Risk Factors for Overweight and Obesity in Young Healthy Adults During Compulsory Military Service

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Abstract

Background: In view of the rising prevalence of obesity, the identification of young adult populations at risk is important for the formulation of intervention and prevention programs.

Objectives: To assess demographic and behavioral factors associated with an increase in body mass index in young healthy adults and to identify the incidence of overweight/obesity in this population.

Methods: Data on anthropometric measures, demographic characteristics, and health behaviors were collected retrospectively for a representative sample of young Israeli adults (11,391 men, 11,280 women) on their release from military service (age 20–22 years) between 1989 and 2003. The incidence of overweight (BMI < 25-< 30 kg/m^2), incidence of obesity (BMI ≥ 30 kg/m^2), and increase in BMI during military service were calculated.

Results: The average increase in BMI during military service was 1.11 kg/m^2 in males and 1.08 kg/m^2 in females. A greater increase was positively associated with low paternal education and smoking cessation, and negatively associated with high physical activity. Twelve percent of subjects with a normal BMI on recruitment became overweight, and 21.7% of overweight subjects became obese. On multivariate logistic regression analysis, a higher incidence of overweight was associated with low education level (in both the subject and his or her father) in both genders, and non-use of oral contraceptives and low level of physical activity in females.

Conclusions: BMI appears to increase significantly during early adulthood. Intervention programs should be targeted specifically at subjects with low education or who started smoking before age 18, and physical activity (especially among females) should be encouraged.

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According to several studies, the prevalence of obesity has increased worldwide during the last four decades [1-6]. Such a rise over a relatively short period may reflect changes in the lifestyle of the population [3]. In Israel, obesity rates increase with age, reaching 22.4% and 40.4% in males and females aged 55–64, respectively [5]. Adult obesity has been described by the World Health Organization as one of the most blatantly visible public health problems – yet the most neglected – that threatens to overwhelm both more and less developed countries [5]. Obesity is a major cause of morbidity and mortality and impairs quality of life [8-10]. It also places a burden on health facilities: Overall, the direct costs of obesity and physical inactivity account for approximately 9.4% of all health care expenditures in the United States [10].

Previous studies have addressed the predictive roles of (adolescent) age at onset of obesity and parental obesity on long-term obesity in adulthood [12]. Yarnell and co-workers [13] found that obesity at age 18 predicts subsequent 14 year mortality and coronary events. However, data on factors associated with becoming overweight or obese during early adulthood remain sparse.

The aim of the present study was to assess the demographic and behavioral risk factors associated with an increase in body mass index in healthy young adults and the incidence of overweight and obesity in this population. The data were derived from a large-scale survey of a representative sample of Israeli men and women at discharge from military service. These findings could serve as a basis for planning an appropriate prevention program in this age group.

Subjects and Methods

Induction into military service is compulsory in Israel for both men and women at age 18. Our study sample was drawn from a unique ongoing survey of Israel Defense Forces personnel designed to provide population-based data and prevalence estimates of health-related factors in young adults. The data are collected at discharge from compulsory military service, usually at age 20–21 for women and 21–22 for men, from a representative sample of subjects. The systematic sampling process is based on a predetermined combination of digits of the subjects' military serial number, as previously described [12]. Of those approached to participate in the survey, 91% agreed and provided signed informed consent. The survey was approved by the Medical Corps Review Board of the Israel Defense Forces. The present study comprised 22,671 subjects (11,391 males and

BMI = body mass index

11,289 females) surveyed over 15 years, from January 1989 to December 2003.

Data collection

Trained nurses from the Health Surveillance Section of the Israel Defense Forces interviewed the participants with a structured questionnaire covering demographic data (subjects' country of birth and years of formal education, paternal country of birth and education, and subjects' number of siblings) and health-related behaviors (smoking, use of oral contraceptives among females, and level of physical activity). Subjects were also asked to report their current weight and their weight on recruitment. Weight and height at discharge were measured with a weight and standing height scale (Sunbeam Products, Inc., Bridgeview, IL, USA) after removal of outer garments and shoes.

