Fast Food Consumption, Liver Functions, and Change in Body Weight Among University Students: A Cross-Sectional Study

Abstract

Background: Over the past decades, the consumption of fast foods has increased worldwide and became favored by people of most age groups. The objective of this research was to assess the impact of fast foods on liver enzyme levels and body weight. Methods: A cross-sectional study was conducted at Yarmouk University/Jordan using survey questionnaire and enquired university students about their dietary habits, in addition to laboratory investigations of liver enzymes. Results: In the cross-tabulation analysis, only age and body mass index (BMI) were significantly associated with alanine aminotransferase (ALT) enzyme level. However, all differences between aspartate aminotransferase (AST) level and other variables were statistically insignificant. The AST/ALT ratio was calculated and revealed significant statistical association with BMI of participants (P = 0.001). Change in body weight during one year was significantly associated with eating fast food (P = 0.031), drinking beverages with fast food meals (P = 0.001), and ALT level (P = 0.026). However, this association was statistically insignificant with AST level. Conclusions: Fast food consumption among university students in Jordan was not significantly associated with increasing levels of ALT and AST liver enzymes. However, eating fast food and drinking soft drinks were associated with increasing body weight, which is expected to have adverse effect on liver functions in the long term.

Keywords: Fast foods, Jordan, liver, universities, students

Introduction

Over the past decades, the consumption of fast foods has increased worldwide and became favored by people of most age groups as they are quick to prepare, easy to access, and relatively inexpensive.[1] In the public debate on fast food consumption, it is often argued that fast food is an important determinant of weight gain and obesity due to high fat content and the massive and widespread fast food industry. Therefore, scientific societies still recommend low-fat diets to promote overall health and the loss of excess bodyweight.[2] Several studies concluded that fast food intake predicts weight gain and obesity in all age groups.[3-4] However, some groups in the population, such as adolescents and young adults, are more likely to be more frequent consumers getting higher proportions of their total daily calories from fast food.[5] The high energy density and high glycemic index of fast foods may increase the prevalence of obesity and cardiovascular risk factors.[6] Nevertheless, a study on metropolitan transit workers reported that the association between fast food consumption and body weight was statistically insignificant.[10] Eating fast food was found to be associated with weight gain in the Arab Gulf Region countries,[11] and other Arab countries.[12] Furthermore, a causal relationship of fast food and obesity was reported among university students in Lebanon[13] and Saudi Arabia.[14] Fast food consumption is usually associated with higher fat intake as fast foods are rich sources of saturated fatty acids and trans fatty acids leading to excess adiposity and nonalcoholic fatty liver disease.[15] Although serum liver enzyme elevation does not accurately measure liver damage, it may be a valuable marker to monitor development of liver disease.[16] In Sweden, it has been reported that increased alanine aminotransferase (ALT) and aspartate aminotransferase (AST) levels were associated with fast food consumption.[17] Another study in Germany concluded that excessive calorie intake is associated with...
abnormal ALT and AST levels. A study conducted in Greece reported that adherence to the fast food type dietary pattern was independently associated with higher odds for liver disease. Similar results were reported from Lebanon. It has been reported that nutrition transition is a crucial factor that can affect dietary habits, particularly in developing countries. Jordan, as one of these countries, is experiencing alarming rates of obesity due to unhealthy dietary habits. Several studies have been conducted to assess the impact of fast foods on health status of Jordanians. Results from these studies have revealed that fast foods are associated with increased risk of colorectal cancer, overweight and obesity among adolescents, overweight and obesity among university students, and bacterial contamination of fast food sandwiches. Nevertheless, up to the researchers’ knowledge, no studies have been conducted to assess the impact of fast foods on liver among Jordanians. In this article, we seek to identify the causal effect of fast food consumption on weight gain and levels of liver enzymes among university students. It was hypothesized that frequent fast food consumption would be associated with weight gain and increased levels of liver enzymes.

