Gac Méd Caracas 2025;133(2):429-438
DOI: 10.47307/GMC.2025.133.2.12

Relationship between anthropometric parameters and serum monocyte chemoattractant protein-1 levels in adult subjects

Relación entre los parámetros antropométricos y los niveles séricos de la proteína quimioatrayente de monocito-1 en sujetos adultos

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SUMMARY

Anthropometry is a method used to assess the human body's size, proportion, and composition. Anthropometric values can be used as diagnostic criteria for obesity. Obesity contributes to low-grade systemic inflammation; when macrophages invade adipose tissue, they produce pro-inflammatory cytokines, the source of inflammation in these tissues. Monocyte Chemoattractant Protein-1 is among the chemokines that regulate monocyte migration and invasion. Many cytokines and other factors regulate fibroblasts, astrocytes, monocytes/macrophages, smooth muscle cells, endothelial cells, epithelial cells, and microglial cells. This study examined the relationship between anthropometric factors (weight, height, body mass index, upper arm circumference, waist circumference, and hip circumference) and blood MCP-1 levels in adults. Eighty subjects, including twenty obese women, twenty non-obese women, twenty obese men, and twenty non-obese men, participated in the cross-sectional study design using an observational analytical approach. No significant correlation existed between serum MCP-1 levels, height (r = -0.162 p = 0.150), and weight (r = 0.172 p = 0.128). Meanwhile, there was a significant correlation between serum MCP-1 levels, waist circumference (r = 0.265 p = 0.017), and BMI (r = 0.275 p = 0.014). In addition, there was no correlation between Hip circumference and serum MCP-1 levels (r = 0.185 p = 0.100), nor between serum MCP-1 levels and mid-upper arm circumference (MUAC) in either obese or non-obese adult individuals (r = 0.150 p = 0.183). Our findings indicate that serum MCP-1 levels in adult subjects who are obese and those who are not increase with waist circumference and body mass index (BMI).

Keywords: *Anthropometry, obesity, MCP-1, BMI.*

DOI: https://doi.org/10.47307/GMC.2025.133.2.12

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Recibido: 5 de febrero 2025
Aceptado: 20 de marzo 2025

RESUMEN

La antropometría es un método utilizado para evaluar el tamaño, la proporción y la composición del cuerpo humano. Los valores antropométricos pueden utilizarse como criterios diagnósticos de la obesidad. La obesidad contribuye a la inflamación sistémica de bajo grado; cuando los macrófagos invaden el tejido adiposo, producen citocinas proinflamatorias, que son el origen de la inflamación en estos tejidos. La proteína quimioatrayente de monocitos-1 es una de las quimiocinas esenciales que regula la migración y la invasión de monocitos. Los fibroblastos, astrocitos, monocitos/macrófagos y las células musculares lisas, endoteliales, epiteliales y microgliales están regulados por muchas citocinas y otros factores. Este estudio pretende examinar la relación entre los factores antropométricos (peso, altura, índice de masa corporal, perímetro braquial, cintura y cadera) y los niveles sanguíneos de MCP-1 en individuos adultos. Ochenta sujetos, entre ellos veinte mujeres obesas, veinte mujeres no obesas, veinte hombres obesos y veinte hombres no obesos, participaron en el diseño del estudio transversal utilizando un enfoque analítico observacional. No hubo correlacion significativa entre los niveles séricos de MCP-1, la estatura (r = -0,162 p = 0,150) y el peso (r = 0,172 p = 0,128). Los niveles séricos de MCP-1, el perímetro de la cintura (r = 0,265 p = 0,017) y el IMC (r = 0,275 p = 0,014) mostraron correlacion sugnificativa. No hubo correlacion significativa entre la circunferencia de la cadera y los niveles séricos de MCP-1 (r = 0,185 p = 0,100), tampoco entre los niveles séricos de MCP-1 y la circunferencia media del brazo (MUAC) en adultos obesos ni en adultos no obesos (r = 0,150 p = 0,183). Nuestros resultados indican que los niveles séricos de MCP-1 en sujetos adultos obesos y no obesos aumentan con la circunferencia de la cintura y el índice de masa corporal (IMC).

