Research Article

NUT CONSUMPTION IS ASSOCIATED WITH DEPRESSIVE SYMPTOMS AMONG CHINESE ADULTS

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Background: ***Affective disorders, especially depressive symptoms, bring such a burden to mortality and morbidity that they are associated with physical and psychological health and quality of life. Nuts, a foodstuff rich in multiple micronutrients, macronutrients, and other useful components, were considered to be a protector against depressive symptoms. Here, we conducted an analysis to examine the relationship between nut consumption and depressive symptoms.*** **Methods:** ***The study performed a cross-sectional study to examine whether nut consumption is related to depressive symptoms among 13,626 inhabitants in Tianjin. Nut consumption was assessed using a validated food frequency questionnaire and depressive symptoms was assessed using the Chinese version of 20-item Self-rating Depression Scale (SDS) with four cutoffs (40, 45, 48, and 50) to indicate elevated depressive symptoms.*** **Results:** ***The prevalence of depressive symptoms was 38.7, 19.1, 11.4, and 7.3% for SDS ≥40, 45, 48, and 50, respectively. After adjustments for potential confounding factors, the odds ratios (95% confidence interval) of having elevated depressive symptoms with SDS ≥40 by increasing frequency of nut consumption were 1.00 for <once per week (reference), 0.82 (0.75, 0.90) for 1–3 times per week, and 0.82 (0.73, 0.92) for ≥4 times per week. Similar relations were observed with the use of other cutoffs as a definition of depressive symptoms.*** **Conclusion:** ***The present study is***

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the first to find that nut consumption is independently associated with depressive symptoms. It is suggested that nut consumption may be beneficial to the prevention of depressive symptoms. Depression and Anxiety 33:1065–1072, 2016.

Key words: *depressive symptoms; nuts; cross-sectional studies*

INTRODUCTION

Affective disorders have been some of the most alarming global public health issues, having multiple adverse effects on a person's health condition.[1–3] Of these, depressive symptoms are the major disorder, bearing a high prevalence and high disability rate in reference to social function and quality of life.[4,5] Depressive symptoms is one of the leading cause of mortality and morbidity accounting for about 4.4% of disease burden,[6] and is closely related to suicide, which is becoming a member contributing to the total mortality.[7,8]

An emerging body of evidence supports the relationship between nutrition in foodstuffs or diets and depressive symptoms.[9] The importance of *n*-3 polyunsaturated fatty acids (*n*-3 PUFAs) or fish for depression is well recognized.[10,11] However, nuts, a unique type of tasty and superiorly healthy snack, have not been addressed. Nuts come from many different plant families and are classified as either tree nuts (a one-seeded fruit in a hard shell) or peanuts (a member of the Leguminosae family). Despite their diversity, nut varieties share many common nutrition characteristics.[12,13] They are some of the most nutrient-dense fatty foods commonly consumed in daily life, cholesterol-free and a good source of unsaturated fatty acid. Moreover, they also contain a substantial amount of other important nutrients contributing to a people's well-being, such as phytosterols and polyphenolic compounds,[14] which are not existed in animal food.

It has been documented that frequent nut consumption in the diet is associated with common physical health outcomes, including decreased risk of coronary artery disease, hypertension, diabetes, cancer, metabolic syndrome (MS), obesity, and gallstone disease.[15–20] In addition, several studies conducted in animals and humans also demonstrated that nuts in the diet had effects on the structure, the biochemistry, the physiology, and thus the function of the brain. Frequent nut consumption was considered to play health beneficial role in the human brain, cognition, and neuropsychiatric disorders.[21–28] It is hypothesized that nut consumption may be beneficial to depressive symptoms, mainly with regard to their various bioactivities: mediation of the neurotransmitters,[29,30] anti-inflammatory effects,[31] and alteration of the central nervous system,[21,23,28] which are the important components in the pathogenetic mechanism and development of depressive symptoms.[32]

However, to date, there is no study that focused on the relationship between nut consumption and depressive symptoms. The present study is to examine the relationship between nut consumption and depressive symptoms in Chinese adults.

