantly differed by obesity status(p=.000) and age(p=.005) among females.

DISCUSSION

Age and IL-6

The present study showed that mean IL-6 levels progressively increased with age, with the highest concentrations observed in participants aged ≥50 years. This trend supports the concept of "inflammaging," a phenomenon characterized by chronic, low-grade inflammation that develops with advancing age. Elevated IL-6 in older individuals may be attributed to increased adiposity, oxidative stress, cellular senescence, and dysregulated immune responses, all of which contribute to a pro-inflammatory milieu. [11,12] The observed variability in IL-6 among older groups indicates heterogeneity in the aging process, likely influenced by genetic predisposition, lifestyle factors, and comorbidities. Higher IL-6 levels have been linked to the pathogenesis of several age-related conditions, including cardiovascular disease, type 2 diabetes, frailty, and neurodegenerative disorders.[13,14]These findings highlight the role of IL-6 as a potential biomarker of biological aging and support the need for interventions—such as exercise, weight control, and anti-inflammatory dietary approaches—that may attenuate systemic inflammation and promote healthy aging.[15]

Gender and IL-6

In this study, mean IL-6 levels were slightly higher in females compared to males; however, the difference was not statistically significant. This finding indicates that gender did not exert a major influence on circulating IL-6 concentrations within the study population. The wide standard deviations observed in both groups highlight considerable inter-individual variability, suggesting that factors other than sex—such as body composition, adiposity, lifestyle, and comorbid conditions—may play a greater role in determining IL-6 levels. Previous studies on sex differences in inflammatory markers have reported mixed results. Some evidence suggests that females may exhibit higher baseline inflammatory responses due to hormonal influences, particularly estrogen, which modulates cytokine production (16,17). However, other studies have found no consistent gender effect on IL-6 concentrations, especially after controlling for confounding factors such as age and BMI (18,19). Our results are in line with the latter, indicating that systemic inflammation, as measured by IL-6, may not differ substantially between males and females in the absence of other strong determinants. This underscores the importance of considering broader metabolic and lifestyle factors rather than gender alone when assessing inflammatory risk.

BMI and IL-6

Significant association between BMI and IL-6 has been revealed in the present study. The circulating level of IL-6 was significantly high in obese subjects which implies that Atisthoulya is characterized by low grade inflammation responsible for the serious complications and other metabolic disorders in obese. Ayurveda too considers inflammation either as a cause, symptom or complication of degenerative conditions. Obesity has been considered a bad prognostic feature in persons with inflammatory conditions.

IL-6, a pro-inflammatory cytokine, is predominantly secreted by adipose tissue in obesity. [7] Increased fat mass results in hypertrophic adipocytes and infiltration of macrophages within adipose tissue, which in turn secrete IL-6, leading to a state of chronic low-grade systemic inflammation, often referred to as metaflammation.[6]

Elevated IL-6 levels contribute to insulin resistance, atherogenesis, and systemic inflammation, thereby accelerating tissue degeneration and aging processes.[10] From an Ayurvedic perspective, this condition correlates with the pathogenesis of Atisthoulya. The excessive accumulation of Meda due to Medodhatvagnimandya (diminished metabolic activity of adipose tissue) leads to the formation of Abaddha Medas (unprocessed, pathological fat) and Ama, which behaves similarly to inflammatory mediators like IL-6. This Ama circulates within the system, causing Srotorodha (obstruction of channels) and vitiation of Rasa, Rakta, and Meda dhatus. Just as IL-6 induces insulin resistance and systemic inflammation, Ama and Kapha-Meda dushti in Ayurveda result in metabolic derangements, early degenerative changes, and predisposition to disorders such as Prameha and Hridaya roga. Thus, IL-6 can be considered a modern biochemical representation of the inflammatory state described in Ayurveda as Ama-mediated pathology in Atisthoulya.

Ayurvedic Justification for IL-6 Elevation in Atisthoulya

Modern Concept	Ayurvedic Correlation
Chronic low-grade inflammation (IL-6)	Kapha-Meda vriddhi → Ama sanchaya (toxic metabolites) → Dushti of Medovaha srotas → Dhatvagnimandya
Inflammatory adipokines from fat	Abaddha Medas acts as Ama → spreads systemically → vitiates Rasa, Rakta, Meda dhatu
IL-6 promotes catabolism (muscle loss, bone resorption)	Dhatukshaya of Mamsa and Asthi due to excessive Meda, Margavarana of Vata → degeneration
Insulin resistance & metabolic syndrome	Agnimandya → Kapha vriddhi → Medo dhatu dushti → improper nutrient utilization

