A Study on Body Mass Index, Blood Pressure, and Red Blood Cell Indices in New Entering Students of the University of Isfahan

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ABSTRACT

Objectives: Obesity and increased blood pressure are identified as risk factors for cardiac and pulmonary disorders. On the other hand, iron deficiency (another preventable disease) is common in adolescence and considered as associated with health impairment. The present study evaluates body mass index (BMI) and its association with blood pressure and hematological indices in freshman students entering the University of Isfahan in 2009.

Methods: All the 1675 students who entered the University of Isfahan in September 2009 were examined. Height, weight, BMI, blood pressure, hemoglobin (Hb) and red blood cell (RBC) indices of these students were measured. The prevalence of high blood pressure, its association with BMI and the relation between BMI and anemia, iron deficiency and educational achievement were assessed.

Results: All participants, including 514 males and 1161 females, went under clinical observations. The average age was 20.7 ± 3.8 year. Among the students, 18.2% of males and 20% of females were underweight. High systolic blood pressure was more common in the students with BMI > 25 kg/m² (p < 0.001). Anemia was seen in 8.7% of females. In males, however, a relation between anemia frequency and BMI < 18.5 kg/m² was more distinct (p = 0.002). There was no association between anemia and students’ average test scores.

Conclusions: High incidence of abnormal BMI in the study population, and its association with systolic blood pressure indicate the importance of nutritional guidelines and counseling programs for freshman students. On the other hand, high incidence of anemia in this population ascertains the necessity of anemia screening programs before academic studies.

Keywords: Body mass index, Systolic blood pressure, Iron deficiency anemia.

INTRODUCTION

Measuring height, weight, and body mass index (BMI) gives significant information on the nutritional and health status of individuals. There are evidences that an increase in BMI is associated with a wide range of factors including blood pressure level, heart disease, asthma, headache, and backache.1 It has been reported that a BMI above 27.8 and 27.3 kg/m² for men and women, respectively, may increase mortality. Some reports have even extended the safety limits and mentioned a BMI of below 25 kg/m² as a suitable index for women.1,2 On the other hand, a significantly low BMI in women not only indicates disorder and mal-nutrition, but also leads to osteopenia and osteoporosis and increases the risk of prematurity and giving birth to under-weight children.3

High blood pressure is one of the most important potential causes of heart and vascular
disorders. It is a problem which may start during youth but can, however, be subdued by medical control. The association of high blood pressure and BMI is topic of much discussion, which highlights the importance of BMI. It has been reported that low BMI is associated with iron deficiency anemia. Iron deficiency anemia is one of the most common nutrition-related problems in Iran and many other parts of the world, and is characterized by a wide range of hematological and non-hematological symptoms. Iron deficiency, in addition to being a possible result of digestive disorders, stems from two other factors, i.e. increased physiological needs and nutritional problems. Since these factors are involved, iron deficiency has a high prevalence in youth especially in females. Whatever the roots, non-hematological iron deficiency symptoms in any age may have significant impacts on learning abilities of students and consequently their progress through the stage of higher education. University students are exposed to potential threats due to not only probable economic difficulties, but also cultural orientations and nutritional habits. Therefore, they are at high risk for iron deficiency anemia, and may as a result fail to advance to higher academic circles. The importance of the issue is obvious, especially considering the fact that it concerns people who make the future of the society.

Addressing the aforementioned problems, considering their possible impacts during the critical stage of academic studies, can be very rewarding for society in general. The current study was carried out to determine height, weight, body mass index, blood pressure level and red blood cell (RBC) indices (as a sign of iron deficiency anemia) in freshman students, in order to facilitate the planning of a suitable health care program to be carried out for them based on their present status.

METHODS

All of the freshman students entering the University of Isfahan in 2009 were examined following admission to the clinical health centre of the university. The height and weight of these students were measured and the BMI was calculated. The normal BMI range was considered as 18.5-25 kg/m², according to the WHO guidelines. After entering the clinic, the students completed a personal information form. Then, (approximately five minutes after entry) their blood pressure was measured using a mercury monometer in sitting position and recorded by the clinic doctor. The students have had breakfasted at least half an hour before entering the clinic. A systolic blood pressure exceeding 130 mmHg, or a diastolic blood pressure above 90 mmHg was considered as a sign of high blood pressure. Complete blood count (CBC) was performed to determine and record hemoglobin (Hb) levels and RBC indices. Normal values for mean corpuscular volume (MCV) and Hb were considered as ≥ 80 fl, ≥13.7 g/dl in men and 12.2 gr/dl in women, respectively.

