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Original Research Article

MAGNITUDE AND ASSOCIATED FACTORS OF ZINC DEFICIENCY AMONG PATIENTS WITH ACNE VULGARIS: A CROSS-SECTIONAL STUDY

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Abstract

Background: Zinc deficiency is one of the main health problems affecting many peoples in developing countries. The acne like papule pustular lesions in zinc deficiency and their rapid improvement with zinc supplementation have led to assess the relationship between serum zinc levels and acne. **Methods: the** Facility-based cross-sectional study was conducted on 102 patients with acne vulgaris in Ayder Referral Hospital from March to April 2016. Individual dietary diversity score was determined as the sum of the number of food groups consumed in 24 hours prior to the study. Serum zinc concentration was determined using Flame Atomic Absorption Spectroscopy and zinc deficiency was defined at serum levels less than 70µg/dL. Logistic regression analysis was conducted to identify factors associated with serum zinc deficiency. Moreover, independent t-test and one-way ANOVA were done to compare the mean serum zinc level between different groups. The significance was declared at $p< 0.05$. **Results:** The mean serum zinc concentration was 95.38 ± 20.95 µg/dL (95% confidence interval [CI]: 91.28 – 99.49) and 19.61% of the patients were zinc deficient. Higher prevalence of zinc deficiency was noticed in patients with acne who were regularly doing exercise (Adjusted odds ratio [AOR]=3.27; 95% CI: 1.211–8.20), drinking alcohol (AOR=3; 95% CI:1.95–11.00), consuming no meat (AOR = 4; 95% CI: 1.86–10.00) and taking milk (AOR = 5; 95% CI: 1.52–11.70). There was also a significant difference in mean score of serum zinc level among groups who experience diarrhea; women with regular menses; with cereal, vegetable, and meat consumption; and acne duration. **Conclusion:** The prevalence of zinc deficiency was higher among patients with acne vulgaris in the hospital. Regular exercise, no meat consumption, high alcohol and milk intake were factors associated with zinc deficiency. Clinicians should consider serum zinc level and the contributing factors while diagnosing and treating patients with acne vulgaris.

Keywords: zinc deficiency, magnitude, and acne vulgaris.

Background

Zinc is a broadly distributed essential bio-metal and dietary factor and presents in living tissues, secretions and different organs such as skin that accommodates about six percent of the total body's zinc pool. This bio meta- plays a momentous role in body's immunity; and cellular repair, growth, and reproduction [1].

According to the World Health Organization (WHO) estimation, zinc deficiency affects about 31% (ranging from 4% to 73%) of the globe's population. The prevalence of zinc deficiency is low (4–7%) in developed countries such as the USA and Europe; however, higher prevalence is found throughout South and Central Africa (37–62%), North Africa and the Eastern Mediterranean (25–52%), and South and South-East Asia (34–73%). Regarding the worldwide mortality associated with zinc deficiency, this deficiency contributes to 1.4% of deaths [2].Achieving sufficient dietary zinc is a problematic phenomenon in resource-restrained societies due to the expensive nature of zinc-enriched meals – such as meat and fish – for many families in developing countries [3,4].

Asa chronic disease of the pilosebceous gland, acne usually commences in teens and resolves in the middle-twenties. This disease affects roughly 85% of youngsters – the incidence reaches a peak during adolescence – but infants are also affected by this disorder. Further, about 12% of women and 3% of men will continue to have clinical acne until the age of 40's. Despite the scarcity of studies related to the prevalence of acne in Ethiopia, one study reported that 19.4% of the study participants living in Mekelle (Ethiopia) were affected by acne [5].

According to the findings of previously published studies, acne patients have a relatively lower level of zinc compared to healthy subjects [6–12]. Further studies also reported that minerals and vitamins have a considerable role in acne's pathophysiology [8]. Zinc promotes vitamin A metabolism in the body, i.e., it involves the conversion of vitamin A to retinal, the active form of it. Additionally, zinc is essential for wound and acne healing, displays some anti-androgen activity [13] and has an inhibitory effect on the *Propionibacterium acne*, a type of bacteria found in sebaceous glands. Most importantly, a large proportion of studies has demonstrated a noteworthy achievement of treatment outcome with oral zinc therapy inpatients suffering from acne[12,14,15].The proposed mechanisms for the beneficial effects of zinc in acne management are a) its anti-inflammatory effect, b) its inhibitory effect on the *Propionibacterium acne*'s lipases and free fatty acid levels, and c) its anti-androgenic effect and thereby suppression of sebum production [16,17].

