European Journal of Clinical Nutrition (2022) 76:126–133
https://doi.org/10.1038/s41430-021-00917-2

ARTICLE

Nutrition and health (including climate and ecological aspects)

The consumption of wholegrain is related to depressive symptoms among Chinese adults: a cross-sectional study

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Received: 8 January 2021 / Revised: 19 March 2021 / Accepted: 31 March 2021 / Published online: 30 April 2021

Abstract

Background Wholegrains contribute a range of beneficial nutrients, such as dietary fiber and several minerals and vitamins, that are beneficial to depressive symptoms. However, there are a few studies aimed at exploring whether a wholegrain diet is related to depressive symptoms. We conducted this study to investigate the relationship between wholegrains consumption and depressive symptoms.

Methods This cross-sectional study included a total of 24,776 (mean age: 39.9 years, age range: 18.1–91.3 years; males, 54.1%) inhabitants living in Tianjin, China. Wholegrains consumption was assessed using a valid self-administered food frequency questionnaire. Depressive symptoms were evaluated using the Chinese version of Zung Self-Rating Depression Scale (SDS) and the cutoff point was set at 45. Multiple logistic regression analysis was used to estimate the relationship between wholegrains consumption and depressive symptoms.

Results The prevalence of depressive symptoms was 19.1% and 22.4% in males and females, respectively. After adjustments for potential confounding factors, the odds ratios (95% confidence intervals) of depressive symptoms across wholegrains consumption were 0.77 (0.65–0.91) for <1 time/week, 0.73 (0.62–0.86) for 1 time/week and 0.68 (0.59–0.79) for ≥2 time/week in males compared with the control group (almost never). In females, the odds ratios (95% confidence intervals) were 0.86 (0.71–1.04) for <1 time/week, 0.94 (0.78–1.13) for 1 time/week, and 0.76 (0.65–0.91) for ≥2 time/week. Similar results were observed when we use other cut-offs (SDS ≥ 40 and 50) to define depressive symptoms.

Conclusion This study first demonstrated that the higher consumption of wholegrains might have effects on the prevention and improvement of depressive symptoms. Prospective or intervention studies are needed to confirm these findings.

Introduction

Depressive symptom is a common but serious mental health disorder [1]. It is considered as a major cause of higher mortality [2]. The disease burden attributable to the depressive symptom exceeded that for infectious, cardiovascular, or neoplastic disease in middle-income countries (including China) [3]. Globally, the cumulative economic loss of depressive symptom is estimated to be $5.36 trillion from 2011 to 2030 [4]. Compared with any other disease burden, the costs of depressive symptom have increased

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considerably in recent years and current treatments are estimated to address only one-third of them [5]. Therefore, it is urgent to find new methods to prevent the occurrence and development of depressive symptom.

The structure of all grains is consisted of three parts: endosperm, germ, and bran [6]. The whole-grain, which is defined by the American Association of Cereal Chemists as the relative proportion of these three structural components, is the same as that of intact caryopsis [7]. Although classified as carbohydrates, wholegrains contain much more than that, contributing a range of beneficial nutrients including dietary fiber, vitamins, minerals, and phytochemicals [8]. Epidemiological studies and animal experiments have established that several minerals and vitamins such as zinc, magnesium, and B vitamin in wholegrains were beneficial to mood states [9–11]. In the latest research, the dietary fiber in wholegrains has also been shown to have positive effects on depression, mainly resulting from gut microbiota. These change gene transcription, mediate neurotransmitters and have anti-inflammatory effects [12]. Despite this breadth of research, the relationship between wholegrains and depressive symptom is still unclear.

Therefore, we conducted this large-scale cross-sectional study to explore how wholegrains consumption is related to the prevalence of depressive symptoms in the general population.