**Methods**

In a cross-sectional study, from June to September 2018, 256 university students were interviewed and asked about fast food consumption and other dietary habits. Out of the 256 responses, 55 were excluded as they either submitted incomplete information or their blood samples were clotted leaving 201 responses valid for the final analysis.

**Setting and data collection**

The study took place at Yarmouk University in Northern Jordan where trained research assistants interviewed students for 4 months. A pilot-tested structured questionnaire was prepared and administered by the trained interviewers to collect information relevant to the current research problem. The questionnaire involved items on demographics, medical history, education level, average monthly family income, daily pocket money, and dietary habits. Educational brochures and pamphlets were distributed to students at the time of data collection.

**Anthropometric and blood measurements**

Anthropometric measurements including body weight and height were obtained to calculate the body mass index (BMI). To assess the liver function tests, a 10-ml whole blood sample was obtained by a laboratory technician from all participants who agreed to participate. The procedure involved using sodium fluoride potassium oxalate tubes, and samples were kept in ice box and sent to the central laboratory (distance = 300 m from event location) for immediate analysis every hour during the event days. Analysis of blood samples was carried out via Beckman Coulter AU 480 using kinetic UV method based on the recommendations of the International Federation of Clinical Chemistry. Serum liver enzymes AST and ALT were estimated, and normal kit ranges were: ALT and AST: <50 units per liter (U/L) for males (adult) and <35 U/L for females (adult). AST to ALT ratio was calculated as follows: <1 = Optimal, 1–1.49 = borderline, and ≥1.5 = abnormal.

**Definition of fast food**

It was made clear to participants that eating shawarma (a Middle Eastern most popular street foods meat preparation made of lamb, mutton chicken, turkey, beef, or veal), burgers, hot dog, and other familiar or habitual types of fast food in the Jordanian context are meant when they were asked about fast food consumption.

**Ethical considerations**

The study was approved by the Institutional Review Board at King Abdullah University Hospital in Northern Jordan (No. 15/2017). An informed consent was obtained from every participant and all study procedures followed Helsinki declaration guidelines. Mobile phone numbers of all participants were collected to inform them about laboratory results based on the consents. Participants were notified that their information will be used for research purposes only and no one other than the research team will have access to them.

**Statistical analysis**

All statistical analysis was implemented using the Statistical package for social sciences (SPSS, version 20.0) with P < 0.05 considered statistical significance.

**Results**

**Sociodemographic and clinical characteristics of the sample**

Of the 201 subjects included in the study, about 58% (n = 116) were males and 42% (n = 85) were females. The majority of participants (85.1%) were younger than 30 years. About 42% of study subjects had overweight or were obese. Demographic and clinical characteristics of study population are shown in Table 1.

As noted in Table 1, the vast majority of the sample had normal levels of liver enzymes (92.5% and 96.5% for ALT and AST, respectively).

A cross-tabulation analysis was performed to assess the association between demographic characteristics and lifestyle factors with ALT and AST levels as shown in Tables 2 and 3, respectively.

As illustrated in Table 2, only age and BMI were significantly associated with ALT enzyme level. With respect to AST level,
there were some differences between variables; however, all of these differences were statistically insignificant.

Surprisingly, eating different types of fast food was not associated with significant differences for both ALT and AST levels.

The AST to ALT ratio was calculated and revealed significant statistical association with BMI of participants; however, this correlation was insignificant for eating fast foods and change in body weight as illustrated in Table 3.

A binary logistic regression analysis was performed to assess the association between demographic and lifestyle factors with ALT level. Remarkably, BMI and gender were significantly relevant to an increase in ALT level. Table 4 illustrates these associations.

Change in body weight during one year was tested for its correlation with dietary habits and levels of ALT and AST. As illustrated in Table 5, eating fast food, drinking beverages with fast food meals, and ALT level were all significantly associated with the change in body weight. However, this association was statistically insignificant with AST level.

