The association of Carbohydrate and Monosaturated fat with the risk of iron deficiency

G11 AP Statistics

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Proposal

Research Question

Both macronutrients (e.g carbohydrates and fat) and micronutrients (e.g vitamins and minerals) are included in our daily intakes. Iron homeostasis is important in human's health system. The abnormal of iron homeostasis such as iron-deficiency (ID) may cause diseases such as anemia. One of my primary school classmates had diagnosed as iron-defected anemia 6 years ago. She gradually recovered through regulating her diet and ate specific food such as pork liver to directly increase the iron intake. This is an insight that the adjustment of diet may help treat iron-deficiency anemia. I am wondering whether there are other nutrients indirectly contribute to the recovery of iron-deficiency. Carbohydrate and monosaturated fat occupy a large proportion of daily diet. Thus, this research aims to find out whether carbohydrate and monosaturated fat in particular affect body iron homeostasis.

Background Information

Iron is required for the survival of most organisms, including bacteria, plants, and humans [1]. The abnormal of iron homeostasis may cause pathophysiological conditions: the defection of iron may lead to anemia, and the overload of iron may lead to genetic disorders, inflammation and infection, cardiovascular diseases, cancer, and neurodegeneration diseases [2]. Given that ferritin level reflects on total iron stores in the blood, and the transferrin saturation indicates the iron transportation ability, the ferritin level and transferrin saturation usually are used to evaluate iron status in the clinical studies [3]. Therefore, this research will choose ferritin level and transferrin saturation as the two response variables to specify the iron status.

Humans derive iron from their everyday diet, predominantly from plant foods and the rest from foods of animal origin [4]. Iron absorption can vary from 1 to 40% [5] due to the different components of meal. Carbohydrates are one of the three macronutrients in the human diet, along with protein and fat. [6] They serve as the energy source and participate in sugar and insulin metabolism. However, there is few studies reflected the relationship between carbohydrate and the iron homeostasis. Besides, monounsaturated fats also present in daily diet and play an important role in human body to regulate LDL cholesterol level [7]. They are found in plant foods, such as nuts, avocados, and vegetable oils [8] Therefore, carbohydrate and monosaturated fat are selected as explanatory variables. Human generally consume micronutrients along with macronutrients, so this research considers both micronutrients and macronutrients except carbohydrate and monosaturated fat as confounding variables.

Sampling and experimental design

Type of study: This research is an observational study which utilizes the dietary data of participants and iron status examination data.

Variables: The total amount of carbohydrate and monosaturated fat are chosen as explanatory variables. The ferritin level and transferrin saturation are chosen as response variables.

Data collection: The research obtained all the data from NHANES 2017-2020 database [6] (Data in this database was collected from 2019 to March 2020 and were combined with data from the NHANES 2017-2018 cycle to form a nationally representative sample of NHANES 2017-March 2020 pre-pandemic data.)

Scope of inference: The sample size of each dataset is larger than 9000, so it is enough to be generalized to the population of people all over the world.

Exploratory Data Analysis

The full join was performed between all variables except ferritin level and transferrin saturation. The right join was performed between all explanatory variables, confounding variables and ferritin level. The right join was also performed between all explanatory variables, confounding variables and ferritin level.

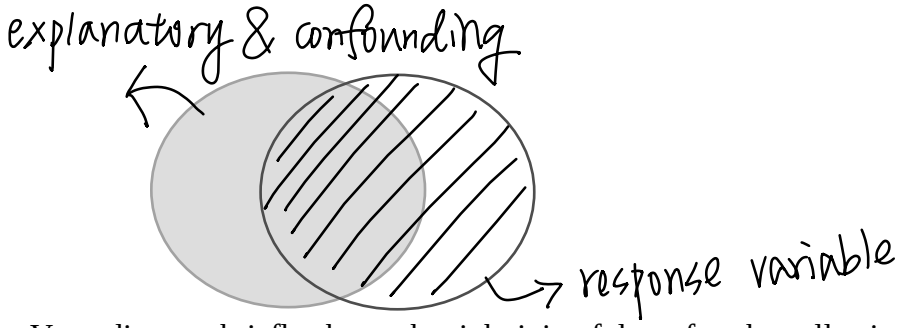

Figure 1. The Venn diagram briefly shows the right join of data after the collection.