Data analysis

BMI was calculated as weight in kilograms divided by height in meters squared. The discharge BMI was based on the measured weight and height at discharge; the recruitment BMI was based on the reported weight at recruitment and measured height at discharge. Normal weight was defined as a BMI of 18.5–24.99 kg/m^2; overweight as BMI of 25–29.99 kg/m^2; and obesity as BMI of 30 kg/m^2 or higher [15,16]. Ethnic origin was defined according to the birthplace of the subject's father or, if the father was born in Israel, the paternal grandfather, and categorized as follows – western: Europe (excluding Turkey), the Americas, Australia, or South Africa; eastern: Asia, Turkey, North Africa, or Ethiopia; or Israeli (both father and paternal grandfather born in Israel). Additional demographic and behavioral variables included the subject's number of siblings (≤ 2 or > 2), extent of subject's schooling (< 12 years, 12 years, or > 12 years), paternal schooling (< 12 years, 12 years, or > 12 years), subject's cigarette use (non-smoker, current smoker who started before recruitment, current smoker who started after recruitment, or ex-smoker), and use of oral contraceptives (in females) (non-user, user who started before recruitment, and user who started after recruitment). Since compulsory physical activities differ among the various military units, we referred to the subjects' weekly physical activity level as follows – low: less than one routine aerobic activity session per week; medium: one to three routine aerobic activity sessions per week; and high: four or more routine aerobic activity sessions per week.

Statistical analysis

All analyses were performed with gender stratification. Mean differences in BMI between recruitment and discharge were calculated and compared according to the categories of demographic and behavioral variables using the *t*-test (for two categories) or one-way analysis of variance (ANOVA) between groups (for three or more categories). ANOVA models (experimental method) were applied to compare means of BMI within categories after adjusting for ethnic origin, father's and subject's years of schooling, number of siblings, smoking status, physical activity, and use of oral contraceptives. In addition, we calculated the incidence of overweight at discharge in subjects with a normal BMI at recruitment, and of obesity at discharge in subjects with a normal BMI at recruitment and subjects who were overweight at recruitment. Comparisons within categories of demographic and behavioral variables were performed with χ^2 tests. Multivariate analyses of the risk for overweight and obesity were performed with stepwise forward logistic models, with becoming overweight or obese as the dependent variable (yes or no) and origin, father's and subject's years of schooling, smoking status, physical activity, and use of oral contraceptives (in women) as the independent variables. All possible interactions among the dependent variables were assessed in the ANOVA models, and between smoking and physical activity in the logistic models. To estimate the possible bias of basing the recruitment BMI on self-reported weight, we examined the correlation of reported weight at discharge to measured weight at discharge, with and without controlling for the demographic and behavioral variables. All statistical analyses were performed using SPSS™ software, version 12.0 (SPSS Inc., Chicago, Il).

Results

The characteristics of the study participants are presented in Table 1. Among the male subjects, the prevalence of overweight was 11.9% at recruitment and 19.3% at discharge, and the prevalence of obesity was 2.0% at recruitment and 3.9% at discharge. Among the female subjects, the prevalence of overweight was 7.4% at recruitment and 12.0% at discharge, and of obesity, 1.4% and 2.4%, respectively [Table 1].

The average increase in BMI during military service was 1.11 kg/m^2 in males and 1.08 kg/m^2 in females. The mean differences in BMI between discharge and recruitment by demographic and behavioral variables are presented in Table 2. The differences were significantly greater in subjects with a lower paternal education ($P = 0.005$ for males and $P = 0.007$ for females) and a lower level of physical activity ($P = 0.001$ for males and females). Within the category of smoking status, the difference in BMI was greatest among ex-smokers (1.40 kg/m^2 for males, $P < 0.001$; 1.37 kg/m^2 for females, $P = 0.02$) and lowest among subjects who started smoking before their recruitment (0.98 kg/m^2 for males, and 0.96 kg/m^2 for females; both non-significant). The same differences with a high level of statistical significance were observed after adjustment for demographic and behavioral variables. None of the interactions between the dependent variables was statistically significant.

The incidence of overweight at discharge among participants who had a normal BMI at recruitment is presented in Table 3. Differences in the risk of becoming overweight were statistically significant for both sexes within the categories of the father's years of schooling and smoking status, and for females, within the categories of oral contraceptive use and physical activity. The risk was highest in subjects whose father had the lowest level of education (16.0% in males, 12.1% in females), smokers who started smoking after recruitment (18.0% in males, 11.7% in females), males who had less than 12 years of education (14.0%), and females who did not use oral contraceptives (11.7%). The risk was lowest in females with a high level of physical activity (7.3%, vs. 9.75 in females with a moderate level of activity and 10.6% in females with a low level). These differences remained statistically significant on multivariate logistic regression analysis [Table 4], where low level of paternal education (in both genders), smoking that started after recruitment (in males), and low level of physical activity and non-use of contraceptives (in females) were all associated with a high risk of becoming overweight. Among males, the Nagelkerke R^2 for smoking was found to be 0.004. Adding father's years of schooling to the model increased the R^2 to 0.006. Further addition of other variables did not affect the R^2. Among females, the Nagelkerke R^2 for oral contraceptive usage was found to be 0.007. Adding physical activity to the model increased R^2 to 0.012, while adding origin, father's and subject's years of schooling increased the R^2 to 0.019. Further addition of other variables did not affect the R^2. A statistically significant correlation was observed between the father's and subject's level of education and oral contraceptive use ($R = 0.046$, $P < 0.001$). However, these correlations were minor and therefore these