The acne-like papule pustular lesions observed in zinc deficient patients and their rapid improvement with zinc supplementation have led some investigators to assess the relationship between serum zinc levels and acne. However, these studies are few in number but have shown that patients with acne have low serum zinc levels [18]. Some clinicians have, therefore, combined zinc with other treatments of inflammatory acne, and zinc is still used with varying rates of success [19–21]. Nevertheless, previous studies are scanty and some are contradictory, even to the investigators' best knowledge, no research related to the association of zinc with acne is done in Ethiopia. Therefore, the aim of the study was to determine the magnitude of the serum zinc deficiency and associated factors among patients with acne vulgaris in a tertiary referral hospital.

Methods and Participants

The study was conducted in the Ayder Referral Hospital (ARH), Northern Ethiopia, from February 2016 to March 2016. A

facility-based cross-sectional study was employed. The source population was all patients with acne vulgaris who obtained services at the dermatology clinic of ARH and the study population was all patients with acne vulgaris who visited the dermatology clinic during the study period. The study units were all patients with acne vulgaris who visited the dermatology clinic and who fulfilled the inclusion criteria during the study period.

Patients aged ten years or older diagnosed with acne vulgaris and without evidence of other comorbid dermatology disorders were enrolled in the study. On the other hand, patients with acne vulgaris who took zinc or iron supplementation for any purposes, patients with acne vulgaris suffering from any chronic diseases, patients who were pregnant and breastfeeders, and patients who were not willing to give an informed consent form were excluded from the study.

The sample size for this study was calculated to be 102 using a formula for a single population proportion considering the following assumptions: a 95% confidence level, 5% margin of error, 50% maximum variability, and 10% contingency. A consecutive sampling method was employed to select the study samples from the study population at the dermatology unit. All patients were examined for the presence of acne and acne grading was also done by a senior dermatologist.

To assure data quality, the investigators gave training and orientation to four trained laboratory technicians, who were recruited as data collectors. Continuous follow-up and supervision were made by the supervisors and the principal investigator throughout the data collection period. Concerning the validation of the data collection tool, the questionnaire was originally prepared in English. Both forward (from English to Tigrigna) and backward (from Tigrigna to English) translation were done to check for the consistency of the meanings. The reconciled and final Tigrigna version was then undergone a cognitive interview stage in 10 patients. Finally, the questionnaire was pre-tested prior to the actual data collection in 5% of respondents at the clinic.

Eligible patients were selected, interviewed and their blood samples were taken by the trained laboratory technicians. These technicians also measured the anthropometric measurements of the study subjects. Overall, the data collection procedure was having three parts: Part-I was interviewing the patients to extract the socio-demographic, socioeconomic, dietary and behavioral factors using a structured questionnaire; part-II was measuring and recording anthropometric data (weight & height) and; part-III was taking a blood sample.

The weight of the study subjects was measured to the nearest 0.1kilograms (kg) on a battery powered digital scale, and height was also measured to the nearest 0.1 centimeters (cm) using a wooden height-measuring board with a sliding head-bar following standard anthropometric techniques. For weight and height measurements, study subjects removed their shoes, jackets and wore light clothes. The data collectors frequently checked and calibrated the accuracy of the scale. Using a Microsoft® Office Excel and through dividing the weight (in kg) by the height (in m^2), the body mass index (kg/m^2) was then calculated. Lastly, individual dietary diversity score (IDDS) was also computed as the addition of the number of different food groups, in the previous 24 hours prior to study enrollment, consumed by the study subject.