The minimum, first quartile, median, mean, third quartile, maximum were generated by using R. (summary ())

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     SEQN          Gender         Age            Race      Country.of.birth Ratio.of.family.income.to.poverty     Weight
Min.   :109264   1:4622   Min.   :12.00   1:1208   1 :6994          Min.   :0.000                      Min.   : 27.60
1st Qu.:113185   2:4831   1st Qu.:26.00   2: 973   2 :2454          1st Qu.:1.140                      1st Qu.: 64.90
Median :117063            Median :46.00   3:3277   77:   4          Median :2.100                      Median : 77.80
Mean   :117076            Mean   :45.05   4:2372   99:   1          Mean   :2.526                      Mean   : 81.23
3rd Qu.:120973            3rd Qu.:62.00   5:1623                    3rd Qu.:4.080                      3rd Qu.: 93.80
Max.   :124822            Max.   :80.00                             Max.   :5.000                      Max.   :254.30
                                                                    NA's   :1250                       NA's   :129
    Height         Energy.1       Protein.1      Carbohydrate.1   Total.sugars.1   Dietary.Fiber.1   Total.fat.1
Min.   :131.1   Min.   :    0   Min.   :  0.00   Min.   :   0.0   Min.   :  0.00   Min.   :  0.00   Min.   :  0.00
1st Qu.:159.0   1st Qu.: 1418   1st Qu.: 49.90   1st Qu.: 160.6   1st Qu.: 55.72   1st Qu.:  8.80   1st Qu.: 15.60
Median :165.9   Median : 1944   Median : 70.42   Median : 224.6   Median : 90.36   Median : 13.80   Median : 24.40
Mean   :166.4   Mean   : 2114   Mean   : 78.19   Mean   : 247.1   Mean   :106.53   Mean   : 15.99   Mean   : 27.85
3rd Qu.:173.6   3rd Qu.: 2628   3rd Qu.: 98.20   3rd Qu.: 310.7   3rd Qu.:137.81   3rd Qu.: 20.60   3rd Qu.: 36.24
Max.   :198.7   Max.   :12501   Max.   :545.20   Max.   :1586.2   Max.   :931.16   Max.   :103.40   Max.   :268.59
NA's   :140     NA's   :792     NA's   :792      NA's   :792      NA's   :792      NA's   :792      NA's   :792
Total.monosaturated.fat Total.polysaturated.fat  Cholesterol        Iron          Vitamin.C         Vitamin.D
Min.   :  0.00          Min.   :  0.00          Min.   :   0.0   Min.   :  0.00   Min.   :   0.00   Min.   :  0.000
1st Qu.: 17.34          1st Qu.: 11.02          1st Qu.: 129.0   1st Qu.:  8.08   1st Qu.:  16.90   1st Qu.:  1.100
Median : 25.88          Median : 17.40          Median : 232.0   Median : 11.85   Median :  45.20   Median :  2.900
Mean   : 29.36          Mean   : 20.42          Mean   : 305.2   Mean   : 13.55   Mean   :  76.01   Mean   :  4.339
3rd Qu.: 37.61          3rd Qu.: 26.46          3rd Qu.: 412.0   3rd Qu.: 16.83   3rd Qu.: 104.70   3rd Qu.:  5.600
Max.   :200.10          Max.   :218.70          Max.   :2403.0   Max.   :111.04   Max.   :1977.40   Max.   :105.700
NA's   :792             NA's   :792             NA's   :792      NA's   :792      NA's   :792       NA's   :792
  Vitamin.K         Calcium         Phosphorus     Magnesium          Zinc           Copper          Sodium         Potassium
