ORIGINAL ARTICLE

Acne and obesity: A nationwide study of 600,404 adolescents

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Background: The association between body mass index (BMI) and acne is unclear.

Objective: To determine the association between BMI and acne in youths.

Methods: A nationwide, population-based, cross-sectional study was conducted in 2002-2015 by using medical data on 600,404 youths during compulsory military service. BMI was measured at age 17 years. Acne was diagnosed by dermatologists. Unadjusted and adjusted odds ratios (aORs) of acne in relation to BMI (stratified into 8 groups) were calculated, with the low-normal group (18.5≤ BMI ≤21.99 kg/m^2) serving as the reference.

Results: The study included 299,163 males (49.9%) and 301,241 females (50.1%) with a mean age of 18.9 years (standard deviation, 0.6) and 18.7 years (standard deviation, 0.5), respectively, at recruitment. Acne was diagnosed in 55,842 males (18.7%) and 48,969 females (16.3%). The proportion of participants with acne decreased gradually from the underweight to the severely obese group (males, from 19.9% to 13.9%; females, from 16.9% to 11.3%). The findings on multivariable analysis were similar to the unadjusted analysis results, showing the lowest odds of acne in severely obese participants (aOR for males, 0.53; 95% confidence interval, 0.42-0.64; aOR for females, 0.5; 95% confidence interval, 0.37-0.62). The findings persisted in the sensitivity analyses.

Limitations: Information was lacking on potential confounders and acne severity.

Conclusion: In youths, overweight and obesity are inversely associated with acne in a dose-dependent manner. (J Am Acad Dermatol https://doi.org/10.1016/j.jaad.2019.04.009.)

Key words: acne; adolescents; body mass index; obesity; odds; overweight; youths.

Acne vulgaris is the most common skin disorder in the Western world, affecting more than 85% of youths (adolescents and young adults).[1,2] Patients with acne can experience significant psychosocial and physical morbidity.[3] The pathogenesis of acne is complex, involving increased sebum production due to enhanced androgen activity at onset of adolescence and inflammation.[4] It has been suggested that different factors, including the Western diet and obesity, may influence acne prevalence.[5]

There are several physiologic factors that potentially link obesity to acne, such as release of adipokine-driven inflammatory cytokines.[6] The dramatic increase in obesity rates among adolescents in developed countries (including Israel) in recent

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years has led to an increasing interest in the association of these 2 conditions.[7-12] However, studies evaluating the risk of acne in overweight and obese adolescents have yielded conflicting results. In some studies, overweight and obesity conferred an increased risk of childhood and adult acne,[13] and in others, it had a protective effect.[14]

The present study was based on a national database of more than 600,000 Israeli youths during army service for whom weight and height data and medical follow-up were available. The objective of the study was to assess the relationship between body mass index (BMI) and acne in this age group.

CAPSULE SUMMARY

- The association between body mass index and acne is unclear. In this nationwide, population-based, cross-sectional study, overweight, obese, and severely obese participants had 20%, 35%, and 50% decreased odds of acne compared with normal-weight participants.
- In youths, overweight and obesity are inversely associated with acne in a dose-dependent manner.

METHODS

Study design and population

One year before beginning mandatory military service, 17-year-old Israeli citizens are required to undergo medical and physical assessment. During their service (duration for males, 36 months; duration for females, 24 months), soldiers are followed by their primary care military physician and are referred to specialists for further evaluation and treatment as appropriate. Since 2002, the medical data collected for each soldier before and during army service have been recorded in a central computerized database.

The study sample included all 897,611 soldiers in active military service between January 1, 2002, and April 2, 2015 (Fig 1). We excluded soldiers serving beyond the regular compulsory period (such as career army soldiers) (n = 224,892) and soldiers with missing weight or height data (n = 2346). To avoid misclassification, we also excluded soldiers who served for a shorter time (n = 69,969), defined as less than 1 year for females and 2 years for males. The final study sample included 600,404 compulsory-service soldiers, of whom 299,163 were male (49.9%) and 301,241 were female (50.1%). Of note, severe acne does not disqualify examinees, whereas individuals with extreme BMI values (>42 or <15 kg/m^2) are exempted from service.

