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# PREVALENCE OF WEIGHT ANOMALIES AMONG ADULTS IN THE EASTERN PROVINCE OF SAUDI ARABIA

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Abstract

*Background: Lifestyle-related weight anomalies, particularly the obesity, have been spreading out rapidly over the past two decades in Saudi Arabia, reaching high records.*

*Objectives: The aim of this primary data analysis was to determine the current prevalence and predict the future trend of such anomalies among the adult population of the largest region in the kingdom: the Eastern Province.*

*Methods: A total of N=1,200 students (825 males, 375 females) aged 19-29, randomly selected from the main universities in the Eastern Province of Saudi Arabia: King Fahd University of Petroleum and Minerals, Prince Mohammad Bin Fahd University, and Imam Abdulrahman Bin Faisal University, were asked to take a survey. The BMI was calculated and the prevalence was determined using the international classification as prescribed by WHO (2004). Chi-Square test was used to examine the significance of the effect of some variables on the BMI.*

*Results: For the sample, the overall prevalence was 16% for obesity, 25% for overweight and 8% for underweight. The figures highly depended on the gender, with an obesity prevalence about 3.5 times higher among males (21%), overweight prevalence about 1.8 times higher among males (29%), and underweight prevalence of about 2.7 times higher among females (13.1%). Several factors were shown to be significantly associated with the BMI. As a result, a multiple linear model involving four variables (gender, age, fat intake and meal-replacement bars) was designed to predict with 95% of confidence, for the entire adult population of the Eastern Province, that by 2020, obesity prevalence will increase to 26.1% (±2.9%) for males from 21% (±2.7%) presently and will go up to 6.3% (±2.5%) for females from 5.9% (±2.4%) currently. As for overweight prevalence, it would remain unchanged 15.7% (±3.7%) for females but rise to 35.9% (±3.2%) from 29% (±3%) now for males. However, female underweight prevalence will go up to 16.3% (±3.7%) from 13.1% (±3.4%) now in less than one year.*

*Conclusion: The results show concerning current and future trends of weight anomalies: obesity and overweight among males and underweight among females. The socio-ecological model is recommended to address this health issue in the Eastern Province of Saudi Arabia.*

**Keywords:** *BMI, Eastern Province, Obesity, Overweight, Prevalence, Saudi Arabia, Underweight.*

## Introduction

Currently, the United States health researchers have estimated that obesity and obesity-related behaviors, including poor dietary practices and physical inactivity, account for approximately 300,000 preventable deaths annually. Many of the health conditions associated with overweight and obesity-related diseases are largely irreversible and, once developed, must be managed for life. In children, those who are overweight suffer from more health-related problems, and they face more health challenges than children who are not overweight [WHO, 2007]. Weight can affect the social, physical, psychological wellbeing of overweight or obese children. The psychological issues may include a feeling of stigmatization, social marginalization, poor self-esteem, low self-worth, and competencies [*Shatoor AS, et al., 2011*].

High body mass index (BMI) has been linked to a number of serious health risks, ranging from car-

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diovascular disease to diabetes. U.S. Department of Health and Human Services finds that 70% of obese children had at least one cardiovascular disease risk factor, and 39% had two or more [*NIDDK, 2012*]. Hospitalization rates from complications of obesity in children and adolescents have tripled. Obese children also have increased risk of impaired glucose tolerance, insulin resistance, and type II diabetes. Moreover, breathing problems such as sleep apnea and asthma are also observable in overweight or obese children, as compared to children who are not overweight or obese. Children who are obese experience bone and joint problems, musculoskeletal discomfort, fatty liver disease, gallstones, and gastro-esophageal reflux (i.e., heartburn). Overweight adolescents have a 70% chance of becoming adults who are overweight or obese. This increases to 80% if one or more parents are overweight or obese. Overweight or obese adults are at risk for a number of health problems including heart disease, type II diabetes, high blood pressure, high cholesterol, and some forms of cancer. The reasons lie in sedentary lifestyle, lack of physical exercise, over-consuming, particularly on fast food and carbonated beverage [*Al-Hazzaa H. M., 2007*].

