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Original Article

Pathology Section

Relevance of Haematologic Parameters in Obese Women with or without Metabolic Syndrome

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ABSTRACT

Introduction: Obesity is rapidly growing problem worldwide. It predisposes to a variety of serious ailments including heart disease, diabetes mellitus, degenerative joint disease, atherosclerosis, etc. This is probably related to proinflammatory state associated with obesity due to release of several inflammatory mediators by the adipose tissue. The mediators are also probably responsible for metabolic syndrome associated with obesity. Besides, they may also induce significant changes in haematological parameters associated with inflammation.

Aim: Present study was undertaken to ascertain the relationship between obesity and leucocyte counts (particularly TLC and ANC) and find out if the changes induced in them are significant enough to be used as predictors of metabolic syndrome.

Materials and Methods: This case-control study was carried out on 243 female subjects allocated to four groups based on WHO and IDF criteria: Control, Overweight, Obese and Obese with Metabolic Syndrome. From all the subjects, data pertaining to obesity related anthropometric measurements, lipid profile, fasting plasma glucose levels and complete blood counts were collected. These were analysed statistically.

Results: There was a strong positive correlation between obesity related anthropometric measurements (BMI, BF, WC) and leucocyte counts – TLC and ANC – which were statistically highly significant; TNC and ANC also showed strong positive correlation with FPG. Mean values for TLC and ANC showed statistically significant difference between each and every group. The difference in the mean values of these parameters between obese and metabolic syndrome was highly significant. Both elevated FPG and BMI were independently associated with relative leucocytosis; when both of them were elevated simultaneously, the effect appeared to be potentiating.

Conclusion: Increase in obesity associated anthropometric measurements (BMI, WC, BF) is associated with relative leucocytosis within the physiological range. The changes in TLC and ANC are significant enough to be used as predictors of onset of metabolic syndrome in obese subjects.

Keywords: Absolute neutrophil count, Body mass index, Body fat content, Fasting plasma glucose, Obesity, Total leucocyte count, Total neutrophil count, Waist circumference

INTRODUCTION

Worldwide, the problem of obesity is truly daunting. One-third of the world population is either overweight or obese and the number is increasing [1]. Excessive urbanization with its attendant junk food dependence and lack of physical activity have been blamed for the emergence of lifestyle diseases like obesity. Unlike what has been achieved through antibiotics, improved sanitation and timely vaccination with regard to communicable diseases, which at one time accounted for one-third of all deaths [2], no lasting relief is in sight. So far, no country (including all the developed ones) has managed to develop a coherent strategy to keep the obesity in check. In India, there were more than 30 million obese people in 2013 [1]. Obesity on its own is responsible for anywhere from 3 to 4 million deaths worldwide [1].

Obesity may be associated with a variety of metabolic/biochemical derangements including changes in lipid levels, insulin resistance, elevated fasting glucose etc. It is well-known that obesity predisposes to heart disease, cerebrovascular accidents, degenerative joint disease and diabetes mellitus [1]. How obesity predisposes to these serious debilitating disorders is not entirely clear. But several recent studies suggest that inflammation plays an important role in the development of some of these disorders including metabolic syndrome. In obesity, increased release of cytokines – particularly IL-6– from adipocytes has been documented and it may be responsible for a proinflammatory state [3-5]. The latter contention is supported by the occurrence of peripheral blood and tissue leucocytosis, a dominant expression of inflammatory process, in obese subjects as documented in some studies [6,7]. Attempts have been made to use elevated leucocyte count and neutrophil-lymphocyte ratio as predictors of type 2 diabetes mellitus and metabolic syndrome [8,9]. Whether these changes involving leucocytes occur in healthy obese individuals is not clear. So, in the present study we have tried to ascertain the changes in certain haematological parameters, especially Total Leucocyte Count (TLC) and Absolute Neutrophil Count (ANC), in healthy obese women and also to find out if the changes observed in these parameters can be used as a predictors of onset of metabolic syndrome in obese individuals.