Min.   :   0.0   Min.   :   2.0   Min.   :   0   Min.   :   5.0   Min.   :  0.00   Min.   : 0.018   Min.   :    2   Min.   :    0
1st Qu.:  38.5   1st Qu.: 513.0   1st Qu.: 848   1st Qu.: 183.0   1st Qu.:  6.02   1st Qu.: 0.683   1st Qu.: 2141   1st Qu.: 1574
Median :  70.0   Median : 793.0   Median :1201   Median : 254.0   Median :  8.90   Median : 0.989   Median : 3059   Median : 2241
Mean   : 115.4   Mean   : 908.8   Mean   :1323   Mean   : 284.3   Mean   : 10.36   Mean   : 1.138   Mean   : 3413   Mean   : 2452
3rd Qu.: 129.0   3rd Qu.:1161.0   3rd Qu.:1650   3rd Qu.: 352.0   3rd Qu.: 12.86   3rd Qu.: 1.377   3rd Qu.: 4265   3rd Qu.: 3076
Max.   :2561.1   Max.   :6495.0   Max.   :7373   Max.   :1506.0   Max.   :477.53   Max.   :43.248   Max.   :25949   Max.   :14358
NA's   :792      NA's   :792      NA's   :792    NA's   :792      NA's   :792      NA's   :792      NA's   :792     NA's   :792
   Selenium        Caffeine      total.length.of.food.fast.minutes Transferrin.Saturation
Min.   :   0.0   Min.   :   0.0   Min.   :  0.00                   Min.   : 2.00
1st Qu.:  67.7   1st Qu.:   4.0   1st Qu.: 14.00                   1st Qu.:19.00
Median :  98.1   Median :  72.0   Median : 30.00                   Median :25.00
Mean   : 110.3   Mean   : 125.1   Mean   : 29.19                   Mean   :26.57
3rd Qu.: 139.1   3rd Qu.: 174.0   3rd Qu.: 44.00                   3rd Qu.:33.00
Max.   :1195.6   Max.   :4320.0   Max.   : 59.00                   Max.   :92.00
NA's   :792      NA's   :792
```

Figure 2. The data summary of cleaned Transferrin Saturation dataset

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      SEQN          Gender         Age          Race     Country.of.birth Ratio.of.family.income.to.poverty     Weight
 Min.   :109264   1:5201   Min.   : 1.00   1:1334   1 :8036          Min.   :0.000                      Min.   :  8.2
 1st Qu.:113201   2:5356   1st Qu.:20.00   2:1087   2 :2516          1st Qu.:1.073                      1st Qu.: 60.2
 Median :117077            Median :42.00   3:3677   77:   4          Median :2.040                      Median : 75.2
 Mean   :117085            Mean   :41.25   4:2670   99:   1          Mean   :2.477                      Mean   : 75.3
 3rd Qu.:120983            3rd Qu.:61.00   5:1789                    3rd Qu.:4.000                      3rd Qu.: 91.5
 Max.   :124822            Max.   :80.00                             Max.   :5.000                      Max.   :254.3
                                                                     NA's   :1379                       NA's   :144
     Height         Energy.1       Protein.1      Carbohydrate.1   Total.sugars.1   Dietary.Fiber.1   Total.fat.1
 Min.   : 78.3   Min.   :    0   Min.   :  0.00   Min.   :   0.0   Min.   :  0.00   Min.   :  0.00   Min.   :  0.00
 1st Qu.:157.2   1st Qu.: 1372   1st Qu.: 47.95   1st Qu.: 158.7   1st Qu.: 56.36   1st Qu.:  8.60   1st Qu.: 15.32
 Median :164.9   Median : 1883   Median : 68.11   Median : 220.3   Median : 90.15   Median : 13.40   Median : 23.69
