Association of Body Mass Index (BMI) on Complete Blood Count (CBC) Parameters Among 2 to 15-year-old Obese and Non-Obese Children

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Abstract: - Obesity is a chronic health problem that can initiate at a young age and is proven challenging by the risk factors' complexity. Overall, it is considered as one of the major global concerns as the prevalence of obesity increases in a worldwide aspect. However, in the Philippine setting, there was a lack of obesity-related studies involving pediatric patients, as research investigations mostly involved adults. Hence, this study is aimed to provide more information concerning obesity among children using Body Mass Index (BMI) as a tool for further analysis, and also establish better understanding on how the BMI of obese and non-obese children, aged 2-15 years old, were associated with the various Complete Blood Count (CBC) parameters. With a total of 360 respondents, the research employed a quantitative research method with a descriptive, correlational design where secondary data retrieval was done in a local pediatric hospital in Ormoc City, Leyte. The main findings from various statistical tools analyzed in R ver. 4.0.3 are as follows: (1) The age and sex are not significantly associated to the BMI of the obese and non-obese children; (2) Generally, only RBC count, MID, and hematocrit are significantly associated with the obesity of children being higher by $0.20x10^{12}$/L, $0.31x10^{9}$/L and 1.67%, respectively; and (3) The results for the three groups of non-obese children showed that the hemoglobin is lower, while the hematocrit is higher in underweight as compared to those classified as normal and overweight. In conclusion, there is a significant association of BMI on CBC parameters among obese and non-obese children, thus body coposition must be considered alongside with the child's hematologic parameters assessment to establish appropriate preventive measures and mitigation on health protocols of children, which may prevent further complications in adulthood.

Key Words*: — Obesity, Body Mass Index (BMI), Complete Blood Count (CBC) parameters*

I. INTRODUCTION

Throughout history, obesity, in general, had been a very intriguing issue in the medical field, which made it one of the most pressing problems for policymakers worldwide in the first quarter of the 21st century. With the rapid increase of technology that focuses on customers' convenience and instant gratification, people often question the right path for a secured and healthy life.

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At the start of the 21st century, 28.8% of children and adolescents from the ages 2 to 19 in the United States of America were obese [1]. Just 16 years later, 28.8% grew to 35.1%, with an average increase in the prevalence of 2.7% every 2 years. This percentage was separated from the total prevalence of obesity today, which was already 42.4% [2]. More than just numbers, there is a proportionality of the frequency of metabolic syndromes to the prevalence of obesity, along with cardiovascular diseases being the most threatening effects of obesity and top cause of deaths in 2019, which further heightens the significance of preventing chronic obesity among children [2][3][4].

Obesity may be due to different factors such as dietary lifestyles, routines and habits, and various life choices, which made obesity such a pressing issue, especially for young children who were already building the habit of poor choices and increased risk for diseases that may affect them as they grow much older [5][6]. Certain health measures were proposed throughout the years on how one could decrease obesity across different ages and encourage people, especially parents, to consider obesity seriously [7][8]. At the same time, health practitioners had been raising their efforts to promote a healthy lifestyle and good diet even to pediatrics patients. Unfortunately, the public health fight against obesity has been inefficient due to corporate forces heavily attached to people's lifestyles [9].

Therefore, the study focused on the association of the Body Mass Index (BMI) on the complete blood count (CBC) parameters among the obese and non-obese populations of these children aged 2 to 15 years old. The researchers' goal was to be able to continue further academic pursuits in the study of metabolic effects from obesity and to promote proper public health solutions that focus on children, and decrease the percentage of prevalence that continuously increases every year. Lastly, this research aimed to give hope that it is possible to combat obesity.

II. METHODOLOGY

A quantitative research with a descriptive correlational design was employed in the gathering of secondary data. The research was conducted in the local pediatric hospital in Ormoc City, Leyte, Philippines. A purposive and convenience sampling were used for the selection of the participants, taking the inclusion and exclusion criteria as a consideration.

The inclusion criteria were as follows:

- Healthy children from the local pediatric hospital in Ormoc City, with complete anthropometric measures and hematologic analysis reports;
- Age of children which are non-stratified, ranging from two (2) to fifteen (15) years old;
- BMI of the respondents used as the sole health indicator of childhood weight status, classifying obese from non-obese respondents;
- CBC parameters of the respondents, namely RBC count, WBC count, hemoglobin, hematocrit, RBC indices (MCV, MCH, MCHC), RDW and differential WBC count (LYM, GRAN, MID) were used to associate with the BMI of the children.