Palabras clave: *Antropometría, obesidad, MCP-1, IMC.*

INTRODUCTION

The increase in overweight and obesity rates has many consequences for health, quality of life, and the economy. These consequences are felt globally, including in Indonesia (1). Decreased physical activity and a reduced metabolism can cause adults to age more quickly. This can lead to a decline in muscle mass, further slowing metabolism. Aging can slow down energy burning, making it harder to burn off the energy from food. This is due to decreased resting energy expenditure and physical activity (2). Environmental causes of weight gain include unhealthy eating patterns, sedentary lifestyles, socioeconomic circumstances, and genetic abnormalities that alter hormone production and metabolism; all of these contribute to weight gain and obesity, which are growing global health problems (3).

Anthropometric measurements can help estimate body composition and weight gain. Anthropometry is a method of evaluating nutritional status by measuring body size and composition. It can help assess protein and energy deficiency problems and nutritional status related to energy and protein deficiency (4). Anthropometry is a method used to measure the human body's size, proportion, and composition. It measures the body's bone, muscle, and fat to estimate body composition (5). To indicate nutritional status, anthropometry can measure several parameters, including weight, height, circumference of the hips, waist, and upper arms, and fat thickness under the skin (6).

Anthropometric measurements can be used to diagnose obesity, one of the leading causes of cardiovascular disease risk, diabetes mellitus, and other diseases (7). Anthropometry also plays a vital role in monitoring, taking therapeutic interventions, and as a diagnosis (8).

In Indonesia, the prevalence of obesity is still rising every year. In 2013, the prevalence of obesity in the population aged >15 years was 26.6 % and increased to 31.0 % in 2018, while the rate of obesity in adolescents aged 15-24 years in Riau was 12.6 % (9).

Obesity is a condition that occurs when fat cells increase in size (hypertrophy) and number (hyperplasia). This expansion of adipose tissue stores excess energy from an imbalance of calories consumed and expended. Fat cells, or adipocytes, are the main component of adipose tissue, also known as fat tissue, which makes up 2 %-70 % of humans' weight. Adipose tissue is a complex organ that stores energy, regulates metabolism, and produces hormones.

The most common cause of excess body fat is consuming more calories than the body uses, which is called an energy imbalance. Triglycerides are fatty acid esters of glycerol and represent the main lipid component of dietary fat and animal fat depots, which store these surplus nutrients. The adipocytes that house these triglycerides are called fat cells (10).

Adipose tissue is a major endocrine organ that regulates energy and glucose homeostasis. Adipose tissue stores energy and secretes adipokines, which are biologically active substances. Among them are hormones like cytokines like Tumor Necrosis Factor α (TNF-α) and interleukin-6 (IL-6), chemokines like Monocyte Chemoattractant Protein-1 (MCP-1), interleukin-8 (IL-8), and leptin. They play important roles in regulating metabolism, inflammation, immunity, cardiovascular function, insulin sensitivity, lipid metabolism, energy balance, appetite, fat deposition, glucose homeostasis, angiogenesis, and cancer (11).

The adipose tissue accumulation releases significant amounts of pro-inflammatory cytokines and adipokines, resulting in low-grade systemic inflammation. However, the mechanisms behind the development of obesity-related diseases are not fully understood. Macrophages release pro-inflammatory cytokines when they invade adipose tissue, which leads to inflammation. This inflammation contributes to obesity and metabolic diseases. Monocyte chemoattractant protein-1 (MCP-1) is a member of the C-C chemokine family and a potent chemotactic factor for monocytes that contributes to macrophage infiltration into adipose tissue. This process can lead to insulin resistance and obesity. MCP-1 is the primary ligand for the C-C chemokine receptor 2 (CCR2), expressed in macrophages, adipocytes, and skeletal muscle cells (12).

Oxidative stress, hypoxia, adipocyte hypertrophy and hyperplasia, recruitment of macrophages, and increased release of inflammatory cytokines such as MCP-1, Tumour Necrosis Factor α (TNF-α), and Interleukin 6 (IL-6) are all factors associated with obesity and inflammation. Cytokines significantly impact peripheral tissues, vascular endothelial homeostasis, and insulin sensitivity in the liver. Elevated levels of MCP-1, a chemokine involved in inflammation and immune cell recruitment, are linked to vascular dysfunction in both obesity and atherosclerosis (13)..