 Mean   :161.8   Mean   : 2065   Mean   : 76.07   Mean   : 243.3   Mean   :105.84   Mean   : 15.58   Mean   : 27.22
 3rd Qu.:172.9   3rd Qu.: 2564   3rd Qu.: 95.52   3rd Qu.: 304.8   3rd Qu.:136.06   3rd Qu.: 19.90   3rd Qu.: 35.43
 Max.   :199.6   Max.   :12501   Max.   :545.20   Max.   :1586.2   Max.   :931.16   Max.   :103.40   Max.   :268.59
 NA's   :362     NA's   :990     NA's   :990      NA's   :990      NA's   :990      NA's   :990      NA's   :990
 Total.monosaturated.fat Total.polysaturated.fat  Cholesterol         Iron          Vitamin.C         Vitamin.D
 Min.   :  0.00          Min.   :  0.00          Min.   :   0.0   Min.   :  0.000   Min.   :   0.00   Min.   :  0.00
 1st Qu.: 16.62          1st Qu.: 10.61          1st Qu.: 123.0   1st Qu.:  7.905   1st Qu.:  17.80   1st Qu.:  1.10
 Median : 24.96          Median : 16.70          Median : 223.0   Median : 11.560   Median :  47.10   Median :  3.00
 Mean   : 28.51          Mean   : 19.78          Mean   : 296.0   Mean   : 13.266   Mean   :  76.65   Mean   :  4.44
 3rd Qu.: 36.59          3rd Qu.: 25.58          3rd Qu.: 397.5   3rd Qu.: 16.470   3rd Qu.: 105.40   3rd Qu.:  5.90
 Max.   :200.10          Max.   :218.70          Max.   :2403.0   Max.   :111.040   Max.   :1977.40   Max.   :105.70
 NA's   :990             NA's   :990             NA's   :990      NA's   :990       NA's   :990       NA's   :990
   Vitamin.K         Calcium        Phosphorus      Magnesium          Zinc            Copper           Sodium         Potassium
 Min.   :   0.0   Min.   :   2   Min.   :   0   Min.   :   5.0   Min.   :  0.000   Min.   : 0.018   Min.   :    2   Min.   :    0
 1st Qu.:  36.1   1st Qu.: 518   1st Qu.: 836   1st Qu.: 177.0   1st Qu.:  5.855   1st Qu.: 0.650   1st Qu.: 2050   1st Qu.: 1551
 Median :  66.0   Median : 797   Median :1179   Median : 248.0   Median :  8.670   Median : 0.955   Median : 2950   Median : 2199
 Mean   : 110.1   Mean   : 909   Mean   :1302   Mean   : 277.3   Mean   : 10.098   Mean   : 1.102   Mean   : 3311   Mean   : 2411
 3rd Qu.: 122.9   3rd Qu.:1161   3rd Qu.:1624   3rd Qu.: 343.0   3rd Qu.: 12.520   3rd Qu.: 1.343   3rd Qu.: 4170   3rd Qu.: 3025
 Max.   :2561.1   Max.   :7038   Max.   :7373   Max.   :1506.0   Max.   :477.530   Max.   :43.248   Max.   :25949   Max.   :14358
 NA's   :990      NA's   :990    NA's   :990    NA's   :990      NA's   :990       NA's   :990      NA's   :990     NA's   :990
    Selenium         Caffeine      total.length.of.food.fast.minutes    Ferritin
 Min.   :   0.0   Min.   :   0.0   Min.   : 0.00                     Min.   :   1.04
 1st Qu.:  64.5   1st Qu.:   2.0   1st Qu.:14.00                     1st Qu.:  37.00
 Median :  94.4   Median :  58.0   Median :30.00                     Median :  80.70
 Mean   : 106.9   Mean   : 115.7   Mean   :28.99                     Mean   : 132.80
 3rd Qu.: 134.8   3rd Qu.: 158.0   3rd Qu.:44.00                     3rd Qu.: 166.00
 Max.   :1195.6   Max.   :4320.0   Max.   :59.00                     Max.   :5190.00
 NA's   :990      NA's   :990
```