Blood sample collection, serum extraction, and zinc level determination

A venous blood sample of 5 milliliters was obtained from the median cubital vein under aseptic conditions using venipuncture and maintained in cold-chain. After allowed to clot for 20 minutes, the blood samples were

consecutively centrifuged at 3000 × g (gravity) for 10 minutes. Serum was extracted and transferred immediately into screw-top vials within 40 minutes of sample collection. During this time, visibly hemolyzed samples were discarded. In the entire process, the sample was protected from dust and direct light. Following this, the samples were kept in an ice box and then transferred to a refrigerator of (-) 20 °C. Lastly, the serum samples were transported, using the ice box, to the laboratory of the Ethiopian Public Health Institute (EPHI). Serum zinc concentration was determined at EPHI using Flame Atomic Absorption Spectroscopy (AA 6800 model, Japan).

Data management and analysis

Data were collected and checked for completeness and logical sequence of responses. The collected data were entered using Epi-Info® version 3.5.1 and then transferred to SPSS® version 20 for analysis. Data, from results of descriptive statistics, were presented in tables, graphs, and numerical numbers. Bivariate analysis was also carried-out to determine the magnitude of zinc deficiency in association with the independent variables. Binary logistic regression analysis, after checking model fitness, was computed to determine odds ratio and the 95% confidence interval of statistical associations. Variables with a *p*-value less than 0.25 in the univariate analysis were taken to multivariate analysis. Independent t-test and one-way ANOVA were also done to compare the mean serum zinc level between different groups. The strength of statistical association was measured by adjusted odds ratios (AOR) and 95% confidence intervals (CI). The statistical significance was declared at $p<0.05$.

Operational Definitions

The following operational definitions were used in this study. Mild acne was defined as the presence of few papules and pustules mixed with comedones, but no nodules. Moderate acne was characterized by the presence of many papules and pustules together with a few nodules. Severe acne was characterized by the presence of numerous papules and pustules, as well as many modules.

Zinc deficiency was defined as a serum zinc concentration level of less than 70 µg/dL for both males and non-pregnant females aged ten years or older [22].Dietary diversity was also defined as the number of different foods or food groups consumed over a given reference period. Besides this, dietary diversity scores were defined as the result of the sum of the food groups consumed by an individual over a 24-hour period out of the standard nine food groups. Lastly, the minimum dietary diversity (MDD) indicator was calculated based on the sum of foods consumed over a 24-hour period. Consumption of ≤ 3 food groups was considered as low dietary diversity, while 4 - 6 food groups were considered medium dietary diversity and ≥7 food groups were classified as high dietary diversity.

Results

Socio-demographic characteristics and serum zinc deficiency

A total of 102 patients was participating in the study making a response rate of 100%. The mean (±SD) age of the respondents was 20.8 (± 3.2) years, in which about a half (52%) of the patients' age was between 11 to 20 years. Fifty-four percent of the respondents were males while 94.1% of the respondents were Orthodox by religion. The majority (46.1%) of the patients was having an educational level of college and above. Students constitute the largest occupational status (73.5%) followed by employed individuals (17.6%). Nearly three-fourth (77.5%) of the respondents were living in urban and about two-third (66.7%) of the participants were never married. About three-out of four households had a family income of less than 138 US dollars per month (Table 1).

Table 1. Socio-demographic characteristics of patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.

Variable	Category	Frequency (n = 102)	Percent (%)
Age	11 to 20 years	53	52
	21 to 30 years	48	47
	30 years and above	1	1
Sex	Male	55	54
	Female	47	46
Religion	Orthodox	96	94.1
	Muslim	6	5.9
Educational level	Unable to read & write	26	25.5
	Able to read & write	8	7.8
	Grade 1-8	4	3.9
	Grade 9-12	17	16.7
	College and above	47	46.1
Occupation	Student	75	73.5
	Employee	18	17.6
	Unemployed	5	4.9
	Self-employed	3	2.9
Place of residence	Urban	79	77.5
	Rural	23	22.5
Marital status	Single	68	66.7
	Married	24	23.5
	Divorced	10	9.8
House-hold family income	<1000 ETB*	14	13.7
	1001-2000 ETB	38	37.3
	2001-3000 ETB	23	22.5
	3000 ETB and above	27	26.5

*ETB: Ethiopian Birr (1 ETB was approximately 0.046 US dollars during the study period).