Meanwhile, the exclusion criteria were as follows:

- Conditions such as folate or iron or vitamin B12 deficiency.
- Genetic diseases (e.g. beta-thalassemia, hemophilia, sickle cell anemia).
- Those with hemorrhage and concomitant acute infections.
- Chronic diseases (e.g. diabetes mellitus, asthma, congenital heart disease, cystic fibrosis, etc.).
- Those under specific regimen or medications.

The sample size was calculated based on the study's objectives and other research journals. To detect a difference of 0.10 in the true value of the correlation coefficient, at a 5% level of significance, at least 360 samples were used to achieve at least 80% of the test's power. This result was based on Pinhas-Hamiel (2003) result that BMI and iron levels correlate [10].

Upon the submission and approval of the communication letter directed to the laboratory manager, attending physician, and medical director of the local pediatric hospital in Ormoc City, Leyte, the data gathering and retrieval was done from patients' health records and hematology report analysis. The encoder who is a registered medical technologist tabulated and processed the gathered secondary data through Microsoft Excel/Spreadsheet, using the dummy table sent by the researchers through email. Also, the researchers ensured confidentiality and anonymity of the respondents wherein there was no retrieval or collection of patient names and other individually identifying information by the researchers.

The laboratory manager, attending physician, and medical director were all informed through a letter, regarding the purpose of the study and the confidentiality agreement. In addition, the researchers ensured that all necessary information was completely revealed and that all signatories were mentally competent to comprehend the communication letter provided. Furthermore, the laboratory manager, attending physician, and medical director were briefed regarding the study's potential benefits and risks. They were also given the option to withdraw at any time without jeopardizing their involvement in future services or relationships with any of the researchers/research

bodies involved. Upon agreement with the terms and conditions, an approval letter was signed by the signatories. Any communication regarding the research was conducted with utmost honesty and in a transparent manner, without any misleading information and an unbiased representation of the primary data findings. The researchers also ensured that the results of the study were given to the local pediatric hospital in Ormoc City, Leyte before the final paper was passed.

After obtaining the data from the respondents, the researchers proceeded to data analysis. The data was organized by the statistician through the statistical software, The Comprehensive R Archive Network, ver 4.0.3, where Student's t-test, Fisher's exact test, simple linear regression, one way analysis of variance (ANOVA), and Tukey's HSD for post hoc analysis were used as statistical tools/measures.

III. RESULTS AND DISCUSSION

Detailed analysis and interpretation of statistical findings on the association of BMI and CBC parameters among 2 to 15-year old obese and non-obese chldren was provided. Mean and standard deviation (SD) were used to summarize the gathered CBC parameters of obese and non-obese respondents. Meanwhile, counts and percentage summarized the age. In the physical characteristics of the respondents, Student's t-test was used in the comparison of the age of obese and non-obese children while Fisher's exact test was used in the association of sex with BMI.

Furthermore, simple linear regression was performed to determine if there is an association between BMI and the different CBC parameters. On the other hand, one way analysis of variance (ANOVA) was used to compare the age and CBC parameters of the non-obese children, with Tukey's HSD for post hoc analysis. Fisher's exact test was also used in the association of sex with obesity for non-obese groups. *P*-values less than 0.05 indicate that the CBC is associated with the BMI of children. All the statistical tests were performed in R ver 4.0.3.

A. Physical Characteristics of the Respondents

Table 1. Demographic Characteristics of the Respondents

		BMI Classification	

	All	**Non-obese**	**Obese**	***p*-value**
Number of Respondents	360	321	39	-
BMI (kg/m^2)	16.2 ± 3.2	15.4 ± 2.0	22.5 ± 4.0	-
Age (years)	5.3 ± 3.3	5.4 ± 3.3	4.6 ± 2.7	0.128
Sex: Male	200 (55.6%)	176 (54.8%)	24 (61.5%)	0.496
Female	160 (44.45)	145 (45.2%)	15 (38.5%)	

Values displayed are expressed as mean ± SD or counts (%).
P-values are based on Student's t-test and Fisher's exact test.

A total of 360 respondents were selected in the study, with mean age of 5.3 years (range, 2 to 15), composed of 200 (55.6%) males and 160 (44.5%) females. Their mean BMI is 16.2 kg/m^2 (range, 10.0 to 33.1). The mean age of obese and non-obese children did not differ (p=0.128) and their sex is not associated (p=0.496) with BMI classification as being obese or not.

