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Effects of subjective feeling of environmental temperature on appetite and food intake in Chinese sociodemographic and ethnic groups

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Abstract

Background: A better understanding of the effect of environmental temperature variation on appetite and food intake may inform the public of adopting appropriate prophylactic eating behaviors. Seasonal weather temperature variation has been shown to have adverse effects on appetite and food intake in humans. The main purpose of this study was to examine the effect of environmental temperature variation on the appetite and eating patterns in Chinese adults.

Methods: Cross-sectional analysis of data obtained from 1297 Chinese adults, including two Chinese ethnic groups, Han ($N = 897$) and Hui ($N = 400$). Participants responded to a modified paper-and-pencil self-administered dietary habits and food intake survey. In addition to sociodemographic factors and ethnic group affiliation questions, the survey included a question regarding the effect of the subjective feeling of environmental temperature variation (SFETV) on appetite and food intake as an independent variable**.** *t* tests and chi-square analyses were performed to analyze the parametric and nonparametric variables respectively.

Results: No significant difference was found in the effect of SFETV between the following dependent variables: male and female respondents ($p < .998$), married and single respondents ($p < .281$), full-time and part-time employed or retired participants ($p < .187$). Although it has not affected their SFETV responses, there was a statistically significant difference in the education level between the married and single respondents ($p < .001$). The single respondents were more likely to be college educated with a rate of (68.48%) compared with their married counterparts with a rate of 30.2%. There was a statistically significant difference between the eight cities and one rural town ($p < .001$). The appetite and food intake of the respondents from these cities were more likely to be affected by the SFETV. The appetite and food intake of the Han ethnic group were more likely to be affected by the SFETV with a rate of 28.09% juxtaposed to the Hui ethnic group with a rate of 12.64%.

Conclusions: The findings suggest that exposure to outdoor temperature variation (hot or cold) has a limited effect on the appetite and food intake of Chinese adults. However, the appetite and food intake of the permanent residents of the eight cities and one rural town were more likely to be affected by the exposure to outdoor temperature variation (hot or cold).

Keywords: Environmental temperature, Appetite, Food intake, Eating behavior, China, Sociodemographic factors, Ethnic affiliation, Han Nationality, Hui Nationality

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Introduction

There is a scarcity of published scientific research that has examined the possible effect of environmental temperature variation on appetite and food intake in Chinese adults. In part, this lack of scholarly data can be explained by the fact that the priority of scientific research in China has been focused on addressing non-communicable chronic diseases (NCDs). As a result of the rapid socioeconomic development coupled with rising modern lifestyle behavioral risk factors, the incidence of NCDs has increased sharply and is currently estimated to cause 85% of the total mortality rates among Chinese [1]. This current scarcity of relevant secondary literature positions the present study to cast further light upon and reinforce the current insufficient body of scientific literature in this area of research in China and other developing countries.

The Han and Hui Nationalities are two of the most culturally diverse ethnic groups among the 56 officially recognized ethnic groups in China. According to the 2011 Chinese census, the Han ethnic group constitutes the predominant ethnic group with nearly 89.1% of the total Chinese mainland population, whereas the Hui Nationality comprises the third-largest minority ethnic group in China with nearly 1.8% of the total mainland population. Both ethnic groups have distinctive cultural characteristics, unique dietary practices, and discernable culinary preparation styles [2–4]. The dietary practices of the Han and Hui ethnic groups are significantly influenced by factors such as their history, geography, religious affiliation, socioeconomic status, and traditional eating habits. For various reasons, even within one country or culture, people usually prepare and consume a variety of food ingredients for different economic reasons, religious beliefs, energy needs, and utilize food as a prophylactic against diseases. Moreover, people living in different cultures obtain and consume their food from different sources to survive and maintain good health. Therefore, dietary habits and food consumption patterns are both cultural tradition and biological process rather than merely physiological, and biochemical processes [5]. Food may also function as an important, or even a determining cultural criterion in a group of people who share the same food culture denoting their inimitable cooking style, eating patterns, social status, and behaviors toward food. However, even within the same culture, dietary behaviors do not necessarily have to be homogenous. As a rule, they are not homogenous due to socio-cultural phenomena such as diversity in food sources, demographics, socioeconomic strata, and religious beliefs. Moreover, the Chinese food culture is uniquely characterized by well-established traditions and beliefs about food, which have transformed how food is prepared and consumed. Some of the cooking traditions can be traced back to the Chinses teacher and philosopher Confucius. He was instrumental in developing proper cooking techniques. To the present day, his teachings concerning cooking methods are still regarded as an essential element of Chinese food culture [6].