Discussion

The problem of consuming fast food has dramatically increased among populations, especially adolescents and young adults. It has been implicated as a likely contributing factor to the growing obesity rates worldwide. The current study assessed the associations between fast food consumption on one side and major liver enzymes levels and change in body weight on the other side.

Surprisingly, consuming fast food was not significantly associated with differences in both ALT and AST enzyme levels. This result is inconsistent with results from a study conducted in Sweden on 18 persons and reported that increased ALT and AST levels were associated with fast

| Characteristic                          | n (%)        | ALT | P     |
|-----------------------------------------|--------------|-----|-------|
| Gender                                  |              |     |       |
| Male                                    | 116 (57.7)   |     |       |
| Female                                  | 85 (42.3)    |     |       |
| Age/year                                |              |     |       |
| <30                                     | 171 (85.1)   |     |       |
| ≥30                                     | 30 (14.9)    |     |       |
| BMI                                     |              |     |       |
| Underweight                             | 15 (7.5)     |     |       |
| Normal                                  | 101 (50.2)   |     |       |
| Overweight                              | 52 (25.9)    |     |       |
| Obese                                   | 33 (16.4)    |     |       |
| ALT level                               |              |     |       |
| Normal                                  | 186 (92.5)   |     |       |
| High                                    | 15 (7.5)     |     |       |
| AST level                               |              |     |       |
| Normal                                  | 194 (96.5)   |     |       |
| High                                    | 7 (3.5)      |     |       |
| Living status                           |              |     |       |
| With family                             | 160 (79.6)   |     |       |
| Dormitory or private                    | 41 (20.4)    |     |       |
| Eat shawarma/week                       |              |     |       |
| Never                                   | 63 (31.3)    |     |       |
| 1-3 times                               | 120 (59.7)   |     |       |
| More than 3 times                       | 18 (9.0)     |     |       |
| Eat other types of fast food            |              |     |       |
| No                                      | 100 (49.8)   |     |       |
| Yes                                     | 101 (50.2)   |     |       |
| Daily pocket/JD                         |              |     |       |
| <3                                      | 26 (12.9)    |     |       |
| 3-5                                     | 107 (53.2)   |     |       |
| >5                                      | 68 (33.8)    |     |       |
| Smoking status (if the participant smokes) |          |     |       |
| No                                      | 122 (60.7)   |     |       |
| Yes                                     | 79 (39.3)    |     |       |
| Passive smoking (if a member in the family smokes) | | | |
| No                                      | 146 (48.7)   |     |       |
| Yes                                     | 154 (51.3)   |     |       |

BMI=Body mass index

Table 1: Demographic and clinical characteristics of study population (n=201)

Table 2: Cross tabulation of demographic and lifestyle factors associated with ALT level in Northern Jordan (n=201)
However, in this study, the conditions expected to have adverse effect on liver functions in the long term.

In the regression model, males were three times more likely to have increased ALT level compared to females. This result is consistent with previous results reporting that males have greater risk for having abnormal liver functions, chiefly ALT.[29-33] Furthermore, participants who were overweight and obese had an OR of 3 and 4 to have elevated ALT level, respectively. This result is in agreement with previous studies reporting similar trend.[34-36]

With respect to the change in body weight during one year, eating fast food, drinking beverages with fast food meals, and ALT level were all significantly associated with that change. In agreement with our results, previous results concluded that fast food is one of the most significant factors that played an important role in gaining weight and increasing the prevalence of overweight and obesity in Jordan,[24-26] the Arab Gulf Region countries,[11] and other Arab countries.[12] A causal relationship of fast food and obesity was reported among university students in Lebanon[13] and Saudi Arabia.[14] Moreover, in Iran, high intakes of fast foods were significantly associated with overweight among adolescent girls[17] and children.[38]

It has been reported that the use of fructose as a sweetener (e.g., in beverages) has been implicated in the increasing prevalence of liver disease and metabolic syndrome.[39] University students in India gained weight due to soft drink consumption.[40]

**Conclusions**

In the current study, fast food consumption among university students was not significantly associated with increasing levels of ALT and AST liver enzymes. However, we have found that fast food consumption and soft drinks were associated with increasing body weight, which is expected to have adverse effect on liver functions in the long term.