The evidence indicates that MCP-1 is increased in the adipose tissue of obese people. Compared to lean control patients, obese people have higher levels of MCP-1 gene expression in both their visceral and subcutaneous adipose tissue than lean people. In fact, visceral fat from people with extreme obesity has higher MCP-1 expression than subcutaneous fat (13).

Drawing inflammatory cells from the circulation to adipose tissue reduces adipose inflammation. The expression of MCP-1 in adipocytes is positively correlated with adiposity, which is reflected in elevated levels of MCP-1 in the blood. MCP-1 increased expression in adipose tissue precedes the expression of other macrophage markers during the development of obesity, worsens metabolic characteristics and promotes macrophage recruitment. On the other hand, reducing the expression of MCP-1 or its receptor CCR2 can reduce insulin resistance, hepatic steatosis, and pro-inflammatory macrophages in adipose tissue. Meijer et al., found that MCP-1 produced from adipocytes may promote inflammation in human adipose tissue without the involvement of leukocytes or macrophages (14). However, MCP-1 is produced by various adipose tissue cells, such as adipocytes and macrophages/leukocytes. MCP-1 is implicated both directly and indirectly in the pathophysiology of many illness situations, such as the novel coronavirus, cancer, neuroinflammatory diseases, rheumatoid arthritis, and cardiovascular diseases (15).

Nucleotide-binding oligomerization domain-like receptors (NLRs) and Toll-like receptors (TLRs) are pattern recognition receptors (PRRs) that detect pathogens and damaged cell products. They are part of the innate immune system and play a key role in the body's defense against infection; they are activated when MCP-1 is regulated. MCP-1 (monocyte chemotactic protein-1) can cause endoplasmic reticulum (ER) stress by binding to its receptor, CCR-2 (C-C chemokine receptor 2). This process involves the zinc-finger protein MCPIP (MCP-1-induced protein) (16).

Epithelial cells, endothelial cells, smooth muscle cells, monocytes/macrophages, fibroblasts, astrocytes, and microglial cells are the main sources of MCP-1, which is controlled by several cytokines and other variables. MCP-1 is involved in the pathogenesis and progression of several diseases, including epilepsy, ischemic stroke, and secondary brain injury (14). Numerous studies have demonstrated that MCP-1 can be used to assess the degree of inflammation in various illnesses due to its possible involvement in several pathological situations. With comparable levels of MCP-1 in multiple diseases, it has been proposed as a potential predictive and diagnostic biomarker, highlighting its importance (15).

Ghodoosi et al. assessed the associations between dietary inflammatory potential, body composition, and inflammation in obese Iranian women. Previous studies have shown that different dietary components have varying effects on body composition and inflammation. This cross-sectional study found that subjects with a higher dietary inflammatory index had lower fat-free mass and higher fat mass than others, independent of potential confounders. Furthermore, independent of confounders, the dietary inflammatory index and MCP-1 are related. Their results support the proposition that higher dietary inflammatory diet scores (pro-inflammatory diet) are directly correlated with increased fat mass, decreased fat-free mass, and increased MCP-1 and other inflammatory markers (12).

Given the background this study aimed to asses the relationship between anthropometric parameters and serum MCP-1 levels in healthy adult subjects.

MATERIALS AND METHODS

Research Design and Population

This study combined a cross-sectional study design technique with an observational analytical method. The research participants were all adult subjects who volunteered to be research subjects. 80 obese and non-obese individuals were involved, including 40 females and 40 males. The inclusion criteria were non-obese or obese adult males and females aged 18-40 who volunteered to participate in the research. The exclusion criteria included being pregnant, having diabetes mellitus in the past, having a history of hypertension, having inflammation/ infection diagnosed by a doctor, suffering from malignancy, icteric, lipemic, and hemolyzed serum samples. This study was conducted after ethical clearance with an ethical number from Hasanuddin University State College Hospital's Health Research Ethics Commission (KEPK) 820 / UN 4.6.4.5.31 / PP36 / 2024.