The computerized medical records of all study participants were searched to identify those with a documented diagnosis of acne made by a board-certified dermatologist (*International Classification of Diseases, Ninth Revision*, code 706.1X). The Israel Defense Forces (IDF) institutional review board approved the study on the basis of strict maintenance of participants' anonymity.

Study variables

BMI (individuals' weight in kilograms divided by the square of their height in meters) was calculated by using the weight (rounded to 0.1 kg) and height (rounded to 0.5 cm) measurements made at the pre-enlistment medical examination. In all cases, a beam balance and stadiometer were used, with participants barefoot and wearing underwear. Data were collected for each participant by review of the computerized IDF records as follows: date of birth, age at medical assessment, date of recruitment and date of discharge from service, sex, place of origin (defined by the father's country of birth, and if Israeli-born, by the birthplace of the paternal grandfather), place of birth, years of schooling, and residential socioeconomic status.

Statistical analysis

We expected that adolescents in our study would have completed at least 98.5% of their growth[15]; thus, absolute BMI measures were used as categoric and continuous variables, as appropriate. BMI values were grouped according to the World Health Organization[16] definitions as follows (in kg/m^2): less than 18.5 (underweight), 18.5 to 21.99 (reference group), 22 to 24.99, 25 to 27.49 (overweight), 27.5 to 29.99, 30 to 32.49 (obese), 32.5 to 34.99, and 35 or more (severely obese). Given that the length of obligatory service for males is 1 year longer than for females and adolescent acne is more prevalent among males, the analysis was stratified by sex.[17]

To analyze the association between BMI group and acne, odds ratios (ORs) and their 2-sided 95% confidence intervals (CIs) were calculated by using a logistic regression model. Two models were applied: unadjusted and multivariable adjusted for year of birth, place of origin, country of birth, education, height, and socioeconomic status. We included variables in the multivariable models only if they were associated with acne.

Several sensitivity analyses were performed. We conducted a sensitivity analysis limited to participants who began military service from 2010 onward (the last 5 years of the study period) and to participants who had completed full military service (males who served ≥34 months and females who served ≥22 months) to minimize time-period and attrition bias, respectively. We also stratified the

Abbreviations used:

aOR: adjusted odds ratio
BMI: body mass index
IDF: Israel Defense Forces
OR: odds ratio

analysis by place of birth and by place of origin to determine whether the association between BMI and acne was birthplace and/or ethnicity dependent. Data analysis was performed by using SPSS software (version 24.0, IBM, Armonk, NY).

RESULTS

Study population

Table I summarizes the characteristics of the study participants. Between 2002 and 2015, acne was diagnosed in 55,842 males (18.7%) and 48,969 females (16.3%). The mean age at recruitment was similar for males and females with and without acne (for males, 18.8 years [standard deviation, 0.9 years] vs 18.9 years [standard deviation, 0.6 years]; for females, 18.6 years [standard deviation, 0.5 years] vs 18. years [standard deviation, 0.5 years], respectively). Most of the participants completed full military service (>88%), were born in Israel (>82%), and completed high school (>95%). There was substantial heterogeneity in place of origin. Only a minority of participants (<5%) were of low socioeconomic class. In all, 41,659 males (13.9%) and 37,881 females (12.6%) were overweight, and 15,210 males (5.1%) and 12,997 females (4.3%) were obese or severely obese.