MATERIALS AND METHODS

This case-control study was carried out on 243 female subjects aged between 20 and 80 years (average age, 47.10 years) attending the Master Health Check-up clinic and the Outpatient Departments of Chettinad Hospital and Research Institute, Kelambakkam, Chennai. The study was initiated after obtaining clearance from the Institutional Human Ethics Committee and was carried out over a period of four months, from the beginning of March to the end of June, in 2015. The subjects were enrolled, after getting informed consent, under four broad groups.

1. Control,
2. Overweight,
3. Obese,
4. Obese with metabolic syndrome.

Inclusion Criteria

Control group: Clinically healthy adult women with a Body Mass Index (BMI) of less than 24.9 kg/m^2 as per WHO criterion [10]. This group includes "normal" (BMI of less than 22.9 kg/m^2) and "overweight" (BMI ≥23 to ≤24.9 kg/m^2) categories for Asian/Indian population as recommended by WHO [11] and ICMR [12].

Overweight group: Clinically healthy adult women with a BMI ≥25 and ≤29.9 kg/m^{2}as per WHO criteria.

Obese group: Clinically healthy adult women with a BMI ≥ 30 kg/m^2 (WHO).

Obese with metabolic syndrome: Adult women with a BMI ≥30kg/m^2, waist circumference of more than 80 cm and any two of the following findings (International Diabetes federation criteria) [13]:

- HDL<50mg/dl *or* on hypo-lipidaemic treatment.
- Blood pressure ≥130mmHg systolic *Or* ≥85mmHg diastolic *Or* on anti- hypertensives.
- Fasting plasma glucose ≥100mg/dl.

Exclusion Criteria

Presence of nutritional or any other type of anemia, pregnancy, history of lactation, immediate post-operative period, and any other obvious disease like malignancy which influences haematological parameters were used as exclusion criteria for all groups.

Data Collection

Height, weight and BMI of all the study subjects were measured using Tanita automated scale (Tanita India Ltd.). Waist circumference was measured using a measuring tape, at the top of iliac crest; the hip circumference was taken around the widest portion of the buttocks [14]. Waist to hip ratio was calculated by dividing waist circumference by hip circumference. Body fat content was calculated using the following Deurenberg formula [15]:

Body Fat % = (1.20 x BMI) + (0.23 x Age) – (10.8 x Gender) - 5.4;

(Value for the gender: males = 1, females = 0).

Systolic and diastolic blood pressures were recorded using sphygmomanometer.

Blood samples were collected from all the subjects in appropriate vacutainers to carry out the following investigations:

- Overnight fasting samples were used to determine Fasting Plasma Glucose (FPG) and lipid profile including total cholesterol (CHOD-POD method), triglycerides (GPO-POD method), low density lipoprotein (Friedwald formula) and high density lipoprotein (Direct enzymatic colorimetric method) in Siemens autoanalyser (Siemens Diagnostics)
- Samples collected in K_2EDTA vacutainer were utilized for complete blood count (CBC) determination {particularly Total Leucocyte Count (TLC), Absolute Neutrophil Count (ANC), Absolute Lymphocyte Count (ALC), Platelet Count (PLT)} in Coulter LH 780 haematology analyser (Beckman Coulter). Neutrophil-lymphocyte ratio was calculated from absolute values for those two parameters (N/L) [16]. Derived neutrophil-lymphocyte ratio (dNLR) was calculated using the following formula: dNLR=N/ (TLC-N) [17].

STATISTICAL ANALYSIS

All the data were analysed using SPSS (version 21.0) and Graphpad (version 6.0) softwares. Summary statistics were expressed as mean and standard deviation. Relationship between the variables of various groups were analysed with Pearson's correlation test. Partial correlation analysis of predictive function of TLC and ANC, independent of confounders was done. One-way ANOVA, multiple comparison t-test and means t-test were carried out to compare the groups. A p-value <0.05 was considered significant.