Laboratory Procedures

The study was conducted by recording the identity of the participants. An anthropometric examination was performed (weight, height, body mass index, upper arm circumference, waist circumference, and pelvic circumference measurements). Blood sampling was done in the morning after 8-12 hours of fasting, employing anticoagulant-free tubing. Blood samples in tubes without anticoagulants were centrifuged for 10 to 15 minutes at 3000 rpm to separate serum from blood cell components. The resulting serum was kept at -20°C. The enzyme-linked immunosorbent assay (ELISA) technique was used to conduct the MCP-1 test with the MyBioSource (United States of America) brand insert kit.

Data Analysis

SPSS version 22 was used to analyze the data. Statistical methods were descriptive statistical calculations (range, median, mean, standard deviation, and data distribution) and statistical tests. The distribution of MCP-1 data and anthropometric parameter measurements were assessed using the Kolmogorov-Smirnov normality test. The relationship between anthropometric parameters and serum MCP-1 levels was tested using the Pearson correlation test to see if the data were regularly distributed; if not, the Spearman correlation test was used. Results were considered statistically significant for a p-value <0.05.

RESULTS

A total of 80 subjects comprised 40 males and 40 females, with an age range between 18 and 40 years, with 26.16 years as the average age.

The subjects had an average BMI of 25.5 kg/ m^2, height 160.7 cm, body weight 65.8 kg, waist circumference 81.5 cm, pelvic circumference 93.03 cm, Mid-Upper Arm Circumference (MUAC) 29.5 cm, fasting blood glucose (FBG) 90.01 mg/dL, oral glucose tolerance test (OGTT) 101.2 mg/dL, systolic 112.6 mmHg, diastolic 75.9 mmHg, MCP -1 41.6 pg/mL (Table 1).

Table 1. Characteristics of Subjects

Variables	n (%)	Mean±SD	Median	Min - Max
Age				
Year	80(100)	26.16 ± 6.48	31.0	18 - 56
Gender				
Male	40 (50)			
Female	40 (50)			
BMI (kg/m^2)				
< 18	4 (5)			
18.0 - 24.9	36 (45)	25.5 ± 4.95	24.95	16.8 - 44.9
25.0 - 29.9	27 (34)			
>30	13 (16)			
Height (cm)	80 (100)	160.7± 8.29	160.95	143.5 - 177
Body Weight (kg)	80 (100)	65.8± 14.27	65	42.1 - 125.9
Waist Circumference (cm)	80 (100)	81.5 ± 10.70	82	61 - 118
Pelvic Circumference (cm)	80 (100)	93.03 ± 14.19	94.5	10 - 124
MUAC (cm)	80 (100)	29.5 ± 4.28	30	21 - 48
FBG (mg/dL)	80 (100)	90.01 ± 9.28	89.35	52.5 - 123.5
OGTT (mg/dL)	80 (100)	101.2 ± 28.55	98.8	41.7 - 190.1
Systolic (mmHg)	80 (100)	112.6±11.53	112.5	82 - 138
Diastolic (mmHg)	80 (100)	75.9 ± 8.37	75	54 - 100
MCP-1 (pg/mL)	80 (100)	41.6 ± 16.37	39.9	16.2 - 92.4

Source: Primary Data

Normality Test

Normality test of anthropometric parameters with MCP-1 levels in adults with and without obesity as a whole and based on obesity and non-obesity status whether the distribution of the data is normal or not. The normality test used is the Kolmogorov - Smirnov test to assess the significance of the value $\alpha = 0,05$ (Table 2).

Based on the Kolmogorov - Smirnov test in Table 2, for the parameters of height, weight, Body wight, Intima-media thickness (IMT), waist circumference, and MCP-1, the p-value is 0.200> α (0.05), demonstrating the regularly distributed nature of the data, while the p-value for the pelvic circumference parameter is 0.006 and MUAC 0.029 < α (0.05), showing that the data is not distributed regularly.

Correlation Test

Using the Pearson correlation test, the results show that there is no correlation between MCP -1 and height (p-value of the height variable is 0.150 ($p>0.05$), there is no correlation of MCP-1 with body weight (p-value of the weight variable is 0,128 ($p > 0.05$), there is a correlation with MCP -1 with BMI (p-value of the BMI variable is 0.014 ($p < 0.05$), there is a correlation with MCP-1 with waist circumference (p variable value of waist circumference is 0.017 ($p < 0.05$). The Pearson correlation tests between anthropometric parameters and MCP-1 levels are shown in Table 3.