Among the mélange of Chinese ethnic groups is the Muslim Hui Minority Nationality. The present-day Hui people's ancestors were Arab and Persian merchants and missionaries who migrated to China during the Tang and Ming Dynasties (seventh century to mid-thirteenth century AD). When they arrived in China through trekking the overland and maritime Silk Road trade routes, they settled down incipiently in the southwestern and northwestern regions. Some of the Hui progenitors settled alongside the middle and lower reaches of the fertile land of the Yellow River Basin. Unlike other Chinse Muslim nationality groups such as the Uzbeks, Kazaks, and Tatars, the Chinese Hui people have their distinctive style of producing and cooking "halal food" (Arabic: لال), which means "permissible food." Principally, the Hui people's dietary practices are strongly influenced by their observance of Sunni Islam, which is also the religion of their Arab, Turkic, and Persian ancestors [4, 7]. The practice of halal food consumption by the Hui people since arriving in China in the early seventh century is one of the key differences between the Hui and Han food culture traditions, whereas the Hui ethnic group is religiously circumscribed to consuming only halal food that is strictly prepared according to prescribed Islamic dietary regulations, the Han Ethnic group does not have similar specific religious dietary restrictions. Comparable to the Hui people, the Han people's staple diet includes a wide variety of wheat, rice, and noodles gastronomies. However, the chief differences between their dietary practices lie in the preparation and consumption of meat products and alcoholic beverages. Meat obtained from animals and fowls such as chicken that are not slaughtered according to Islamic regulations is not permissible for the Huis to consume. Specifically, pork, porcine byproducts, meat sourced from beasts, vultures, dead animals, and animal blood are among the prohibited foods for consumption by the Huis. Similarly, different from the Hans, any quantity of alcoholic beverages prohibited for consumption by the Huis. Therefore, in many cities and towns across China, the Hui people have their halal food restaurants (Chinese: Qīngzhēn-清真食品) that are regularly patronized by the Han people as well [8].

Human appetite and food intake are regulated and influenced by several factors chiefly among them the cyclical variation of environmental temperatures. Published empirical evidence showed that eating behavior can be directly affected by seasonal weather changes, however, this effect may vary discretely according to the ambient

environmental temperature variation. People who live in a cold climate eat differently when they live in a hot climate. A growing body of scientific research has examined the effect of environmental temperature variation on appetite, food intake, food selection, eating pathologies, thermogenesis, and energy expenditure. Findings from several studies conducted on the effect of environmental temperature conditions suggested that seasonal weather conditions can have varying effects on the daily activity patterns of individuals, including appetite and eating behaviors [9, 10]. The desire for food intake occurs in a contextual influence of a myriad of environmental stimuli that can significantly affect people's eating behavior. Scientific research indicated that one of these influential stimuli is the seasonal weather temperature variation (hot and cold), which can consciously or subliminally influence people's appetite and food consumption by either curtailing or enhancing their desire to eat [11]. According to Westerterp-Plantenga [12], certain environmental conditions such as circadian rhythms, environmental temperatures, and altitude may affect food intake in humans. Westerterp-Plantenga [12] further explained that in cold conditions, keeping adequate food intake is essential for maintaining normal adaptive physiological responses to cold conditions. Research findings indicated that there is a possible cold-induced upsurge in appetite and food intake due to increased energy demand to maintain core body temperature and other physiological functions [13]. These findings have been supported by a similar clinical study that purported exposure to lower ambient temperatures resulted in a significant increase in free fatty acid levels indicating increased demand for energy in cold those conditions [14].