The overall mean (±SE) value of serum zinc concentration of the study participants was 95.38 (± 20.95) µg/dL(95% CI: 91.28 – 99.49 µg/dL) ranging from41.79 µg/dL to 132.5µg/dl (Fig 1a). Based on the cutoff points of low serum zincconcentration (<70 µg/dL), it was found that 20(19.61%) participants had a serum zinc deficiency. Prevalence of zinc deficiency was higher in females (60%) than males (40%). The mean serum zinc level (in µg/dL) for female and male patients were 94.18 (SE: 3.28; 95% CI: 87.59 – 100.78) and 96.41 (SE: 2.64; 95% CI: 91.10 – 101.71) respectively (Fig 1b).

Higher prevalence of zinc deficiency was occurring in the age group of 11-20 years (n=10 cases, 18.9%). Almost 100% of patients with acne who had a serum zinc deficiency was less than 30 years of age. The mean serum zinc level (in µg/dL) for patients aged 11-20 years and 21-30 years were 94.08 (SE: 2.51; 95% CI: 89.01 – 99.12) and 96.77 (SE: 3.43; 95% CI: 89.97 – 103.67) respectively (Fig 1c). Sixty-five percent of the subjects with zinc deficiency were having an educational level of college and above.The mean serum zinc level (in µg/dL) for patients who were unable to read and write, able to read and write, grade 1-8,

grade 9-12, and college and above were 95.46 (SE: 4.28; 95% CI: 86.65 – 104.27), 111.38 (SE: 5.91; 95% CI: 97.41 – 125.36), 107.52 (SE: 6.80; 95% CI: 85.86 – 129.17), 100.15 (SE: 4.34; 95% CI: 90.95 – 109.35), and 89.89 (SE: 3.05; 95% CI: 83.72 – 96.01) respectively (Fig 1d).

Behavioral and clinical characteristics, and serum zinc deficiency

Out of 102 patients with acne vulgaris, 45.1% of the patients were performing regular exercise and 96.1% of them never smoked tobacco. From the 47 female participants,6.4%, 29.9% and 23.4% of them were using oral contraceptive agents, having irregular menses and experiencing heavy bleeding during their menses respectively(Fig 2).

On clinical examination, the severity of acne was categorized as mild in 13 patients (12.7%), moderate in 41 patients (40.2%) and severe in 48 (47.1%) patients. The deficiency of serum zinc level was noticed in 19.6% of acne patients. A large proportion (62.7%) of the study subjects was presented with moderate acne duration (3 months to 3 years). Out of 11 subjects who experienced heavy bleeding during their menses, 36.4% of them were zinc deficient. Thirty-two percent of those who perform exercise and 50% of those who had irregular menses were zinc deficient.

Dietary characteristics and serum zinc deficiency

Out of the study subjects, 86.3% of them were having a low dietary score compared to13.7% of the study subjects with medium diet diversity scores. More than one-third (37.2%) of the study subjects were overweight (BMI ≥ 25 kg/m^2) (Fig 3).

Ninety percent of the study subjects with low IDDS was seen to have zinc deficiency compared to those with medium IDDS (10%). Most of the study subjects had a low dietary diversity score, which is a proxy indicator for dietary habit and this research revealed that most of the participants were consuming below the recommended level. Consumption of meat, processed bread, fruit juice, cereals, alcohol, milk, and coffee were significantly associated with zinc deficiency.Out of 102 participants,37.3 % of them had eaten meat 1-2 times per week compared to 55.9% and 56.9% of the study subjects who had never consumed vegetables and fruits respectively. On the other hand, almost all (95.1%) of the study subjects had never eaten fish (Fig 4). The result of independent t-test revealed that there was a significant difference in mean score of serum zinc level between respondents who had and had not diarrhea, women with and without regular menses (Table 2).

Table 2. Independent sample t-test result on serum zinc deficiency and its associated factors among patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.

Variable	t-value	df	*p*-value
Sex	0.533	1	0.595
Residence	-1.411	1	0.161
Regular menses	3.071	45	0.004*
Diarrhea	-2.859	1	0.005*

Abbreviation: df: degree of freedom

*The mean difference is significant at $p < 0.05$.

