Original paper

Relationship between body mass index *z*-score and acne severity in adolescents: a prospective analysis

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Abstract

Introduction: Acne vulgaris is a prevalent skin disorder influenced by a variety of factors, including a high body mass index (BMI) and obesity.
Aim: To investigate the association between BMI *z*-scores and acne severity in boys and girls aged 10–18 years.
Material and methods: A 72-patient prospective analysis was performed, in which patient weight, height, body mass index (BMI), body mass index *z* score (BMI *z*-score), percentiles, and demographic information were collected, and acne severity was categorized as mild or moderate/severe.
Results: The results indicated that patients with moderate/severe acne were significantly older and had higher weight, height, BMI, and BMI *z*-scores than those with mild acne ($p < 0.01$).
Conclusions: The findings suggest that higher BMI *z*-scores are linked to increased acne severity. These results emphasize the importance of addressing weight-related risk factors for the prevention and treatment of acne vulgaris. The early detection and management of weight-related conditions can play a crucial role in improving the overall well-being of individuals with acne, considering its negative impact on mental health and social functioning.

Key words: acne vulgaris, body mass index, overweight, obesity.

Introduction

The global prevalence of overweight and obesity is on the rise, affecting individuals of all ages. Particularly, the prevalence of overweight or obese children and adolescents aged 5–19 has significantly increased from 4% to 18% between 1975 and 2016 [1]. This upward trend holds substantial implications for public health. Acne vulgaris, the most prevalent skin condition worldwide [2], predominantly affects the pilosebaceous units on the face, chest, and back. It stands as the predominant dermatological issue among adolescents and young adults, impacting over 85% of individuals in Western countries [3]. While prior research has illuminated various facets of acne, there remains a notable gap in our understanding regarding the potential relationship between overweight/obesity and acne severity. In Turkey, the reported prevalence of acne among teenagers aged 13–19 is 60.7% [4]. Despite uncertainty about the precise pathophysiology of acne, it is acknowledged to involve genetic susceptibility, hormonal imbalances, and sebum production disruptions as underlying factors. Additionally, dietary habits and environmental influences may contribute to acne development [5, 6].

One important tool used to assess weight status relative to peers is the body mass index (BMI) and BMI *z*-score. The BMI *z*-score indicates whether a child's BMI is above or below the mean for their age and sex, considering standard deviations [7]. Previous research has shown a correlation between BMI *z*-scores and adverse alterations in body fat and lipid profiles, indicating an increased propensity for adiposity in hyperlipidemic children [8]. Excessive body fat, or adiposity, has been proposed as a contributing factor to acne development by influencing insulin and insulin-like growth factor-1 (IGF-1) levels. Insulin and IGF-1 are hormones responsible for regulating glucose metabolism and cellular growth, respectively. Elevated levels of these hormones can stimulate the production of sebum, an oily substance that contributes to the development of acne. Moreover, they may also facilitate the growth of skin cells and the pro-

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liferation of Propionibacterium acnes, a bacterium commonly associated with acne [9].

Given the possible association between the severity of acne and an individual's weight status, the primary objective of this study was to investigate how BMI, percentile, weight, and height relate to acne severity in boys and girls aged 10–18.

Aim

Our purpose in conducting this research was to contribute to an improved comprehension of the complex relationship between weight status and dermatological health, with the ultimate goal of providing valuable insights for more effective strategies in managing and preventing acne.

Material and methods

This prospective study assessed children aged 10–18 years who visited the general paediatrics department with acne concerns and were then referred to the dermatology department for evaluation. At the dermatology visit, the patients received a diagnosis of acne vulgaris (the most common form of acne) made by a board-certified dermatologist based on visual skin examination. To quantify acne severity in an objective manner, the dermatologist utilized the Global Acne Severity Scale (GEA Scale) [10]. This is a validated assessment tool for acne that assigns numerical severity scores based on the number and type of lesions present across different facial regions. Global Acne Severity Scale (GEA Scale) categorizes acne lesions, including comedones, papules, pustules, and nodules, and assigns severity levels based on their presence and extent. Higher scores indicate more severe acne.