Table 1. Characteristics of study participants

Variable	Males (N=11,391) N	Males %	Females (N=11,280) N	Females %
Origin	**9944**	**100.0**	**10,309**	**100.0**
Israel	689	6.9	589	5.7
West	4449	44.7	4690	45.5
East	4806	48.3	5030	48.8
Father's schooling (yrs)	**10,037**	**100.0**	**10,556**	**100.0**
< 12	3197	31.9	3182	30.1
12	3738	37.2	4281	40.6
> 12	3102	30.9	3093	29.3
Subject's schooling (yrs)	**11,357**	**100.0**	**11,261**	**100.0**
< 12	1536	13.5	381	3.4
≥ 12	9821	86.5	10,880	96.6
No. of siblings	**11,379**	**100.0**	**11,261**	**100.0**
≤ 2	6407	56.3	6876	61.1
> 2	4972	43.7	4385	38.9
Smoking status	**11,333**	**100.0**	**11,205**	**100.0**
Non-smoker	6614	58.4	7731	69.0
Smoker, started before recruitment	3308	29.2	2413	21.5
Smoker, started after recruitment	913	8.1	739	6.6
Ex-smoker	498	4.4	322	2.9
Oral contraceptive usage	**–**	**–**	**11,068**	**100.0**
Non-user	–	–	4508	40.7
User, started before recruitment	–	–	3171	28.7
User, started after recruitment	–	–	3389	30.6
Physical activity level*	**10,680**	**100.0**	**10,604**	**100.0**
Low	3854	36.1	5408	51.0
Medium	3028	28.4	3278	30.9
High	3798	35.6	1918	18.1
Weight and BMI**				
At recruitment				
Overweight	1358	11.9	836	7.4
Obese	223	2.0	153	1.4
At discharge				
Overweight	2197	19.3	1356	12.0
Obese	446	3.9	275	2.4
Mean values (± SD)				
Weight on recruitment (kg)	68.9 ± 10.8		55.7 ± 8.5	
Weight on discharge (kg)	72.4 ± 11.6		58.5 ± 9.3	
BMI on recruitment (kg/m^2)	22.1 ± 3.0		20.9 ± 2.9	
BMI on discharge (kg/m^2)	23.2 ± 3.2		22.0 ± 3.2	

* Defined by number of weekly routine aerobic activity sessions, from 1 (low) to 4 (high)

** BMI: overweight 25–29.99 kg/m^2, obese ≥ 30 kg/m^2

Table 2. Mean difference in BMI between recruitment and discharge, according to demographic and behavioral variables

Variable	Males Unadjusted BMI difference (kg/m^2)	Males Unadjusted P**	Males Adjusted BMI difference (kg/m^2)	Males Adjusted P***	Females Unadjusted BMI difference (kg/m^2)	Females Unadjusted P**	Females Adjusted BMI difference (kg/m^2)	Females Adjusted P***
Origin								
Israel	1.25	0.103	1.20	0.210	1.08	0.132	1.08	0.132
West	1.09		1.07		1.03		1.03	
East	1.09		1.05		1.06		1.06	
Father's schooling (yrs)								
<12	1.19	0.005	1.19	0.014	1.07	0.007	1.07	0.007
12	1.11		1.12		1.09		1.09	
>12	1.03		1.02		0.96		0.96	
Subject's schooling (yrs)								
<12	1.08	0.660	1.09	0.568	1.01	0.726	1.01	0.726
≥12	1.11		1.13		1.05		1.05	
No. of siblings								
≤2	1.08	0.090	1.08	0.176	1.05	0.743	1.05	0.743
>2	1.14		1.14		1.04		1.04	
Smoking status								
Non-smoker	1.14	< 0.001	1.17	< 0.001	1.07	0.020	1.09	0.001
Smoker, started before recruitment	0.98		0.97		0.96		0.94	
Smoker, started after recruitment	1.17		1.28		1.08		1.11	
Ex-smoker	1.40		1.39		1.37		1.34	
OC usage								
Non-user	–	–	–	–	1.08	0.295	1.08	0.123
User, started before recruitment	–	–	–	–	1.03		1.03	
User, started after recruitment	–	–	–	–	1.03		1.03	
Physical activity level								
Low	1.20	0.001	1.18	< 0.001	1.15	0.001	1.15	0.001
Medium	1.10		1.07		1.05		1.05	
High	1.04		0.98		0.90		0.90	

* Adjusted for origin, father's and subject's years of schooling, smoking status, physical activity level and use of oral contraceptives (in females).