One-way ANOVA also showed that the mean scores of serum zinc level had significant difference within the categories of cereal consumption, vegetable consumption, meat consumption and acne duration. Using post hoc test, the mean score of serum zinc level among respondents that consume cereals more than two times per week, consume vegetables 1-2 times per week, consume meat more than two times

per week, and three months to three years of duration of acne significantly differ with their respective counter groups (Tables 3).

Table 3. One-way ANOVA result of serum zinc deficiency and its associated factors among patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.

Variables		**Serum zinc level ± SEM**
Cereal consumption	None	76.35 ± 4.00
	1-2 times per week	85.37 ± 4.79[a3]
	≥ 3 times per week	100.23 ± 2.24[bc3]
Vegetable consumption	None	93.89±3.02[c2]
	1-2 times per week	96.21±4.09[b2]
	≥ 3 times per week	98.50±3.61
Meat consumption	None	91.83 ± 5.22[a2]
	1-2 times per week	92.65 ± 2.94[b2]
	≥ 3 times per week	99.19 ± 3.29[b2]
Acne duration	< 3 months	94.59 ± 4.43
	3 months to 3 years	99.61 ± 2.58[d1]
	> 3 years	86.30 ± 3.88[e1]

SEM, standard error of mean
[a]compared to ≥ 3 times per week; [b]compared to none; [c]compared to 1-2 times per week; [d]compared to > 3 years; [e]compared to 3 months to 3 years.
[1]statistically significant at *p*-value < 0.1; [2]statistically significant *p*-value< 0.05; [3]statistically significant *p*-value < 0.01

Associated Factors

Multivariate analyses were conducted to assess the net effect of selected variables on the level of serum zinc. The result of this regression analysis revealed that patients who were performing regular exercise were not consuming meat at least once per weak, who were consuming alcohol and milk were significantly associated with zinc deficiency among patients with acne. Patients with acne who were regularly doing exercise were about three(AOR = 3.27; 95% CI: 1.211 - 8.2) times more likely to develop zinc deficiency than who were not doing regular exercise.Patients who were regularly drinking alcohol were three(AOR = 3; 95% CI: 1.95 - 11) times more likely to develop zinc deficiency than patients who never took alcohol. Likewise, individuals who never had a regular meat consumption at least once per week were four (AOR =4; 95% CI: 1.86 - 10) times more likely to develop zinc deficiency than individuals who were eating meat three and more times a week (Table 4).

Table 4. Results of multivariate analyses on serum zinc deficiency and its associated factors among patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.

Characteristics		**Total**	**Zinc deficiency**		**COR [95% CI]**	**AOR [95% CI]**
			Yes (%)	**No (%)**		
Regular exercise	Yes	46	15(32.6%)	31(67.4%)	4.94[1.63 - 14.92]*	3.27 [1.21 - 8.2]*
	No	56	5(8.9%)	51(91.1%)	Ref	Ref
Diarrhea	Yes	19	8 (42.1%)	11 (57.9%)	4.3[1.4, 12]	5.38 [0.96 - 13]
	No	83	12 (14.5%)	71 (85.5%)	Ref	Ref
Meat consumption	None	19	8(42.1%)	11(57.9%)	4.73 [1.35 - 16.54]*	4 [1.86 - 10]*
	1-2 times per week	38	6(15.8%)	32 (84.2%)	1.22 [0.35 - 4.14]	5[0.68 - 12]
	≥ 3 times per week	45	6(13.0%)	39(87.0%)	Ref	Ref
Alcohol	None	80	11(13.75%)	69(86.25%)	Ref	Ref
	≥ 1 times per week	22	9(41.0%)	13 (59.0%)	4.34 [1.50 - 12.56]*	3 [1.95 - 11]*
Milk	None	48	3(6.25%)	45(93.75%)	Ref	Ref
	1-2 times per week	35	9(25.7%)	26(74.3%)	5.19 [1.29 - 20.91]*	4.5 [1.56 - 13]*
	≥ 3 times per week	19	8(42.0%)	11 (58.0%)	10.91 [2.48 - 48.02]*	5 [1.52 - 11.7]*

Abbreviations: COR, crude odds ratio; AOR, adjusted odds ratio; ref, reference category
*Significantly associated variables at $p < 0.05$.