BMI is a practical measure used to determine overweight and obesity. According to the U.S Center for Disease Control, an overweight child, or teen has a BMI at, or above the 85$^{th}$ percentile, but lower than the 95$^{th}$ percentile [*Wang Y. et al., 2002*]. The percentile indicates the relative position of the child's BMI measurement among children of the same gender and age [*Alqahtani N, et al., 2015*]. In terms of obesity, a child or teen is deemed obese when he or she has a BMI score that is above the 95$^{th}$ percentile. BMI is a measure of the body weight in relation to the height of an individual. It used to determine weight status. Basically, obesity sets in when the total body weight exceeds 32% fat in girls and 25% fat in boys [*Al Othanimeen Al, et al., 2007*]. BMI is the most widely accepted method used to screen for overweight and obesity in children and adolescents. BMI is age and gender-specific for children and teens, and it is a reliable indicator of body fat. However, BMI's pattern is complex [WHO, 2015]. It varies with gender, age, socioeconomic status, ethnicity, geography, and through the passage of time [*Mohsen A. F. El-Hazmi & Arjumand S. Warsy., 2002*]. Although many researchers use the measurement, not all researchers are satisfied with this methodology [*Mohsen A. F et al., 2002*]. Cole et al merged data collected internationally and developed age and gender specific cut-off points [*Cole Tim J et al., 2007*]. Mohsen and Warsy applied this method in their study. [*Mohsen A. F et al., 2002*].

Saudi Arabia is experiencing an epidemiological change, along with demographic transition [*Mahfouz, A. A, et al.,* 2007]. This is demonstrated by a rapidly growing burden of chronic non-communicable diseases, coupled with the population demand and their expectation for the ever-expanding quality health care services. The current health data shows that there has been an alarming increase in the prevalence of chronic diseases, diabetes, and cancer. For example, the prevalence of diabetes among males is 14.7%, among females is 13.8%, obesity among males is 29.5%, and among females is 39.5%. Cardiovascular disease accounts for 46% of the total mortality rate, as opposed to 26% in neighboring Bahrain [*WHO, 2012-2016*].

The rise of obesity in Saudi Arabia is concerning and it stretches across the board. It affects 30% males and 28.4% females Saudis. The incidence rate is high, as demonstrated in several regions within the Kingdom. For example, in Hail, the rate is 33.9%, in Al Sharqiya, it is 27.7%, in Riyadh, it stands at 21.7%, Makkah's number is 19.3%, Jeddah's reads at 16.4%, and Jisan stands 11.7%. As compared to a healthy sample, this adolescents group is 5.5 times more likely to have impaired health-related quality of life. Furthermore, the studies revealed that, in 50% to 77% of the sample group, obesity tends to follow them into their adulthood. Consequently, it increases their risk of developing serious and often life-threatening conditions. Statistics show that this risk will increase to 80% if one parent is obese. Obese children and adolescents, those defined as between the age of 5-18 years, have a significantly lower quality of life than those children with healthy body weight [*Aldaqal, M, S, & Sehlo, M., 2013*]. This research analyzes the current prevalence of weight anomalies among adults in the Eastern Province of Saudi Arabia, which is considered the largest province in the kingdom. As active researchers and university faculty we had an opportunity to collect 1,200 surveys from the leading universities in this region.

## Material and Methods

The analyses were based on 1,200 surveys collected in 2016 from the main universities in the Eastern Province of Saudi Arabia: King Fahd University of Petroleum and Minerals, Prince Mohammad Bin Fahd University, and University of Dammam. The authors developed the surveys in both Arabic and English.

The participants, aged 19-29, were randomly selected among full-time university students from the Eastern Province of the Kingdom. This was a convenient sample consisting of 31% of females and 69% of males. They were asked questions about socio-demographic characteristics, socio-economic status, and lifestyle. The lifestyle questions focused on the level of physical activity and carbohydrate and fat intake. Prior to the survey, the questionnaire was pre-tested by a randomly selected group of students and approved by the institutional review board. All subjects provided a written consent to participate.

The data were analyzed using SPSS 24. The underweight (UW), overweight (OW), and obesity (O) prevalence rates were calculated for the entire sample of 1,200. Prior to the statistical analysis, the BMI was calculated for each student, as the ratio of the weight (in kilograms) to the square of the height (in meters). The results were then converted into the widely known four BMI categories. The conversion was done using the international classification, specifically for adults, as prescribed by the World Health Organization [*WHO, 2004*]. Other variables, such as gender, age, fat intake, consumption level of meal-replacement bars, and time spent on sports physical activities were determined to examine the significance of their effect on the BMI.