** *P* values were calculated using *t*-test (for two categories) or ANOVA (for three or more categories)

*** *P* values were calculated using ANOVA model (expserimantal method)

Table 3. Risk of becoming overweight (BMI 25–29.99 kg/m^2) in subjects with a normal BMI (18–25 kg/m^2) at recruitment by demographic and behavioral variables

	Males			Females			Total		
	Normal weight at recruitment (N)	Became overweight (%)	*P**	Normal weight at recruitment (N)	Became overweight (%)	*P**	Normal weight at recruitment (N)	Became overweight (%)	*P**
Total	9060	14.4	–	8776	9.5	–	17836	12.0	––
Origin									
Israel	529	16.8	0.169	461	9.3	0.869	990	13.3	0.239
West	3543	14.8		3680	9.7		7223	12.2	
East	3837	13.9		3867	9.4		7704	11.6	
Father's schooling (yrs)									
< 12	2536	16.0	0.014	2484	12.1	< 0.001	5020	14.1	< 0.001
12	2971	14.2		3319	8.8		6290	11.3	
>1 2	2506	13.2		2451	8.0		4957	10.7	
Subject's schooling (yrs)									
< 12	1199	13.9	0.645	285	14.0	0.007	1484	13.9	0.013
≥ 12	7838	14.4		8480	9.3		16318	11.8	
No. of siblings									
≤ 2	5098	14.1	0.383	5389	9.1	0.153	10487	11.5	0.035
> 2	3952	14.8		3370	10.0		7322	12.6	
Smoking status									
Non-smoker	5322	14.4	0.008	6041	8.9	0.050	11363	11.5	0.001
Smoker, started before recruitment	2601	13.1		1858	10.5		4459	12.0	
Smoker, started after recruitment	696	18.0		565	11.7		1261	15.1	
Ex-smoker	396	16.4		258	8.9		654	13.5	
Oral contraceptive usage									
Non-user				3350	11.7	< 0.001	3350	11.7	<0.001
User, started before recruitment				2547	8.0		2547	8.0	
User, started after recruitment				2708	8.2		2708	8.2	
Physical activity level									
Low	2989	15.0	0.243	4151	10.6	0.001	7140	12.5	0.368
Medium	2428	15.2		2573	9.7		5001	12.4	
High	3100	13.7		1539	7.3		4639	11.6	

* *P* values were calculated using the χ^2 test

variables were not excluded from the logistic regression model. The interaction between smoking and physical activity was not statistically significant and was not included in the model.

Overall, 12% of participants with a normal BMI on recruitment became overweight by the time of discharge. The rate of obesity at discharge was 0.3% among subjects whose BMI was normal before recruitment and 21.7% among those who were overweight at recruitment. Subjects at risk were males who reported a low level of physical activity (26.8% vs. 19.2% among those with moderate physical activity and 18.7% among those with high physical activity, $P = 0.014$). No statistically significant differences in the risk of becoming obese were observed in these two groups by ethnic origin, subject's level of education, smoking status, or oral contraceptive use. None of the statistically significant differences identified by category remained significant in the logistic regression model.

There was a strong correlation between the reported and measured weight at discharge ($R = 0.956$ for males and 0.955 for females). The strength of the correlation was not affected by ethnic origin, father's or subject's years of schooling, number of siblings, smoking status, physical activity, or use of oral contraceptives (in females) (adjusted $R = 0.954$ for males and 0.953 for females).

Discussion

Our survey of a large population-based sample of young Israeli adults after military service demonstrated that among those with a normal BMI at age 18 years, 12% were overweight at age 20–22 years and 0.3% were obese. Furthermore, 21.7% of the participants who were overweight at recruitment had become obese at the time of discharge.

Late adolescence/early adulthood is the pivotal time for determining the development of chronic overweight or obesity later in adulthood. The potential factors affecting excessive weight gain in this age group include genetic traits, demographic characteristics, and lifestyle and nutritional habits.