In the Jordanian context, more research is needed to establish causal relationship between fast food consumption and gaining weight, which may affect liver functions.

To combat the adverse health impact of fast foods in Jordan and other countries, it is the role of Food and Drug Authority and Ministry of Health to establish policies and guidelines for the fast food restaurants to announce about the amount of calories intake for each fast food meal or soft drink. This information should be visibly stated to customers inside the restaurants and in all promotional materials. Moreover, surveillance and monitoring of the implementation and commitment of such policies is crucial.

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**Table 3: Cross tabulation of AST/ALT ratio with eating fast foods or change in body weight in Northern Jordan (n=201)**

| Variable | Optimal (n %) | Borderline (n %) | Abnormal (n %) | P |
|----------|---------------|-----------------|---------------|---|
| Change in body weight | | | | 0.079 |
| No change | 20 (74.1) | 3 (11.1) | 4 (14.8) | |
| + (1-5) | 41 (77.4) | 10 (18.9) | 2 (3.8) | |
| + (6-10) | 24 (58.5) | 12 (29.3) | 5 (12.2) | |
| + (≥11) | 4 (44.4) | 5 (55.6) | 0 (0.0) | |
| − (1-5) | 32 (69.6) | 12 (26.1) | 2 (4.3) | |
| − (6-10) | 8 (72.7) | 1 (9.1) | 2 (18.2) | |
| − (≥11) | 12 (85.7) | 2 (14.3) | 0 (0.0) | |
| Eat fast food/week | | | | 0.309 |
| Never | 39 (61.9) | 18 (28.6) | 6 (9.5) | |
| 1-3 times | 89 (74.2) | 22 (18.3) | 9 (7.5) | |
| ≥4 times | 13 (72.2) | 5 (27.8) | 0 (0.0) | |
| BMI | | | | 0.001 |
| Underweight | 14 (93.3) | 0 (0.0) | 1 (6.7) | |
| Normal | 88 (87.1) | 10 (9.9) | 3 (3.0) | |
| Overweight | 27 (51.9) | 19 (36.5) | 6 (11.5) | |
| Obese | 12 (36.4) | 16 (48.5) | 5 (15.2) | |

**Table 4: Logistic regression analysis of demographic factors associated with increased ALT level**

| Variable | OR | 95% Conf. Interval | P |
|----------|----|-------------------|---|
| Gender | | | |
| Female | 1* | 1.12 | 8.95 | 0.029 |
| Male | 3.17 | | |
| BMI | | | |
| Underweight | 1* | 0.103 | 8.73 | 0.047 |
| Normal | 0.926 | 0.333 | 25.34 | |
| Overweight | 2.90 | 0.430 | 35.21 | |
| Obese | 3.89 | | |

*Reference for other categories

The study from Greece reported that eating fast food was independently associated with higher odds for liver disease.[19] Similar trend was reported in Lebanon.[20] However, studies from Greece and Lebanon did not assess ALT or AST levels. The discrepancy in results may refer to the fact that experimental group in the Swedish study had at least two fast food based meals a day for 4 weeks in combination with adoption of a sedentary lifestyle. However, participants in the current study were asked about the usual weekly consumption of fast food and their physical activity was not restricted. Moreover, the lifestyle factors in Western communities are different from those in the Jordanian context.
Table 5: Factors associated with change in body weight during 1 year (n=201)