Proportions and ORs of acne according to BMI

The proportions and ORs of acne according to BMI group are shown in Table II. There was a graded decrease in the proportion of participants with acne, commencing in males from the underweight group (19.9%) to the severely obese (13.9%) group and in females from the low-normal group (16.9%) to the severely obese group (11.3%). Calculation of the unadjusted ORs confirmed these findings. The findings of the multivariable analysis (Fig 2) were only minimally different from those of the unadjusted analysis, showing a gradual decrease in adjusted ORs (aORs) of acne from the high-normal ($22 \leq$ BMI ≤ 25 kg/m^2) range (aOR_{males}, 0.92 [95% CI, 0.89-0.94]; $aOR_{females}$, 0.97 [95% CI, 0.95-1.00]) to the severely obese range (aOR_{men}, 0.53 [95% CI, 0.42-0.64]; $aOR_{females}$, 0.50 [95% CI, 0.37-0.62]). Odds estimates were significantly lower among obese participants than among overweight participants (aOR_{males}, 0.65 [95% CI, 0.58-0.71] vs. 0.77 [95% CI, 0.74-0.81]; $aOR_{females}$, 0.62 [95% CI, 0.54-0.70] vs. 0.88 [95% CI, 0.84-0.92]). For each 1-unit increase in BMI above the underweight range (>18.5 kg/m^2), the aOR of acne decreased by 3.2% (95% CI, 2.9%-3.5%) in males and by 2.6% (95% CI, 2.3%-3%) in females.

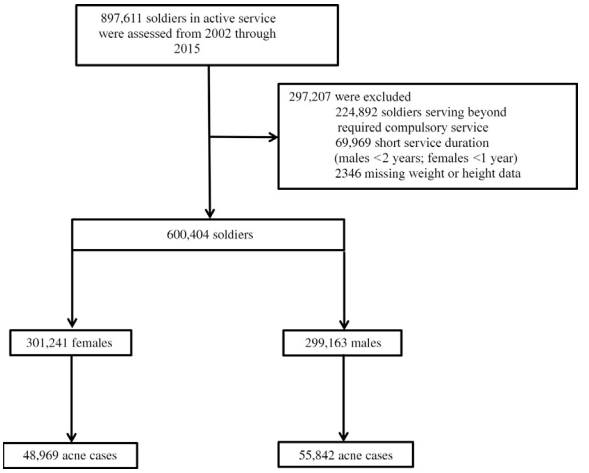

Fig 1. Study design. Body mass index was calculated from the weight and height values determined at the pre-enrollment medical examination when participants were 17 years of age. The occupational database of the Israel Defense Forces was searched to identify compulsory-service soldiers (mean age of the males at enrollment, 18.9 years [standard deviation, 0.6 years]; mean age of the females, 18.7 years [standard deviation, 0.5 years]) with a diagnosis of acne documented by a board-certified dermatologist (*International Classification of Diseases, Ninth Revision,* code 706.IX).

Sensitivity analyses

Lower aORs of acne persisted among participants with overweight and obesity when the cohort was stratified by origin (Table III) or by country of birth (data not shown). Limiting the analysis to participants who were recruited in the last 5 years of the study (data not shown) or to participants who completed the full duration of military service (data not shown) did not materially change the results.

DISCUSSION

The present nationwide study of military recruits representative of the Israeli young adult population sought to assess the association between BMI and acne. The results revealed a strong, inverse, and dose-dependent relationship. In participants of both sexes with a BMI within the overweight, obese, and severely obese ranges, the aORs for acne was decreased by 20%, 35%, and 50%, respectively, relative to those of participants with a low-normal BMI. For each 1-unit increase in BMI, the adjusted odds of acne decreased by 3.2% (95% CI, 2.9%-3.5%)

Table I. Characteristics of male and female participants with acne and their respective controls