Previously, the normality test was carried out on the MCP-1 value data with pelvic circumference and MUAC, which shows that it

Table 2. Normality test of anthropometric parameters with MCP-1 levels

Variables	n	p	Description
Height	80	0.200	Normal
Body Weight	80	0.200	Normal
Intima-media thickness (IMT)	80	0.200	Normal
Waist Circumference	80	0.200	Normal
Pelvic Circumference	80	0.006	Not Normal
MUAC	80	0.029	Not Normal
MCP-1	80	0.200	Normal

Source: Primary Data
Description: p = Significance in the Kolmogorov- Smirnov test

is not normally distributed. Thus, the Spearmen correlation test assessed the correlation between pelvic circumference and MUAC parameters on MCP-1 levels. The Spearman correlation test indicated pelvic circumference parameters and MCP -1 levels a p-value = 0.100. For MUAC with MCP-1 levels, the p-value = 0.183> α (0.05). Consequently, there is no significant relationship between the value of MCP-1 levels and anthropometric parameters. Based on the correlation coefficient (r) value of the pelvic circumference variable obtained of 0.185 and the MUAC variable of 0.150, it can be stated that the relationship between anthropometric parameters and MCP-1 levels has a significant relationship with a positive direction. This means that an increase in MCP-1 levels will also increase the value of anthropometric parameters in all adult participants, both fat and non-obese. The findings of the Spearman correlation analysis between MCP-1 levels and anthropometric factors are shown in Table 3.

Table 3. MCP-1 correlation Test with anthropometric parameters in obese and non-obese adult subjects

Variables	r	p
Height	-0.162	0.150 *
Body Weight	0.172	0.128 *
Intima-media thickness (IMT)	0.275	0.014 *
Waist Circumference	0.265	0.017 *
Pelvic Circumference	0.185	0.100 #
MUAC	0.150	0.183 #

Source: Primary Data
Note r = coefficient of correlation, *p = Pearson correlation test, and #p Spearman correlation test.

DISCUSSION

This study assessed the relationship between height, weight, waist circumference, and upper arm circumference (anthropometric measurements, body mass index, and hip circumference) and serum MCP-1 levels in adult subjects from October to December 2024. It involved 80 obese and non-obese adult subjects: 20 obese males, 20 non-obese males, 20 obese females, and 20 non-obese females.

BMI is an indicator of the amount of body fat for most people. It is used as a screening tool to identify whether an adult is at a healthy weight. BMI is a numerical value of weight relative to height. A BMI between 18.5 and 25 kg/m^2 indicates a normal weight. A BMI of under 18.5 kg/m^2 is considered underweight. A BMI between 25 kg/m^2 and 29.9 kg/m^2 is considered overweight. A BMI of 30 kg/m^2 or higher is considered obese.

Obesity is defined by an increase in fat mass caused by increased adipocyte cell size (hypertrophy) and proliferation (hyperplasia). Consuming more nutrients than the body requires is often the cause of excessive body fat buildup. These extra nutrients are stored as triglycerides, which are also referred to as fat. The adipocytes that store these triglycerides are called fat cells. Adipose tissue is mainly made up of fat cells, or adipocytes. Adipose tissue, which makes up 2 %-70 % of the weight of humans, is a big, active endocrine organ that stores energy (10).

Obesity is characterized by persistent low-grade inflammation and elevated blood levels of inflammatory cytokines and other factors. Low-grade inflammation induced by obesity also happens locally, mostly in white adipose tissue, and is typified by an increase in cytokine, chemokine, and adipokine production, as well as immune cell activation and infiltration. Adipocytes generate chemoattractant molecules and inflammatory mediators that can attract and activate T lymphocytes and macrophages. Most cytokines in adipose tissue, especially those that cause the initiation of insulin resistance, such as TNF-α, are produced by macrophages, which are important mediators of low-grade inflammation brought on by obesity (17).