| Variable                              | Change in body weight during one year/kg | P     |
|---------------------------------------|------------------------------------------|-------|
|                                       | No change 0 | 1-5 | 6-10 | ≥11 | 1-5 | 6-10 | ≥11 |
| Eat fast food/week                    |             |     |      |     |     |      |     |
| Never                                 | 8 (12.7)    | 19 (30.2) | 6 (9.5) | 3 (4.8) | 14 (22.2) | 5 (7.9) | 8 (12.7) | 0.031 |
| 1-3 times                             | 17 (14.2)   | 31 (25.8) | 28 (23.3) | 3 (2.5) | 30 (25.0) | 5 (4.2) | 6 (5.0) |       |
| ≥4 times                              | 2 (11.1)    | 3 (16.7) | 7 (38.9) | 3 (16.7) | 2 (11.1) | 1 (5.6) | 0 (0.0) |       |
| ALT                                   |             |     |      |     |     |      |     |
| Normal                                | 23 (12.4)   | 53 (28.5) | 35 (18.8) | 7 (3.8) | 43 (23.1) | 11 (5.9) | 14 (7.5) | 0.026 |
| High                                  | 4 (26.7)    | 0 (0.0) | 6 (40.0) | 2 (13.3) | 3 (20.0) | 0 (0.0) | 0 (0.0) |       |
| AST                                    |             |     |      |     |     |      |     |
| Normal                                | 27 (13.8)   | 53 (27.3) | 38 (196) | 9 (4.6) | 43 (22.2) | 11 (5.7) | 13 (6.7) | 0.301 |
| High                                  | 0 (0.0)     | 0 (0.0) | 3 (42.9) | 0 (0.0) | 3 (42.9) | 0 (0.0) | 1 (14.3) |       |
| Drink beverages with fast food        |             |     |      |     |     |      |     |
| Yes                                   | 11 (11.3)   | 36 (37.1) | 35 (36.1) | 6 (6.2) | 7 (7.2) | 1 (1.0) | 1 (1.0) | 0.001 |
| No                                    | 16 (15.4)   | 17 (46.3) | 6 (5.8) | 3 (2.9) | 39 (37.5) | 10 (9.6) | 12 (12.5) |       |

Furthermore, the government is responsible for public education and awareness about the negative impact of fast food on health. This might be conducted by using a variety of health education approaches involving health information messages in the teaching curricula at schools and universities, TV channels, awareness campaigns, and social media.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent none and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

