



Research Article

# Dietary Energy and Nutrients Intake of Secondary School Students in Macao: A Cross- Sectional Study

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## Abstract

The present study aimed to investigate the nutritional intake status of Macao secondary school students. A cross-sectional study was conducted. Food consumption of four hundred and twenty- four secondary school students was obtained by using a semi-quantitative Food Frequency Questionnaire (FFQ). Data was analyzed through independent-samples T test by SPSS. Percentages of overweight and obesity in male and female were 27.9% and 17.8% respectively. Compared with the Dietary Reference Intakes (DRIs), the average daily energy intake of male younger than 14 years old was 300 kcal higher than the recommended level, mainly due to double intake of protein. For female, all groups showed insufficient energy intake because of low carbohydrates intake. Both genders were unable to meet the appropriate dietary fiber intake of 25 g. Other nutrients such as vitamin A, vitamin D, calcium and iodine were also under recommended levels. It is suggested that secondary school students in Macao should pay more attention to the intake requirements of energy and various nutrients for their age groups, in order to maintain balanced dietary patterns and healthy dietary behaviors. Moreover, further evaluation of nutritional intake status is required to formulate suitable nutritional approaches for adolescents in Macao.

**Keywords:** Macao secondary school students; Food frequency questionnaire; Overweight; Obesity; Nutrients

## Introduction

Adolescence, which refers to the transition from puberty to adulthood spanning from ages 10 to 19, is a critical and unique period for both physical and psychological development. During this second phase of rapid growth in lives, adolescents establish their behavioral patterns, including those related to diet and physical activity. And the dietary patterns adopted during this stage lay the foundation for future health [1]. With the socio-economic development, the prevalence of malnutrition has gradually declined. However, the problem of adolescent obesity and nutritional imbalance has intensified due to societal civilization, diversification of diets and changes in lifestyles [2]. The dietary patterns of adolescents are also influenced by multiple factors, including social environment, family background, interpersonal

relationships and individual factors such as mental, physiological, and lifestyle factors. At this phase, peers have a greater influence than parents. Common issues include irregular eating habits, frequent consumption of high-calorie and high-sugar foods, inappropriate dieting and insufficient physical activity. These unhealthy eating behaviors and lifestyles can contribute to a range of health issues, such as underweight or overweight due to imbalanced calorie consumption, inadequate vitamins and minerals intakes, as well as eating disorders like anorexia nervosa and binge eating disorder [3-5]. Among these issues, the consumption of energy-dense foods which are high in fat and sugar, coupled with sedentary behavior and lack of physical activity are the major causes of obesity and overweight [6]. Obesity during childhood and adolescence is likely to persist into adulthood, posing multiple risks to the cardiovascular, endocrine, respiratory, liver, musculoskeletal, psychological and cognitive systems, and placing long-term burdens on society in terms of economics and healthcare [7,8].

According to data from the World Health Organization (WHO), the prevalence of overweight and obesity among children and adolescents aged 5 to 19 increased from 4% in 1975 to 18% in 2016, representing a more than four-fold increase [6,9]. A study analyzing data from seven national surveys on the physical fitness and health of Chinese students revealed that the prevalence of overweight and obesity among Chinese children and adolescents aged 7 to 18 increased from 1.2% in 1985 to 23.4% in 2019, with an increase of more than 18 times. The prevalence was higher in boys than girls (28.4% and 18.4%) and higher in urban areas than rural areas (25.4% and 21.5%). Among provinces, Shandong had the highest prevalence (38.9%), while Guangdong had the lowest (12.2%) [10]. In Hong Kong, the Survey on Physical Fitness of Secondary School Students in 2019/20 and 2020/21 reported a higher prevalence of overweight and obesity compared to the 2014/15 academic year. The survey found that 32.1% of boys and 20.8% of girls were classified as overweight or obese, with an increase of 9.1% and 0.8% respectively compared to the figures recorded in 2014/15 [11]. In Macao, a survey conducted in 2018 regarding food consumption among secondary school students indicated that the overall proportion of overweight and obese students was 23.3%, in which boys and girls are 30.1% and 16.8% respectively [12]. The fourth Macao Citizens' Physical Fitness Monitoring conducted in 2020 showed an increase in the overweight and obesity rates among all students compared to 2015. For boys, the overall overweight and obesity rates were 31.0%, representing an increase of 4.8%. As for girls, although the overweight and obesity rates decreased by 2.0% to an overall rate of 17.0%, there was a notable increase of 1.9% in the rate of underweight, indicating that boys are more prone to overweight issues while girls tend to be overly concerned with maintaining a slim figure [13].