Methods

Participants

The data of this large-scale cross-sectional study is from the Tianjin Chronic Low-grade Systemic Inflammation and Health (TCLSIH) cohort study. The study, which began in 2007, is a large prospective, dynamic cohort study. In this study, the participants were recruited, while having their annual health examinations at the Tianjin Medical University General Hospital-Health Management Center, the largest and most comprehensive physical examination center in Tianjin. Participants in the present study were sampled by a random process, using a random number generator. Nearly all occupations and retired persons over the age of 18 that living in residential communities of Tianjin are covered in this study. Therefore, the sample population used here is representative of the general adult population in Tianjin. The participants were asked to complete a structured self-administered health status questionnaire according to their actual situation. We can obtain information about their overall bodily, mental health, physical activity, food intake, in addition to other related questions through questionnaires submitted by volunteers. In this study, 32,737 adults who completed the health examination and returned the questionnaire were sampled. Moreover, the participants with missing data ($n = 6,562$) or had a history of CVD ($n = 1,201$) or cancer ($n = 198$) were excluded. After that, 24,776 participants were comprised in this study.

The Institutional Review Board of Tianjin Medical University has approved this study protocols and procedures. Besides, all the participants have written the informed consent.

Assessment of depressive symptoms

In this study, we use the Chinese version of Zung Self-Rating Depression Scale (SDS) to evaluate depressive symptoms. This scale was designed by Zung in 1965 and has been confirmed to have high sensitivity (83.6%) and specificity (96.4%) when using in the Chinese population [13, 14]. The SDS has 20 items, each item has 1–4 points. The total score ranges from 20 to 80, and higher score indicate that depressive symptoms were serious [13]. We set the cutoff score to 45 in our present study, score higher than that can be considered as depressive symptoms.

Assessment of dietary data

We use the modified version of the FFQ which included 100 food items (the initial one included 81 food items) with specified serving sizes to assess the dietary intake. As shown previously, the FFQ has been confirmed to be valid and reproducible. Each food in this FFQ has seven frequencies (ranging from almost never to two or more times a day) and eight frequencies for beverages consumed (ranging from almost never to four or more times a day). All participants were asked how often they had consumed on average last month. Finally, we summarized the frequencies of wholegrains consumption in the following way: hardly never, <1 time/week, =1times/week, and >1 times/week. The total energy intake (kcal/day) was calculated by using an ad hoc computer program developed to analyze the FFQ and the nutrient database derive from Chinese Food Composition Tables [15].

Factor analysis was applied to generate dietary patterns and factor loadings for each food item (gram). Varimax rotation was applied to enhance interpretability. After combining eigenvalues criteria (>1.0), scree plot test, and interpretability, three dietary patterns were descriptively named as “sweets”, “healthy”, and “animal” dietary pattern according to the high loading (absolute value) food items [16]. A higher factor score means greater conformity to this dietary pattern, contrarily unrelated. These scores were confounding factors applied for further analyses.

Assessment of other variables

All participants received standardized physical examination, to obtain the height and weight data. Body mass index

(BMI, kg/m2) was calculated using weight divided by height square. The waist circumference was measured at the navel level while the participants were standing and breathing at the end of expiration and before the beginning of inspiration. Physical activity (PA) in recent week was assessed by using the short form of the International Physical Activity Questionnaire [17]. Total PA levels was calculated according to the following formula: metabolic equivalent (MET) × hour/week.

Demographic variables including sex, age, education level, marital status, household income. We also collect information about whether they are living alone and the frequency of visiting friends. Lifestyle factors including smoking status, alcohol drinking status, as well as individual and family history of chronic diseases. All these data are derived from the self-administered questionnaire.

All the participants were asked to fast overnight before collecting blood samples. Glucose oxidase method was used to measure fasting blood glucose (FBG), enzymatic methods was used to measure total cholesterol (TC) and triglycerides (TG), polyvinyl sulphuric acid precipitation method was used to measure low-density lipoprotein cholesterol (LDL-C) and chemical precipitation method was used to measure high-density lipoprotein cholesterol (HDL-C) with an automatic biochemistry analyzer (Roche Cobas 8000 modular analyzer, Mannheim, Germany). International Federation of Clinical Chemistry method was used to measure serum alanine aminotransferase (ALT). Blood pressure (BP) was measured at the upper left arm with an automatic device (TM-2655P, A&D company, Ltd., Tokyo, Japan). The participants' BP was measured twice and calculated the mean of the two data. The average systolic BP ≥ 140 mm Hg and/or average diastolic BP ≥ 90 mm Hg or having history of hypertension or use of antihypertension medications was defined as hypertension [18]. The TC level ≥5.17 mmol/L or TG level ≥1.7 mmol/L or LDL-C level ≥3.37 mmol/L or having history of hyperlipidemia or use antihyperlipidemic medication was considered having hyperlipidemia. And the situation of long term medication (past 6 months) was investigated by questionnaire.