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**References**

1. Bahadoran Z, Mirmiran P, Golzarand M, Hosseini-Esfahani F, Azizi F. Fast food consumption in Iranian adults; dietary intake and cardiovascular risk factors: Tehran lipid and glucose study. Arch Iran Med 2012;15:346-51.
2. Estruch R, Martínez-González MA, Corella D, Salas-Salvadó J, Fité M, Chiva-Blanch G, et al. Retracted: Effect of a high-fat Mediterranean diet on bodyweight and waist circumference: A prespecified secondary outcomes analysis of the PREDIMED randomised controlled trial. Lancet Diabetes Endocrinol 2016;4:666-76.
3. ALFaris NA, Al-Tamimi JZ, Al-Jobair MO, Al-Shwayiat NM. Trends of fast food consumption among adolescent and young adult Saudi girls living in Riyadh. Food Nutr Res 2015;59:26488.
4. Duffey KJ, Gordon-Larsen P, Jacobs Jr DR, Williams OD, Popkin BM. Differential associations of fast food and restaurant food consumption with 3-Y change in body mass index: The coronary artery risk development in young adults study. Am J Clin Nutr 2007;85:201-8.
5. Pereira MA, Kartashov AL, Ebbeling CB, Van Horn L, Slattery ML, Jacobs Jr DR, et al. Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. Lancet 2005;365:36-42.
6. Rosenheck R. Fast food consumption and increased caloric intake: A systematic review of a trajectory towards weight gain and obesity risk. Obes Rev 2008;9:535-47.
7. Jeffery RW, Baxter J, McGuire M, Linde J. Are fast food restaurants an environmental risk factor for obesity? Int J Behav Nutr Phys Act 2006;3:2.
8. Barnes TL, French SA, Mitchell NR, Wolfson J. Fast-food consumption, diet quality and body weight: Cross-sectional and prospective associations in a community sample of working adults. Public Health Nutr 2016;19:885-92.
9. Isaganiatis E, Lustig RH. Fast food, central nervous system insulin resistance, and obesity. Arterioscler Thromb Vasc Biol 2005;25:2451-62.
10. French SA, Harnack LJ, Toomey TL, Hannan PJ. Fast food consumption with 3-y change in body mass index: The CARDIA study: 15-year prospective analysis. Lancet 2005;365:36-42.
11. Al-Mahroos F, Al-Roomi K. Overweight and obesity in the Arabian Peninsula: An overview. J R Soc Promot Health 1999;119:251-3.
12. Musaiger AO, Al Hazzaa HM, Al-Qahtani A, Elati J, Ramadan J, AboulElla NA, et al. Strategy to combat obesity and to promote physical activity in Arab countries. Diabetes Metab Syndr Obes 2011;4:89.
13. El-Kassas G, Itani L, El Ali Z. Obesity risk factors among Beirut
Arab University students in Tripoli-Lebanon. J Nutr Food Sci 2015;5:1.
14. Al-Otaibi HH, Basuny AM. Fast food consumption associated with obesity/overweight risk among University female student in Saudi Arabia. Pak J Nutr 2015;14:511.
15. Asgary S, Nazari B, Sarrafzadegan N, Parkhideh S, Saberi S, Esmaillzadeh A, et al. Evaluation of fatty acid content of some Iranian fast foods with emphasis on trans fatty acids. Asia Pac J Clin Nutr 2009;18:187-92.
16. Rodrigue G, Gallego S, Breidenassel C, Moreno LA, Gottrand F. Is liver transaminases assessment an appropriate tool for the screening of non-alcoholic fatty liver disease in at risk obese children and adolescents? Nutr Hosp 2010;25:2721-7.
17. Kechagias S, Ernerrson Å, Dahlqvist O, Lundberg P, Lindström T, Nystrom FH, et al. Fast-food-based hyper-alimentation can induce rapid and profound elevation of serum alanine aminotransferase in healthy subjects. Gut 2008;57:649-55.
18. Wehmeyer MH, Zyriax BC, Jagemann B, Roth E, Windler E, zur Wiesch JS, et al. Nonalcoholic fatty liver disease is associated with excessive calorie intake rather than a distinctive dietary pattern. Medicine 2016;95:e3887.
19. Kalafati IP, Borsa D, Dimitriou M, Revenas K, Kokkinos A, Dedoussis GV. Dietary patterns and non-alcoholic fatty liver disease in a Greek case-control study. Nutrition 2019;61:105-10.
20. Fakhoury-Sayegh N, Younes H, Heraoui G, Sayegh R. Nutritional profile and dietary patterns of lebanese non-alcoholic fatty liver disease patients: A case-control study. Nutrients 2017;9:1245.