According to WHO's standard, anyone with a BMI below 18.5 is considered as underweight. Those who are considered normal have a BMI that ranges 18.5-24.99, and overweight or pre-obese have a BMI measuring 25-29.99. Anyone, who has a BMI beyond 30, falls into the obese category [WHO, 2006].

Finally, it was necessary to apply cross tabulations in order to calculate the proportion of each BMI category across gender, age, and other variables. Odds ratios were determined to evaluate relative risks such as those of UW, OW and O. Chi-Square test was used to examine the significance of the association between BMI categories and these factors. A correlation with a p-value of less than 0.05 was considered as statistically significant. In addition, confidence intervals were calculated to estimate the prevalence of UW, OW and O for the entire adult population in the Eastern Province of Saudi Arabia.

## Results

### Descriptive Characteristics of the Sample

As given in Table 1, the sample was composed of female students (31%) and male students (69%) randomly selected from the main universities in the Eastern Province, KSA. On average, they are about 21 years old; 43% of them are 20 or 21 and 42% are over 21. The average height was 1.60 m for females and 1.74 m for males, and in each side heights were very similar (very small SD). However, this was not the case when it comes to the weight. Indeed, Table 1 shows an average of 57 kg for females with an SD of 12 and 79 kg for males with an SD of 19, which represent respectively 21% and 24% of the corresponding average. This placed female students in normal

**Table 1.**

*Socio-demographic characteristics of 1,200 university Students, Eastern Province, KSA (2016)*

| Characteristics | Categories | N (%) | Average | SD* |
|---|---|---|---|---|
| Gender | Female | 375 (31) | - | - |
| | Male | 825 (69) | | |
| Age (years) | 19 or less | 185 (15) | 21 | 2 |
| | 20 | 206 (17) | | |
| | 21 | 307 (26) | | |
| | Over 21 | 502 (42) | | |
| Height (m) | Female | 375 (31) | 1.60 | 0.06 |
| | Male | 825 (69) | 1.74 | 0.08 |
| Weight (kg) | Female | 375 (31) | 57 | 12 |
| | Male | 825 (69) | 79 | 19 |
| BMI (kg/m²) | Female | 375 (31) | 22.5 | 4.1 |
| | Male | 825 (69) | 26.1 | 5.8 |
| Family Size | 3 or Less | 90 (8) | 7 | 2 |
| | 4 to 6 | 518 (43) | | |
| | 7 to 9 | 469 (39) | | |
| | 10 or More | 123 (10) | | |

Note: * SD: Standard Deviation

weight category in average (BMI ≈ 22.5) and male students among slightly overweight on average (BMI ≈ 26.1). As for their families, who share in general the same household, which mostly includes their grand-parents, they were composed of 7 people on average, but the size varied extensively (SD ≈ 2). In the sample, two majorities were identified: families with 4-6 people (43%) and families with 7-9 people (39%).

**Prevalence of Underweight, Overweight and Obesity**

Figure 1 shows that, among the 1,200 participants, the UW, OW and O prevalence were respectively 8%, 25%, and 16%. However, as shown in [Figure 2], the prevalence highly depends on the gender. As for the entire adult population in the Eastern Province, a straightforward calculation with a confidence level of 95% would place the prevalence between 5.9% and 8.9% for the underweight, between 22.4% and 27.3% for the overweight, and between 13.9% and 18.1% for the obesity.

***Factors having significant effect on Body Mass Index***

In this survey, eight factors having possible influence on BMI were examined. Chi Square test was used to evaluate the statistical significance of their effect. Based on a significance level set at a *p-value* of 0.05 or less, the test revealed six significant factors sorted below in descending order of significance.