RESULTS

Overall, 243 subjects were enrolled in the study; the group-wise distribution of the subjects is given in [Table/Fig-1].

	Group	Criteria (BMI)	No. of Cases
1	Control (WHO)	≤24.9	49
2	Overweight (WHO)	≥25 to ≤29.9	39
3	OBESE (WHO)	≥30	76
4	OBESE with Metabolic Syndrome	≥30	79

[Table/Fig-1]: Group-wise distribution of subjects based on BMI (WHO). BMI=Body Mass Index (kg/m^2); WHO=World Health Organisation.

Of the 49 subjects in the control group, 22 subjects were within "normal" category for Asian/Indian population with a BMI ≤22.9 kg/m^2. The summary statistics are given in [Table/Fig-2].

Mean ages of occurrence of obesity and metabolic syndrome were much higher than the mean age of the control group. As expected, increase in BMI was associated with corresponding increase in waist circumference and body fat content. In one-way ANOVA, *F*-statistic was particularly high for waist circumference, body fat content, TLC and absolute neutrophil count. Overall, there was statistically significant variation between the groups. There was a progressive increase in the values of the following parameters as the BMI increased: Waist Circumference (WC), Fasting Plasma Glucose (FPG), Body Fat % (BF), Total Leucocyte Count (TLC), Absolute Neutrophil Count (ANC) and ratios (N/l & dNLR). Most of these parameters showed positive correlation which was statistically significant (p=<0.05 to <0.0001) [Table/Fig-3]. Among the haematological parameters, TLC and ANC showed the strongest correlations with BMI, WC, BF and FPG.

Mean values of the different variables between various groups were analysed in multiple comparison t-test and statistical significance was determined by Holm-Sidak method. In addition, means of two groups were tested by means t-test.

The mean values for TLC in each group did not exceed accepted physiological range. But there was relative leukocytosis between the categories. Mean values for TLC showed statistically significant differences between control group and other three groups (overweight, obese and obese with metabolic syndrome), with the latter groups recording progressively higher values for TLC. The p-values varied from <0.05 to <0.0001 [Table/Fig-4].

Similar differences were also observed between overweight group and the two obese groups, and between obese group and metabolic syndrome group. The significance persisted after confounding effect of FPG was excluded. The results were similar with absolute neutrophil count. There was statistically significant increase across all the groups [Table/Fig-5]. In addition, differential neutrophil count also showed progressive increase with increase in BMI (55.14%, 56.97%, 60.07% and 60.52% in four groups). The values for ALC, ratios (N/L and dNLR) and platelets showed statistically significant differences between control group and obese group with or without metabolic syndrome [Table/Fig-6]. But the strength of the association appeared to be less than that observed with TLC or ANC. Although the values for ALC showed progressive increase with the increase in BMI, differential lymphocyte count showed progressive decrease (34.18%, 32.14%, 29.64% & 28.95% in four groups) with lower values being recorded in obese subjects with or without metabolic syndrome suggesting that the increase in ALC was being offset by the proportionately greater increase in neutrophils and other cells.

We also statistically analysed the mean values of all the variables for normal group as defined for Asian/Indian population (BMI <22.9 kg/m). The values for WC, BF, TLC, ANC, ALC and platelet count were lower than those for normal (WHO) group, but were not statistically significant. Besides the number of cases was low.