Research by Tomasik et al. [15] showed that the concentration level in plasma ghrelin, the hunger hormone that plays a role as an appetite stimulant, was significantly higher at 2 °C (35.6 °F) temperature than that at 30 °C (86.0 °F) temperature. Conversely, findings from a later study on the effect of warmer ambient temperature on adult men and women maintained that both gender groups in the study experienced decreased food intake. Whereas men and women consumed less food, the study further reported that the female participants consumed nearly 350 calories less than their male counterparts. These findings also revealed that for every 1 °C (33.8 °F) rise in the ambient temperature, both male and female participants consumed less food equivalent to 85.9 calories [16]. Similar research on the effect of ambient temperatures on food intake showed a decrease in food intake and energy metabolism. Furthermore, in a short exposure at 27 °C (81 °F) compared to 22 °C (72 °F), there was evidence of a reduction in energy intake among the female participants, which was principally associated with body temperature changes and secondarily to changes in energy expenditure [17]. In addition to the environmental temperature variation, the palatability of food itself may also play a key role in food intake in a cold climate. Research by Rode and Shepard [18] reported that between 1970 and 1990 there was a twofold increase in the hypodermic fat stratum of the Inuit children between the ages of 9–19 years living on Igloolik Island in northernmost Canada. This increase in the hypodermic fat was ascribed to what occurred in 1970, where the Inuit children in the study consumed a conventional Eskimo diet that was rich in a combination of animal fat and protein with no carbohydrate intake. In comparison, in 1990, the Inuit children were fed a traditional Western-style diet comprised mainly of surgery soft drinks, popcorn, sweets, ice cream, and candy bars. The findings from this study suggested that the reason for increasing food intake in cold weather conditions could not be only for the extra energy intake to keep warm, but also for the palatability of the food consumed by the children.

In similar research on the association between exposure to cold conditions and overfeeding, Wijers et al. [19] reported changes in the total daily energy expenditure (TDEE) during both overfeeding and exposure to mild cold conditions. Further, there was a considerable inter-individual variation in TDEE among participants. Wijers et al. [19] further observed that there were individual changes in energy expenditure under the two conditions of mild cold exposure and overfeeding, which were found to be statistically closely correlated ($p = 0.005$) indicating a significant positive association between them. In significantly higher temperatures, clinical research by Kojima et al. [20] presented evidence of subjective feelings of hunger by participants in the 36 °C (96.8 °F) and 24 °C (75.2 °F) trials respectively were found to be significantly lower than those participants in the 12 °C (53.60 °F) degrees trial ($p < 0.05$). These findings suggested that higher ambient temperatures at 36 °C (96.8 °F) and 24 °C (75.2 °F)] may curtail appetite and depress the sensation of the subjective feeling of hunger. A similar study on warm weather temperature in college females living in the Southeastern and a Northeastern Regions of the USA, with an average temperature of 21 °C (69.8 °F) and 31 °C (89 °F) found that living year-round in a warm weather environment may lead to an increased risk for developing pathological symptoms of an eating disorder by suppressing appetite and curtailing food intake [21].

Materials and methods

Study setting

The present study was conducted in China between May and August of 2016. Participants were unpaid volunteer permeant residents of eight cities and one rural town located in six geographically and climatically diverse Provinces, including Beijing ($N = 283$), a Providential-level

city; Kaifeng (N = 264), Henan Province; Zhengzhou (N = 241), Henan Province; Luoyang (N = 190), Henan Province; Xiaoping (N = 75) (rural town), Henan Province; Xi'an (N = 85), Shaanxi Province; Ji'nan (N = 72), Shandong Province; Quanzhou (N = 48), Fujian Province; and Xiamen (N = 39), Fujian Province (Table 1, Fig. 1).

Inclusion and exclusion criteria

Participants who qualified for inclusion in this cross-sectional study were a cohort of 1297 adult men and women between the ages of 18 years and older, and who self-identified their ethnic group affiliation as either Chinese Han or Chines Hui. Participants whose ages were outside the age range of 18 years and older or did self-identify their group ethnicity as Han Nationality nor Hui Nationality were excluded from the study.

Survey development and procedures

Participants in the present study comprised of 1297 Chinese adults aged 18 years and older, including male (N = 724, 55.83%) and female (N = 573, 44.17%). The study participants responded to an adapted version of a paper-and-pencil self-administered dietary history and food intake cross-sectional population survey. The questions encompassed daily food and beverages intake, the number of full meals consumed each day, the time of the meals consumed each day, and the subjective feeling of environmental temperature variation (SFETV) (the overall weather temperature of the outdoor air in the surrounding environment). The study employed a modified version of the National Cancer Institute Food Frequency Questionnaire (FFQ) and the Diet History Questionnaire (DHQ) [15, 16]. The study questionnaire consisted of 28 questions to collect relevant data from the respondents concerning their sociodemographic information, including the level of education, age, marital status, employment status, ethnic group affiliation, and gender identification.