Discussion

The level of serum zinc deficiency among the study participants was noticed in 19.6% of the study participants, which is congruent with a case-control study done in Iran that reported a prevalence level of 23% [23]. Moreover, some of the patients are suffering from low level of zinc in this study, which is substantiated by the findings of previous studies [9,11,12,24,25] done in the last thirty years. The decreased serum zinc level noticed in this study is, cumulatively, attributable to the inflammatory nature of the disease [21], nutritional deficiency of zinc, reduced gastrointestinal absorption of zinc, and enhanced excretion of this bio-metal via sweat or feces. On the other hand, zinc's anti-inflammatory activity on inflammatory cells, particularly granulocytes, and its effect on androgen and vitamin A metabolism can explain the possible correlation between the element and the disease [26,27].

Another finding revealed in this study is the absence of significant association between serum zinc level and duration of the disease which is in line with the results of previous studies done in Iraq [23,28].It remains elusive to explain the nonexistence of this association; however, acute disorders may affect the serum zinc level to a greater extent compared to chronic conditions.

Most of the socio-demographic characteristics (namely sex, age, race), dietary diversity, and BMI were not found statistically significant with mean serum zinc levels of patients with acne vulgaris and this result corresponds with previous studies done in Iraq and Iran [28,29]. The absence of this sign may be owing to the similarity of the patients in terms of socio-economic status and geographical residence, where the major source of their food is similar. Besides the above findings, less consumption of meat, and higher consumption of alcohol and milk were significantly associated with serum zinc deficiency. The possible explanation for this finding may be the nature of these foods and beverages, in which less consumption of meat –rich in bioavailable zinc – and more consumption of foods containing fibers and phytates – known inhibitors of zinc absorption– results in zinc deficiency in the body [30,31].

Patients who routinely drink alcohol were more likely to be zinc deficient; thus, drinking alcohol is significantly associated with a low serum zinc level. Michaelsson and his colleagues reported that the prevalence of zinc deficiency in alcoholic patients is about 30–50%; as alcohol causes increased zinc elimination in urine and reduced zinc absorption in the intestine[32]. In addition, the variety and amount of food consumed by many alcoholics are limited, leading to inadequate zinc intake.

In a similar fashion, patients who regularly perform exercises were more likely to develop zinc deficiency than patients who never do any exercise.The plausible explanation for this finding is associated with decreased serum level of zinc during exercise.Even though one study reported the association of unbalanced diet and frequent zinc deficiencies in athletes, in certain circumstances, vigorous exercise results in low level of zinc by accelerating zinc loss through perspiration and relocation of zinc from plasma to red blood cells [33,34].From this research, patients who were taking milk 1-2 times and ≥3 times per week were 4.5 and 5 times, respectively, more likely to develop zinc deficiency compared to patients who never took milk at least once a week. [35,36].In cow's milk, there is a high level of calcium and casein, which form insoluble and unabsorbable complexes by interacting with zinc and phytates, thus rendering zinc less bioavailable [35,36].

The study has certain limitations. First, the study design was cross-sectional which measures the exposure and outcome at the same time and hence the design cannot measure the cause and effect relationship. Second, a recall bias might be introduced in filling the IDDS questions. Therefore,

studies with a follow-up design, and with longer assessment periods should be planned in the future.

Conclusion

The prevalence of zinc deficiency was high among patients with acne vulgaris in the hospital. There was a significant difference in mean score of serum zinc level between respondents who had and had not diarrhea, and women with and without regular menses. Furthermore, cereal, vegetable and meat consumption, and acne duration significantly affect the mean score of serum zinc level. Regular exercise, no meat consumption at least once a week, high alcohol and high milk intake were the factors associated with serum zinc deficiency.Therefore, clinicians should consider serum zinc level and the contributing factors while diagnosing and treating patients with acne vulgaris. Regular health education and nutritional counseling regarding maintenance of adequate and healthy diet should be given to patients with acne vulgaris.