	Control (BMI ≤24.9)	Overweight (BMI ≥25 -≤ 29.9)	Obese (BMI ≥30)	Met. Syndrome (BMI ≥30)	One-way ANOVA Significance	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	F	p-value
Age	42.41±13.22	44.77±10.41	45.95±11.00	52.29±10.30	9.39	<0.0001
BMI	22.15±2.76	27.02±1.44	34.29±3.50	34.77±4.44	175.56	<0.0001
WC	74.82±6.44	83.92±4.79	98.53±9.53	101.7±10.14	124.44	<0.0001
BP (S)	113.3±8.51	113.6±9.86	118.2±10.16	122±15.39	7.35	<0.0001
BP (D)	72.24±7.43	72.82±7.24	74.61±6.62	77.09±10.27	4.35	0.0052
FPG	99.98±19.37	103.3±27.19	122.6±48.87	145.1±43.19	17.12	<0.0001
TGL	99.57±43.61	99.82±27.10	95.95±33.53	118.1±52.52	4.23	0.0061
HDL	46.12±9.85	47.10±14.25	48.80±9.78	40.59±10.15	8.22	<0.0001
LDL	122.8±41.52	117.6±32.13	102.5±33.43	107.7±34.00	4.02	0.008
Chol	189.8±43.25	181.1±33.79	169.3±42.77	173.0±43.79	2.72	0.044
BF%	30.93±5.08	37.32±2.73	46.31±4.60	48.35±5.98	154.17	<0.0001
TLC	6590±1608	7405±1711	8759±1882	10110±1947	43.51	<0.0001
PLT	265.4±50.02	279.7±70.34	307.8±87.01	320.1±66.73	7.23	<0.0002
ANC	3706±1315	4268±1269	5310±1471	6148±1499	35.11	<0.0001
ALC	2203±527	2340±583	2554±613	2916±786	14.07	<0.0001
N/L	1.74±0.65	1.89±0.64	2.17±0.72	2.22±0.66	6.7	<0.0003
dNLR	1.29±0.42	1.38±0.41	1.58±0.44	1.60±0.42	7.08	0.0001

[Table/Fig-2]: Mean and SD values of all the variables in various groups with one-way ANOVA.
BMI =body mass index (kg/m^2); WC=waist circumference (cm); BP (S) =blood pressure systolic; BP (D) = blood pressure diastolic; FPG=fasting plasma glucose (mg/dL); TGL=triglycerides (mg/dL); HDL=high density lipoprotein (mg/dL); LDL=low density lipoprotein (mg/dL); Chol=cholesterol (mg/dL); BF%=body fat%; TLC=total leucocyte count (/mm^3); PLT=platelet count(x10^9/L); ANC= absolute neutrophil count (/mm^3); ALC=absolute lymphocyte count(/mm^3); N/L=Absolute neutrophil-lymphocyte ratio; dNLR=derived neutrophil-lymphocyte ratio;

		AGE	BMI	BF	WC	FPG	TLC	ANC	ALC	N/L	dNLR	PLT
AGE	r	1	0.222	0.514	0.349	0.301	0.206	0.195	0.135	0.087	0.098	-0.032
	p	------	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.005**	**<0.005**	**<0.05**	0.178	0.129	0.623
BMI	r	0.222	1	0.950	0.877	0.331	0.604	0.551	0.434	0.222	0.231	0.286
	p	**<0.001**	------	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
BF	r	0.514	0.950	1	0.883	0.387	0.597	0.547	0.425	0.223	0.235	0.241
	p	**<0.001**	**<0.001**	------	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
WC	r	0.349	0.877	0.883	1	0.447	0.571	0.524	0.417	0.196	0.224	0.233
	p	**<0.001**	**<0.001**	**<0.001**	------	**0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.005**	**<0.001**	**<0.001**
FPG	r	0.301	0.331	0.387	0.447	1	0.333	0.322	0.199	0.162	0.168	0.035
	p	**<0.001**	**<0.001**	**<0.001**	**<0.001**	-------	**<0.001**	**<0.001**	**<0.005**	**<0.02**	**<0.01**	0.588
TLC	r	0.206	0.604	0.597	0.571	0.333	1	0.949	0.664	0.420	0.450	0.474
	p	**<0.005**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	------	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
ANC	r	0.195	0.551	0.547	0.524	0.322	0.949	1	0.418	0.661	0.698	0.449
	p	**<0.005**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	------	**<0.001**	**<0.001**	**<0.001**	**<0.001**
ALC	r	0.135	0.434	0.425	0.417	0.199	0.664	0.418	1	-0.357	-0.276	0.306
	p	**<0.05**	**<0.001**	**<0.001**	**<0.001**	**<0.005**	**<0.001**	**<0.001**	------	**<0.001**	**<0.001**	**<0.001**
N/L	r	0.087	0.222	0.223	0.196	0.162	0.420	0.661	-0.357	1	0.961	0.191
	p	0.178	**<0.001**	**<0.001**	**<0.005**	<0.02	**<0.001**	**<0.001**	**<0.001**	------	**<0.001**	**<0.005**
dNLR	r	0.098	0.231	0.235	0.224	0.168	0.450	0.698	-0.276	0.961	1	0.207
	p	0.129	**<0.001**	**<0.001**	**<0.001**	**<0.01**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	------	**0.001**
PLT	r	0.032	0.286	0.241	0.233	0.035	0.474	0.449	0.306	0.191	0.207	1
	p	0.623	**<0.001**	**<0.001**	**<0.001**	0.588	**<0.001**	**<0.001**	**<0.001**	**<0.005**	**0.001**	------