Figure 3. The data summary of cleaned Ferritin dataset

The dot plot and loess regression curve were performed to roughly predict the relationship between explanatory variables and response variables.

Based on the exploratory data analysis, the LOESS curve shows an almost horizontal curve in each graph. However, there are multiple outliers. Further work will manage to treat these outliers. Also, the confounding variables are not considered, so the research will conduct linear regression by R more precisely and optimize a function which considers the explanatory variables, the confounding variables and the response variables.

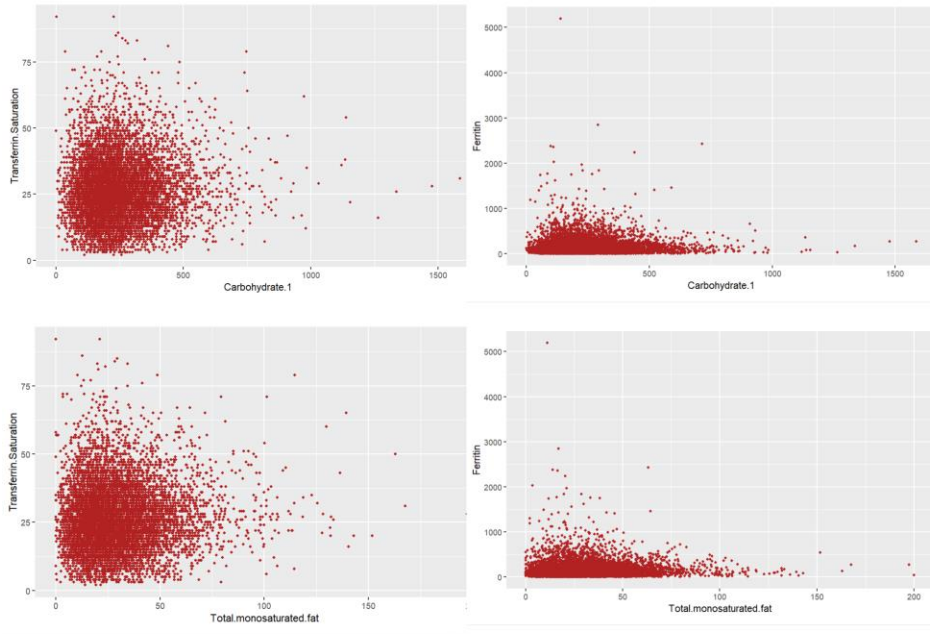

Figure 4. The dot plot of four groups

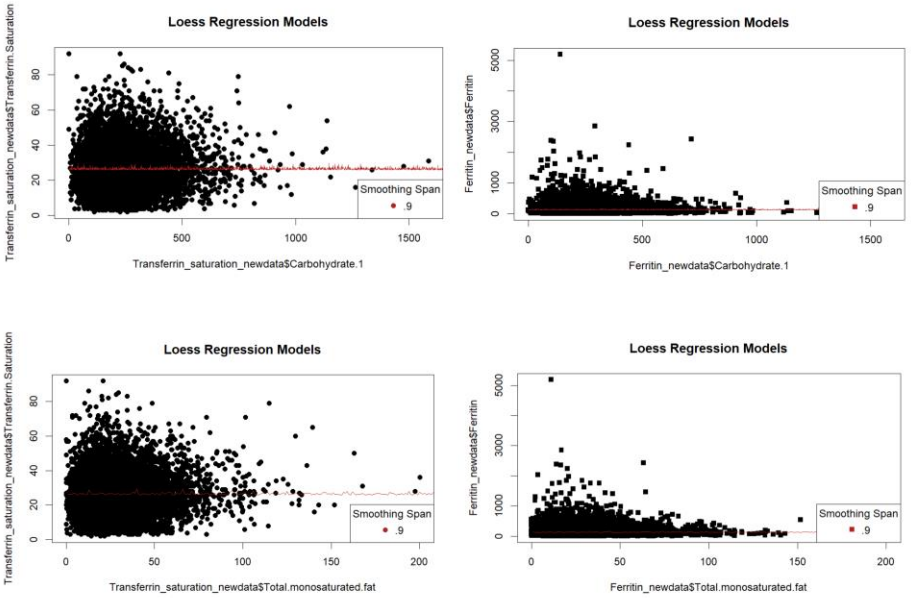

Figure 5. The LOESS Regression Model of four groups

Group Task Assignments and Timeline

In this project, I (Ura) am responsible for all the work included literature review, exploratory data analysis, establishing regression models and final write up. The exploratory data analysis will be done on May 15th. The regression model will be generated and optimized on May 17th. The main research context write-up will be done by May 20th. The presentation will be in class.