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List of abbreviations

µg/dL, microgram per deciliter; AOR, adjusted odds ratio; ARH, Ayder Referral Hospital; BMI, body mass index; CI, confidence intervals; COR, crude odds ratio; IDDS, Individual diet Diversity Score; MDD, minimum dietary diversity; SD, standard deviation; WHO, World Health Organization.

Fig 1. Box-and-whisker plots for the level of serum zinc deficiency for patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.

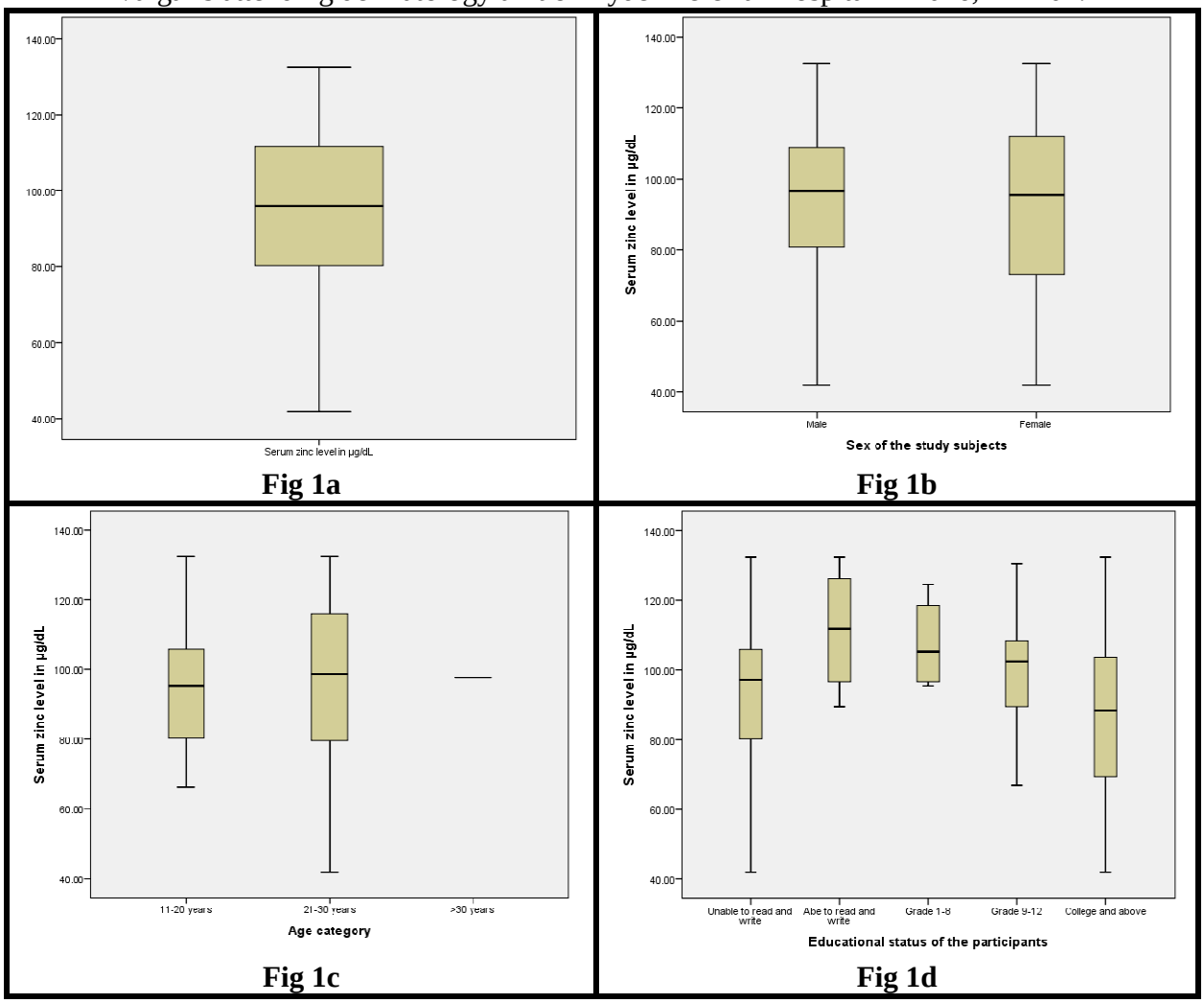
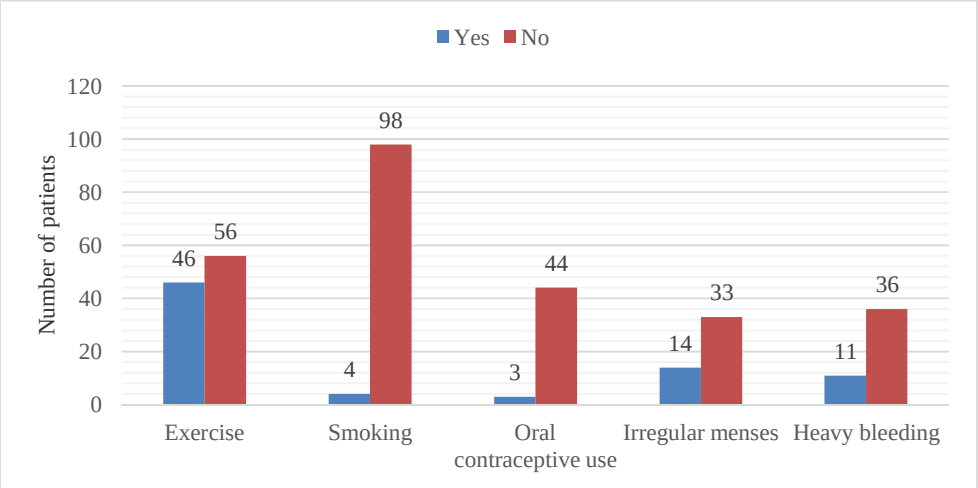
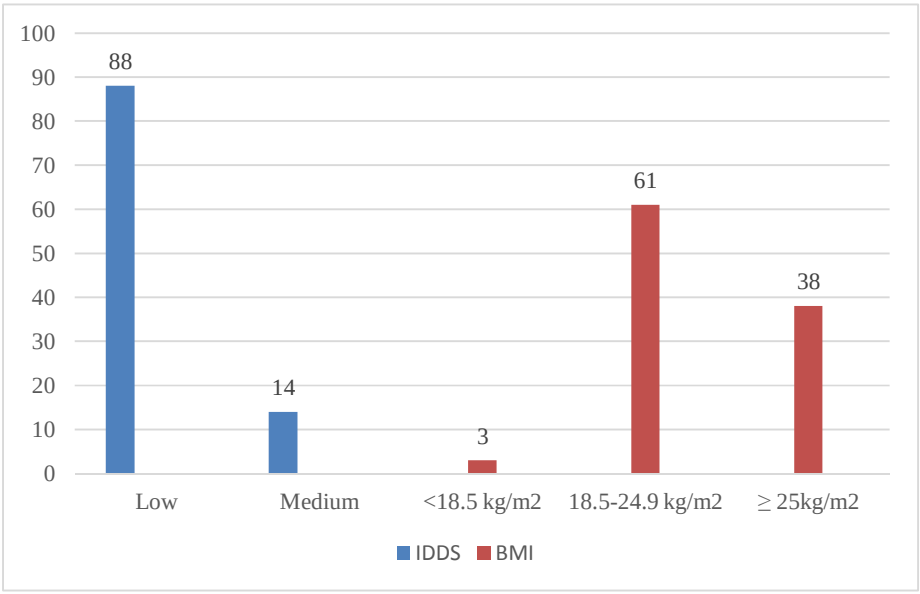


Fig 2. Distribution of behavioral and clinical characteristics of patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.



Legend: The terms 'Yes' and 'No' refer to whether the patient is doing a regular exercise or not; is a smoker or not; uses oral contraceptive or not; has irregular menses or not; and experiences heavy bleeding or not, respectively. Regular exercise was defined as a moderate-to-high intensity exercise for at least 30 minutes for five days or 150 minutes in a week.

Fig 3. Distribution of dietary diversity characteristics and body mass index of patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016, n = 102.



Abbreviations: BMI, body mass index; IDDS, individual diet diversity score

Fig 4. Dietary habit characteristics of patients with acne vulgaris attending dermatology unit of Ayder Referral Hospital in 2016.