Table.2. CBC Parameters of Respondents

	BMI Classification			**β Coefficient**
	Non-obese	**Obese**	***p*-value**	**(95% CI)**
WBC	10.73 ± 4.40	11.58 ± 4.99	0.264	0.85 (-0.64 to 2.34)
LYM	3.86 ± 2.16	4.34 ± 2.8	0.208	0.48 (-0.27 to 1.22)
GRAN	5.84 ± 4.11	5.90 ± 4.96	0.941	0.05 (-1.35 to 1.46)
MID	1.04 ± 0.86	1.34 ± 1.01	0.038	0.31 (0.02 to 0.61)
RBC	4.67 ± 0.49	4.87 ± 0.48	0.017	0.20 (0.04 to 0.36)
HGB	12.47 ± 1.41	12.88 ± 1.09	0.075	0.42 (-0.04 to 0.88)
HCT	38.04 ± 4.59	39.71 ± 2.96	0.027	1.67 (0.19 to 3.15)
MCV	81.85 ± 4.00	81.83 ± 4.84	0.981	-0.02 (-1.38 to 1.35)
MCH	26.74 ± 1.99	26.57 ± 2.25	0.625	-0.17 (-0.84 to 0.51)
MCHC	327.12 ± 18.12	324.31 ± 16.04	0.355	-2.81 (-8.79 to 3.16)
RDW	12.95 ± 0.73	13.11 ± 0.90	0.217	0.16 (-0.09 to 0.41)

Values displayed are expressed as mean ± SD.
P-values are based on Simple linear regression

As seen in Table 2, only MID (p=0.038), RBC (p=0.017) and HCT (p=0.027) are associated with obesity. It shows that, at an average, obese children have MID that is higher by $0.31x10^9$/L (95% CI: 0.02 to 0.61) as compared to non-obese children. Additionally, at an average, obese children have RBC count that is higher by $0.20x10^{12}$/L (95% CI: 0.02 to 0.61) as compared to non-obese children. Likewise, at an average, obese children have HCT that is higher by 1.67% (95% CI: 0.19 to 3.15) as compared to non-obese children.

It was not evident that WBC (p=0.264), LYM (p=0.208), GRAN (p=0.941), HGB (p=0.075), MCV (p=0.981), MCH (p=0.625), MCHC (p=0.355), and RDW (p=0.217) are associated with obesity.

A study conducted by [11] established that the RBC count of obese patients, ages 33 to 76 years old, with coronary heart disease (CHD) is higher than those in non-obese groups (p<0.01). Hence, this serves as one of the indicators or risk factors for obese patients. However, there were no studies with children as their respondents regarding an increase in RBC count for obese groups compared to non-obese. Meanwhile, a study established that BMI is positively correlated with HCT, as well as other clinical chemistry tests (e.g. insulin, FBC, TG, VLDL-C, LDL-C, uric acid, and ALT) [12]. However, no further studies have shown the association of MID with BMI in obese groups, Moreover, various studies have shown that there is no significant difference or positive correlation with hemoglobin, MCV, MCH, MCHC, [13][14][15].

On the contrary, the result of other CBC parameters' association with BMI differs from similar studies elsewhere. For instance, a different study concluded that an increase in platelet count is associated with obese groups [16]. Furthermore, the study of [15], shows a significant positive association between BMI and CBC parameters: RDW, WBC Count, LYM, GRAN and platelet count (p<0.05). Similarly, a study by proved a direct correlation with LYM and platelet count being significantly increased in obese children [17].

B. Physical Characteristics of Non-obese Respondents

Table.3. Demographic Characteristics of the Non-Obese Respondents

	BMI Classification			
	Underweight	**Normal**	**Overweight**	***p*-value**
Number of Respondents	76	219	26	-
BMI (kg/m^2)	13.18 ± 1.14	15.79 ± 1.42	18.46 ± 1.25	-
Age (years)	5.14 ± 3.38	5.48 ± 3.35	5.58 ± 2.97	0.725
Sex: Male	46 (60.5%)	117 (53.4%)	13 (50%)	0.500
Female	30 (39.5%)	102 (46.6%)	13 (50%)	

Values displayed are expressed as mean ± SD or counts (%).
P-values are based on Student's t-test and Fisher's exact test.

In Table 3, it shows that the mean age of the three groups of non-obese children (underweight, normal, and overweight) did not differ (p=0.725). Additionally, sex is not associated (p=0.500) with the non-obese BMI classification.