***Gender:*** According to [Figure 2], the UW prevalence was about 2.7 times higher among females (13%), OW prevalence was about 1.8 times higher among males (29%), and O prevalence was about 3.5 times higher among males (21%). Furthermore, the odds ratio of overweight and obesity combined (males to females) was about 3.6, which implies that the risk for a male adult of getting overweight or obese is 3.6 times as much for a female adult. Setting a confidence level at 95%, this led to an estimation of 13.1±3.4% and 5.1±1.5% of underweight, 15.7±3.7% and 29±3% of overweight, and 5.9±2.4% and 21±2.7% of obese among female and male adults respectively in the entire region. These differences in BMI between females and males were by far the most significant (with a p-value as tiny as $1/10^{20}$) compared to those related to other factors.

***Age:*** [Figure 3] shows a gap between 20-year-old students and the others. Indeed, it is among this group that UW-prevalence was by far the highest (13%) and O prevalence was by far the lowest (10%). OW prevalence was also the lowest among this group (18%). As for the UW prevalence, it was almost the same among the youngest ones and 21-year old students. However, the oldest ones (over 21) held the double record of the lowest UW prevalence (4%) and the highest O prevalence (19%). Statistically, all of these differences were highly significant (p ≈ 0.0001).

***Frequency of Lipids Intake*** **(*meals/week*):** According to [Table 2], the highest O-prevalence (25%) and the lowest UW-prevalence (2.5%) were,

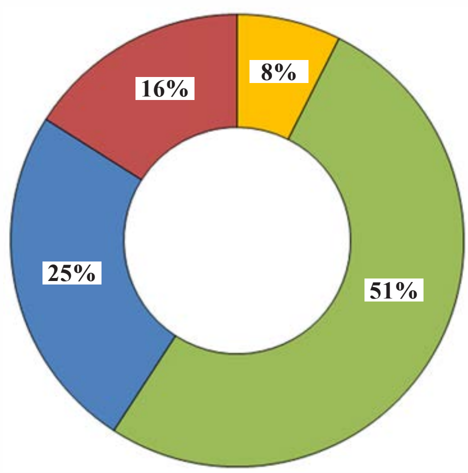


*FIGURE 1. Prevalence of underweight (yellow section), overweight (blue section), obesity (red section) and normal weight (green section) among 1,200 university students, Eastern Province, KSA (2016)*

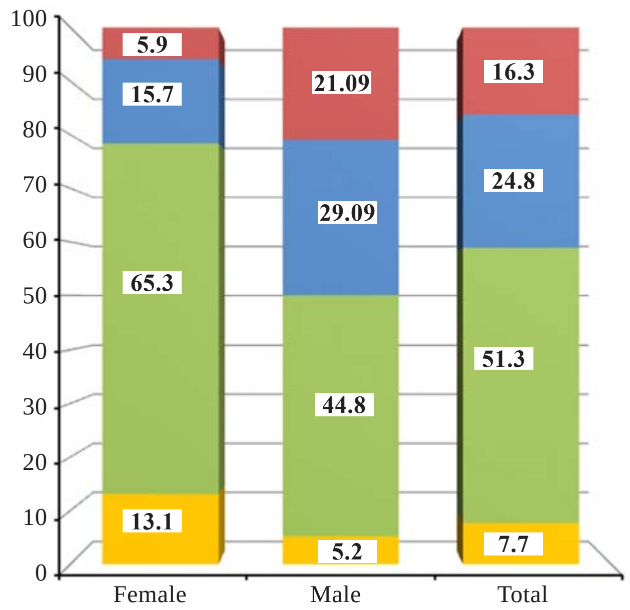


*FIGURE 2. Prevalence of underweight (yellow section), overweight (blue section), obesity (red section) normal normal weight (green section) among 1,200 university students, across the gender, Eastern Province, KSA 2016)*