On the public health level, overweight, obesity and their related non-communicable diseases are largely preventable. Supportive environments and communities, including measures taken by the government, are fundamental and essential elements in shaping people's choices for a healthy lifestyle. These measures encourage individuals in making accessible and affordable choices, including healthy and nutritious foods, as well as resources and environments that facilitate physical activity, thereby fostering healthy lifestyles and preventing overweight and obesity [6]. Addressing the causes of childhood and adolescent overweight and obesity requires a comprehensive approach that targets various stakeholders and environments, including individuals, families, schools, communities and government. Therefore, it is crucial to develop comprehensive intervention measures with the involvement of professionals [14]. Although the current weight status of Macao adolescents is known from the government's monitoring of the physical fitness of Macao residents, the

research report did not investigate the nutritional intake aspect. Therefore, this study aimed to explore the nutritional intake status of Macao secondary school students and provide appropriate recommendations.

## **Materials and Methods**

### **Study design and recruitment**

A cross-sectional descriptive method was applied in this study to investigate the secondary school students in Macao during the 2020/21 academic year, with a total of 27,627 students enrolled [15]. Stratified random cluster sampling was conducted by selecting 3 schools from a pool of 47 schools. From each selected school, one class was randomly chosen from every grade level, resulting in a sample of 18 classes.

### **Procedure**

Data was gathered from a total of 18 classes within 3 schools. Following the acquisition of consent and coordination with the school directors, questionnaires were distributed to each class. The researcher presented a slideshow featuring images of various food items alongside their corresponding names, portion sizes and actual tableware at the site. The students independently completed the forms, providing estimations of the servings they consumed daily.

### **Ethical aspects**

Participation in the study was completely voluntary and the anonymity of questionnaire was ensured for all respondents. Before administering the survey, the research objectives were clearly communicated to the participants, who were informed of their right to decline participation or withdraw from the study at any point. The questionnaires and research materials were handled with strict confidentiality. This study was approved by the Faculty of Medicine of the Macau University of Science and Technology.

### **Food frequency questionnaire (FFQ)**

A questionnaire with 13 food groups, total 61 food items was developed according to the research objectives and relevant literature, followed by reliability and validity verification by seven experts specializing in public health, nutrition and epidemiology. To assist the subjects in differentiating between different types of food and their quantities, a supplementary tool in the form of a food map was applied, indicating the weight or volume of each food item. By analyzing the data collected in the survey, we were able to understand subjects' intake status of energy and nutrients.

### **Data analysis**

To determine the weight status of the students, the calculated body mass index (BMI) from height and weight would be matched

with the “Growth Reference BMI-for-Age Percentiles for Children and Adolescents Aged 5-19” from the WHO, then classified into different categories, including severe thinness, thinness, normal weight, overweight, and obesity [16]. The energy and nutrients intake were derived from food composition database of China, Japan and Hong Kong according to the weight or volume of each food item [17-19]. All data was analyzed via IBM SPSS 24.0 (IBM, Armonk, New York, USA). Independent- samples T Test was used to assess the difference of energy and nutrients intake between genders in each age group. Statistical significance was set at  $p < 0.05$ . The average daily energy and nutrients intake were reported as the mean and Standard Deviation (SD) for normally distributed variables, and as percentiles for variables with skewed distributions.

## Results

### General demographic characteristics of the subjects

A total of 432 questionnaires were distributed and 424 (98.1%) were obtained as valid questionnaires after screening and eliminating those were missed or filled-in inappropriately. Table 1 shows the distribution of the subjects according to the demographic characteristics.