Among the students with MCV < 80 fl, iron deficiency anemia was differentiated from thalassemia minor regarding the RBC indices, including red blood cell distribution width (RDW), mean corpuscular hemoglobin concentration (MCHC) and Mentzer index. The frequency of anemia, high blood pressure, and their relations to BMI were then investigated. Students didn’t receive any medications for iron deficiency anemia until the end of semester, as there was a delay between collecting the data and analyzing the hematological findings. Each student's average test score was calculated at the end of the semester to assess any possible relation between iron deficiency and their academic progress.

Statistical analysis

Data are expressed as the mean ± SD or percentage. Differences between groups were evaluated using student's t-test, Fisher's exact test, Mann-Whitney U test, and Cramer’s V test.

RESULTS

The study population consisted of 1675 new coming students of the University of Isfahan, including 514 males and 1161 females. They went under clinical observations and were put on medical record. The average age was 21.2 ± 4.4 and 20.5 ± 3.4 years among male and female students, respectively. BMI details of 1224 students, including 445 males and 779 females, were recorded precisely. A percentage of 19.4 of the whole student population (18.2% male, 20% female) were underweight. A BMI level above 25 was more common in the males (21.6% males vs. 13.5% females) (p = 0.004). The overall percentage of overweight students was 16% (2.2% were obese). Among all students, 0.9% of males and 5.5% of females had a diastolic blood pressure equal to or above 90 mmHg. A systolic
blood pressure above 130 mmHg was seen in 7.8% of the males and 1.3% of the females.

**BMI and high blood pressure**
A direct relationship was observed between increased systolic blood pressure and BMI, i.e. the higher BMI level, the more the number of cases with high systolic blood pressure. The percentage of individuals with a systolic blood pressure of above 130 mmHg in the BMI > 25 kg/m² group was 11.8%, but among those with a BMI level equal to or below 25, only 2% showed a systolic blood pressure above 130 mmHg (p < 0.001). This was more significant in the males (21.5% vs. 3.5% in females with BMI over 25 kg/m²). In case of diastolic blood pressure, the differences were not meaningful.

**Hematologic findings**
The average Hb level was 13.4 ± 1 g/dl (from 8.6 to 16.9 g/dl) and 15.6 ± 1 g/dl (from 12 to 18.4 g/dl) in female and male students, respectively. The MCV levels in females and males were 86 ± 5.9 vs. 85 ± 5.5 fl (p > 0.05). Low Hb levels were identified in 8.7% of females and 4.5% of males. Anemia was more widespread in those above 20 years old. Other hematological findings are presented in Table 1.

BMI < 18.5 was associated with anemia in males (p = 0.002) but not in females (Table 2). Sixty eight percent of students with low Hb levels (13.7 g/dl and 12.2 g/dl in males and females, respectively) were categorized as the ‘iron deficiency anemia’ group. Of the overall student population, 3.9% (with or without anemia) were categorized as ‘with signs of minor thalassemia’.

**Anemia and academic progress**
According to the university records, the prevalence of iron deficiency in the students with highest average test scores in the first academic semes-

ter was almost similar to those with the lowest average test scores (31% vs. 29%, P > 0.01).

**DISCUSSION**
The current study indicated that 365 students had weight and height discrepancies. The evaluation of BMI can be an indirect way of determining the current nutritional status and subsequently the level of social health care in a country. Therefore, regulatory policies on the basis of normal BMI in each nation, which may help overcoming weight discrepancies, would be of special importance for improving people's life standards. In some populations the BMI 18.5 to 25 is defined as normal.\(^\text{10}\) Taking this BMI level as normal, weight discrepancy among the new coming students of the University of Isfahan would be 36% which is worrying and must be taken into consideration.