Data

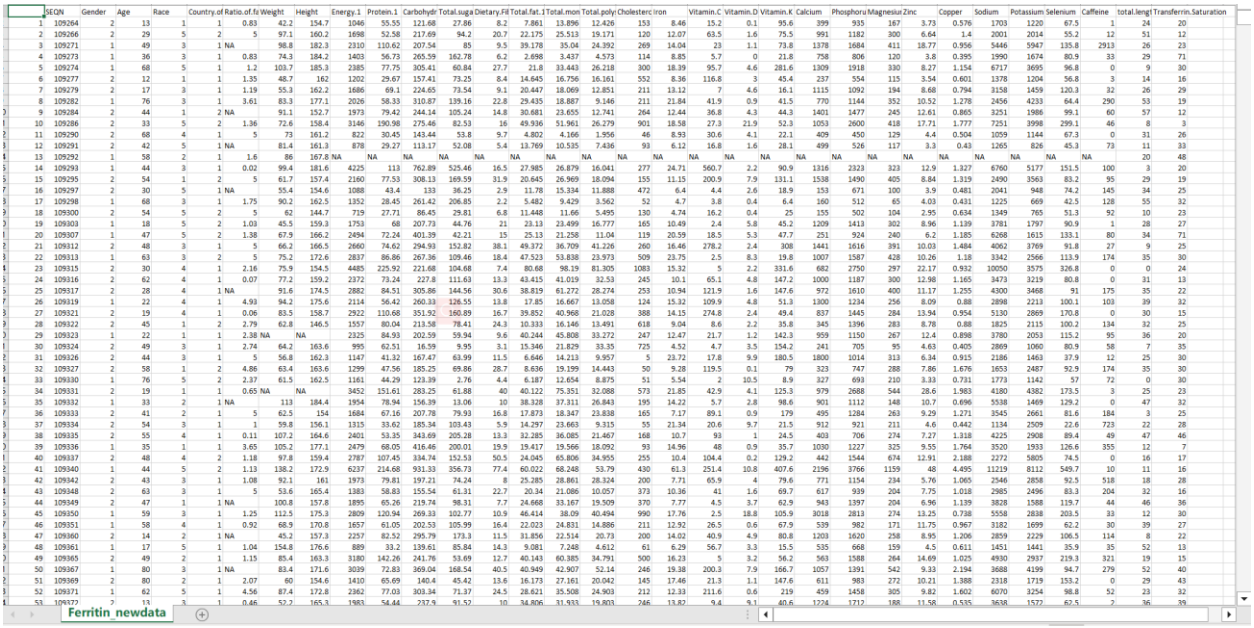

Figure 6. Cleaned data in regard of transferrin saturation. The sample size is 9453.

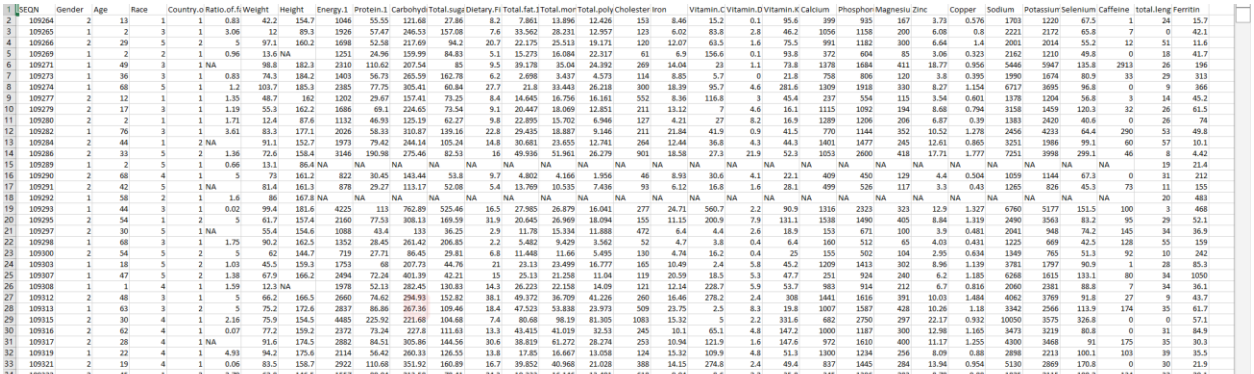

Figure 7. Cleaned data in regard of ferritin. The sample size is 124822.

Reference

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