Variable	Sub-Variable	<i>n</i>	%
Gender	Male	154	36.3
	Female	270	63.7
Age (years)	<14	42	9.9
	14-17	256	60.4
	≥18	126	29.7
Grade	Junior 1	77	18.2
	Junior 2	75	17.7
	Junior 3	80	18.9
	Senior 1	77	18.2
	Senior 2	59	13.9
	Senior 3	56	13.2

**Table 1:** General demographic characteristics of the subjects ( $n = 424$ ).

### Body Mass Index (BMI)

The average BMI of all subjects was  $20.6 \pm 0.2$  (kg/m<sup>2</sup>). Average BMI for male and female were  $21.8 \pm 0.4$  (kg/m<sup>2</sup>) and  $19.9 \pm 0.2$  (kg/m<sup>2</sup>), respectively. According to the BMI category [20,21], the subjects were classified into severe thinness, thinness, normal weight, overweight and obesity, and the distribution is shown in Table 2.

Category	Male	Female
	<i>n</i> (%)	<i>n</i> (%)
Severe thinness	1 (0.6)	5 (1.9)
Thinness	25 (16.2)	43 (15.9)
Normal weight	85 (55.2)	174 (64.4)
Overweight	24 (15.6)	27 (10.0)
Obesity	19 (12.3)	21 (7.8)
Total	154	270

**Table 2:** Distribution of subjects’ BMI classification ( $n = 424$ ).

### Difference of energy and nutrients intake between genders in each age group

The difference of energy and nutrients intake between male and female subjects in each age group is shown in Tables 3-5. Compared with the DRIs [22-26], the energy intake of male in the <14-year-old and 14-17-year-old groups were significantly higher than in female ( $p < 0.05$  and  $p < 0.001$ ), in which the <14-year-old group having energy intake higher than the DRIs. Protein intake in the <14-year-old and 14-17-year-old groups were also significantly higher than in female ( $p < 0.01$  and  $p < 0.001$ ), being 2 times and 1.5 times more than the DRIs, respectively. These two groups also consumed more fat ( $p < 0.001$  and  $p < 0.001$ ) and phosphorus ( $p < 0.05$  and  $p < 0.001$ ), especially phosphorus exceeding the DRIs by more than double. However, the intakes of dietary fiber, vitamin A, vitamin D and calcium in male were inadequate. In female, the intake of carbohydrates was significantly lower than that of male in the 14-17-year-old group ( $p < 0.001$ ), and it was lower than the DRIs as well. This group also had inadequate intake in energy and various nutrients, including fat, dietary fiber, vitamin A, vitamin D, calcium and iodine, with daily intake below the DRIs.

Energy and nutrients	Age	Male	Female	p- value
		Mean ± SD	Mean ± SD	
Energy (kcal)	<14	2362.9 ± 427.1	1437.5 ± 122.5	0.014
	14-17	2213.2 ± 164.0	1598.6 ± 57.9	<0.001
	≥18	1918.0 ± 97.6	1498.8 ± 79.0	0.162
Carbohydrates (g)	<14	323.1 ± 37.9	215.2 ± 15.8	0.538
	14-17	320.2 ± 21.6	226.6 ± 8.4	<0.001
	≥18	269.8 ± 13.0	217.6 ± 11.5	0.329
Protein (g)	<14	129.2 ± 33.9	71.8 ± 7.6	0.002
	14-17	113.9 ± 9.9	84.2 ± 3.2	<0.001
	≥18	104.6 ± 7.1	82.7 ± 4.8	0.122
Fat (g)	<14	68.6 ± 19.6	36.2 ± 4.1	<0.001
	14-17	58.2 ± 6.1	43.9 ± 2.0	<0.001
	≥18	50.3 ± 3.7	37.4 ± 3.3	0.380
Cholesterol (mg)	<14	435.0 ± 157.1	312.0 ± 36.1	0.030
	14-17	545.1 ± 61.9	404.0 ± 19.3	<0.001
	≥18	525.7 ± 53.6	375.8 ± 27.3	0.007
Fiber (g)	<14	23.4 ± 4.0	15.2 ± 1.8	0.196
	14-17	19.1 ± 1.8	16.4 ± 0.8	0.009
	≥18	12.4 ± 0.9	16.2 ± 1.4	0.014

*n* of male with age: <14=10, 14-17=84, ≥18=60; *n* of female with age: <14=32, 14-17=172, ≥18=66.