The difference between the two genders, regarding the BMI discrepancy, is predictable and in harmony with the social layout and in line with other societies.\(^\text{13,14}\) Overall, a BMI level below 18.5 was more common in females. Conversely, a BMI above 25 was significantly less common in females in comparison with their male counterparts. This difference probably stems from a difference in male and female ideals and the nutritional habits among females who deem it incumbent upon themselves to be slender. In any case, a 20% decrease in the BMI of the future mothers of the society is what social welfare authorities should be concerned about. Pregnancy in females with low BMI may contribute to serious problems including giving birth of premature or underweight infants. A possible solution to this dilemma is to encourage females toward exercise as a means of weight control rather than dieting and also promoting exercise facilities and areas at the same time.

**Table 1. Hematologic indices in the population of university students**

| Total number | Hb | MCV | MCHC | RDW |
|--------------|----|-----|------|-----|
| Mean (g/dl)  | n(%) | Mean (fl) | n(%) | Mean (g/dl) | n(%) | Mean > 16 |
| Men          | 511 | 15.6 ± 1 | 23(4.5) | 39(7.6) | 3.3 ± 3 | 13(2.5) | 13.8 ± 43 |
| Women        | 1160 | 13.5 ± 1 | 101(8.7) | 86.5 ± 5.9 | 101(8.7) | 33.8 ± 31 | 13.9 ± 157 |

Hb: hemoglobin; MCV: mean corpuscular volume; MCHC: mean corpuscular hemoglobin concentration; RDW: red blood cell distribution width

\(^1\) Number (percent) of samples with hemoglobin less than normal.

Normal Hb is 13.7 g/dl for men and 12.2g/dl for women. Normal MCV is 80 fl. Normal MCHC is 31 g/dl.
Table 2. The relation between BMI and anaemia

| BMI (kg/m²) | Gender | Anemia¹ | Normal Hb | Total |
|------------|--------|---------|-----------|-------|
| < 18.5     | Male   | 6 (7.2%) | 74 (92.8%) | 239   |
|            | Female | 12 (7.5%)| 147 (92.5%)|       |
| 18.5 ≤ and < 25 | Male | 8 (2.9%)  | 259 (97.1%) | 782   |
|            | Female | 46 (8.5%) | 469 (91.5%)|       |
| ≥ 25       | Male   | 5 (5.4%)  | 87 (94.6%) | 197   |
|            | Female | 11 (9.5%) | 94 (90.5%) |       |
| Total      | Male   | 19 (4.3%) | 420 (95.7%) | 1218  |
|            | Female | 69 (8.8%) | 710 (91.2%)|       |

BMI: Body Mass Index         Hb: Hemoglobin
¹ Anemia is defined by Hb < 12.2 for females and Hb < 13.7 for males; ² Numbers show the number of individuals with defined Hb and BMI; ³ Parenthesis show the percentage of individuals with defined Hb and BMI.

Although in this research we observed a relatively low frequency of overweightness, results are different in other reports.¹⁵,¹⁶ BMI depends on several variables, including behavior patterns, nutritional habits, social ideals and also changes due to aging.¹⁷ Therefore, the aforementioned differences are to be expected, and BMI discrepancies may vary from one report to the other upon different conditions and circumstances in which a study is conducted. However, the 16.6% level of overweightness evidenced in this study indicates a significant potential danger (high blood pressure, diabetes, heart disease, etc) for the individual. Possible solutions are physical activity promotion, extracurricular sporting activities (especially for females considering the social constraints on female physical activities), counseling sessions on nutritional habits (recommendations on consuming fruits, and vegetables) and an increase in social propaganda concerning healthy foodstuffs.¹⁸

The relationship between BMI and blood pressure and the mutual effect of the two on physical status has been known and under discussion for years.¹⁹ There are many articles dealing with the connection of BMI and isolated systolic blood pressure.²⁰,²² Some articles have also studied connection of both diastolic and systolic blood pressure with BMI.²³,²⁴ The reason of the differences in the results of such studies in not clear. Genetic differences, sample size, the age range, and the heterogeneity of the populations involved may be probable causes. The relationship between BMI and isolated systolic blood pressure may be attributed to conditions found in overweight individuals, including disorder in the autonomic (sympathetic) system, insulin resistance and high fasting insulin level.²¹,²⁵ The findings of the present study affirmed the connection between BMI and isolated systolic blood pressure. In addition, the significant number of males having high systolic blood pressure can be explained by the higher BMI levels observed in these individuals.