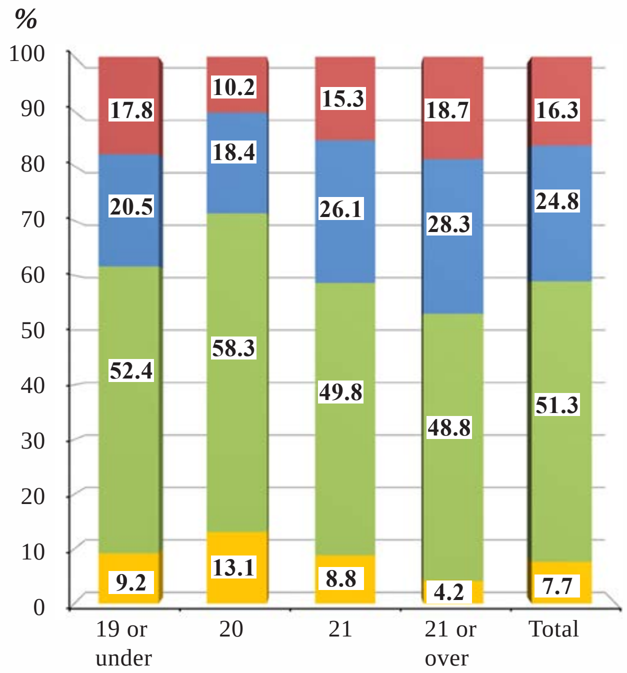


*FIGURE 3. Prevalence of underweight (yellow section), overweight (blue section), obesity (red section) and normal weight (green section) among 1,200 university students, across the age, Eastern Province, KSA (2016)*

as expected, among the most familiar with meals rich in fat (at least one every day). But surprisingly, the highest OW-prevalence (26%) was among those whose lipids intake is minimized. As for the intermediate two groups, UW and OW prevalence were similar, but O prevalence was higher among those who take more meals rich in fat (20% against 17%). The differences in BMI relative to frequency of lipids intake were highly significant (p ≈ 0.007).

***Time of Sports Physical Activities (hours/week):***

[Table 2] indicates that while 25% of the sample often entertain their bodies (3 hours or more per week), almost one student out of three keeps away from sports physical activities or spends on these less than one hour a week. Among these sports-free subjects, O and OW-prevalence were similar and represented together about 43%. But surprisingly, OW-prevalence was higher for each of the other sports-time-categories (27%). However, not only the lowest O-prevalence but also the lowest UW-prevalence was among the most regular in sports physical activities (12% and 4% respectively), whereas sports-free subjects and those who work out occasionally held the record of the highest UW-prevalence (about 9% and 10% respectively). Overall, the differences in BMI relative to time of sports physical activities were significant (p ≈ 0.01).

*Consumption Level of Meal-Replacement Bars*:

Only high BMI seems to be sensitive to the consumption level of bars students take instead of principal meals. Indeed, [Table 2] shows a quite higher O-prevalence among low consumers (18% against 11%) but figures were similar for both types of consumers when it comes to UW-prevalence and OW-prevalence. Note that one student out four usually takes meal-replacement bars. Given a p-value close to 0.02, the differences in BMI with regard to consumption level of these bars were statistically significant.

***Frequency of Sugar Intake (meals/day):***

As indicated in [Table 2], two students out of three were considered as moderate sugar consumers (up to one single pastry or ice-cream per day). The difference in prevalence between these and the highest consumers (7.5% of the sample) was below 3%. As for intermediate sugar consumers (2 or 3 sweet meals per day), they got the highest UW-prevalence (10.5%) and by far the lowest O-prevalence (11%). These differences were statistically significant (p ≈ 0.03).

***REGRESSION ANALISIS AND PREDICTIONS***

**Multiple Linear Regression:** Having examined the significance of the associations between the factors presented previously, it turns out that the most significant correlations involved either the gender (for the first four factors after the gender) or the frequency of lipids intake (for the last one), and this occurred at a very high level. Indeed, the lowest p-value for the differences in each of factors 2-5 was relative to the gender: about $4/10^{10}$ for the age (almost half of the males were among the oldest ones, whereas female age groups were balanced), $9/10^{9}$ for the frequency of lipids intake (almost half of the females and one-third of males were among the lowest consumers), and $8/10^{5}$ for the consumption level of meal-replacement bars (almost one-third of females and one-fifth of males were high consumers). On the other hand, the lowest p-value for the differences in frequency of sugar intake was relative to frequency of lipids intake (about $6/10^{23}$).