**Table 3:** Daily intakes of energy and nutrients from food.

Vitamins	Age	Male	Female	p- value
		Mean ± SD	Mean ± SD	
Vitamin A (µgRAE)	<14	727.3 ± 217.3	361.5 ± 48.2	0.004
	14-17	600.3 ± 54.1	451.8 ± 22.0	<0.001
	≥18	421.4 ± 35.6	469.5 ± 39.7	0.371
Vitamin B1 (mg)	<14	1.2 ± 0.4	0.7 ± 0.1	<0.001
	14-17	1.1 ± 0.1	0.8 ± 0.0	<0.001
	≥18	1.1 ± 0.1	0.8 ± 0.1	0.001
Vitamin B2 (mg)	<14	1.2 ± 0.3	0.8 ± 0.1	0.167
	14-17	1.3 ± 0.1	1.0 ± 0.0	0.001
	≥18	1.1 ± 0.1	0.9 ± 0.1	0.016
Vitamin B6 (mg)	<14	0.7 ± 0.2	0.5 ± 0.1	0.037
	14-17	0.7 ± 0.1	0.7 ± 0.0	0.084
	≥18	0.7 ± 0.1	0.7 ± 0.1	0.891
Vitamin B12 (µg)	<14	2.9 ± 1.0	2.3 ± 0.3	0.197
	14-17	3.5 ± 0.4	2.7 ± 0.1	<0.001
	≥18	3.8 ± 0.4	2.7 ± 0.2	0.004

Folate (µg)	<14	140.2 ± 37.7	63.2 ± 6.7	<0.001
	14-17	112.5 ± 12.1	84.8 ± 5.4	0.010
	≥18	93.2 ± 10.2	65.4 ± 4.6	<0.001
Vitamin C (mg)	<14	121.3 ± 43.5	85.3 ± 16.1	0.567
	14-17	116.8 ± 13.6	96.6 ± 7.9	0.044
	≥18	60.6 ± 7.2	101.2 ± 12.2	0.003
Vitamin D (µg)	<14	8.8 ± 3.5	4.3 ± 0.5	<0.001
	14-17	7.7 ± 0.9	5.8 ± 0.4	<0.001
	≥18	6.3 ± 0.7	5.7 ± 0.6	0.374
Vitamin E (mg)	<14	33.5 ± 13.1	11.2 ± 1.3	<0.001
	14-17	19.2 ± 2.0	13.8 ± 0.8	<0.001
	≥18	14.1 ± 1.2	13.0 ± 1.0	0.142
Vitamin K (µg)	<14	89.8 ± 20.3	115.0 ± 14.0	0.517
	14-17	122.2 ± 8.9	114.3 ± 5.9	0.177
	≥18	115.2 ± 9.8	102.0 ± 10.2	0.851
<i>n</i> of male with age: <14=10, 14-17=84, ≥18=60; <i>n</i> of female with age: <14=32, 14-17=172, ≥18=66.				

**Table 4:** Daily intakes of vitamins from food.

Minerals	Age	Male	Female	<i>p</i> - value
		Mean ± SD	Mean ± SD	
Calcium (mg)	<14	888.6 ± 163.6	609.6 ± 72.9	0.226
	14-17	848.6 ± 65.6	679.1 ± 30.4	<0.001
	≥18	654.8 ± 43.1	631.6 ± 41.5	0.799
Iron (mg)	<14	45.1 ± 9.1	23.8 ± 2.9	0.003
	14-17	35.3 ± 3.3	26.9 ± 1.4	0.002
	≥18	26.5 ± 1.6	28.2 ± 2.4	0.171
Iodine (µg)	<14	101.2 ± 22.8	76.7 ± 8.4	0.256
	14-17	129.3 ± 15.0	91.1 ± 6.5	<0.001
	≥18	97.0 ± 15.1	74.3 ± 5.3	0.015
Zinc (mg)	<14	18.6 ± 4.3	10.9 ± 1.1	0.004
	14-17	17.0 ± 1.3	11.8 ± 0.4	<0.001
	≥18	15.6 ± 1.0	12.2 ± 0.7	0.090
Selenium (µg)	<14	84.7 ± 18.8	50.7 ± 7.0	0.046
	14-17	80.9 ± 8.9	62.1 ± 3.4	<0.001
	≥18	61.4 ± 5.1	62.9 ± 5.6	0.713
Copper (mg)	<14	9.6 ± 2.9	3.9 ± 0.7	0.002
	14-17	7.2 ± 1.0	5.4 ± 0.5	0.102
	≥18	5.3 ± 0.9	3.7 ± 0.4	0.006
Magnesium (mg)	<14	508.2 ± 101.2	301.7 ± 31.0	0.016
	14-17	438.6 ± 32.3	338.5 ± 14.7	<0.001
	≥18	338.4 ± 18.5	340.4 ± 20.6	0.406