SUBJECTS AND METHODS

STUDY PARTICIPANTS

Participants in this study were recruited during 2013–2014 from the Tianjin Chronic Low-grade Systemic Inflammation and Health (TCLSIHealth) cohort, a prospective dynamic cohort focusing on the relationship between chronic low-grade inflammation and the health status of a population living in the Tianjin,[33] a city located in the northeast of the North China Plain with approximately 10.43 million inhabitants. All participants were asked to complete a structured self-administered health status questionnaire used in the TCLSIHealth cohort study during their annual health examinations at the Health Management Centre of Tianjin Medical University General Hospital, the largest and most comprehensive physical examination center in Tianjin. Subjects in the present study were sampled by a random process, using a random number generator. Nearly all occupations are covered in this study, and we also included retired individuals living in residential communities. Therefore, the sample population used here is representative of the general adult population in Tianjin. The questionnaire consisted of the following contents: demographic and socioeconomic characteristics (e.g., gender, age, education, occupation, household income, marital status, cohabitation, and relationships), physical health status (MS), lifestyle and health-related habits (e.g., smoking and drinking habits, and physical activity (PA)), depressive symptoms, and dietary habits evaluated by a validated food frequency questionnaire. The blood sample was routinely drawn 12 ml of whole blood for 2 ml of plasma and 10 ml of serum from each subject.

The data at baseline during 2013–2014 from TCLSIHealth cohort were used to conduct a cross-sectional analysis in this study. The participants who received health examinations were excluded by criterions as follows: not completing data collection about food frequency questionnaire, depression scale, anthropometric measurements (height and/or weight), PA, and having a history of CVD, cancer or autoimmune diseases, such as systemic lupus erythematosus, rheumatic arthritis, rheumatic heart disease, autoimmune hepatitis, and myasthenia gravis.

The protocol of this study was approved by the Institutional Review Board of Tianjin Medical University and written informed consent was obtained from all participants.

ASSESSMENT OF DEPRESSIVE SYMPTOMS

Depressive symptoms were evaluated by the Chinese version of the Zung Self-Rating Depression Scale (SDS). There are 20 items defined as either positive or negative, and study participants were required to grade on a scale of 1 to 4 points for each item. Total score produced by all 20 items ranges from 20 to 80, with greater values indicating increased severity. In the present study, four cut-off points (40, 45, 48, and 50) were used to define depressive symptoms and scores higher than the cut-offs are indicators of moderate-to-severe

depressive symptoms.[34,35] If a participant was taking antidepressants, he or she was also considered to have depressive symptoms.

ASSESSMENT OF DIETARY INTAKE

The participants were instructed to fill out a validated 88-items self-administered food frequency questionnaire (including fruits, vegetables, animal food, seafood, sugared beverages and snacks, and refined grain and grain products, etc.) with specified serving sizes described by natural portions or standard weight and volume measures of the servings commonly consumed in the study population. The mean daily intake of nutrients was calculated by using an ad hoc computer program developed to analyze the questionnaire. The valid and reliable Chinese food composition tables were used as the nutrient database. By combining the information obtained from the food frequency response with the food composition table, we were able to compute the mean total energy intake for each participant.

Participants indicated the mean frequency of consumption of nuts (including peanuts, chestnuts, pistachio, pine nuts, hazelnuts, almond, and walnut) over the previous 1 month in terms of the specified serving size by selecting seven possible frequency categories: almost never or rarely, <once per week, once per week, 2–3 times per week, 4–6 times per week, 1 time per day, and ≥2 times per day. The final categories of the frequency of nut consumption according to the frequency distribution of the responses were as follows: <once per week, 1–3 times per week, and ≥4 times per week.

ASSESSMENT OF OTHER VARIABLES

The other information contained in the health status questionnaire included demographic and socioeconomic characteristics, physical health status, lifestyle, and health-related habits. The anthropometric variables (e.g., height and body weight) were measured by using a uniform protocol with participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as the weight in kilograms (kg) divided by square of the height (m^2).

For socioeconomic characteristics, the educational level was measured by asking the question "what is the highest degree you earned?" and was divided into two categories: <College graduate or ≥College graduate. Marital status was classified as married or unmarried. The subjects were also classified as living alone or living with others. Employment status was classified as either Senior Officials and Managers or Professionals. And visiting friends were evaluated by the question of "do you visit your friends?"