[Table/Fig-3]: Pearson's correlation matrix for selected variables with significance.
Legend: BMI=body mass index; BF=body fat; WC=waist circumference; FPG=fasting blood glucose; TLC=total leucocyte count; ANC= absolute neutrophil count; ALC=absolute lymphocyte count; N/L=neutrophil-lymphocyte ratio; dNLR=derived neutrophil-lymphocyte ratio;PLT=platelet count; *r*=Correlation coefficient; *p=p-value*. Statistically significant values are depicted in bold characters.

DISCUSSION

Obesity is a rapidly growing problem worldwide. Since 1980, the number of obese people has doubled. In 2014, well over 600 million people aged over 18 years were obese and 42 million children were obese or overweight [1,10]. Although it is still a problem of prosperous countries, it is rapidly rising in the urban areas of developing countries [10]. The principal causes of obesity are excessive dependence on high-calorie take aways and sedentary life style, both being occasioned by excessive urbanization.

Obesity classification is based on BMI. A raised BMI is a major risk factor for cardiovascular diseases, diabetes mellitus, musculoskeletal disorders and some types of neoplastic diseases [10,18,19]. Many studies have tried to throw light on the contributory role played by obesity in causing these disorders. The

Groups	Statistical Values		Normal	Overweight	Obese	Metabolic syndrome
Normal BMI<25	Mean	6590	-------	p= 0.0241 +	p <0.0001 ++++	p <0.0001 ++++
	SD (n-1)	±1608				
	SEM	229.7				
Overweight BMI 25 to <30	Mean	7405	p= 0.0241 +	-------	p=0.0003 +++	p< 0.0001 ++++
	SD (n-1)	±1711				
	SEM	274				
Obese BMI> 30	Mean	8759.21	p <0.0001 ++++	p=0.0003 +++	-------	p< 0.0001 ++++
	SD (n-1)	±1881.78				
	SEM	215.86				
Metabolic Syndrome	Mean	10110.13	p< 0.0001 ++++	p< 0.0001 ++++	p< 0.0001 ++++	-------
	SD (n-1)	±1946.63				
	SEM	219.01				

[Table/Fig-4]: Comparison of Mean values and SD of TLC in different Group with statistical significance.
+=p<0.05; ++=p<0.01; +++=p=<0.001; ++++=p=<0.0001; SD=standard deviation; SEM=standard error of the mean

Group BMI	Statistical Values		Normal	Overweight	Obese	Metabolic syndrome
Normal BMI<25	Mean	3706.16	-------	p=0.046 +	p<0.0001 ++++	p<0.0001 ++++
	SD (n-1)	±1314.86				
	SEM	187.84				
Overweight BMI 25 to <30	Mean	4267.56	p=0.046 +	-------	p=0.0002 +++	p<0.0001 ++++
	SD (n-1)	±1269.46				
	SEM	203.28				
Obese BMI≥ 30	Mean	5310.30	p<0.0001 ++++	p=0.0002 +++	-------	0.0006 +++
	SD (n-1)	±1470.69				
	SEM	168.70				
Metabolic syndrome	Mean	6148.39	p<0.0001 ++++	p<0.0001 ++++	0.0006 +++	-------
	SD (n-1)	±1499.50				
	SEM	168.71				