Sodium (mg)	<14	1573.1 ± 520.1	816.4 ± 93.4	0.005
	14-17	1317.3 ± 127.8	971.8 ± 45.0	<0.001
	≥18	1187.6 ± 115.3	845.4 ± 75.8	0.069
Potassium (mg)	<14	4325.8 ± 905.1	2492.9 ± 302.1	0.030
	14-17	3575.0 ± 298.1	2860.4 ± 133.1	0.001
	≥18	2672.6 ± 177.5	2793.0 ± 191.5	0.475
Phosphorus (mg)	<14	1686.0 ± 362.4	1031.0 ± 103.4	0.027
	14-17	1580.5 ± 118.1	1161.2 ± 43.1	<0.001
	≥18	1396.3 ± 80.8	1128.3 ± 61.5	0.100
<i>n</i> of male with age: <14=10, 14-17=84, ≥18=60; <i>n</i> of female with age: <14=32, 14-17=172, ≥18=66.				

**Table 5:** Daily intakes of minerals from food.

### Average daily energy intake from various food groups

Table 6 shows the mean and SD, and the percentile of average energy daily intake from all 13 food groups. Overall, cereals and grains are the primary sources of energy with 674.4 kcal, followed by other common foods and drinks with 304.4 kcal (including snacks like potato chips, biscuits, and sugary beverages) and livestock with 203.9 kcal. Food groups provided energy within 100-200 kcal included milk and dairy products and fruits. Other food groups with less than 100 kcal intake included poultry, seafood, soybean products, eggs, vegetables and legumes, nuts and seeds, starchy products and seaweed and mushrooms.

Food Group	Mean ± SD	P5	P25	P50	P75	P95
Cereals and grains	674.4 ± 372.1	251.1	441.2	606.6	812.0	1348.1
Starchy rhizomes	13.6 ± 21.4	0.0	2.46	9.9	19.7	39.4
Soybean products	56.7 ± 103.3	0.0	11.1	31.4	71.9	170.7
Vegetables and legumes	42.7 ± 41.3	5.4	17.3	31.3	52.4	115.4
Seaweed and mushrooms	6.5 ± 11.1	0.0	1.0	3.9	7.7	27.1
Fruits	116.0 ± 137.7	0.0	32.3	75.0	149.7	410.5
Nuts and seeds	25.2 ± 81.0	0.0	0.0	0.0	22.1	88.3
Livestock	203.9 ± 217.8	28.3	75.6	143.7	252.4	576.0
Poultry	62.2 ± 89.0	3.25	18.8	39.0	85.6	193.3
Milk and dairy products	135.5 ± 158.2	0.0	20.6	88.4	178.8	497.0
Eggs	55.4 ± 60.8	1.4	21.7	35.9	76.0	155.9
Seafood	59.4 ± 84.2	0.0	14.6	35.0	71.5	234.4
Other common foods and drinks	304.4 ± 386.1	26.8	88.9	186.4	366.6	994.3
Total	1755.9 ± 987.8	764.3	1159.0	1550.1	2063.3	3359.2

**Table 6:** Average daily energy intake from 13 food groups (kcal).

### Discussion

Countries worldwide place significant emphasis on the well-being and proper development of children and adolescents, implementing a range of policies and measures to foster their overall health. Currently, 96 countries have developed dietary guidelines, and among them, 12 countries have formulated dietary guidelines specifically for school-aged children, aiming to guide their balanced diets and foster healthy behaviors [27]. The “Healthy China Action (2019-2030)” issued by the State Council of China includes “Action for Balanced Diet” and “Action for Health Promotion in Primary and Secondary Schools” as major initiatives. In recent years, the nutritional