In addition to the dermatological evaluation, anthropometric measurements including height, weight, BMI and BMI percentiles adjusted for age and sex were obtained from each patient. Weight was measured using a medical-grade digital scale calibrated according to standard procedures. Patients were asked to remove their shoes and heavy outer clothing. They then stepped on the scale platform, which displayed their weight in kilograms to one decimal place. After the person to be measured stood upright with their back straight and head in a neutral position, with eyes looking forward, the measurement was taken from the top of the head downward using a measurement device or the measurement lines on a wall. For quality control, the scale was checked using known weights at the start of each study day. The scale measurements were recorded directly into the patients' study files.

The data were recorded in the hospital information system, and forms retrieved from the system between 1 September 2022, and 1 December 2022 were reviewed. Patients with documented endocrine disorders, hormonal imbalances, a history of medication use, a diagnosis of polycystic ovarian syndrome, or insulin resistance were thoughtfully excluded from the analysis. To quantify the weight status and body mass of the patients, we harnessed the power of ChildMetrics©, a specialized application thoughtfully developed by the Turkish Pediatric Endocrinology Association, specifically designed to cater to the unique anthropometric nuances of Turkish children [10, 11].

The patients were categorized based on the severity of their acne. We formed two groups: Group 1 consisted of individuals with mild acne, whereas Group 2 comprised individuals with moderate to severe acne.

All of the people who took part and their families volunteered, and the treatments were done according to the rules of the local ethics committee and with Gülhane Training and Research Hospital, Gülhane Scientific Research Ethics Committee approval (2022-279). After being informed about the study, informed written consent was obtained from the parents of the children. The procedures followed in this study were conducted in strict accordance with the ethical principles outlined in the Helsinki Declaration of 1975, as revised in subsequent editions. All aspects of patient recruitment, data collection, and analysis were carried out with utmost consideration for the well-being, privacy, and informed consent of the participants.

Statistical analysis

Frequency, mean, median, and percentage were used to compare the data, and Kolmogorov-Smirnov and Shapiro-Wilk tests were used to examine the normal distribution of the data. The Mann-Whitney *U* test, Student's *t*-test, and χ^2 test were used to compare the groups, and those with $p < 0.05$ were considered significant. Logistic regression analysis was used to identify the risk factors. In univariate analyses, those with $p < 0.01$ were included in the multiple regression analysis, and those with $p < 0.05$ were considered significant.

Results

The mean age, height, weight, acne severity, percentile score of weight, median BMI and BMI *z*-score, and median weight *z*-score of participants were 14.7 ±1.8 years, 165.0 ±8.3 cm, 59 ±10.16 kg, 2.61 ±0.76, 67.7 ±16.0, 21.1, 0.08 and 0.1 respectively (Table 1). A significant association was found between acne severity and the BMI, BMI *z*-score, weight *z*-score, and percentile score ($p < 0.001$) (Table 2). Group 2 children also had a higher mean weight (64 ±7.72 kg) compared to Group 1 (53.9 ±9.29 kg) ($p < 0.001$). Group 2 children had a higher mean BMI (20.23 ±1.62 kg/m^2) compared to Group 1 (22.9 ±1.80 kg/m^2) ($p < 0.001$). Group 2 (Moderate + Severe Acne) showed statistically significant differences compared to Group 1 (Mild Acne) in terms of weight and BMI z score ($p < 0.001$) (Table 2).

