

The Relationship Between Dietary Fiber Intake and the Risk of Type 2 Diabetes

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Abstract. This investigation explores the link between consuming wheat and the prevalence of Type 2 Diabetes (T2D) among the population of Weifang, China. It relies on preliminary data sourced from 35,509 participants enrolled in the China Kadoorie Biobank. The study categorizes wheat intake frequencies and correlates these with demographic and health-related characteristics of the participants. Findings indicate that individuals who consume wheat more frequently are typically younger, predominantly male, and possess higher educational and income levels compared to those who consume wheat less frequently. There appears to be a strong inverse relationship between how often wheat is eaten and the occurrence of T2D, hinting that a greater consumption of wheat could be linked to a reduced chance of coming down with this persistent ailment. The research underscores the critical role that nutritional elements play in both the control and deterrence of long-standing health conditions, particularly in the context of increasing global T2D rates. The findings powerfully suggest that wheat could be a key player in diet-based strategies to lower the likelihood of developing Type 2 Diabetes. This highlights the urgency for more comprehensive studies to corroborate these results and delve into the biological processes involved.

Keywords: Dietary Fiber Intake, Type 2 Diabetes, Public Health, Dietary Patterns.

1. Introduction

With the improvement of modern economic and medical standards, infectious diseases that were once rampant have been effectively controlled or even gradually eliminated. The escalating prevalence of long-term, non-transmissible illnesses like DM is becoming increasingly common, hypertension, and hyperlipidemia is significantly affecting public health. Many factors or their interactions can cause NCDs, such as genetic, socioeconomic, lifestyle, and psychological factors, thus these diseases are also known as lifestyle diseases [1]. DM, often seen as a disease of affluence in modern society, is witnessing a gradual increase in prevalence and incidence globally, making it a chronic disease of significant concern [2]. DM stands as a long-term metabolic disorder predominantly marked by high blood sugar levels. This condition manifests in various forms, each distinguished by its underlying cause. Type 2 diabetes (T2D) emerges as the prevalent variant, representing the lion's share of diabetes diagnoses worldwide [3]. The mechanism of T2D is believed to be associated with insulin resistance produced by fat accumulation in various parts of the body, leading to decreased insulin sensitivity in the liver and muscles, which in turn results in increased glucose output by the liver and impaired glucose utilization by muscles [4,5]. T2D is the most prevalent form of diabetes, comprising over half of all global diabetes cases and accounting for 90% of diabetes cases worldwide. In recent decades, the incidence and prevalence of T2D have surged, making it a sustained public health issue globally. As per the 10th edition of the International Diabetes Federation Diabetes Atlas, the year 2021 saw 537 million adults between the ages of 20 and 79 diagnosed with diabetes globally. Projections indicate this number will soar to 783 million. Inadequate control of Type 2 Diabetes can result in several serious complications, such as diabetic nephropathy, diabetic peripheral neuropathy, and diabetic retinopathy. Consequently, it's crucial to devise robust treatment and prevention plans to tackle these issues [6].

A multitude of elements impact the persistence of chronic illnesses, with nutritional components taking on a crucial role in both prevention and management. This is particularly evident in the dietary regulation and daily consumption patterns associated with thwarting and managing T2D. Therefore,

early and effective intervention and control of T2D and other chronic diseases from the dietary perspective is a significant area for future research and exploration. Presently, research on the link between primary food consumption and the occurrence of chronic illnesses remains somewhat scant, highlighting the significance of examining wheat consumption as a major dietary element in connection with T2D incidence as a noteworthy investigation. The cultivation of wheat boasts an extensive history, traceable to its consumption as a dietary staple by inhabitants along the Yangtze River in China around 8000-9000 years ago. Currently, over half of the global population relies on wheat as a primary food source, especially in densely populated nations such as China, Japan, and India. Refined wheat, also known as white rice, primarily consists of starch and undergoes a series of mechanized production processes including husking and milling, ultimately appearing as the main type of wheat consumed [7].

Research on the intake of wheat and its relationship with T2D remains relatively rare both domestically and internationally, and results have been controversial. In particular, no studies have been reported in the northern regions of China regarding this relationship. Therefore, analyzing the wheat intake in the northern regions and its association with T2D is a topic worth exploring. For this purpose, this study utilized baseline data from 35,509 participants in the Weifang area from the "China Kadoorie Biobank" to understand the wheat intake and diabetes prevalence among residents of Weifang City, providing foundational data for further research into T2D and exploring the correlation between wheat intake and the incidence of T2D, to support the prevention of this disease.