Characteristics	Males			Females		
	Acne	Controls	*P* value*	Acne	Controls	*P* value*
Total, n (%)	55,842 (18.7)	243,321 (81.3)		48,969 (16.3)	252,272 (83.7)	
Mean age at recruitment, y (SD)	18.8 (0.9)	18.9 (0.6)	<.001	18.6 (0.5)	18.7 (0.5)	<.001
Full service, n (%)†	51,416 (92.1)	216,215 (88.9)	<.001	46,192 (94.2)	229,037 (90.7)	<.001
Born in Israel, n (%)	46,658 (83.6)	201,461 (82.8)	<.001	40,842 (83.4)	209,789 (83.2)	<.001
Place of origin, n (%)‡						
Israel	5475 (10.9)	22,950 (10.7)	<.001	3341 (8.0)	18,044 (8.7)	<.001
Africa	10,221 (20.4)	47,962 (22.3)	<.001	10,082 (24.2)	46,458 (22.4)	<.001
Western	12,798 (25.6)	51,199 (23.8)	<.001	9042 (21.7)	51,080 (24.6)	<.001
Asia	10,277 (20.4)	45,959 (21.3)	<.001	9644 (23.1)	44,096 (21.2)	<.001
Former USSR	10,002 (20)	40,735 (18.9)	<.001	8687 (20.8)	42,278 (20.4)	<.001
Ethiopia	999 (2)	5610 (2.6)	<.001	657 (1.6)	4472 (2.2)	<.001
Other	273 (0.5)	1064 (0.5)	.14	264 (0.6)	1233 (0.6)	.35
Education ≥12 y, n (%)	53,755 (96.3)	232,259 (95.5)	<.001	48,351 (98.8)	248,203 (98.4)	<.001
Low socioeconomic status, n (%)§	1875 (3.4)	10368 (4.2)	<.001	709 (1.5)	3120 (1.2)	<.001
Mean height, cm (SD)	174.6 (6.7)	174.2 (6.8)	<.001	162.2 (6.2)	162.1 (6.2)	<.001
Mean BMI, kg/m^2 (SD)	21.5 (3.6)	21.9 (4)	<.001	21.3 (3.6)	21.5 (3.9)	<.001
BMI categories, n (%)						
Underweight	10,117 (18.1)	40,602 (16.7)	<.001	9717 (19.8)	50,050 (19.8)	<.001
Normal weight	36,794 (65.9)	154,781 (63.6)	<.001	31,902 (65.1)	158,694 (62.9)	<.001
Overweight	6833 (12.2)	34,826 (14.2)	<.001	5743 (11.7)	32,138 (12.7)	<.001
Obese	1648 (2.9)	10,116 (4.1)	<.001	1257 (2.6)	8646 (3.4)	<.001
Severely obese	450 (0.8)	2996 (1.2)	<.001	350 (0.7)	2744 (1.1)	<.001

BMI, Body mass index (calculated as weight in kilograms divided by height in meters squared); *SD*, standard deviation; *USSR*, Union of Soviet Socialist Republics.
*Comparisons by the chi-square test for binary variables or by the Student *t* test for continuous variables.
†Full service refers to males and females who completed at least 34 and 22 months of service, respectively.
‡Defined by father's country of birth, and if Israeli-born, by the birthplace of the paternal grandfather.
§According to place of residence.

Table II. Proportions and ORs of acne according to BMI among males and females

BMI, kg/m^2	Males			Females		
	Acne, n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*	Acne, n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)*
<18.5	10,117 (19.95)	1.03 (1-1.05)	1.03 (0.98-1.05)	9717 (16.20)	0.96 (0.93-0.98)†	0.94 (0.90-0.96)†
18.5-22	23,040 (19.70)	1 (reference)	1 (reference)	20,264 (16.85)	1 (reference)	1 (reference)
22-25	13,754 (18.43)	0.92 (0.9-0.95)†	0.92 (0.89-0.94)†	11,638 (16.54)	0.98 (0.95-1.00)	0.97 (0.95-1.00)
25-27.5	5104 (16.46)	0.8 (0.77-0.82)†	0.77 (0.74-0.81)†	4460 (15.61)	0.91 (0.88-0.95)†	0.88 (0.84-0.92)†
27.5-30	1729 (16.22)	0.79 (0.74-0.83)†	0.76 (0.70-0.82)†	1283 (13.78)	0.79 (0.74-0.84)†	0.75 (0.68-0.82)†
30-32.5	1249 (14.36)	0.7 (0.66-0.75)†	0.65 (0.58-0.71)†	941 (12.78)	0.72 (0.67-0.77)†	0.62 (0.54-0.70)†
32.5-35	399 (13.00)	0.63 (0.56-0.7)†	0.53 (0.42-0.65)†	316 (12.44)	0.7 (0.63-0.79)†	0.63 (0.50-0.76)†
>35	450 (13.29)	0.62 (0.56-0.7)†	0.53 (0.42-0.64)†	350 (11.31)	0.63 (0.56-0.70)†	0.5 (0.37-0.62)†