Table 1. Demographic data of patients (n = 72)

Parameter	Mean ± SD*	Median	Range
Age	14.7 ±1.8	15	11–18
Height	165.0 ±8.3	166	145–180
Weight	59 ±10.16	58	35–80
Severity	2.61 ±0.76	2	2–5
BMI [kg/m^2]	21.5 ±2.18	21.2	16.7–26.4
Percentile↓	67.7 ±16.0	69	27–93
Height z-score**	0.14 ±0.66	0.09	(–) 1.60–1.82
Weight z-score	0.15 ±0.66	0.1	(–) 1.65–1.65
BMI z-score	0.14 ±0.62	0.08	(–) 1.1– 1.46
Parameter		***n***	**%**
Gender	Male	36	50
	Female	36	50

SD – standard deviation. Percentile↓: The percentile value indicates the relative position of an individual's measurement compared to the distribution of measurements in the reference population. The resulting z-score indicates how many standard deviations a data point is away from the mean.*

The z scores for weight, and BMI did not show significant associations with the outcome variable in either/any of the multiple regression analyses. The significant associations observed in the multiple regression analyses remained consistent for BMI. The odds ratio for BMI remained at 2.5 (OR = 2.5), with a 95% CI of 1.6-3.7, and the p-value remained < 0.001 (Table 3).

Discussion

This study focused on children aged 10–18 with acne, analysing various anthropometric measurements, BMI-related parameters, and acne severity. The results highlighted a significant association between acne severity and BMI, BMI z-score, weight z-score, and percentile score. These findings suggest that promoting healthy weight maintenance may positively affect acne severity in adolescents.

The correlation between BMI and acne is currently without scientific consensus, mired in controversy due to unclear underlying mechanisms. Nonetheless, several theories have been posited to explore this potential association. Obesity increases adipose tissue, where androgen is synthesized, leading to hyperandrogenism [12]. Androgens stimulate the sebaceous gland; thus, hyperandrogenism leads to increased sebum production, resulting in acne [13, 14]. Obesity can affect acne development in several ways. Obesity has been suggested to lead to an increase in androgen levels, which are hormones known to stimulate sebum production, a key factor in the pathogenesis of acne [15].

Various studies have suggested an association between obesity, androgen levels, and the severity of acne in women. For instance, Alan *et al.* reported a higher prevalence of hyperandrogenism and obesity in women with acne, with a positive correlation between BMI and acne severity. Similarly, Borgia *et al.* identified a negative correlation between acne severity and serum sex

Table 2. Comparison of children from Group 1 (Mild Acne) and Group 2 (Moderate + Severe Acne)

Parameters	Units	Group 1 (n = 39)			Group 2 (n = 33)			
		Mean ± SD	Median	Range	Mean ± SD	Median	Range	*P*-value
Age	years	14.1 ±1.90	14	11–18	15.3 ±1.36	15	13–18	0.04
Height	cm	162.6 ±8.29	162	145–180	168 ±7.43	169	149–180	< 0.001
Weight	kg	53.9 ±9.29	54	35–78	64 ±7.72	65	53–80	< 0.001
Severity		2 ±0.0	2	2–2	3.3 ±0.5	3	3–5	< 0.001
BMI	kg/m^2	20.23 ±1.62	20.0	16–24	22.9 ±1.80	23.0	20–26	< 0.001
Percentile	P	60.7 ±15.01	63	27–85	76 ±13.2	78	36–93	< 0.001
Percentile category	AN/N	1.02 ±1.16	1	1–2	1.3 ±0.47	1	1–2	< 0.001
Height z-score		0.18 ±0.69	0.09	(–) 1.51–1.82	0.09 ±0.63	0.02	(–) 1.60–1.29	0.59
Weight z-score		–0.13 ±0.56	–0.09	(–) 1.65–0.84	0.49 ±0.61	0.53	(–) 1.1–1.65	< 0.001
BMI z-score		–0.18 ±0.42	–0.15	–1.1+0.45	0.51 ±0.6	0.51	(–) 0.94–1.46	< 0.001
Parameter			***n***	**%**		***n***	**%**	
Gender	Male		17	43.6		19	57.6	0.23
	Female		22	56.4		14	42.4	

AN – abnormal, BMI – body mass index, N – Normal, SD – standard deviation.