2. Study Subjects and Methods

2.1. Study Subjects

2.1.1. Selection of study subjects

The China Kadoorie Biobank (CKB) involves surveys in 10 regions across the country, divided into five urban and five rural sites, with Weifang being one of the study sites [8]. Cluster sampling was used to include all residents and employees from 133 community committees in 12 street offices and 14 enterprises in Weifang City who met the study inclusion criteria. A total of 35,509 participants met these criteria and completed all baseline survey items in this study.

2.1.2. Inclusion criteria for study subjects

The inclusion criteria for the baseline survey were as follows: adults of both sexes born between 1930 and 1970, i.e., aged between 30-79 years; permanent residents of Weifang City, excluding transient and temporary populations, military personnel, and government employees; those without severe diseases and who voluntarily agreed to participate in the study and signed an informed consent form.

2.2. Study Content

The questionnaire survey was conducted using a computerized electronic questionnaire jointly implemented by the China Centers for Disease Prevention and Control and the Oxford University Medical School. The survey covered general information about the participants, tea drinking habits, alcohol consumption, smoking habits, dietary intake, passive smoking and indoor air pollution, personal and family health status, physical activity, reproductive history in women, mental, sleep and emotional states, and physical examination records. The relevant sections of the questionnaire included:

General Information: Name, gender, date of birth, highest level of education attained, current main occupation, current marital status, and total annual household income.

Alcohol Consumption: Frequency of drinking over the past year and the usual types of alcoholic beverages consumed.

Smoking Habits: Frequency of smoking and the usual types of cigarettes smoked.

Dietary Intake: Frequency of food consumption over the past year, including wheat, pasta, coarse grains (such as corn and sorghum), poultry and products, fresh vegetables, soy products (including soy milk), pickled vegetables, fresh fruits, and dairy products (such as milk and yogurt), categorized into five frequency groups: almost never, 1-3 times/month, 1-3 times/week, 4-6 times/week, and daily.

Personal and Family Health Status: Prevalence of common chronic diseases (such as diabetes and hypertension) among the participants and diabetes among immediate family members, with all diseases confirmed by local district/county-level hospitals or higher.

Physical Activity: Nature and duration of physical activities related to work.

3. Results

3.1. Demographic Information of Participants

A total of 35,509 participants completed the baseline survey, including 15,626 males (44.0%) and 19,883 females (56.0%), with a gender ratio of 1:1.27. The average age of all participants was 50.3 ± 10.2 years, with males averaging 51.0 ± 10.3 years and females 49.4 ± 10.0 years. The majority of both male and female participants were married, employed in agriculture, forestry, fishing, and labor, and most were overweight (47.7% of males and 41.0% of females). The majority of females were non-smokers (97.8%), while a majority of males were smokers (58.8%). In terms of alcohol consumption, most females either did not drink or drank infrequently (45.3%), while a significant proportion of males were current drinkers (48.0%), as shown in Table 1. A higher percentage of females had a family history of diabetes compared to males (15.1% vs. 14.5%, $P < 0.001$), and females also had higher rates of hypertension (15.4% vs. 11.2%, $P < 0.001$) and obesity (26.5% vs. 20.6%, $P < 0.001$). Males had higher levels of education, annual income, and marriage rates than females ($P < 0.001$ for all).

Table 1. Sociodemographic baseline characteristics of subjects

-	Options	Percentage%
Gender	Males	44.0
	Females	56.0
Weight StatusBMI>24 kg /cm ⁻²)	Males	47.7
	Females	41.0
Smokers	Males	58.8
	Females	2.2
Drinkers	Males	48.0
	Females	45.3
Family history of diabetes	Males	14.5
	Females	15.1
Hypertension	Males	11.2
	Females	15.4
ObesityBMI>28 kg cm ⁻²)	Males	20.6
	Females	26.5

3.2. Prevalence of Type 2 Diabetes Among Participants

Of the participants, 3,409 were diagnosed with T2D, including 2,059 females and 1,350 males, with a prevalence of 5.8% in females and 3.8% in males. The study found that among females, lower levels of education(Junior high school and below) and annual income were associated with higher rates($\geq 35,000$ RMB/year) of Type 2 diabetes ($P < 0.001$ for both). The highest diabetes rates were observed among participants engaged in domestic, retired, unemployed, and other occupations, as well as among those who were overweight ($P < 0.001$ for both genders). Among males, current

smokers and drinkers had the highest diabetes rates, while among females, non-drinkers and non-smokers had the highest rates ($P < 0.001$ for both).