status of Chinese children had shown significant improvement, reflected in the increase in average height and weight. According to the “Report on Nutrition and Chronic Diseases among Chinese Residents (2020)”, the rate of growth retardation among children and adolescents aged 6-17 had decreased from 4.7% to 2.2% [28]. However, with the changes in social and lifestyle patterns, they also faced challenges of malnutrition, overweight and obesity and micronutrient deficiencies. In the sixth national nutrition survey conducted between 2015 and 2017, compared to 1982, the prevalence of overweight and obesity had risen from 1.3% to 22.7% among boys and from 1.4% to 14.9% among girls. Micronutrient deficiencies, such as inadequate intakes of calcium, iron, vitamin A and vitamin D are also common [29]. Currently, the average daily energy intake for Chinese adolescents aged 12-17 is 1995.0 kcal, with carbohydrate intake of 253.8 g, protein intake of 61.4 g and fat intake of 84.5 g. The energy contribution ratios of these three macronutrients are 50.6%, 12.3%, and 37.1% respectively. Overall, in comparison to the recommended percentages of energy intake from carbohydrates 50-65%, protein 10-15%, and fat 20-30% for a balanced diet of 2000-2400 kcal according to the DRIs, their protein intake is aligned with the recommended level. Nevertheless, their energy and carbohydrates intakes barely met the minimum requirements, while fat intake exceeded the recommended range, leading to an imbalanced energy contribution ratio of the three major macronutrients. In general, the average daily energy intake, carbohydrates intake, fat intake, and protein intake of adolescents aged 12-17 are higher in boys than in girls [30].

Similar to above report in China, male subjects in this study had higher energy and macronutrients intake compared to female. However, unlike Chinese adolescents, the overall energy intake of secondary school students in Macao was lower than the recommended levels. The intakes of carbohydrates and fat fell within the recommended ranges, but protein intake was excessive. Their average daily energy intake was 1755.9 kcal, with 251.2 g of carbohydrates, 92.9 g of protein and 42.1 g of fat. The energy contribution percentages of the three major macronutrients were 57.2%, 21.2%, and 21.6% respectively. For boys, although the overall energy intake of 2107.9 kcal met the recommended level, but the <14-year-old age male group had an average daily energy intake that exceeded the DRIs by over 300 kcal. This was mainly due to excessive protein consumption, with an intake of more than twice the recommended amount of 60 g according to the DRIs. The fat intake in this group was also slightly higher, possibly due to excessive consumption of fatty meat. It is crucial for adolescents to maintain a balance between their energy intake and expenditure, adopt healthy dietary patterns and exercise habits, and avoid excessive energy intake that can lead to fat accumulation during the development stage. And it is advisable to

prioritize the consumption of protein sources with high biological value, such as eggs, milk, cheese, and lean meat, as these sources provide essential amino acids and nutrients necessary for proper growth and development. For girls, the average daily energy intake across all age groups was lower than the DRIs. It is noteworthy that female adolescents often tend to excessively focus on their body image, have misconceptions about obesity, and engage in dieting and restricting energy intake. Such behavior can lead to long-term health problems caused by inadequate energy and nutrient intake, including anemia and menstrual irregularities. Furthermore, there was an overall insufficient intake of dietary fiber and could not fulfill recommended amount 25 g in both subjects in this study and among Chinese adolescents, with daily intakes of only 16.4 g and 9.2 g respectively [29,31]. It is suggested to consume foods rich in fiber such as fruits, vegetables, legumes and grains.

Inadequate vitamin A intake is also a concern among the adolescents in the study and in China. Vitamin A helps maintain normal vision, the integrity of epithelial cells, and enhances immune function. It is recommended to increase the consumption of foods rich in vitamin A such as carrots, milk, cheese and vegetables [29,32]. Vitamin D is involved in calcium metabolism and promotes its absorption. Both dietary calcium intake and vitamin D status are important nutritional factors influencing optimal bone development in childhood and adolescence [33]. In this study, it can be observed that students had inadequate intake of these two nutrients. The daily intake of calcium among all subjects was lower than the recommended level, reaching only around 700 mg. Previous nutrition surveys conducted in China have also revealed that over 90% of school-age children had dietary calcium intake below the Estimated Average Requirement (EAR) of 800 mg [29]. According to the “Report on the Nutrition and Chronic Diseases Status of Chinese Residents (2020),” adolescents aged 12-17 consumed only 342.8 mg of calcium, which was related to their low consumption of dairy products [28]. Furthermore, the overall intake of vitamin D in this study only reached half of the recommended level of 10 µg. Therefore, in addition to consuming dairy products to enhance calcium absorption, it is also necessary to consume eggs, fish and vitamin D-fortified foods, as well as increase outdoor activities to obtain vitamin D [34].