Table 3. Evaluation with multiple regression analyses

Parameters	Units	Univariate analysis			Multivariate analysis		
		P-value	OR	95% CI	*P*-value	OR	95% CI
Age	years		1.5	1.1–2.1			
Gender	M/F	0.24	0.6	0.2–1.4			
Height	cm	0.008	1.1	1.1–1.2			
Weight	kg	< 0.001	1.2	1.1–1.3			
BMI	kg/m^2	< 0.001	2.5	1.6–3.7	< 0.001	2.5	1.6–3.7
Percentile	P	< 0.001	1.1	1.1–1.2			
Percentile category	AN/N	0.006	19.1	2.2–157			
Height *z*-score		0.59	0.8	0.4–1.7			
Weight *z*-score		< 0.001	6.3	2.3–17.8			
BMI *z*-score		< 0.001	14.3	3.8–53.5			

AN – abnormal, BMI – body mass index, N – normal, SD – standard deviation.

hormone-binding globulin (SHBG) levels, indicating a link between peripheral hyperandrogenism and acne severity. Additionally, Yang *et al.* observed that obese women had a lower incidence of acne compared to non-obese women, despite having higher serum testosterone levels [16–18].

This relationship becomes particularly important when considering the multifaceted effects of acne vulgaris. The presence of acne can lead to significant alterations in sex hormones, serum lipids, metabolic status, and BMI. However, Gayen *et al.* [19] found that female patients with acne vulgaris had altered sex hormone levels, including elevated testosterone and progesterone with low oestrogen. Wang *et al.* [20] also found higher levels of testosterone, androstenedione, and dehydroepiandrosterone-sulfate in women with acne vulgaris compared to controls. These findings suggest that hyperandrogenemia may play a role in the development and exacerbation of acne vulgaris.

The effects of obesity and hormonal factors on acne severity may differ depending on one's age and developmental stage. While current evidence offers preliminary links between weight measures, levels of sex hormones and severity, their roles may vary at different developmental periods. An especially prudent analytical approach would be to examine groups across different life stages (paediatric, adult, gender-specific) in a longitudinal framework.

The relationship between BMI and acne has been investigated by several researchers in children. Karciauskiene *et al*. found that children with higher BMI had a higher prevalence of acne [21], Anaba *et al.* reported a similar trend in adolescents, with a higher prevalence of acne in those with higher BMI [22], Lu *et al.* [23] also found that patients with moderate to severe acne had a higher mean BMI compared to controls. However, Tsai *et al.* [24] showed that the mean BMI of acne-free children was lower than that of children with acne. Snast *et al.* [25] found an unexpected inverse association between overweight/obesity and acne in a nationwide study of adolescents. The proportion of adolescents with acne gradually decreased from underweight to severely obese. Rodriguez Baisi *et al.* investigated the incidence of acne in preadolescent girls and boys, and observed that it was higher in girls and increased with age. Our findings are consistent with those of previous studies that demonstrated a link between BMI and acne development. This study established a significant connection between acne severity and variables including BMI, BMI *z*-score, weight *z*-score, and percentile score. Nevertheless, it is essential to acknowledge the research's limitations, such as a relatively small sample size and its restriction to a single hospital, which may affect the broader applicability of the results.

Rodriguez Baisi *et al.* found that preadolescents with acne were more likely to be obese compared to those without acne [26]. Tsai *et al.* study supported the positive associations between BMI and acne development, and showed the severity of acne may start to worsen in the upper grades of elementary school [27]. Tsai *et al.* further supported the findings of Rodriguez Baisi *et al.*, who demonstrated positive associations between BMI and acne development. The study also indicated that acne severity tends to worsen in the upper grades of elementary school. Building upon these previous findings, our own study included participants who had entered puberty and were older than in both the Rodriguez Baisi *et al.* and Tsai *et al.* studies. The consistent relationship between age and acne severity, as observed in our study, aligns with prior research findings. Age is a critical factor to consider when evaluating acne as it may reflect not only the natural progression of the condition but also its potential connection to various underlying factors, including weight status. Understanding the interplay

of age, acne severity, and weight status is essential for implementing effective acne management and treatment strategies. Hence, a comprehensive assessment of sex hormones is advisable for acne patients, irrespective of the severity or symptom burden. Additionally, the presence of hirsutism can be a valuable clinical indicator for lipid abnormalities and may serve as a marker for evaluating the lipid profile in individuals with acne vulgaris. Nevertheless, further research is imperative as the precise role of sex hormones in the pathogenesis of acne vulgaris remains incompletely understood.