Our study did not demonstrate a significant effect of ethnic origin on the development of overweight and obesity, in contrast to the study by Freedman et al. [17] where racial differences proved significant in tracking changes in BMI from childhood to adulthood. The lack of an association in our study might be attributable to the vast majority of the study population being Jewish, which may have restricted the genetic variability.

Paternal education, which is a strong marker of socioeconomic status, was shown to be associated with obesity. A similar finding was described by Wang and co-workers [18] in a Chinese population, as well as in additional studies [19-21].

The negative correlation found here between level of physical activity and incidence of overweight is in accordance with other

Table 4. Multivariate analysis* of the risk of becoming overweight by demographic and behavioral variables

	Males			Females		
	OR	95% CI	P	OR	95% CI	P
Origin						
Israel	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
West	0.94	0.72-1.24	0.681	1.11	0.78-1.57	0.575
East	0.81	0.62-1.07	0.138	0.91	0.64-1.29	0.595
Father's schooling (yrs)						
< 12	Ref	Ref	Ref	Ref	Ref	Ref
12	0.90	0.77-1.06	0.212	0.76	0.63-0.92	0.004
> 12	0.81	0.68-0.96	0.014	0.72	0.59-0.89	0.002
Subject's schooling (yrs)						
< 12	Ref	Ref	Ref	Ref	Ref	Ref
≥ 12	1.10	0.86–1.41	0.443	0.63	0.42–0.94	0.025
No. of siblings						
≤ 2	Ref	Ref	Ref	Ref	Ref	Ref
> 2	1.10	0.95–1.27	0.216	1.11	0.93–1.32	0.236
Smoking status						
Non-smoker	Ref	Ref	Ref	Ref	Ref	Ref
Smoker, started before recruitment	0.91	0.77–1.07	0.367	1.14	0.94–1.38	0.180
Smoker, started after recruitment	1.55	1.23–1.95	< 0.001	1.23	0.91–1.66	0.185
Ex-smoker	1.08	0.78–1.50	0.622	0.94	0.59–1.51	0.803
Oral contraceptive usage						
Non-user				Ref	Ref	Ref
User, started before recruitment				0.69	0.57–0.84	< 0.001
User, started after recruitment				0.66	0.55–0.80	< 0.001
Physical activity level						
Low	Ref	Ref	Ref	Ref	Ref	Ref
Medium	1.02	0.86–1.21	0.786	0.97	0.81–1.15	0.727
High	0.92	0.78–1.08	0.302	0.65	0.51–0.82	< 0.001

* The multivariate analysis was performed by a forward, stepwise, logistic regression model

studies as well [19,22]. This is the most important modifiable lifestyle parameter identified in this study, and it is also relevant to the risk of chronic diseases such as diabetes [23]. Smoking cessation is known to be associated with weight gain [24] and was found by us to be an important independent influencing factor on multivariate analysis. More surprising was the negative association between oral contraceptive use and overweight (odds ratio = 0.69 and 0.66 if started before or during military service, respectively). This finding, which proved to be robust on multivariate analysis, has not yet been described and should be studied further. Some of this association may be explained by the correlation between oral contraceptive use and the father's level of education.

The design of the present study on the development of obesity in young adults is noteworthy in several aspects. Owing to the large sample size of over 22,000 we were able to stratify the data by gender and to accurately assess the effect of demographic and behavioral factors on multivariate analysis. We also used BMI, which is considered the preferred measure of adiposity at this age [25], as the outcome variable. Because the Israeli population is ethnically heterogeneous and is comprised largely of immigrants from a multitude of countries and their Israeli-born offspring, we believe that our findings, which were consistent among the ethnic groups, are probably applicable to populations elsewhere.

The first limitation of our study was the use of self-reported weight at recruitment. This limitation is also true for other reports addressing similar issues [3,13,22]. However, the high correlation between the reported and measured weight at discharge, which was not affected on adjustment for the study's independent variables, may rule out any bias. The second limitation is our inclusion only of subjects recruited to the military. This selection bias was minimized by the mandatory nature of military service in Israel (even individuals with non-severe health problems are drafted in non-combat support capacities); nevertheless, specific subgroups of the population (such as Arabs and ultra-Orthodox Jews) are not inducted and were therefore under-represented.

Conclusions

In young adult females, the main factors directly associated with becoming overweight are infrequent exercise, low level of schooling, and low level of the father's schooling; oral contraceptive use is negatively associated with overweight. In young males, the risks include low level of father's schooling and smoking initiation after age 18. Populations characterized by these factors should be targeted for educational campaigns. These findings have important implications for the development and testing of appropriately targeted intervention programs.

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