Iron-deficiency anemia is common among primary and secondary school students. The anemia rate among Chinese children and adolescents aged 6-17 was as high as 6.1%. Although iron intake among adolescents in this study reached the recommended level, it is worth noting that individuals over the age of 10 gradually enter adolescence, experience rapid growth and girls begin to menstruate. Therefore, it is recommended to consume moderate amounts of meat, fish, seafood, and choose dark green vegetables to ensure sufficient iron intake. Adequate vitamin C should also be ensured to promote iron absorption [29,35]. Only

the group of boys aged 14-17 in this study could obtain sufficient iodine intake from food, while the rest of the groups failed to meet the requirements of the DRIs. Therefore, if iodized salt was not used in place of regular table salt in the diet, the risk of iodine deficiency would be significantly increased. It is recommended to not only consume iodine-rich foods such as kelp, seaweed, and seafood but also use iodized salt to ensure a reasonable level of iodine intake [36-38]. Although the sodium intake of most groups was within the recommended range, it was difficult to accurately assess the amount of salt, cooking oil and seasoning added by using the FFQ. Thus, there was a possibility of underestimating sodium intake in this study.

The results of this study have revealed that the percentage of overweight and obese individuals among males and females was as high as 27.9% and 17.8% respectively. These findings underscore the importance for individuals to be particularly mindful of weight control and implement lifestyle enhancements, encompassing diet and exercise to sustain an ideal body weight. This can be accomplished by reducing the consumption of high-energy density foods rich in sugar and fat, choosing foods with high nutritional value and fiber to mitigate the risk of developing various chronic diseases. Due to limitations in resources and time, this study was unable to conduct nutrient analysis for each food item in the questionnaire. Therefore, considering the need for more accurate and update nutritional information on food available in Macao, the food nutrient data was obtained from databases of China, Japan and Hong Kong. Because of such reasons, it is evident that relevant research requires cooperation and support from the government, schools, families and individuals to develop targeted community nutrition programs in order to achieve effective outcomes. Furthermore, nutrition education serves as a fundamental and primary strategy for improving public nutrition and health levels. Through information dissemination and educational methods, groups or individuals can acquire basic nutritional knowledge, leading to favorable health behaviors and habits [2]. As individuals progress through different stages of life and experience shifts in their activity levels, it is essential for adolescents to be mindful of the evolving nutritional requirements. They should make suitable modifications to their dietary choices to adequately fulfill their body's specific needs for optimal growth and development.

## Conclusions

Through the analysis of energy and various nutrient intake, it was found that secondary school students in Macao exhibited varying degrees of inadequate or excessive intake across different genders or age groups. Male students had excessive energy intake due to excessive protein intake, while female had lower intakes of energy and carbohydrates. Both genders had insufficient dietary fiber intake. The intakes of vitamin A, vitamin D, calcium, and

iodine also showed varying degrees of inadequacy. Although sodium intake was within the appropriate range, there was a possibility of underestimation in this study. It is suggested adolescents should pay more attention to their own nutritional needs, aiming to develop healthy dietary patterns and behaviors to support physical growth and development. Additionally, further assessment of nutritional intake status should be conducted among Macao secondary school students in order to develop appropriate nutritional strategies for this population.

## Author Contributions

Conceptualization, C.L.; methodology, C.L. and Y.X.; formal analysis, C.L.; investigation, C.L., X.Z. and X.T.; resources, C.L. and Y.X.; data curation, C.L. and Y.X.; writing—original draft preparation, C.L.; writing—review and editing, C.L. and Y.X.; supervision, Y.X. All authors have read and agreed to the published version of the manuscript.

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## Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Faculty Review Board of Faculty of Medicine of the Macau University of Science and Technology.

**Informed Consent Statement:** Not applicable

## Data Availability Statement

The data presented this study is available from the corresponding author upon reasonable request, while the data collected from the survey is not publicly available due to confidentiality.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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