Controversial findings have been reported regarding the association between an increased BMI and acne. It is important to acknowledge that the relationship between an elevated BMI and the occurrence of acne has yielded inconsistent and sometimes conflicting findings. A study conducted by Gayen *et al.* concluded that there was no link between acne and obesity, and metabolic syndrome was not directly correlated with the severity of acne [19]. A study of BMI and acne vulgaris in 180 students showed that individuals who were not obese (31.7%) had the condition more frequently than those who were overweight/obese (14.4%) [14]. Another study conducted in 2018 showed that for all acne grades, there was no relationship between BMI and acne severity [28]. In contrast to studies exploring the association between dietary factors and acne, our study did not specifically examine such factors, which could be considered a limitation. Nevertheless, the findings from these studies suggest that what we eat may play a crucial role in the development and severity of acne rather than solely focusing on the quantity of food consumed. More recent analyses have provided support for this notion, particularly with regard to the impact of dietary patterns, such as a Western diet or a high-glycaemic-load diet, on acne. These studies demonstrated that individuals following a low-glycaemic-load (GL) diet exhibited lower androgen concentrations and reduced sebum outflow, leading to a decrease in acne severity [29, 30]. These two studies may lead to the conclusion that what we eat may have an impact on acne development and severity, rather than how much we consume.

The evaluation of acne severity remains a complex challenge due to the absence of a universally accepted gold standard grading system. In this study, we utilized the Global Acne Severity Scale (GEA Scale) to assess acne severity, a choice that merits further discussion and exploration of alternative methods. Global Acne Severity Scale (GEA Scale) has been widely employed in dermatological research and practice, offering a structured and comprehensive approach to assessing acne severity. However, it is essential to acknowledge the limitations of this scale. It may not capture the full complexity of acne severity, potentially leading to variations in grading based on different observers and populations. Our study recognizes this limitation, and several other grading scales, such as the Global Acne Grading System (GAGS), the Investigator's Global Assessment (IGA), and the Leeds Revised Acne Grading System, offer alternative perspectives on acne severity assessment. Moreover, the multifactorial nature of acne underscores the importance of considering other etiological factors that influence its development and severity. Our study focused on the association between BMI z-scores and acne severity, but we acknowledge that familial history, metabolic disorders, and dietary habits can also play significant roles in the pathogenesis of acne.

The sample size of 72 patients is relatively small, and the study was conducted at a single hospital in Turkey. Another limitation is that other acne etiological factors, such as familial history or metabolic disorders, were not considered in our study.

One strength of our study lies in the investigation of the relationship between BMI *z*-scores and acne severity. While we did not specifically examine dietary factors like the studies mentioned earlier, our focus on exploring the correlation between BMI z-scores and acne severity provides a valuable contribution to the existing body of knowledge. By examining this specific aspect, we aimed to further understand the impact of weight status on acne severity among our study participants.

Such a relationship has a significant impact on the treatment of patients with acne as therapy should focus not only on the proper selection of medications, but also on the modification of the patient's dietary habits, physical activity, and, if necessary, reduction of body weight. The study's results could inform about the development of weight management programs for individuals with acne, or prompt dermatologists to consider a patient's weight status when developing treatment plans for acne vulgaris.

Future studies aimed at illuminating such potential variations would benefit from considering influences like genetic background and ethnicity, which likely impact severity. Gaining a deeper understanding of the complex relationships between physiological characteristics and how acne presents itself necessitates investigations that account for a myriad of interrelated influences over one's lifetime. This methodology could help successfully disentangle the many overlapping influences likely at play. Separating obesity and hormone impacts according to context promises to further clarify acne's pathophysiology or underlying medical causes. Only through comprehensive long-term examinations of diverse populations can we hope to distinguish between confounding issues and achieve a more sophisticated comprehension of acne's multifactorial origin or numerous contributing factors.

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Conflict of interest

The authors declare no conflict of interest.

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