Waist circumference was measured at the umbilical level with subjects standing and breathing normally. Blood pressure (BP) was measured twice at the upper left arm using an automatic device (Andon, Tianjin, China) after 5 min of rest in a sitting position. The mean of these two measurements served as the BP value. Blood samples for the analysis of fasting blood sugar (FBS) and lipids level were collected in siliconized vacuum plastic tubes. FBS was measured by the glucose oxidase method, triglycerides (TG) were measured by enzymatic methods, low-density lipoprotein cholesterol (LDL) was measured by the polyvinyl sulfuric acid precipitation method, and high-density lipoprotein cholesterol (HDL) was measured by the chemical precipitation method using reagents from Roche Diagnostics on an automatic biochemistry analyzer (Roche Cobas 8000 modular analyzer, Mannheim, Germany). MS was defined on the basis of the criteria of the American Heart Association scientific statements of 2009.[36]

For lifestyle and habits, smoking status of the study population was defined as three categories: "smoker," "ex-smoker," or "nonsmoker" and drinking status was defined as "everyday," "sometime," "ex-drinker," or "nondrinker" according to the responses to the survey in the questionnaires. PA in the most recent week was evaluated using the short form of the International Physical Activity Questionnaire (IPAQ).[37] The questionnaire surveyed whether subjects had performed any type of activities during the previous week: walking, moderate activity (e.g., household activity or child care), vigorous activity (e.g., running, swimming, or other sports activities). Metabolic equivalent (MET) hours per week for a certain type were computed using corresponding MET coefficients (3.3, 4.0, or 8.0, respectively) on the basis of the following formula: MET coefficient of activity × duration (hours/day) × frequency (days/week). Total PA levels were assessed in terms of weekly MET-h, which was calculated by combining separate hours for different activities.

STATISTICAL ANALYSIS

The frequency of nut consumption was used as independent variable in four categories and depressive symptoms were used as dependent variable. The data were described as the mean with 95% confidence interval (95% CI) or as percentages, and the differences of measured variables among categories of the frequency of nut consumption were examined by analysis of variance for continuous variables and by logistic regression analysis for proportional variables. Multiple logistic regression analysis was used to evaluate the correlation between nut consumption and depressive symptoms. For crude model, the analysis was conducted without any adjustment; then the analysis was adjusted for age, sex, and BMI. For multiple-adjusted model, the analysis was adjusted further, in addition to smoking and drinking habits, PA, educational level, employment status, household incomes, living alone, visiting friends, marital status, total energy intake, MS and eicosapentaenoic acid (EPA) + docosahexaenoic acid (DHA). The final multivariate logistic analysis was performed with the forced entry of all factors considered to be potential covariates. A linear trend across the categories of nut consumption was tested by using the median value of each category as an ordinal variable. A sensitivity analysis was performed after excluding the subjects who reported to have depression and/or take antidepressants. Variance inflation factors (VIFs) were used as an indicator in the test for multicollinearity. VIFs is less than 10,[38] showing that no collinearity is accepted. Moreover, a developed multivariable logistic model was obtained by using a stepwise variable selection method applied to the variables with a P value of <0.2 based on the bivariate analyses. P values <0.05 were considered statistically significant and all tests presented were two-tailed. All statistical analyses were performed by using the Statistical Analysis System 9.3 edition for Windows (SAS Institute Inc., Cary, NC).

RESULTS

SELECTION OF SUBJECTS

During the survey period there were 17,268 participants who had received health examinations (Fig. 1). We excluded participants who did not complete data collection on food frequency questionnaire ($n = 462$), depression scale ($n = 1{,}817$), body height and/or body weight measurements and PA ($n = 121$), or those with a history of CVD ($n = 974$), cancer ($n = 257$), or autoimmune diseases ($n = 11$). The final cross-sectional analyzed population comprised 13,626 participants (males, 55.7%) aged 43.5 years (SD, 12.4 years) after the exclusion.

THE CHARACTERISTICS OF THE SUBJECTS ACCORDING TO THE CATEGORIES OF NUT CONSUMPTION

The characteristics of the subjects according to the categories of nut consumption are shown in Table 1.