Since females experience the monthly period, the significant higher frequency of anemia in their group was predictable. However, the result of female anemia in the age range targeted by the current research differs from similar studies elsewhere. For instance, in a different study carried out in Iran on 14-20 year-olds the minimum Hb level was considered to be 12 g/dl and 21.4% of the females were reported as anaemia sufferers. In the present study, although a 12.2 g/dl minimum Hb level was used as well, the frequency of anemia was much lower (8.7% vs. 21.4%). The age range in the present study was higher than the former report (20.5 ± 3.4 vs. 14-20) and an increase in anemia prevalence was observed with increases in age. Therefore, it is not applicable to assume anemia to be more frequent in lower ages. In another research, carried out on female students within the same age group in Iran, 3.8% of the population was reported to have anemia.²⁶ A precise interpretation of data and accurate comparison among the three mentioned reports is not possible due to the lack of information. However, the differences may result from diverse economic background and variety of social classes. The first of the two above mentioned studies was carried out among students in the Western regions of the country and the second among Tehran University students, two groups which are highly different in terms of cultural practices and social hierarchy. In addition, if iron deficiency is considered to have negative effects on academic progress, Tehran University medical students must obviously enjoy the least degree of iron effi-
ciency (medicine is the most difficult field of study a student can enter in Iran, and Tehran University is the most prestigious academic institution). In the present study, our students ranked lower than Tehran Medical students academically. However, they were economically higher than the students of the Western regions addressed by the first study above. Even though an adequate comparison between these three studies needs more evidence, the observed differences may highlight the effect of iron deficiency on academic progress and call for further investigation. In any case, an 8.7% of anemia (68% of which showed iron deficiency anemia), calls for serious consideration and indicates the importance of anemia screening programs for freshman students entering universities. It should be added that iron deficiency without the symptoms of anemia is more widespread than iron deficiency accompanied with anemia, which gives more emphasis to the necessity of addressing the issue.

In the present study, iron deficiency was associated with BMI ≤ 18.5 kg/m² in males. This may stem from nutritional habits of this population and is in harmony with other studies.\(^1,17\) With regard to the consequences of iron deficiency, and the higher frequency of anemia in students with lower BMI, the need for nutritional guidelines and counseling sessions based on individual medical records deems a necessity.

There are several reports in the literature demonstrating the association of iron deficiency with educational regress.\(^27\) However, in the present study, students with iron deficiency did not illustrate lower test scores compared to those without iron deficiency. This paradox was predicted as iron deficient students were not treated for anemia to show academic progress at the end of semester. Further approach and appropriate clinical trials are required to explain the relationship between iron deficiency and educational progress.