BMI, Body mass index (calculated as weight in kilograms divided by height in meters squared); *CI*, confidence interval; *OR*, odds ratio.
*Adjustment to variables in the multivariable model (year of birth, socioeconomic status, place of origin, place of birth, education, and height).
†Significant confidence intervals.

in males and 2.6% (95% CI, 2.3%-3%) in females. These findings held true in sensitivity analyses that accounted for time period, ethnicity, and attrition bias.

Approximately 17% of the study participants received a dermatologist-based diagnosis of acne during army service. It is arguable that mainly soldiers with moderate- to-severe acne were included in the study, as patients with mild acne are usually not referred to a dermatologist. Accordingly, our findings concur with the reported prevalence of moderate-to-severe acne among

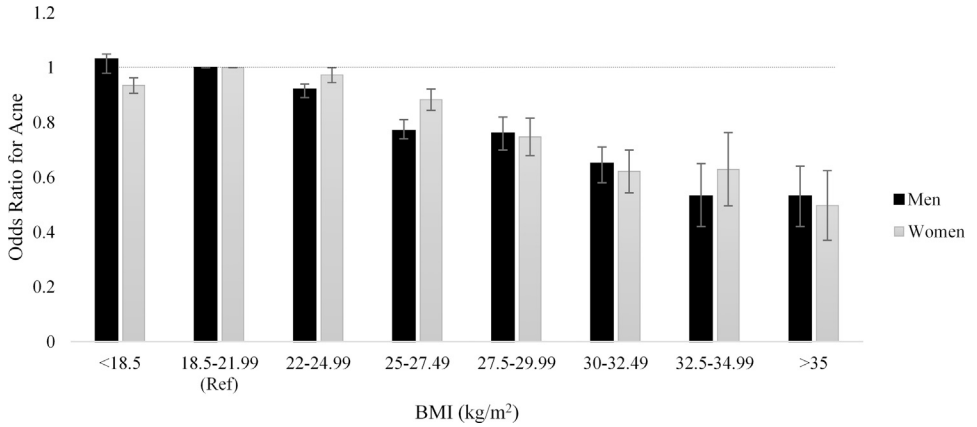

Fig 2. Multivariable logistic regression analyses for the association between body mass index (BMI) and acne in males and females. Adjustment to variables in the multivariable model (year of birth, socioeconomic status, place of origin, place of birth, education, and height).

Table III. The association between BMI and acne stratified by place of origin (adjusted odds ratio for each 1-unit increase in BMI)

	Males			Females		
Origin	**Acne, n (%)**	**Adjusted OR (95% CI)***	***P* value**	**Acne, n (%)**	**Adjusted OR (95% CI)***	***P* value**
Western	53,052 (19.7)	−3.1% (−4.5% to −1.7%)	.0001	48,324 (15.1)	−1.5% (−3.2% to 0.2%)	.079
Africa	48,545 (17.2)	−1.9% (−3.4% to −0.5%)	.007	45,856 (17.7)	−1.6% (−3.2% to 0.0%)	.049
Asia	45,072 (18.2)	−2.0% (−3.6% to −0.4%)	.012	41,570 (18.1)	−2.4% (−4.2% to −0.6%)	.01
Former USSR	41,847 (19.5)	−2.8% (−4.4% to −1.3%)	.0001	39,515 (17.2)	−2.4% (−4.7% to −0.2%)	.032

BMI, Body mass index; *CI*, confidence interval; *OR*, odds ratio; *USSR*, Union of Soviet Socialist Republics.
*Adjustment to variables in the multivariable model (year of birth, socioeconomic status, place of origin, place of birth, education, and height).