Meda dhatu vriddhi in Atisthoulya is not only a quantitative increase but a qualitative abnormality (asamyak meda poshana). This leads to Ama formation at dhatu level → systemic inflammation. Ama in Ayurveda behaves similarly to inflammatory mediators like IL-6 – causing Srotorodha (like vascular inflammation), Dhatukshaya of other tissues (muscle, bone degeneration), Vyadhi utpatti (lifestyle disorders – Prameha, Hridaya roga)

IL-6, a biochemical representation of Ama-mediated inflammation in Atisthoulya. Both lead to Vyadhikshamatva kshaya (immune compromise), Agnimandya (impaired metabolism), Early aging & degeneration (Dhatu kshaya → Jara vriddhi)

F.Ayusha-hrasha(decrease life span/aging/degeneration) & IL-6

Aging is characterized by a chronic, low-grade systemic inflammation without overt infection or disease, termed "inflammaging."[9]IL-6 is one of the major pro-inflammatory cytokines elevated in this state. Higher IL-6 levels in midlife predict frailty, disability, and mortality in later years. IL-6 is considered part of the "geroscience hypothesis" linking inflammation to multiple age-related pathologies. Increased IL-6 levels are observed in conditions like osteoarthritis, sarcopenia, neurodegeneration (e.g., Alzheimer's), and cardiovascular diseases.[9] Chronic IL-6 elevation leads to catabolic effects on muscle, bone, and cartilage, accelerating degeneration.

Mechanisms Linking IL-6 to Aging and Degeneration

Cellular Senescence: Senescent cells secrete IL-6 as part of the Senescence-Associated Secretory Phenotype (SASP),Chronic Inflammation: Persistent IL-6 elevation activates JAK/STAT signaling, leading to tissue damage, Oxidative Stress & Mitochondrial Dysfunction: IL-6 exacerbates ROS production, promoting aging, Cartilage & Bone Degeneration: IL-6 stimulates osteoclastogenesis and cartilage matrix degradation, Longitudinal studies (e.g., Framingham Heart Study) show baseline IL-6 predicts functional decline in older adults, Elevated IL-6 is linked to shorter telomeres, indicating accelerated biological aging, High IL-6 levels correlate with cognitive decline and neurodegenerative diseases.

Javoparodha (diminished activity/sluggishness) & IL-6

Normally, during physical activity or muscle contraction, skeletal muscle fibres release IL-6 in significant amounts, functioning as a myokine. This exercise-induced IL-6 has anti-inflammatory and metabolic benefits, such as stimulating glucose uptake and fat oxidation. In individuals with reduced or absent skeletal muscle activity, this exercise-induced surge in IL-6 is absent. Baseline IL-6 might still be elevated due to systemic inflammation (from adipose tissue or chronic disease), but the acute rise post-exercise is blunted, reflecting diminished muscle activity. In active individuals, IL-6 primarily originates from muscle, promoting beneficial effects. In physically inactive or sarcopenic states, most IL-6 comes from adipose tissue and immune cells, indicating a shift toward chronic low-grade inflammation instead of an exercise response.

Kriccha-vyavayata(difficulty in sexual intercourse/ Infertility) & IL-6

Elevated IL-6 levels are strongly associated with infertility due to their role in chronic inflammation and hormonal imbalance. In women, conditions such as PCOS and endometriosis show increased IL-6, which impairs follicular development, oocyte quality, and endometrial receptivity, leading to implantation failure[10]. Similarly, in men, high IL-6 in seminal plasma contributes to oxidative stress, sperm DNA damage, and reduced motility. Obesity further aggravates this by increasing IL-6 secretion from adipose tissue, disturbing the hypothalamic-pituitary-gonadal axis. Overall, persistently high IL-6 reflects an inflammatory and metabolic state that negatively affects reproductive health, making it a potential biomarker for infertility and poor ART outcomes.

CONCLUSION

The present study demonstrated a significant association between BMI and circulating IL-6 levels, with progressively higher IL-6 observed across increasing categories of obesity. This supports the concept of Atisthoulya as a state of systemic dysfunction characterized by low-grade inflammation, validating the Ayurvedic description of Ashta Doshakara Bhavas in relation to modern inflammatory pathology. Elevated IL-6 levels highlight the increased risk of metabolic, cardiovascular, and degenerative disorders among obese individuals. From both Ayurvedic and biomedical perspectives, IL-6 may serve as a crucial biomarker for early detection of pathological changes, thereby offering scope for preventive and integrative management strategies. Bridging Ayurvedic insights with molecular evidence like IL-6 strengthens the understanding of obesity's multidimensional impact and underscores the necessity for holistic therapeutic approaches.

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