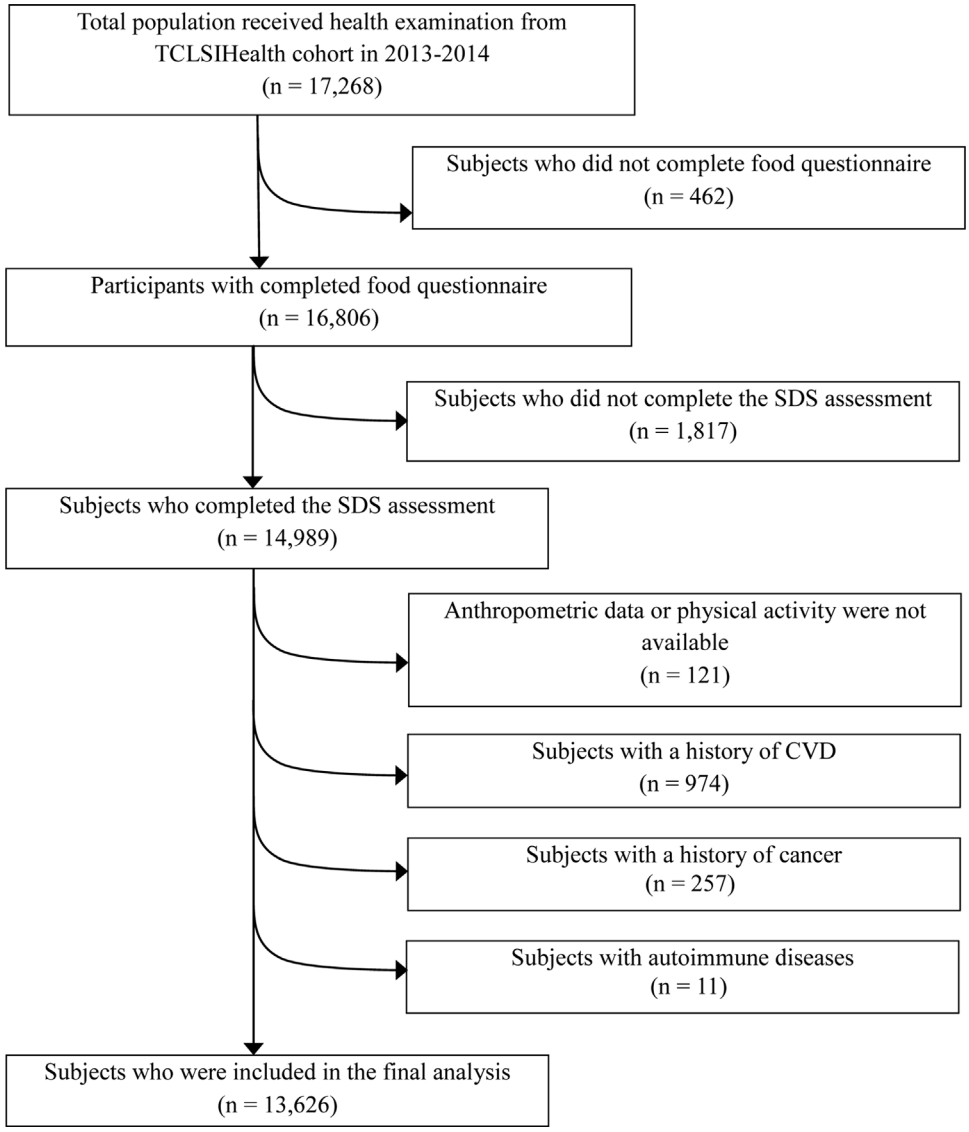

Figure 1. Flow chart of the sample selection. TCLSIHealth cohort: the Tianjin Chronic Low-grade Systemic Inflammation and Health cohort; SDS: the Zung Self-Rating Depression Scale.