young people. A Norwegian study of 2467 students aged 18-19 years found that approximately 14% had moderate-to-severe acne.[18] In a Chinese study that included 389 young adults, 23% of subjects had a diagnosis of moderate, severe, or very severe acne.[19] The obesity rates in our study (5.1% in males and 4.3% in females) also concur with the global prevalence of obesity in late adolescence in developed countries.[7,11,12]

Owing to the cross-sectional study design, we could not infer a causal relationship between BMI and acne. It is possible that the protective effect of excessive BMI against acne is attributed to the increase in aromatase activity and peripheral conversion of androgens to estrogens induced by excessive adipose tissue.[20] Although the exact mechanism is unclear, estrogens are known to decrease sebum production and to oppose androgens' effects on the sebaceous glans, thus possessing a protective role against acne.[21,22] Obesity and intra-abdominal fat were shown to negatively correlate with total testosterone concentration and to positively correlate with estradiol level.[23,24] Others reported that obesity suppressed the activity of 5-α reductase-II, which converts testosterone to the more physiologically active dihydrotestosterone.[25,26] In contrast, other mechanisms were suggested to promote acne by adipose tissue such as adipokine-driven inflammation.[27] Although the net outcome of these contrasting effects has yet to be determined, our findings suggest that there is an inclination toward a protective effect of adiposity. It is noteworthy that underweight females but not underweight males had a slightly decreased aOR of acne. The explanation for this sex-related divergence is unclear; it may be attributable to lean body weight and sex hormones and to their effect on acne.[28,29]

Given that data on the exact time of acne onset and the duration of obesity were unavailable, a reverse causality should also be considered. For instance, weight gain is a side effect of oral contraceptives.[30] Thus, the decreased acne rates found among overweight and obese females might be, at least partially, attributable to treatment of acne with oral contraceptives.

Previous studies of the association between BMI and acne were generally limited by a small sample size and a methodology based on self-diagnosis of

acne. In accordance with our findings, in 2 studies from Taiwan, obese females had a lower incidence of acne.[14,31] However, other studies found either no association between acne and BMI values or a greater prevalence of acne among overweight and obese subjects.[5,13,32-34] The main strengths of our study include a dermatologist-based diagnosis of acne, large sample size allowing us to dissect the entire BMI range in both males and females, and systematic measurement and collection of the study variables.

Our study has several limitations. First, we were unable to account for potential confounders of the BMI-acne association, including previous acne treatments, treatment with acnegenic drugs, oral contraceptive use, and diet.[5] Concerning the latter, compelling evidence implicating Western and high−glycemic load/high−glycemic index diets, as well as consumption of dairy, in the exacerbation of acne has been reported in recent decades.[5,35] Nonetheless, the association between excessive BMI and acne persisted across different ethnic groups with various dietary practices, and our study was conducted in the military setting, where uniform food products were available to the participants. Additionally, we were unable to account for polycystic ovary syndrome, which is associated with acne and obesity and affects between 4% and 18% of reproductive-age women.[36] However, the association between acne and BMI was evident along the entire BMI range in males and females, whereas polycystic ovary syndrome would probably predominantly affect women with a higher BMI. Second, as noted, data concerning acne severity were unavailable. Third, the differentiation between acne and other skin disorders (such as folliculitis) by primary care physicians may be suboptimal. We therefore included only participants whose acne was diagnosed by a board-certified dermatologist (following referral by a primary care physician). It may therefore be argued that our findings could reflect a tendency of decreased referral of obese participants to dermatologists. However, an earlier study conducted in the same setting reported increased referrals of IDF recruits with a high BMI to specialists,[37] making referral bias an unlikely contributor to our results. Last, we lacked clinical data on the number of participants who were exempted from compulsory service because of extreme BMI values. This, however, cannot account for the association between acne and BMI that was already evident well within the normal BMI range.

In conclusion, this study provides evidence that in young adults, overweight and obesity are inversely associated with acne in a dose-dependent manner, implying that metabolically active adipose tissue plays a protective role in acne. Further studies including important variables in the obesity-acne relationship are needed to validate our findings.

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