This led to the question whether or not a multiple linear regression of the BMI would be strong and statistically significant in terms of its most in-

**TABLE 2.**

*Factors having significant effect on the BMI of 1,200 university students, Eastern Province, KSA (2016)*

| | | Body Mass Index | | | | | |
|---|---|---|---|---|---|---|---|
| **Factors** | **Categories** | *Underweight* N (%) | *Normal* N (%) | *Overweight* N (%) | *Obese* N (%) | *Total* N (%) | (Chi² Test) **P-Value** |
| **Gender** | Female | 49 (13.1) | 245 (65.3) | 59 (15.7) | 22 (5.9) | 375 (31.3) | 1.0027E-20 |
| | Male | 43 (5.2) | 370 (44.8) | 239 (29) | 173 (21) | 825 (68.8) | |
| **Age (years)** | 19 or less | 17 (9.2) | 97 (52.4) | 38 (20.5) | 33 (17.8) | 185 (15.4) | 0.0001 |
| | 20 | 27 (13.1) | 120 (58.3) | 38 (18.4) | 21 (10.2) | 206 (17.2) | |
| | 21 | 27 (8.8) | 153 (49.8) | 80 (26.1) | 47 (15.3) | 307 (25.6) | |
| | Over 21 | 21 (4.2) | 245 (48.8) | 142 (28.3) | 94 (18.7) | 502 (41.8) | |
| **Time of Sports Physical Activities (hours/week)** | Less than 1 | 33 (8.7) | 202 (53.2) | 74 (19.5) | 71 (18.7) | 380 (31.7) | 0.0122 |
| | 1 to Less than 2 | 30 (9.9) | 141 (46.5) | 82 (27.1) | 50 (16.5) | 303 (25.3) | |
| | 2 to Less than 3 | 17 (7.6) | 109 (48.4) | 61 (27.1) | 38 (16.9) | 225 (18.8) | |
| | 3 or More | 12 (4.1) | 163 (55.8) | 81 (27.7) | 36 (12.3) | 292 (24.3) | |
| **Meal-Replacement Bars Consumption** | High | 19 (6.5) | 169 (58.1) | 70 (24.1) | 33 (11.3) | 291 (24.3) | 0.0191 |
| | Low | 73 (8) | 446 (49.1) | 228 (25.1) | 162 (17.8) | 909 (75.8) | |
| **Sugar Intake (meals/day)** | 1 or Less | 49 (6.3) | 394 (50.6) | 195 (25.1) | 140 (18) | 778 (64.8) | 0.0306 |
| | 2 or 3 | 35 (10.5) | 177 (53.3) | 83 (25) | 37 (11.1) | 332 (27.7) | |
| | 4 or More | 8 (8.9) | 44 (48.9) | 20 (22.2) | 18 (20) | 90 (7.5) | |
| **Lipids Intake (meals/week)** | 2 or Less | 35 (7.9) | 240 (54.4) | 116 (26.3) | 50 (11.3) | 441 (36.8) | 0.0067 |
| | 3 or 4 | 34 (8.3) | 210 (51.5) | 96 (23.5) | 68 (16.7) | 408 (34) | |
| | 5 or 6 | 20 (8.7) | 106 (46.3) | 57 (24.9) | 46 (20.1) | 229 (19.1) | |
| | 7 or More | 3 (2.5) | 59 (48.4) | 29 (23.8) | 31 (25.4) | 122 (10.2) | |
| | **Total** | **92** (7.7) | **615** (51.3) | **298** (24.8) | **195** (16.3) | **1200** (100) | |

fluent three factors: the gender (**G**), the age (**A**), and the frequency of lipids intake (**L**). According to the regression analysis report carried out on 1,200 observations, there is a highly significant positive multi-linear correlation (even though medium) between the BMI and these factors.

Nevertheless, a more realistic estimation of the BMI can be obtained by considering at least one negative linear correlation. Here, the consumption level of meal-replacement bars (**B**) is better linearly associated with the BMI than the frequency of sugar intake and the time of sports physical activities. This more multiple linear regression is as highly significant as the previous one (but slightly stronger). Using the corresponding report given in [Table 3], the BMI can be estimated as follows:

$$\overline{BMI} \approx 3.34\,G + 0.14\,A + 0.09\,L - 0.3\,B + 16.39 \quad (1)$$

The variables **L** and **B** were shown to be significantly associated with the gender. Indeed, relatively much more males than females were familiar with meals rich in lipids, with an odds ratio of high lipids intake (males to females) around 2.5, whilst relatively more females than males were acquainted to meal-replacement bars, with an odds ratio of high consumption of meal-replacement bars (females to males) about 1.7. This makes the variable **L** a male characteristic and the variable **B** a female one, which can partly explain why males are at more risk of overweight and obesity, and females are at more risk of underweight.