[Table/Fig-5]: Comparison of Mean and SD of ANC in different groups with statistical significance.
+=p<0.05; ++=p<0.01; +++=p=<0.001; ++++=p=<0.0001; SD=standard deviation; SEM=standard error of the mean

adipocytes have been shown to be the sources of several bioactive adipocytokines including Tumour Necrosis Factor-α, Interleukin-1, Interleukin-6, Leptin, Adiponectin and [20,21] Resistin [22]. Interleukin-6, in particular, has been claimed in several studies to be elevated in obesity [3,4]. As many of these factors are powerful mediators of inflammation, a proinflammatory state apparently exists in obese subjects. Peripheral blood leucocytosis and tissue leucocytosis, which are hallmarks of inflammatory process, have been demonstrated in obese patients [6,7]. Studies have shown that inflammation or its haematological manifestation- the elevated leucocyte count- is involved in the development of diabetes and atherosclerosis [19,23]. Consistent association between elevated white cell count and development of type 2 diabetes mellitus has been recorded [9,24]. Although the nature of this association is not yet completely clear, there is growing evidence that elevated leucocytes or active inflammation promote insulin resistance, thus paving the way for development of type 2 diabetes [21,25]. Correlation has also been demonstrated between high leukocyte count and hyperglycemic emergencies [26]. Elevated white cell count is also an important risk factor for coronary heart disease and all-cause mortality [27]. Besides, TLC and neutrophil-lymphocyte ratio have been used as risk predictors in metabolic syndrome [8,28].

The present study was undertaken to find out whether overweight, obesity and metabolic syndrome had an effect on certain haematologic parameters – especially TLC and ANC – and if the changes observed in latter are significant enough to be used as inexpensive markers for metabolic syndrome. In the study, we found that there was a very good positive correlation between obesity related anthropometric parameters like BMI, waist circumference, body fat content and certain haematologic parameters [Table/Fig-3]. The strongest correlations were observed with TLC (r=0.571 to 0.604; p<0.001) and ANC (r=0.524 to 0.551; p<0.001) which are statistically highly significant. Both these parameters (TLC and ANC) also showed strong positive correlation with FPG (r=0.333 and 0.322; p<0.001). Much weaker positive correlations were observed with other haematological parameters, i.e. ALC, platelet count and ratios.

When values for different variables were compared among four groups using multiple comparison t-test and means t-test, the values for TLC and ANC once again showed significant differences between each of the four groups [Table/Fig-4,5]. There was step-wise increase from group 1 (control) to group 4 (metabolic syndrome). These differences were statistically significant (p<0.05 to 0.0001). It appears that the baseline values for TLC and ANC are much higher in healthy overweight and obese women compared to control subjects. This is in agreement with the observation that there is a proinflammatory status in obese individuals as suggested by the presence elevated levels of inflammatory cytokines. However, these increases in TNC and ANC did not exceed the physiological range, much like what has been documented by others [29]. There was statistically highly significant difference (p<0.0001 & 0.0006) in the values of these two parameters between obese subjects (group 3) and subjects with metabolic syndrome (group 4). This suggests that any unexplained increase over the baseline value of these two parameters in obese subjects is likely to be indicative of onset of metabolic syndrome.