21. Popkin BM. Contemporary nutritional transition: determinants of diet and its impact on body composition. Proc Nutr Soc 2011;70:82-91.
22. Rahim HF, Sibai A, Khader Y, Hwalla N, Fadhil I, Alsdyabiyi H, et al. Non-communicable diseases in the Arab world. Lancet 2014;383:356-67.
23. Tayyem RF, Bawadi HA, Shehadah I, Bani-Hani KE, Takruri H, Al-Jaberi T, et al. Fast foods, sweets and beverage consumption and risk of colorectal cancer: A case-control study in Jordan. Asia Pac J Cancer Prev. 2018;19:261-9.
24. Abu Baker NN, Daradkeh SM. Prevalence of overweight and obesity among adolescents in Irbid governorate, Jordan. East Mediterr Health J 2010;16:657-62.
25. Tayyem RF, Al-Hazzaa HM, Abu-Mwe SS, Bawadi HA, Qatash A, Musaiger AO. Association of lifestyle variables with obesity indices among adolescents in Amman, Jordan. Malays J Nutr 2014;20:pp51-62.
26. Suleiman AA, Alboqai OK, Yasein N, El-Qudah JM, Bataineh MF, Obeidat BA. Prevalence of and factors associated with overweight and obesity among Jordan University students. J Biol Sci 2009;9:738-45.
27. Nimri L, AL-Dahab FA, Batchour R. Foodborne bacterial pathogens recovered from contaminated shawarma meat in northern Jordan. J Infect Dev Ctries 2014;8:1407-14.
28. Schumann G, Bonora R, Ceriotti F, Féraud G, Ferrero CA, Franck PF, et al. IFCC primary reference procedures for the measurement of catalytic activity concentrations of enzymes at 37 C. Part 4. Reference procedure for the measurement of catalytic concentration of alanine aminotransferase. Clin Chem Lab Med 2002;40:718-24.
29. Chen SC, Yeh JJ, Chang MH, Liao YK, Hsiao LC, Neoh CA, et al. Gender difference of alanine aminotransferase elevation may be associated with higher hemoglobin levels among male adolescents. PLoS One 2010;5:e13269.
30. Liu CM, Tung TH, Tsai ST, Liu JH, Tsai YK, Chen VT, et al. Serum insulin, insulin resistance, β-cell dysfunction, and gallstone disease among type 2 diabetics in Chinese population: A community-based study in Kinmen, Taiwan. World J Gastroenterol 2005;11:7159.
31. Schwimmer JB, McGreal N, Deutsch R, Finegold MJ, Lavine JE. Influence of gender, race, and ethnicity on suspected fatty liver in obese adolescents. Pediatrics 2005;115:e561-5.
32. Fraser A, Longnecker MP, Lawlor DA. Prevalence of elevated alanine aminotransferase among US adolescents and associated factors: NHANES 1999–2004. Gastroenterology 2007;133:1814-20.
33. Di Bonito P, Sanguineo E, Di Fraia T, Forziato C, Boccia G, Saïta F, et al. Association of elevated serum alanine aminotransferase with metabolic factors in obese children: Sex-related analysis. Metabolism 2009;58:368-72.
34. Yen SL, Chiu TY, Lin YC, Lee YC, Lee LT, Huang KC. Obesity and hepatitis B infection are associated with increased risk of metabolic syndrome in university freshmen. Int J Obes 2008;32:474-80.
35. Sagi R, Reif S, Neuman G, Webb M, Phillip M, Shalitin S. Nonalcoholic fatty liver disease in overweight children and adolescents. Acta Paediatrica 2007;96:1209-13.
36. Fu CC, Chen MC, Li YM, Liu TT, Wang LY. The risk factors for ultrasound-diagnosed non-alcoholic fatty liver disease among adolescents. Ann Acad Med Singap 2009;38:15-7.
37. Azadbakht L, Hajishafiee M, Golshahi J, Esmaillzadeh A. Snacking behavior and obesity among female adolescents in Isfahan, Iran. J Am Coll Nutr 2016;35:405-12.
38. Azemati B, Kelishadi R, Ahadi Z, Shafee G, Taheri M, Ziaodini H, Qorbani M, Heshmat R. Association between junk food consumption and cardiometabolic risk factors in a national sample of Iranian children and adolescents population: The CASPIAN-V study. Eat Weight Disorders 2018;25:329-35.
39. Aroor AR, Habibi J, Ford DA, Nistala R, Lastra G, Manrique C, et al. Dipeptidyl peptidase-4 inhibition ameliorates western diet–induced hepatic steatosis and insulin resistance through hepatic lipid remodeling and modulation of hepatic mitochondrial function. Diabetes 2015;64:1988-2001.
40. Siddiqi Z, Karoli R, Fatima J, Khanduri S, Varshneya S, Ahmad SS. Soft drinks consumption and the risk of nonalcoholic fatty liver disease. J Assoc Phys India 2017;65:28-32.