3.3. Basic Information on Wheat Intake Frequency

The number of participants in the wheat intake frequency groups—almost never, 1-3 times/month, 1-3 times/week, 4-6 times/week, and daily—were 1,427, 4,764, 19,637, 3,467, and 6,214 respectively, accounting for 4.0%, 13.4%, 55.3%, 9.8%, and 17.5% of the sample, as shown in figure 1. As wheat intake frequency increased, the proportion of females decreased ($\chi^2 = 162.650$, $P < 0.001$). Participants who frequently consumed wheat tended to be younger and were more often male, compared to those who seldom ate wheat, have higher levels of education (high school and above), and higher family incomes ($\geq 35,000$ RMB/year) ($\chi^2 = 162.650$, 7.469, and 537.954 respectively, $P < 0.001$ for all). With increasing levels of education and family income, the proportion of participants in the daily wheat consumption group also increased ($\chi^2 = 707.469$ and $\chi^2 = 537.954$, $P < 0.001$). Those employed in sales, services, and private business occupations had the lowest proportion in the daily wheat intake group ($P < 0.001$). With increasing wheat intake frequency, the proportion of non-smokers increased while that of current smokers decreased ($\chi^2 = 286.526$, $P < 0.001$), and the proportion of current drinkers decreased as well ($\chi^2 = 333.717$, $P < 0.001$).

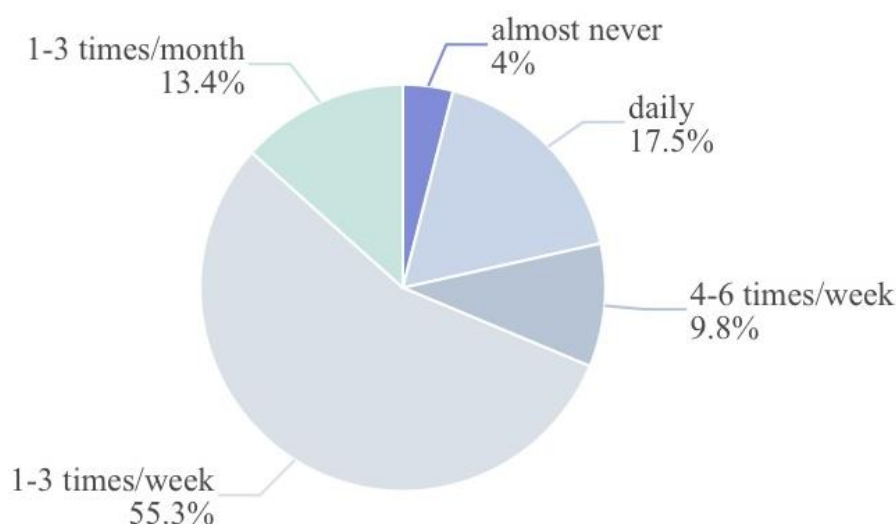


Figure 1. Basic Information on Wheat Intake Frequency

4. Discussion

4.1. Wheat Intake and the Prevalence of Type 2 Diabetes

Using baseline data from 35,509 participants of the CKB Weifang site, this study described and analyzed the wheat intake and the prevalence of T2D among residents. The results showed that the proportions of participants consuming wheat "almost never," "1-3 times/month," "1-3 times/week," "4-6 times/week," and "daily" were 4.0%, 13.4%, 55.3%, 9.8%, and 17.5%, respectively. The majority of participants consumed wheat 1-3 times per week, indicating a relatively low frequency of wheat consumption, which correlates with the food consumption characteristics of staple foods in China, where the southern regions primarily consume rice and the northern regions, including Weifang, predominantly consume wheat-based products, consistent with previous studies. Additionally, the study found that compared to those who almost never ate wheat, participants with higher wheat intake frequencies were younger, predominantly male, more educated, and had higher household incomes. Wheat intake frequency was influenced by age, gender, educational level, and economic status, suggesting that traditional dietary habits might restrict the consumption patterns of staple foods among older and female populations, and lower family income and education levels

could also limit the concept of consuming wheat as a daily staple. Moreover, of the 3,409 participants diagnosed with Type 2 diabetes, females had a higher prevalence rate (5.8%) compared to males (3.8%). Current statistics in China show that the prevalence of diabetes is generally higher in females than in males, with a gender ratio of 1.0:1.1 in diabetes prevalence. The higher rate of diabetes among females in Weifang might be attributed to a significant proportion of women aged 30-79 years being retired and transitioning from working to being homemakers, which may reduce daily physical activity and indirectly increase the risk of diabetes. The commencement of Type 2 Diabetes is impacted by a variety of elements including inherited traits, economic standing, surrounding conditions, and mental perspectives, leading to variations in diabetes prevalence across different regions and genders [9,10].