Although Buyukkaya et al., have claimed neutrophil-lymphocyte ratio as a useful marker for metabolic syndrome [28], in our study, the ratios (N/L and dNLR) were not significantly different between obesity and metabolic syndrome. However, they were significantly elevated in obese subjects when compared to controls. One other

	Groups	Normal	Overweight	Obese	Met. Syndrome
ALC	Normal	--------	p=0.254 (NS)	p<0.0005 (+++)	p<0.0001 (++++)
	Overweight	p=0.254 (NS)	--------	p=0.072 (NS)	p<0.0001 (++++)
	Obese	p<0.0005 (+++)	p=0.072 (NS)	--------	p=0.002 (++)
	Met. Syndrome	p<0.0001 (++++)	p<0.0001 (++++)	p=0.002 (++)	--------
dNLR	Normal	--------	p=0.313 (NS)	p<0.0005 (+++)	p<0.0002 (+++)
	Overweight	p=0.313 (NS)	--------	p=0.02 (+)	p<0.01 (++)
	Obese	p<0.0005 (+++)	p=0.02 (+)	--------	p=747 (NS)
	Met. Syndrome	p<0.0002 (+++)	p<0.01 (++)	p=747 (NS)	--------
N/L	Normal	--------	p=0.280 (NS)	p=0.0006 (+++)	p=0.0001(+++)
	Overweight	p=0.280 (NS)	--------	p=0.032 (+)	p=0.01 (+)
	Obese	p=0.0006 (+++)	p=0.032 (+)	--------	p=700 (NS)
	Met. Syndrome	p=0.0001(+++)	p=0.01 (+)	p=700 (NS)	--------
Platelet Count	Normal	--------	p=0.246 (NS)	p=0.002 (++)	p<0.0001 (++++)
	Overweight	p=0.246 (NS)	--------	p=0.0871 (NS)	p=0.003 (++)
	Obese	p=0.002 (++)	p=0.0871 (NS)	--------	p=0.3226 (NS)
	Met. Syndrome	p<0.0001 (++++)	p=0.003 (++)	p=0.3226 (NS)	--------

[Table/Fig-6]: Summary of the t-test results for ALC, dNLR, N/L and Platelet Count.
$^{+}$=p<0.05; $^{++}$=p<0.01; $^{+++}$=p=<0.001; $^{++++}$=p=<0.0001; NS=not significant; ALC= absolute lymphocyte count; dNLR=derived neutrophil-lymphocyte ratio; N/L=neutrophil-lymphocyte

	TLC (Mean +SD) (/mm^3)	ANC (Mean +SD) (/mm^3)
FPG <100; BMI < 24.9	6383±1727.7	3508.6±1365
FPG >100; BMI < 24.9	6915.8±1379	4018±1199.6
FPG <100; BMI > 24.9	7221±1716.7	4107±1252.9
FPG <100; BMI >25 &<29.9	7405±1711	4267.56±1269.46

[Table/Fig-7]: Effect of FPG and BMI on TLC and ANC.
ANC= absolute neutrophil count; BMI= body mass index; FPG=fasting plasma glucose; TLC=total leucocyte count; SD=standard deviation.

parameter that showed a significant increase in obese subjects with or without metabolic syndrome was platelets [Table/Fig-6]. This is in conformity with earlier observation by Dorit Samocha-Bonet et al., [30]. We also wanted to find out if elevated FPG in the absence of elevated BMI influenced leucocyte counts. As is evident from [Table/Fig-7], elevated levels of both FPG and BMI induced leucocytosis independently of each other. However, the effect was less marked with FPG than BMI; when both BMI and FPG were elevated, there was an enhanced effect leading to slightly higher TLC and ANC than what was observed when only one of them was elevated.

CONCLUSION

The present study was carried out to evaluate the relationship between obesity and certain haematologic parameters like TLC and ANC. We found that both TLC and ANC showed a strong, direct, positive correlation not only with obesity related anthropometric measurements (BMI, BF and WC) but also independently with FPG. In addition, significantly higher mean values were recorded for these two parameters (TLC and ANC) in patients with metabolic syndrome when compared with obese subjects without metabolic syndrome suggesting the possibility that any unexplained increase in the values of these two parameters in obese subjects is likely to be an indicator of the onset of metabolic syndrome. The question "whether relative leukocytosis and neutrophilia can be used as predictors of metabolic syndrome in obese individuals" can only be answered satisfactorily after further study with a larger sample size.

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