Of all the subjects, approximately 24.1% of the subjects reported consuming ≥4 times nuts per week, while 55.5% consumed 1–3 times per week and <once per week for the rest subjects. Subjects with a higher level of nut consumption were older ($P_{trend} < .0001$) and less likely to be males ($P_{trend} < .0001$), and the proportion of subjects who were current smoker, daily drinker, living alone were significantly lower across the categories of nut consumption ($P_{trend} < .0001$). Nevertheless, these subjects were more likely to be married, have higher education and visit friends (P_{trend}: <.0001, .02, <.0001, respectively), have more total energy intake and EPA + DHA intake and have more PA ($P_{trend} \leq .0001$), and the proportion of subjects who were nonsmoker, nondrinker, employed as managers, or had household income ≥10,000 Yuan significantly increased with the frequency of nut consumption (Ptrend < .0001). Otherwise, no significant differences were observed among BMI, presence of MS. Moreover, a significant relationship was found between total SDS score and nut consumption, the score declined with the categories of nut consumption ($P_{trend} < .0001$).

THE RELATIONSHIP BETWEEN NUT CONSUMPTION AND DEPRESSIVE SYMPTOMS

The association between the categories of nut consumption and depressive symptoms is presented in Table 2. The prevalence of depressive symptoms was 38.7, 19.1, 11.4 and 7.3% for SDS ≥40, ≥45, ≥48 and ≥50, respectively. The prevalence was more than twofold for participants who consumed 1–3 times per

TABLE 1. Participant characteristics according to the frequency of nut consumption (n = 13,626)

	Frequency of nut consumption			
	<once per week (n = 2,778)	1–3 times per week (n = 7,567)	≥4 times per week (n = 3,281)	P_{trend}[a]
Age (y)	40.9 (40.5, 41.3)[b]	40.8 (40.5, 41.0)	45.0 (44.5, 45.4)	<.0001
Sex (males, %)	58.9	56.4	51.4	<.0001
BMI (kg/m^2)	24.5 (24.4, 24.6)	24.5 (24.4, 24.5)	24.6 (24.5, 24.7)	.36
Metabolic syndromes (yes, %)	31.4	28.6	31.0	.85
Physical activity (Mets × hour/week)	8.2 (7.8, 8.6)	9.3 (9.1, 9.6)	11.8 (11.2, 12.3)	<.0001
Total energy intake (kcal/d)	1713.6 (1686.5, 1741.2)	2150.6 (2129.9, 2171.5)	3081.4 (3036.4, 3127.1)	<.0001
Intake of EPA + DHA (g/d)	0.07 (0.07, 0.08)	0.09 (0.08, 0.09)	0.12 (0.11, 0.12)	<.0001
SDS score	37.2 (36.9, 37.5)	36.3 (36.1, 36.5)	35.8 (35.6, 36.1)	<.0001
Smoking status (%)				
Smoker	29.8	24.3	20.1	<.0001
Ex-smoker	6.5	6.5	8.2	.01
Nonsmoker	63.7	69.2	71.7	<.0001
Drinker (%)				
Everyday	7.8	5.1	5.0	<.0001
Sometime	57.3	61.8	56.4	.31
Ex-drinker	8.3	7.4	7.7	.38
Nondrinker	26.6	25.8	30.9	<.0001
Marital status (married, %)	86.4	88.1	89.9	<.0001
Living alone (yes, %)	11.0	8.6	6.9	<.0001
Education (≥College graduate, %)	53.6	64.9	57.3	.02
Working status (%)				
Managers	37.8	44.0	45.3	<.0001
Professionals	19.4	21.3	16.4	<.01
Household income (≥10,000 Yuan, %)	31.4	37.4	39.7	<.0001
Visiting friends (yes, %)	60.5	63.7	68.1	<.0001

BMI, body mass index; SDS, self-rating depression scale; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.
[a]Analysis of variance or logistic regression analysis.
[b]Least square geometric mean (95% confidence interval) (all such values).