Statistical analysis

The geometric means (with 95% confidence interval) or percentages where appropriate was used to describe study participants' descriptive data. Multivariate logistic regression models were used to evaluate the relationship between wholegrains consumption and depressive symptoms by sex (interaction for sex, $P < 0.0001$). In the further analysis, the frequency of wholegrains consumption was set as an independent variable and depressive symptoms as a dependent variable. The group "almost never eat" was set as the control group and was used to calculate the odds ratios and the corresponding 95% confidence intervals. Model 1 was crude model. Model 2 was adjusted for age and BMI. Model 3 was additionally adjusted for smoking status, alcohol drinking status, education level, occupation status, household income, total energy intake, PA, marital status, frequency of visiting friends, individual history of disease (including hypertension, hyperlipidemia, and diabetes) and family history of disease (including CVD, hypertension, hyperlipidemia, and diabetes), based on model 2. Model 4 was additionally adjusted for three main dietary pattern score (including healthy dietary pattern, sweets dietary pattern, and animal dietary pattern). The covariates that change estimate of major determinants by >10% or predicted depressive symptoms ($P < 0.05$) were included from the full model. Two-sided $P < 0.05$ was considered as statistically significant. The statistical analyses were performed by SAS version 9.3 (SAS Institute Inc., Gary, NC, USA).

Results

The total number of participants in the study was 24,776 (mean age: 39.9 years, age range: 18.1–91.3 years), 54.1% ($n = 13,393$) were men and 46.0% ($n = 11,383$) were women. Prevalence rates of depressive symptoms in the participants were 15.9% ($n = 2144$) in men and 18.2% ($n = 2082$) in women respectively when the cut-off was set at 45.

In Table 1 the participants were grouped by sex, the distribution of participants with depressive symptoms in social demography, behavior, anthropometry, diet, and clinical characteristics were described. In males, the participants with depressive symptoms had lower levels of BMI ($P < 0.01$) and PA ($P < 0.0001$). They were less likely to be the managers ($P < 0.0001$) and more likely to be other occupations ($P = 0.0001$). They had lower household income ($P < 0.0001$), lower educational level ($P < 0.0001$) and fewer visiting friends ($P < 0.0001$). They also had a higher proportion of current smoker and a lower proportion of ex-smoker and non-smoker (all $P < 0.0001$). Moreover, the participants with depressive symptom were more likely to follow "healthy" and "animal food" dietary patterns (all $P < 0.0001$), and less likely to follow the "sweets" dietary pattern ($P = 0.0001$). In females, the participants with depressive symptoms had lower levels of PA ($P < 0.0001$) and total energy intake ($P < 0.0001$). They were less likely to be the managers ($P < 0.0001$) and more likely to be other occupations ($P < 0.0001$). They had lower household income ($P < 0.0001$), lower educational level ($P < 0.0001$) and fewer visiting friends ($P < 0.0001$). They were more likely to live alone ($P < 0.001$) and less likely to be married ($P < 0.001$). They also had a higher proportion of current smoker ($P < 0.0001$) and a lower proportion of non-smoker ($P < 0.001$). In addition, they were more likely to be an ex-

Table 1 Age-adjusted characteristics of the participants according to depressive symptoms ($n = 24,776$)[a].