Due to compromised cytokine release, a buildup of macrophages in adipose tissue is a major factor in developing low-grade inflammation in obesity. This inflammation is also known as meta-inflammation. This pro-inflammatory activity, which is partially sourced from adipose tissue, is a common characteristic of many childhood and adult obesity-related comorbidities. MCP-1 is a chemokine that recruits memory T cells and can activate leukocytes, primarily monocytes and macrophages. These cells contribute to the inflammatory process by producing inflammatory cytokines, including superoxide, IL-1, and IL-6 (18).

Increased oxidative stress, hypoxia, adipocyte hypertrophy and hyperplasia, recruitment of macrophages, and increased release of inflammatory cytokines such as MCP-1, TNF-α, and IL-6 are all factors associated with obesity and inflammation. Cytokines significantly impact peripheral tissues, vascular endothelial homeostasis, and insulin sensitivity in the liver. The development of inflammatory reactions and the recruitment of immune cells to inflamed areas depend heavily on MCP-1 and its receptors. Increased MCP-1 levels have been linked to vascular diseases brought on by obesity and atherosclerosis (13).

The present study was integrated by 80 subjects, consisting of 20 obese males, 20 non-obese males, 20 obese females, and 20 non-obese females aged between 18 and 40. The Pearson correlation statistical test showed no correlation between height and MCP-1 concentrations, nor between body weight and MCP-1. On the contrary, a significant correlation existed between BMI and MCP-1 and waist circumference and MCP-1.

In this study, the relationship between the variables of height, weight, and Intima-media thickness (IMT) on serum MCP-1 levels was found to have no significant correlation, which means there is no strong or consistent relationship between the two variables. The reason may be because the subjects who participated were obese and non-obese healthy adult subjects and had average oral glucose tolerance testing and fasting blood glucose levels within normal limits. In contrast, the BMI, waist circumference, and hip circumference variables were strongly associated with serum MCP-1 concentrations. People with higher BMI, especially those in the obese category, tend to have more visceral fat (fat located around the internal organs). Adipose tissue in obese people, particularly those containing much visceral fat, generates pro-inflammatory molecules and adipokines, including leptin and adiponectin cytokines, including MCP-1 (19).

The circulating levels of chemokines have been shown to increase in inflammatory processes, including obesity-related pathologies (e.g., atherosclerosis and diabetes). Kim et al. (20)

investigated the circulating levels of selected chemokines MCP-1, macrophage inflammatory protein-1alpha (MIP-1alpha), leukotactin-1, IL-8) and the association between the chemokine levels and obesity-related parameters: BMI, waist circumference, fasting glucose and insulin levels, lipids profile, and the level of C-reactive protein (CRP). They demonstrated that the circulating levels of MCP-1 and IL-8 are related to obesity-related parameters such as BMI, waist circumference, CRP, IL-6, HOMA, and HDL-cholesterol. While chemokines were not substantially elevated in slightly obese patients with a BMI of 25-29.9 kg/m^2, circulating levels of MCP-1 ($P<0.05$) and IL-8 ($P<0.04$) were considerably higher in obese subjects with a BMI of 30 kg/m^2 than in non-obese subjects (BMI of 25 kg/m^2). This data suggests that the circulating MCP-1 and/or IL-8 may be a potential candidate linking obesity with obesity-related metabolic complications such as atherosclerosis and diabetes.

Kostopoulou et al. (18) showed that MCP-1 gene expression was greater in visceral and subcutaneous adipose tissue amounts in obese individuals than in the non-obese group. MCP-1 and the onset of obesity have been closely associated. When adipocytes in obese individuals are exposed to inflammatory cytokines and fatty acids, they produce MCP-1, intensifying the inflammatory response. Other cells, such as hepatocytes, skeletal muscle cells, monocytes, vascular smooth muscle, and endothelial cells, also synthesize MCP-1. In inflammatory adipose tissue and blood arteries, MCP-1 can initiate the recruitment of monocytes that develop into mature adipose tissue macrophages, hence promoting systemic imflammation and contributing to issues associated with obesity. In the study by Kostopoulou et al., favored a portion of the adult population because it only demosntrated that MCP-1, which is generated by M1 macrophages in the adipose tissue of obese people, positively correlates with inflammatory cytokines such as IL1-1β, IL-6, IL-8, IL-10, IL-12, and TNF-α as well as chemokines (18). Lim et al. (16) stated that pro-inflammatory cytokines increased in obese patients in Singapore hospitals; according to the Spearman correlation test, there was a significant correlation: $r = 0.195$ $p = 0.02$.