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REFERENCES

1. Brown WJ, Mishra G, Kenardy J, Dobson A. Relationships between body mass index and well-being in young Australian women. Int J Obes Relat Metab Disord 2000; 24(10): 1360-8.
2. Meisler JG, St Jeor S. Summary and recommendations from the American Health Foundation’s Expert Panel on Healthy Weight. Am J Clin Nutr 1996; 63(3 Suppl): 474S-7S.
3. Villena-Heinsen C, Luxner K, Friedrich M, Quijano F, Schmidt W. Pregnancy and labor in underweight pregnant patients. Z Geburtshilfe Neonatol 1998; 202(3): 115-20. [In German].
4. Angelopoulos PD, Milionis HJ, Grammatikaki E, Moschonis G, Manios Y. Changes in BMI and blood pressure after a school based intervention: the CHILDREN study. Eur J Public Health 2009; 19(3): 319-25.
5. Akramipour R, Rezaei M, Rahimi Z. Prevalence of iron deficiency anemia among adolescent schoolgirls from Kermanshah, Western Iran. Hematology 2008; 13(6): 352-5.
6. Andrews NC, Ulrich CK, Fleming MD. Disorders of Iron metabolism and sideroblastic anemia. In: Lux SE, Editor. Hematology of infancy and childhood. 7th ed. Philadelphia: WB. Sanders; 2009. p. 521-70.
7. Agaoglu L, Torun O, Unuvor E, Sefil Y, Demir D. Effects of iron deficiency anemia on cognitive function in children. Arzneimittelforschung 2007; 57(6A): 426-30.
8. Khedr E, Hamed SA, Elbeih E, El-Shereef H, Ahmad Y, Ahmed S. Iron states and cognitive abilities in young adults: neuropsychological and neurophysiological assessment. Eur Arch Psychiatry Clin Neurosci 2008; 258(8): 489-96.
9. Nelson M. Anaemia in adolescent girls: effects on cognitive function and activity. Proc Nutr Soc 1996; 55(1B): 359-67.
10. World Health Organization. World Health Organization Expert Committee on Physical Status. In: Physical status: the use and interpretation of anthropometry. Geneva: WHO; 1995.
11. Beutler E, Waalen J. The definition of anemia: what is the lower limit of normal of the blood hemoglobin concentration? Blood 2006; 107(5): 1747-50.
12. Hoffman R BEJ, Shattil SJ, Furie B. Hematology: Basic Principles and Practice. New York: Churchill-Livingstone; 2004.
13. Safavi M, Mahmoodi M, Roshandel A. Assessment of body image and its relationship with eating disorders among female students of Islamic Azad University, Tehran center branch. Med J Islamic Azad Univ 2009; 2(19): 129-34.
14. Wang Z, Byrne NM, Kenardy JA, Hills AP. Influences of ethnicity and socioeconomic status on the body dissatisfaction and eating behavior of Australian children and adolescents. Eat Behav 2005; 6(1): 23-33.
15. Heshmat R, Fakhrazadeh H, Pour-ebrahim R, Nouri M, Pahouzhi M. Evaluation of obesity and overweight and their changes pattern among 25-64 aged inhabitants of Tehran University of Medical Sciences population lab region. Iran J Diab Lipid Disord 2004; 3:63-70.
16. Mortazavi Z, Shahrokhipour M. Body mass index in Zahedan University of Medical sciences students. Tabib-e-Shargh 2002; 4(2): 81-6.
17. Paknahad Z, Omidvar N, Mahboub S, Afiatmilani S, Ostadrahimi AR, Ebrahimi M. Body mass index of reproductive age group women and its relationship with iron status. Journal of Tabriz University of Medical Sciences 2001; 35(51): 17-23.
18. El Ansari W, El Ashker S, Moseley L. Associations between physical activity and health parameters in adolescent pupils in Egypt. Int J Environ Res Public Health 2010; 7(4): 1649-69.
19. Ni Mhurchu C, Rodgers A, Pan W, Gu D, Woodward M. Asia Pacific Cohort Studies Collaboration. Body mass index and cardiovascular disease in the Asia-Pacific Region: an overview of 33 cohorts involving 310 000 participants. Int J Epidemiol 2004; 33; 751-8.
20. Burke V, Beilin LJ, Dunbar D, Kevan M. Associations between blood pressure and overweight defined by new standards for body mass index in childhood. Prev Med 2004; 38(5): 558-64.
21. Sorof JM, Poffenbarger T, Franco K, Bernard L, Portman RJ. Isolated systolic hypertension, obesity, and hyperkinetic hemodynamic states in children. J Pediatr 2002; 140(6): 660-6.
22. Bose K, Ghosh A, Roy S, Gangopadhyay S. The relationship of age, body mass index and waist circumference with blood pressure in Bengalee Hindu male jute mill workers of Belur, West Bengal, India. Anthropol Anz 2005; 63(2): 205-12.
23. Paradis G, Lambert M, O’Loughlin J, Lavallee C, Aubin J, Delvin E, et al. Blood pressure and adiposity in children and adolescents. Circulation 2004; 110(13): 1832-8.
24. Nwachukwu DC, Nwagha UI, Obikili EN, Ejezie FE, Okwuosa CN, Nweke ML, et al. Assessment of body mass index and blood pressure among university students in, Enugu, South East, Nigeria. Niger J Med 2010; 19(2): 148-52.
25. Taittonen L, Uhari M, Nuutinen M, Turtinen J, Pokka T, Akerblom HK. Insulin and blood pressure among healthy children. Cardiovascular risk in young Finns. Am J Hypertens 1996; 9(3): 194-9.
26. Shams S, Asheri H, Kianmehr A, Ziaee V, Koochakzadeh L, Monajemzadeh M, et al. The prevalence of iron deficiency anemia in female medical students in Tehran. Singapore Med J 2010; 51(2): 116-9.
27. Goudarzi A, Mehrabi MR, Goudarzi K. The effect of iron deficiency anemia on intelligence quotient (IQ) in under 17 years old students. Pak J Biol Sci 2008; 11(10): 1398-400.

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