4.2. Multifactorial Logistic Regression Analysis of white Rice Intake and the Risk of Type 2 Diabetes

This research utilized a multifactorial logistic regression model to examine the link between rice consumption and the prevalence of Type 2 Diabetes, uncovering an inverse correlation. This suggests that increasing rice consumption may reduce the risk of T2D. Comparable outcomes were documented by Soriguer et al. in a longitudinal study conducted over six years in Southern Spain, it was observed that a rise in the consumption of rice was linked to a decline in the incidence of Type 2 Diabetes, indicating a negative correlation [11]. Comparable results were also found in a study involving American women, where intake of refined grains like rice was negatively correlated with T2D [12]. Fei Dong et al. also reported similar results, differentiating dietary patterns across three regions in China—Northern, Central, and Southern [13]. The highest rice consumption was noted in the Southern region, with the lowest in the Central region. The study found a negative correlation between rice intake and T2D across different dietary patterns, including Western diets in the Central region, In the Northern region, traditional diets prevail, while in the Southern region, diets are predominantly Western and rich in wheat. Subsequent scrutiny uncovered an inverse relationship between the consumption of rice and the incidence of T2D, exclusively in women, while no such correlation was found in males, aligning with a Japanese study that showed a positive correlation among females but no association among males [14].

However, other studies contrast with these findings. For instance, a study among middle-aged women in China indicated that those consuming more rice had a 78% increased risk of developing T2D [15]. Similarly, an American cohort study showed that compared to brown rice, increased white rice consumption raised the risk of T2D by 17%, with similar findings reported in Singapore [16]. Yet, studies from Hong Kong showed no association between rice intake and T2D in the general population, and research from Western countries like Australia, Sweden, Finland, and the USA also indicated no correlation between intake of rice or other refined grains and T2D [17-21].

The discrepancies in study outcomes across different regions could stem from variations in the demographic composition of the study populations. Additionally, actual rice consumption frequency or average daily intake varies between countries and regions, with Asian countries typically consuming more rice than Western countries, and Southern China consuming more than the Northern region. Cooking methods, such as steaming, porridge making, or frying rice, as well as variations in cooking times, the types of oils, and condiments used during processing, can influence the glycemic index of rice, thereby potentially affecting the risk of T2D. However, studies have found that the glycemic index is not the sole or primary cause of increased risk for T2D. For example, some types of rice contain high levels of inorganic arsenic, which can elevate the risk of T2D in regions with high arsenic content in rice [22]. Therefore, inherent differences in rice due to regional variations, such as the types of rice consumed in different countries and the resulting differences in micronutrients and nutrients, could explain the varied relationships between rice intake and T2D. The exact processes through which consuming rice may diminish the likelihood of developing T2D remain elusive and certainly merit more in-depth research. This study anticipates further large-scale cohort research to confirm these findings.

5. Conclusion

Wheat intake is negatively correlated with the prevalence of T2D, suggesting that increasing wheat consumption may reduce the risk of T2D. However, additional extensive cohort studies are necessary to validate these results. Additionally, the interaction of wheat intake with family history of diabetes, alcohol consumption, and BMI exhibits a negative multiplicative model effect in the incidence of T2D. The investigation into this phenomenon presents certain limitations. Firstly, constrained by resources, our study employs a relatively limited sample size, which may hinder our ability to detect minor effects. Secondly, the participants in this study are primarily from specific regions, limiting the national representativeness of the results. Furthermore, the reliance on self-reports from participants poses the risk of social desirability bias affecting the data. Nevertheless, we contend that our findings offer valuable insights for a deeper understanding of the phenomenon and establish a groundwork for subsequent research. It is imperative for future studies to engage larger and more varied groups of participants to enhance the universality and robustness of the findings. Expanding the diversity of research populations will help in capturing a wider range of genetic, lifestyle, and environmental factors that influence Type 2 Diabetes. It's essential to carry out extended research to monitor the enduring impact of nutrition and lifestyle adjustments on the control and deterrence of diabetes. Such studies could provide more definitive evidence regarding causality and the effectiveness of different preventive strategies. Incorporating advanced technologies and data analytics into research methodologies could also enhance the precision and applicability of the results to various populations.

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