TABLE 2. The relationships of the frequency of nut consumption to depressive symptoms (n = 13,626)[a]

	Frequency of nut consumption		
	<once per week (n = 2,778)	1–3 times per week (n = 7,567)	≥4 times per week (n = 3,281)
No. of depressive symptoms (SDS ≥40)	1,212	2,845	1,221
Crude	1.00	0.78 (0.71, 0.85)[b]	0.77 (0.69, 0.85)
Adjusted for age, sex and BMI	1.00	0.77 (0.71, 0.85)	0.77 (0.70, 0.86)
Multiple-adjusted model[c]	1.00	0.82 (0.75, 0.90)	0.82 (0.73, 0.92)
No. of depressive symptoms (SDS ≥45)	632	1,352	623
Crude	1.00	0.74 (0.66, 0.82)	0.80 (0.70, 0.90)
Adjusted for age, sex and BMI	1.00	0.74 (0.66, 0.82)	0.80 (0.70, 0.90)
Multiple-adjusted model[c]	1.00	0.76 (0.68, 0.85)	0.77 (0.66, 0.88)
No. of depressive symptoms (SDS ≥48)	382	782	386
Crude	1.00	0.72 (0.64, 0.83)	0.84 (0.72, 0.97)
Adjusted for age, sex and BMI	1.00	0.72 (0.63, 0.82)	0.84 (0.72, 0.98)
Multiple-adjusted model[c]	1.00	0.75 (0.65, 0.86)	0.78 (0.66, 0.93)
No. of depressive symptoms (SDS ≥50)	244	505	242
Crude	1.00	0.74 (0.63, 0.87)	0.83 (0.69, 1.00)
Adjusted for age, sex and BMI	1.00	0.74 (0.63, 0.87)	0.84 (0.70, 1.01)
Multiple-adjusted model[c]	1.00	0.77 (0.66, 0.91)	0.76 (0.62, 0.94)

SDS, self-rating depression scale.
[a]Obtained by using multiple logistic regression analysis.
[b]Adjusted odds ratio (95% confidence interval) (all such values).
[c]Adjusted for age, sex, body mass index, smoking status, drinking status, physical activity, marital status, total energy intake, household incomes, employment status, educational levels, visiting friends, living alone, metabolic syndrome, and intake of EPA + DHA.

week nuts comparing to those who consumed ≥4 times per week. The assessment of depressive symptoms was performed in four cut-offs (40, 45, 48, and 50) and the odds ratios (ORs) of depressive symptoms in all models significantly decreased across the categories of nut consumption for 40, 45, and 48 cut-off. With a cut-off point of 40, the crude ORs (95% CI) of depressive symptoms associated with the different categories of nut consumption were 1.00 (reference), 0.78 (0.71, 0.85), and 0.77 (0.69, 0.85). Age-, sex- and BMI-adjusted ORs (95% CI) for depressive symptoms across nut consumption categories were 1.00 (reference), 0.77 (0.71, 0.85), and 0.77 (0.70, 0.86). A variety of potential confounders were considered in the final multivariate logistic model, and the adjusted ORs for depressive symptoms across the categories of nut consumption were 1.00 (reference), 0.82 (0.75, 0.90), and 0.82 (0.73, 0.92). The results for other cut-off points as a definition of depressive symptoms were essentially the same as those for the 40 cut-off point. Moreover, all VIFs values for each independent variable were less than 10 (ranges from 1.03 to 2.07). We further performed a sensitivity analysis after excluding the subjects who reported to have depression and/or take antidepressants ($n = 10$). However, the inverse relationship between nut consumption and depressive symptoms did not change (data not shown).

Furthermore, multivariable models were developed using stepwise variable selection and different variables were selected when applying four different cut-off points. Taking SDS ≥40 for example, age, sex, BMI, smoking status, educational levels, employment status, household incomes, PA, marital status, living alone, visiting friends, MS and intake of EPA + DHA were selected in the regression. Using these covariables, the ORs (95% CI) of depressive symptoms across categories of nut consumption were 1.00 (reference), 0.81 (0.74, 0.89), and 0.79 (0.71, 0.88). When compared to using all the variables, there were almost no changes for the adjusted ORs and 95% CI. Similar relationships were also observed with the use of other cut-off points (data not shown).

DISCUSSION

With the aim to examine the relationship between nut consumption and depressive symptoms, the present study finds that frequent nut consumption is significantly associated with a lower prevalence of depressive symptoms. This is the first study to evaluate the relationship between nut consumption and depressive symptoms in such a large general population.