Characteristics	Depressive symptoms (males)		*P* value [b]	Depressive symptoms (females)		*P* value [b]
	No	Yes		No	Yes	
No. of subjects	11,249	2144	–	9301	2082	–
Age (years)	40.6 (40.6, 40.6)	40.6 (40.5, 40.7)	0.87	39.0 (39.0, 39.1)	39.0 (38.9, 39.1)	0.54
BMI (kg/m^2)	25.6 (25.5, 25.7)	25.3 (25.2, 25.5)	<0.01	22.8 (22.8, 22.9)	22.7 (22.6, 22.9)	0.31
WC (cm)	88.2 (88.0, 88.3)	87.9 (87.5, 88.3)	0.27	75.4 (75.2, 75.6)	75.4 (75.1, 75.8)	0.86
TC (mmol/L)	4.79 (4.77, 4.81)	4.79 (4.76, 4.83)	0.93	4.65 (4.63, 4.67)	4.67 (4.64, 4.71)	0.25
TG (mmol/L)	1.40 (1.38, 1.41)	1.42 (1.38, 1.45)	0.28	0.91 (0.91, 0.92)	0.90 (0.89, 0.92)	0.33
LDL-C (mmol/L)	2.83 (2.81, 2.84)	2.81 (2.77, 2.84)	0.31	2.62 (2.60, 2.63)	2.63 (2.60, 2.67)	0.37
HDL-C (mmol/L)	1.20 (1.19, 1.20)	1.19 (1.18, 1.20)	0.48	2.00 (1.49, 1.51)	1.51 (1.49, 1.53)	0.37
SBP (mmHg)	123.4 (123.2, 123.7)	123.2 (122.6, 123.8)	0.45	114.9 (114.6, 115.1)	114.7 (114.1, 115.2)	0.55
DBP (mmHg)	78.8 (78.6, 79.0)	78.7 (78.2, 79.1)	0.46	71.7 (71.5, 71.9)	71.8 (71.4, 72.2)	0.61
FBG (mmol/L)	5.10 (5.08, 5.11)	5.11 (5.08, 5.15)	0.36	4.85 (4.84, 4.87)	4.83 (4.81, 4.86)	0.15
PA (MET × hour/week)	12.1 (11.8, 12.4)	8.73 (8.26, 9.23)	<0.0001	9.40 (9.15, 9.65)	6.95 (6.58, 7.35)	<0.0001
Total energy intake (kcal/day)	2094.1 (2084.2, 2104)	2082 (2059.7, 2104.6)	0.34	1936.3 (1924.6, 1948.0)	1876.1 (1852.4, 1900.2)	<0.0001
"Sweets" dietary pattern score	0.12 (0.10, 0.13)	0.02 (−0.02, 0.07)	0.0001	−0.10 (−0.12, −0.08)	−0.19 (−0.24, −0.15)	<0.0001
"Healthy" dietary pattern score	−0.18 (−0.20, −0.16)	0.04 (0.00, 0.09)	<0.0001	0.15 (0.13, 0.17)	0.28 (0.24, 0.32)	<0.0001
"Animal foods" dietary pattern score	0.20 (0.18, 0.22)	0.59 (0.55, 0.64)	<0.0001	−0.36 (−0.38, −0.35)	−0.05 (−0.09, −0.02)	<0.0001
Smoking status (%)						
Current smoker	36.4	42.9	<0.0001	1.29	2.32	<0.0001
Ex-smoker	9.70	9.25	<0.0001	0.71	0.93	0.32
Non-smoker	53.8	47.9	<0.0001	98.0	96.8	<0.001
Drinking status (%)						
Everyday	8.72	9.18	0.36	0.64	0.97	<0.0001
Sometime	71.9	70.6	0.18	40.1	39.2	0.47
Ex-drinker	9.52	9.93	0.55	9.31	10.4	<0.0001
Non-drinker	9.90	10.3	0.56	50.0	49.4	0.64
Married (%)	87.6	87.4	0.76	85.5	82.4	<0.001
Living alone	9.52	10.4	0.25	6.89	8.76	<0.01
Education level (college or higher, %)	69.8	62.2	<0.0001	66.3	58.7	<0.0001
Occupation (%)						
Managers	45.4	40.2	<0.0001	42.5	36.9	<0.0001
Professionals	20.3	21.1	0.44	13.0	12.6	0.63
Other	34.3	38.7	0.0001	44.5	50.5	<0.0001
Household income (≥10,000 Yuan, %)	39.3	27.1	<0.0001	36.4	26.0	<0.0001
Visiting friends (%)	57.2	51.6	<0.0001	66.0	56.6	<0.0001
Individual history of disease (%)						
Hypertension	31.1	30.5	0.78	13.2	13.7	0.39
Hyperlipidemia	56.3	58.1	0.12	37.3	37.6	0.97
Diabetes	4.51	4.95	0.26	1.95	1.54	0.30
Family history of disease (%)						
CVD	29.0	30.1	0.25	31.0	31.4	0.61
Hypertension	49.8	48.7	0.38	50.5	50.9	0.75

Table 1 (continued)