Our data show that the Spearman correlation test on anthropometric parameter variables with MCP-1 levels in obese subjects and those who are not showed no correlation between pelvic circumference and MCP-1 levels ($r=0.185$, $p=0.100$) nor between MUAC and MCP-1 concentrations ($r=0.150$, $p=0.183$), demonstrating a lack of association between pelvic circumference and MUAC and MCP-1 levels in adult and obese patients.

Anthropometric measures of hip circumference measure body size in the hip area; hip circumference is more associated with subcutaneous fat. When a person has more subcutaneous fat (more related to fat distribution in the hips) than visceral fat (associated with a higher risk of inflammation), there is not always a significant increase in MCP-1 levels. Subcutaneous fat, which tends to be more abundant in the hip area, plays a different role than visceral fat in influencing inflammation. Subcutaneous fat is generally considered more "inactive" in producing inflammatory cytokines, compared to visceral fat, which is more active in producing pro-inflammatory substances such as MCP-1. Although body fat may play a role in the inflammatory process, MCP-1 levels are also influenced by many other factors, such as genetics, diet, physical activity levels, stress, and other diseases. These factors may influence MCP-1 levels without any direct correlation with hip size. The absence of a strong relationship between serum MCP-1 levels and pelvic circumference suggests that although there is a theoretical relationship between body fat distribution and inflammation, the relationship is not strong enough to show a significant correlation in this study (21).

Upper arm circumference is often used to measure nutritional status and body fat distribution. This measure focuses more on subcutaneous fat in the upper arm and is commonly used in the nutritional assessment of obese individuals. Upper arm circumference is more related to subcutaneous fat. In contrast, systemic inflammation influenced by MCP-1 is mainly triggered by visceral fat (fat accumulated around internal organs such as the liver and pancreas). Visceral fat is metabolically active and produces more inflammatory cytokines, such as MCP-1. The lack of significant correlation between upper arm circumference and serum MCP-1 levels in this study may suggest that although both may be associated with obesity, body fat distribution factors (especially visceral fat) are more relevant in influencing inflammation and MCP-1 levels (22).

One of the strong reasons for not finding a correlation in the anthropometric parameters of hip circumference, MUAC with serum MCP-1 levels is that this study used obese and non-obese adult subjects and had oral glucose tolerance testing and blood glucose levels that were on average within normal limits and also had a history of infection/inflammation in the subject.

One factor of obesity is that it is linked to a worse quality of life and a higher chance of developing several illnesses. MCP-1 is linked to several metabolic indices, including obesity, diabetes, and hypertension, and it plays a role in the pathophysiology of metabolic syndrome (23).

MCP-1 is vital in the inflammatory process, defined by more inflammatory cells or expressed factors. The primary process of inflammatory cells migrating and infiltrating the site of inflammation, including monocytes, macrophages, and other cytokines, results in the development of numerous disorders. MCP-1 has a direct and indirect role in the pathophysiology of several diseases. Numerous studies have demonstrated that MCP-1 can be used to assess the degree of inflammation in various illnesses due to its possible involvement in several pathological situations. Its importance is shown by the fact that it has been proposed as a potential prognostic and diagnostic biomarker with matching levels of MCP-1 in a variety of diseases (15).

This study has limitations, and there are some factors to be considered by future researchers. First, there is a comparatively limited sample size, which could impact the findings. Secondly, the cross-sectional design cannot explain the limitation of the causal relationship between other variables. As a third limitation, it would be better if the sample recruitment time is long enough plus has a funding source, not a private one.

CONCLUSIONS

The study's results indicate that the higher the waist circumference values and body mass index (BMI), the higher the serum MCP-1 levels in obese and non-obese adult subjects.

Funding. None

Conflict of Interest. No conflicts of interest are disclosed by any of the authors of this study.

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