Table 1 The frequency distribution of participants in the study by city (N = 1297)

Frequency distribution				
City	Frequency	Percent	Cumulative frequency	Cumulative percent
Beijing	283	21.82	283	21.82
Kaifeng	264	20.35	547	42..17
Zhengzhou	241	18.58	788	60.75
Luoyang	190	14.65	978	75.40
Xi'an	85	6.55	1063	81.95
Xiaoping	75	5.78	1138	87.73
Ji'nan	72	5.55	1210	93.28
Quanzhou	48	3.70	1258	96.98
Xiamen	39	3.02	1,297	100.00

All respondents were volunteers randomly selected from eight urban cities and one rural town. They are Beijing, Kaifeng, Zhengzhou, Luoyang, Xiaoping (rural town), Xi'an, Ji'nan, Quanzhou, and Xiamen. They are in the Midwestern, Central Plains, and Southwestern Regions of China (Fig. 1).

Statistical analyses

The data collected from the eight cities and one rural town were entered into a computer using standardized statistical data entry codes. The data were then analyzed employing the Statistical Analytics Software (SAS) Package, 9.3 TS1M2 version. t tests were performed for the nominal (classification) variables vs. the ordinal variables where the nominal variable had exactly two levels (e.g., male and female, Han and Hui). Descriptive statistics were represented as means, standard deviations, and proportions. Chi-square (mostly 2 by 2) analyses were applied if both variables were nominal. Certain nominal data entries with multiple levels were re-coded into one of two levels prior to performing a 2 by 2 chi-square test (χ^2). Most of the data analyses involved calculating p values and categorizing any value of a test statistic with a p value of less than an alpha level of 0.05 as statistically significant. In the present study, the tests were two-tailed, and statistical significance was set and accepted at a p value < 0.05.

Results

Effect of SFETV (hot or cold) on the sociodemographic groups

Gender factors (male vs. female)

As it can be observed in Table 2, the total participants in the present study were 1297 Chinese adults, including male (N = 724, 69.2%) and female (N = 573, 30.8%). Regarding the effect of SFETV on appetite and food intake, 77.95% of the female respondents indicated no effect on appetite and food intake, whereas 22.05% reported that SFETV does affect their appetite and food intake. With reference to the male respondents, 77.94% reported no effect of SFETV on their appetite and food intake, whereas 22.06% indicated that SFETV does affect their appetite and food intake. There was no statistically significant difference between the male and female respondents concerning the effect of SFETV on appetite and food intake, χ^2 (1, N = 1295), p < .998. SFETV was less likely to affect the appetite and food intake of the male and female respondents.

Marital status and education level factors (married vs. single)

The results of the association between marital status, education level, and the effect of SFETV are presented in Fig. 2. The marital status frequency distribution revealed that the married respondents constituted (N = 765, 59.02%), of the total participants, whereas the single respondents comprised

Fig. 1 China map illustrating the nine cities where the data were collected. The cities depicted in red-inked dots. Source: Adapted from China Tour (2019)

of (N = 532, 40.98%) (Table 2). The married respondents indicated by 79.86% that SFETV does not affect their appetite and food intake, whereas (20.14%) indicated that SFETV does affect their appetite and food intake. With respect to the single respondents, 74.00% reported no effect of SFETV on their appetite and food intake, whereas 26.00% indicated that SFETV does affect their appetite and food intake.

Table 2 The frequency distribution of participants' gender, marital status, and employment status (N = 1297)

Gender	Frequency	Percent	Cumulative frequency	Cumulative percent
Female	573	44.17	573	44.17
Male	724	55.83	1797	100.00
Married	765	59.02	765	59.08
Single	532	40.98	1797	100.00
Full-time employed	1011	70.12	1011	70.12
Part-time/retired	286	20.88	1797	100.00

There was no statistically significant difference between the married and single respondents concerning the effect of SFETV on appetite and food intake, χ^2 (1, N = 1292), $p < .281$. In connection with the marital status and education level, 69.8% of the married respondents received no college education, whereas 30.2% received a college education. In juxtaposition, 31.52% of the single respondents received no college education, whereas 68.48% received a college education. There was a statistically significant difference in the level of education factor between the married and single respondents, χ^2 (1, N = 1294), $p < .001$, whereas there is a significant difference in the level of education between the married and single respondents. The appetite and food intake of the married and single respondents were less likely to be affected by the SFETV (Fig. 2).