Characteristics	Depressive symptoms (males)		*P* value [b]	Depressive symptoms (females)		*P* value [b]
	No	Yes		No	Yes	
Hyperlipidemia	0.36	0.42	0.65	0.37	0.43	0.65
Diabetes	27.4	24.9	0.63	81.7	18.3	0.26

BMI body mass index, *CVD* cardiovascular disease, *DBP* diastolic blood pressure, *FBG* fasting blood glucose, *HDL-C* high-density lipoprotein cholesterol, *LDL-C* low-density lipoprotein cholesterol, *PA* physical activity, *SBP* systolic blood pressure, *TC* total cholesterol, *TG* triglycerides, *WC* waist circumference.

[a]Continuous variables are expressed as least square geometric means (95% confidence intervals) and categorical variables are expressed as percentages.

[b]Analysis of covariance or logistic regression analysis adjusted for age where appropriate.

Table 2 The association of WG consumption with depressive symptoms ($n = 24{,}776$).

Logistic regression models	Frequency of WG consumption			
	all most never	<1 time/week	1 times/week	≥2 times/week
No. of males	1600	2165	2946	6682
No. of depressive symptoms (SDS ≥ 45)	336	358	465	985
Model 1	1.00 (reference)	0.75 (0.63, 0.88)[a]	0.71 (0.60, 0.82)	0.65 (0.57, 0.75)
Model 2	1.00 (reference)	0.74 (0.63, 0.88)	0.70 (0.60, 0.82)	0.65 (0.57, 0.75)
Model 3	1.00 (reference)	0.78 (0.66, 0.92)	0.75 (0.64, 0.88)	0.70 (0.60, 0.81)
Model 4	1.00 (reference)	0.77 (0.65, 0.91)	0.73 (0.62, 0.86)	0.68 (0.59, 0.79)
No. of females	994	1946	2410	6033
No. of depressive symptoms (SDS ≥ 45)	234	378	482	988
Model 1	1.00 (reference)	0.78 (0.65, 0.94)	0.81 (0.68, 0.97)	0.64 (0.54, 0.75)
Model 2	1.00 (reference)	0.78 (0.65, 0.94)	0.81 (0.68, 0.97)	0.63 (0.54, 0.75)
Model 3	1.00 (reference)	0.83 (0.68, 1.00)	0.90 (0.75, 1.01)	0.72 (0.61, 0.86)
Model 4	1.00 (reference)	0.86 (0.71, 1.04)	0.94 (0.78, 1.13)	0.76 (0.65, 0.91)

Model 1 was crude model. Model 2 was adjusted for age and BMI. Model 3 was adjusted for age, BMI, smoking status, drinking status, education level, occupation, household income, total energy intake, physical activity, marital status, visiting friends, individual history of disease (including hypertension, hyperlipidemia, and diabetes), family history of disease (including cardiovascular disease, hypertension, hyperlipidemia, and diabetes). Model 4 was further adjusted for "sweet" dietary pattern score, "vegetable" dietary pattern score and "animal food" dietary pattern score.

SDS self-rating depression scale, *BMI* body mass index.

[a]Odds ratio (95% confidence interval) (all such values).

drinker ($P < 0.0001$) or drink everyday ($P < 0.0001$). Moreover, the participants with depressive symptom were more likely to follow "healthy" and "animal food" dietary patterns, and less likely to follow the "sweets" dietary pattern (all $P < 0.0001$).

Table 2 shows the relationship between wholegrains consumption and depressive symptom in all four models grouped by sex. After adjusting for several potential confounders and set "almost never" as the control group, the odds ratios (95% confidence intervals) of the depressive symptom in males were 0.77 (0.65, 0.91) when they are consuming <1 time/week, 0.73 (0.62, 0.86) when they are consuming =1 time/week and 0.68 (0.59, 0.79) when they are consuming ≥2 time/week. In females, the odds ratios (95% confidence intervals) of the depressive symptom were 0.86 (0.71, 1.04) when they are consuming <1 time/week, 0.94 (0.78, 1.13) when they are consuming =1 time/week and 0.76 (0.65, 0.91) when they are consuming ≥2 time/week. Furthermore, the results were same when we use other cut-offs (SDS ≥ 40 and 50) to define depressive symptoms.