**Predictions (for 2020):** Using model (1), one can predict the impact of higher lipids intake on

**TABLE 3.**

*Multiple linear regression of the BMI of 1,200 university students, Eastern Province, KSA (2016)*

**Model Summary**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | 0.307* | 0.094 | 0.091 | 5.319 |

* Predictors: (Constant), Gender, Age, Lipids, MR Bars

**ANOVA***

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 3520.875 | 4 | 880.219 | 31.108 | 1.1E-24** |
| | Residual | 33813.431 | 1195 | 28.296 | | |
| | Total | 37334.306 | 1199 | | | |

* Dependent Variable: BMI
** Predictors: (Constant), Gender, Age, Lipids, MR Bars

**Coefficients***

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 16.389 | 1.653 | | 9.916 | 2.5E-22 |
| | Gender | 3.341 | 0.342 | 0.297 | 9.771 | 9.6E-22 |
| | Age | 0.139 | 0.073 | 0.097 | 1.897 | 0.058 |
| | Lipids | 0.091 | 0.051 | 0.076 | 1.769 | 0.077 |
| | MR Bars | -0.300 | 0.362 | -0.059 | -0.827 | 0.408 |

* Dependent Variable: BMI

male BMI and higher consumption of meal-replacement bars on female BMI. Indeed, for a male student who takes every year two more meals per week (rich in lipids) and keeps unchanged his consumption for meal-replacement bars, his BMI will increase in four years (2020) by:

$$\Delta BMI(male,2020) \approx 4(0.14\ (1) + 0.09(2)\ ) \approx 1.3\ (kg/m^2) \quad (2)$$

where (1) = 1 more year of age, (2) = 2 more fat – rich meals (per week) each year.

This formula might be enough to make him overweight (if his current BMI is not under 23.7) and even obese (if his current BMI is not below 28.7).

As for a female student whose lipids intake remains almost unchanged over the next four years and who becomes a high consumer of meal-replacement bars, her BMI will increase by:

$$\Delta BMI(female,2020) \approx 0.14\ \Delta \mathbf{A}\text{-}0.3\ \Delta \mathbf{B} = \\ = 0.14\ (4)\text{-}0.3(1) \approx 0.3\ (kg/m^2) \quad (3)$$

where (4) = ΔA= 4 more year of age (2016-2020) (1)= ΔB = change from low high bars-consumer (from 2016 to 2020).

This little increase probably will keep her BMI category unchanged.

As a result, one can expect a rise in prevalence of obesity and overweight, with higher figures in males. Indeed, under the assumption that males will gain on average 1.3 kg/m² by 2020, the same sample of 825 males will have an additional proportion of obese estimated at:

$$p = \frac{N(males,\ 28.7 \le BMI < 30)}{N(males)} \approx 5.1\%, \quad (4)$$

and an extra percentage of overweight determined by:

$$p = \frac{N(males,\ 23.7 \le BMI < 25)}{N(males)} - p \approx 6.9\%, \quad (5)$$

Note that the expected 5.1% of additional obese males correspond to 17.6% of the current overweight category. This means one out of six overweight students is expected to become obese by 2020. In addition, the extra 6.9% of overweight males are mainly due to about 26.8% of normal weight who are expected to become overweight by 2020.

On the other hand, an analogous calculation leads to an expected increase in prevalence of obesity in females of the same sample by 0.4% by 2020 (assuming a rise in BMI by about 0.3 kg/m² in average). This very low expected rise is due to only about 5% of overweight females who are expected to become obese by 2020. However, the overweight category is expected to remain stable, due to only about 1% of normal weight who may become overweight by 2020.

In such a scenario, the O-prevalence in the given sample would go up to 6.3% for females (from 5.9% currently) and to 26.1% for males (from 21% presently). As for the OW-prevalence, it would remain unchanged (15.7%) for females but rise to 35.9% (from 29% now) for males.