Table.4. CBC Parameters of Respondents

	BMI Classification				**Post**
	Underweight	**Normal**	**Overweight**	***p*-value**	**hoc**
WBC	10.85 ± 4.56	10.71 ± 4.41	10.53 ± 3.98	0.945	-
LYM	3.85 ± 2.34	3.92 ± 2.12	3.38 ± 1.89	0.479	-
GRAN	6.06 ± 4.46	5.72 ± 3.97	6.19 ± 4.26	0.748	-
MID	0.94 ± 0.61	1.08 ± 0.94	0.96 ± 0.69	0.458	-
RBC	4.57 ± 0.54	4.70 ± 0.48	4.78 ± 0.35	0.067	-
HGB	12.13 ± 1.45	12.54 ± 1.40	12.83 ± 1.22	0.038	U < (N = O)
HCT	36.76 ± 5.63	38.30 ± 4.22	39.54 ± 3.29	0.009	(N = O) < U
MCV	81.87 ± 4.86	81.74 ± 3.75	82.69 ± 3.32	0.516	-
MCH	26.66 ± 2.17	26.74 ± 1.90	26.87 ± 2.22	0.896	-
MCHC	325.99 ± 15.16	327.79 ± 18.68	324.81 ± 21.40	0.602	-
RDW	12.92 ± 0.74	12.97 ± 0.71	12.93 ± 0.91	0.882	-

Values displayed are expressed as mean ± SD.
P-values are based on ANOVA

As seen in Table 4, only the mean HGB (p=0.038) and HCT (p=0.009) are evidently different with the three groups of non-obese children. Post hoc analysis showed that the mean HGB of underweight children is less as compared to those with normal BMI (p=0.031)) and overweight (p=0.038) children. The mean HGB of children with normal BMI and overweight did not differ (p=0.316). As for the HCT, it is evident that the

mean HCT of underweight children is higher as compared to those with normal BMI (p=0.030) and overweight (p=0.020) children. The mean HCT of children with normal BMI and overweight did not differ (p=0.384).

It was not evident that WBC (p=0.945), LYM (p=0.479), GRAN (p=0.748), MID (p=0.458), RBC (p=0.067), MCV (p=0.516), MCH (p=0.896), MCHC (p=0.602), and RDW (p=0.882) differ with the three groups of non-obese children.

A study conducted by [18] established that underweight children tend to have less mean hemoglobin count, including serum ferritin, as compared to other groups. It was also indicated in a similar study that those who were classified as underweight (125.0 g/L) were more likely to have lesser concentrations of hemoglobin compared to those who were overweight (128.4 g/L) [19]. This is also supported by a study which reported that being underweight has increased prevalence for iron deficiency brought by low hemoglobin levels, accompanied by low concentration of serum ferritin and high concentration of serum transferrin receptor (sTfR) [20].

In contrast to HCT findings, other similar studies have shown varied results for HCT as it is usually presented in low concentrations together with HGB, as indicators for the monitoring and evaluation of anemia. A study established being underweight as one of the major predictors for severe anemia, characterized by low HGB and HCT, commonly in pre-school children [21]. In addition to this, a study reported the correlation of whole blood viscosity with obesity as increased levels of hematocrit is associated with abdominal fat percentage [22].

Meanwhile, a study of [23] stated that there is no significant association of HGB, MCH, MCV, and MCHC among the non-obese classification of BMI (p>0.05). On the contrary, the result of other CBC parameters' association with BMI of non-obese groups differs from similar studies elsewhere. Similarly, the study indicated that there is a significant difference between RDW and non-obese classification of BMI (p<0.02) [23]. Based on other studies results, the mean WBC count, RBC count, HCT and platelet count is significantly increased in those with higher BMI (p<0.05) [24]. Likewise, a study also indicated a strong positive association of HGB (p<0.001) with the dietary intake of children [25]. However, no further studies have shown the association of LYM, GRAN, MID with BMI in the three groups of non-obese children.

IV. CONCLUSION

Based on the statistical analysis of the secondary data, the age and sex are not significantly associated to the BMI of the obese and non-obese children. Furthermore, RBC count, MID and hematocrit are significantly associated with obesity, being higher by $0.20x10^{12}$/L, $0.31x10^{9}$/L and 1.67%, respectively. For more in depth analysis of the three groups of non-obese children, findings suggested that the hemoglobin of underweight children is significantly less compared to other groups, and the hematocrit of underweight children is significantly higher compared to the other non-obese groups. Other CBC parameters not mentioned are not significantly associated with obesity in children.

The findings of this study is significant as it gives a better understanding of the association of BMI on CBC parameters of children as the prevalence of obesity continues to be a growing health concern in the Philippines. Due to the insufficiency of studies involving children, this research serves as a pilot study which gives emphasis on the body composition of children and severity of obesity, alongside with the increased risk of anemia. Hence, this study concludes that the body composition must be considered alongside with the assessment of a child's hematological parameters to establish appropriate preventive measures and mitigation on health protocols of children that may prevent further complications and detrimental effects in adulthood.

Ethical Considerations:
This study has been granted ethical approval by the University of Santo Tomas Faculty of Pharmacy Research Ethics Committee with a study protocol code FOP-REC-2021-01-072.

Conflict of Interest:
The authors of this study declare that there is no conflict of interest.

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