Discussion

The result shows that the wholegrains consumption was contrarily associated with the prevalence of the depressive

symptom. This is the first large-scale comprehensive study of the relationship between the wholegrains consumption and the depressive symptom in a general population.

Previous studies on the relationship between wholegrains consumption and human health have been concentrated on physical health, but no study has directly assessed the impact wholegrains have on mental health. In research on the relationship between nutrition and depressive symptom, some specific dietary pattern that contain wholegrains such as Mediterranean dietary pattern, DASH diet, improved depressive symptoms [19, 20]. Whether wholegrains play an independent and central role is unclear. The present study finds that wholegrains consumption is related to depressive symptoms, and it may be partly explained through multiple potential mechanisms. First, compared with refined cereal products, wholegrains are important sources of dietary fiber because the refining process may lead to the loss of about 58% of fiber [21]. There are multiple and complex mechanisms by which dietary fiber could impact depressive symptom. Previous studies have proved that the consumption of dietary fiber can affecting the diversity and composition of the intestinal flora structure [22], which can regulate gene transcription, increase serotonin concentration and reduce production of inflammatory cytokines [23, 24]. The latest theory of the microbial-gut-brain axis can also partly explain this procedure. Namely, dietary fiber in wholegrains regulate the gut microbiota to show a reduction of depressive-like behaviors [25]. Second, among edible plants, wholegrains have a high Zinc content, which has been shown to be key factor in regulating depressive symptom, inflammation, and oxidation. Several human and rodent tests studies have observed the antidepressant activity of zinc and suggested long-term intake of zinc may modulate depressive symptom [26, 27]. Randomized controlled trials among individuals with depressive symptom reported that compared to antidepressants alone, antidepressants drug treatments supplemented with zinc reduced the symptoms of depressive symptom [28]. Third, melatonin in wholegrains can regulate circadian rhythm disruption which is considered as the pathophysiology manifestations of psychiatric disorders [29]. Finally, some other components in wholegrains (e.g. B Vitamin, Magnesium) could play an important role in altering the functioning of the central nervous system (CNS) especially in the limbic system and cerebral cortex, which play key roles in the onset and development of depressive symptom [30, 31].

Many potential confounding factors were adjusted during data processing in this study. In model 2, we adjusted the age and BMI because they are related to depressive symptom [32, 33], the relationship between wholegrains consumption and depressive symptoms in males and females remains. In model 3, we additionally adjusted some potential relative factors (including smoking and drinking status, education, employment status, family income, total energy intake, PA, marital status, visiting friends, individual and family history of disease) because the demographic variables, lifestyle factors, and chronic diseases can also affect depressive symptoms [33, 34]. However, the similar relationship didn't between wholegrains consumption and depressive symptoms in both sexes. In model 3, we subsequently adjusted three main dietary patterns ("sweets", "healthy", and "animal" dietary pattern) on account of the dietary pattern may influence depressive symptom [35]. After these adjustments, the relationship between the frequency of wholegrains consumption and depressive symptom still observed, indicating that the correlation between them is independently.

However, the present research still has some limitations. First, the reported food intake may not be accurate in self-report FFQ, so there may be recall bias in the study. Second, this is a cross-sectional design, it is impossible to infer causality from the relationship between wholegrains consumption and depressive symptom. Therefore, results could be interpreted contrarily, i.e., depressive symptom may lead to increasing frequency of wholegrains consumption. More prospective studies or intervention studies are needed to confirm a truly causal relationship between wholegrains consumption and depressive symptoms in different sex. Third, even though many confounding factors have been taken into account, some potential residual factors still unavoidable to confound the observed relationship. Finally, the measurement of depressive symptoms depends on SDS rather than clinical diagnosis of psychiatrists, thus further study is necessary to explore the relationship between wholegrains consumption and clinical diagnosis of depressive symptoms.

Conclusion

Findings in the present study suggested that the higher consumption of wholegrains might have effects on a lower prevalence of depressive symptoms in males and females. We therefore suggest that increase in the frequency of wholegrains consumption may be effective in prevention and improvement of depressive symptoms.

Acknowledgements The authors gratefully acknowledge all the people that have made this study.

Funding This study was supported by grants from China Cohort Consortium (No. CCC2020003) and the National Natural Science Foundation of China (No. 81872611, 81673166), China.

Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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