Previous studies have underlined the beneficial effects of nut consumption on human health, but there is no study evaluating the effects on depressive symptoms directly. A past study showed that only a Mediterranean dietary pattern (nuts served as a food group) was inversely associated with depressive symptoms.[39] However, that study did not analyze the relationship between nuts alone and depressive symptoms. The present study finds that nut consumption itself is related to depressive symptoms, consistent to a certain extent with other studies which involved a single nutrient in nuts, such as *n*-3 PUFAs.[10] The finding in this study can be explained through multiple potential mechanisms. First, nuts possess a favorable fatty acid profile with a high content of unsaturated fat (nearly half of the total fat), monounsaturated fatty acids (MUFAs) in most nuts, and mostly PUFAs in walnuts,[40] with the highest content of α-linolenic acid (ALA) among all edible plants.[41] In the nervous system, averagely one fatty acid out of three is polyunsaturated, thus obligatorily of dietary origin,[42] and experimental studies have ascertained that ALA had effects on the structure of the brain cells and sub cells and finally on physicochemical (membrane fluidity), biochemical, and behavioral or learning parameters.[42,43] Second, nuts have been shown to favorably modulate the key factors in depressive symptoms, inflammation and oxidation,[44,45] mainly based on the components MUFAs, ALA, and other chemical constituents (e.g., phenolic acids, flavonoids, phytosterols, and ellagic acid).[31] Several epidemiology and intervention studies have suggested a protective role of nuts against inflammation[46–48] and it was supported that consumption of ALA may provide protection against inflammatory diseases by reduction of inflammatory cytokines.[49] Finally, researchers also demonstrated that components in nuts (e.g., ALA and ellagic acid) could play an important role in the alteration of neural transmitters, especially serotoninergic and dopaminergic neurotransmitters,[29,30] catecholamine,[50] and brain-derived neurotrophic factor (BDNF),[23] all of which are closely related to the onset and development of depressive symptoms.

Although nut consumption showed great benefits for depressive symptoms, whether any kinds of nuts were more beneficial than others is still unknown. In this study, the participants indicated only the mean frequency of their total nut consumption/and not the specific kinds of nuts consumed. Further studies are needed to determine how different varieties of nuts can help improve depressive symptoms. Furthermore, compared to the first group (<once per week), the ORs for depressive symptoms had similarly decreased in the second (1–3 times per week) and third (≥4 times per week) group, which suggests that nut consumption of more than 1–3 times per week might have relatively stable benefits for the prevention of depressive symptoms.

In this study, considerable potential confounding factors that could influence the results were analyzed, including age, gender, BMI, smoking and drinking habits, PA, educational level, employment status, household incomes, living alone, visiting friends, marital status, total energy intake, MS, and intake of EPA + DHA. Even after adjusting for these potential confounders, the significant relationship between the frequency of nut consumption and depressive symptoms remained, indicating that it is independently associated with depressive symptoms. However, there are still several limitations in the present study. First, the relationship between nut consumption and depressive symptoms comes from

a cross-sectional design, which usually precludes the possibility to infer a truly causal relationship. The frequency of nut consumption is ascertained simultaneously with depressive symptoms and, therefore, results could be alternatively interpreted as a consequence of reverse causation bias, that is, depression may lead to poorer dietary habits. However, the correlation between nut consumption and depressive symptoms in this study is still convincing and valid, even though it may not be due to causality. There is a need to conduct more prospective studies or intervention studies to confirm the direction of causality between nut consumption and depressive symptoms and to determine whether more frequent nut consumption is beneficial to the management of depressive symptoms. Moreover, even though considerable confounding factors have been taken into consideration, there are still other dietary factors that might confound the association between nut consumption and depressive symptoms. The present study also cannot exclude the possibility that some other dietary components associated with mental health could be responsible for the observed association. However, the relationship with nut consumption remained significant after controlling for intake of EPA + DHA, a prominent component of fish believed to be beneficial for depressive symptoms.[11] Finally, the measurement of depressive symptoms depends on a validated scales rather than a clinical diagnosis, it is necessary to explore the effects of nuts on the depression in patients with clinical diagnosis.

CONCLUSION

The present study shows a significant relationship between frequent nut consumption and lower prevalence of depressive symptoms in the general population of TCLSIHealth cohort. It is suggested that more frequent nut consumption may be effective in the prevention of depressive symptoms.

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