An extension of this scenario to the entire adult population in the Eastern Province would raise by 2020, with a probability of 95%, the respective male and female O-prevalence to 26.1±2.9% (from 21±2.7% presently) and to 6.3±2.5% (from 5.9±2.4% currently), the male OW-prevalence to 35.9±3.2% (from 29±3% now), and would leave the female OW-prevalence unchanged at 15.7±3.7%.

Another scenario could happen for females in a short term. Indeed, female students could be tempted by more meal-replacement bars over few weeks or months, probably due to the social influence of underweight females. As a result, their BMI would decrease by:

$$|\Delta BMI(\text{female, in less than 1 year})| \approx \approx |-0.3\Delta B| = |-0.3(1)| = 0.3\ (kg/m^2) \qquad (6)$$

This leads to an estimated increase in prevalence of underweight among females of the same sample by:

$$r = \frac{N(\text{females}, 18.5 \leq BMI < 18.8)}{N(\text{females})} \approx 3.2\%, \qquad (7)$$

in less than one year, which would make their UW-prevalence go up to 16.3% from 13.1% now. This rise is due to almost 5% of normal weight females who may become underweight if they get used to meal-replacement bars within few weeks or months. Such a scenario might be extended to most of female adults in the Eastern Province, raising the female UW-prevalence in a short term to 16.3±3.7% (from 13.1±3.4% now).

## DISCUSSION

**Limitations:** Other factors, such as time spent on sports physical activities and family income, could have been retained to explain differences in BMI. But the results would have been biased as a certain number of students may not have given true responses to few questions, probably not being able to hide them from their class neighbors.

Another limitation of this study is that the sample was not equally distributed among male students (31%) and female students (69%) due to the segregated nature of the education system in the Kingdom. Also, the study did not include students who had lost or gained weight and there should be a follow-up period.

**Strengths:** This study was based on a huge number of data individually collected from a large sample of adult students in the largest three Saudi leading universities in the Eastern Province.

In addition, six factors were shown to have a highly significant effect on the BMI. Four of them (gender, age, lipids intake, and meal-replacement bars consumption) were selected as predictors in a linear regression, where the association with the BMI was highly significant ($p \approx 6/10^{25}$).

Moreover, since much more males than females were shown to be among high consumers of meals rich in lipids, and much more females than males among high consumers of meal-replacement bars, a multiple linear model was established, and then used to predict the prevalence of obesity and overweight for the year 2020 and the prevalence of female underweight in a short term.

## CONCLUSION

This survey was conducted on N=1,200 university students from the Eastern Province (Saudi Arabia). The results indicated an overall prevalence of obesity, overweight, and underweight of 16%, 25%, and 8% respectively. These figures highly depended on the gender, the age, the frequency of lipids intake (much higher among males), and the consumption level of meal-replacement bars (much higher among females, who certainly seek to keep or get slim).

A multiple linear model giving the BMI in terms of these variables was designed to predict with 95% of confidence, for the entire adult population of the Eastern Province, the impact of higher fat intake and consumption of meal-replacement bars (mostly under social influence) on males and females respectively. It was shown for instance, that by 2020, their obesity prevalence would go up to 26.1±2.9% (from 21±2.7% now) and 6.3±2.5% (from 5.9±2.4% now) respectively. However, a short-term higher consumption of meal-replacement bars would raise the female underweight prevalence to 16.3±3.7% (from 13.1±3.4% now).

Based on the current estimations and the very likely trend of the prevalence, some precautions need to be taken seriously by individuals and some measures should be implemented publicly. Such commitments are targeted by the *socio-ecological model*, which concept is to facilitate multifaceted, interactive and effective implementation of population health programs, and which ultimate purpose is to inform the development of comprehensive intervention approaches that can systematically target the mechanism of change at several levels of influence: intrapersonal, interpersonal, institutional, community and policy. Community health employees can be effective by connecting multidimensional levels of this model, and as a result, assist overweight adults with the support they need to avoid obesity. For instance, the latter are urged to lower the frequency of meals rich in lipids, whereas underweight female adults should not skip more than two principal meals per week (bars not enough to satisfy nutritional needs). Moreover, regular sports physical activities would help overweight and obese burn extra calories, and underweight take healthy meals on a regular basis. More generally, in order to help adults adjust their BMI, information campaigns should be held frequently on various media platforms, and sport centers need to be opened for public in different areas of the province.

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