Employment status factor (full-time vs. part-time employed or retirees)

The results from the employment status data analysis described in Table 2 indicate that (N = 1011, 70.12%) of

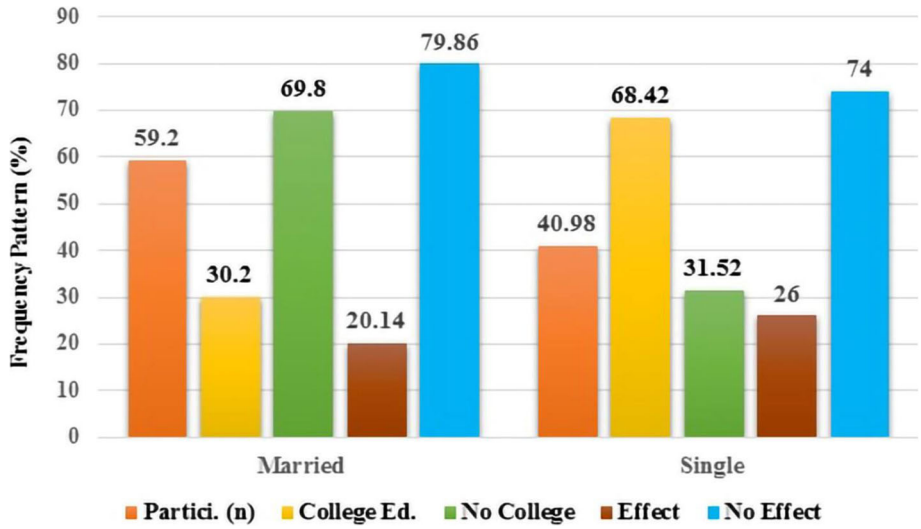

Fig. 2 Association between marital status, level of education, and SFETV effect. Partici. (*n*): the total number of participants in the study. College Ed.: college educated. No College: not college educated. SFETV: the subjective feeling of environmental temperature variation. Effect: appetite and food intake affected by SFETV. No Effect: no effect of SFETV on appetite and food intake

the respondents were employed full-time, whereas (N = 286, 29.88%) were either employed part-time or retired. With respect to the effect of SFETV on appetite and food intake, 69.57% of the full-time employed respondents reported that SFETV (hot or cold) does not affect their appetite and food intake. In comparison, 30.43% indicated that SFETV does affect their appetite and food intake. Concerning the part-time employed or retired respondents, 79.59% reported that the SFETV does not affect their appetite and food intake, whereas 20.41% indicated that the SFETV does affect their appetite and food intake. There was no statistically significant difference between full-time and part-time employed or retired respondents that the SFETV does not affect their appetite and food intake, χ^2 (1, N = 1292), p < .187. The appetite and food intake of the full-time and part-time employed or retired respondents were less likely to be affected by the SFETV.

The eight cities and one rural town geographical location factors

Table 1 and Fig. 1 illustrate that the participants in the current study were 1297 permanent residents of eight cities and one rural town located in six geographically and climatically diverse provinces. Figure 3 represents the combined results obtained from the data analysis. Together with other questions, the participates from each of the eight cities and one rural town responded to a survey question whether the environmental temperature variation (hot or cold) affects their appetite and food intake. There was a statistically significant difference between the eight cities and one rural town that the SFETV does affect their appetite and food intake, χ^2 (1, N = 1294), p < .001. The appetite and food intake of the respondents residing in the eight cities and one rural town were more likely to be affected by the SFETV.

Ethnic group affiliation factor (Han vs. Hui)

As can be viewed in Fig. 4, the Han ethnic respondents in the present study comprised of (N = 897, 69.2%), whereas the Hui ethnic respondents consisted of (N = 400, 30.8%) of the total 1297 participants. The results revealed that 71.91% of the Han respondents reported that the environmental temperature variation does not affect their appetite and food intake, whereas 28.09% indicated that the environmental temperature variation does affect their appetite and food intake. In comparison, 87.36% of the Hui respondents reported that the environmental temperature variation does not affect their appetite and food intake, whereas 12.64% responded that the environmental temperature variation does affect their appetite and food. There was a statistically significant difference between the Han and Hui Nationalities, χ^2 (1, N = 1293), p < .005. Even though a higher proportion of the Han and Hui ethnic groups indicated that their appetite and food intake is not affected by SFETV, the appetite and food intake of the Han ethnic group were more likely to be affected by the environmental temperature variation with a rate of 28.09% juxtaposed to the Hui ethnic group with a rate of 12.64%.

Discussion

An exhaustive review of the available scientific literature indicates that there is a dearth of data-based evidence to provide a better understating of the role of environmental temperature variation (hot or cold) it plays in the human

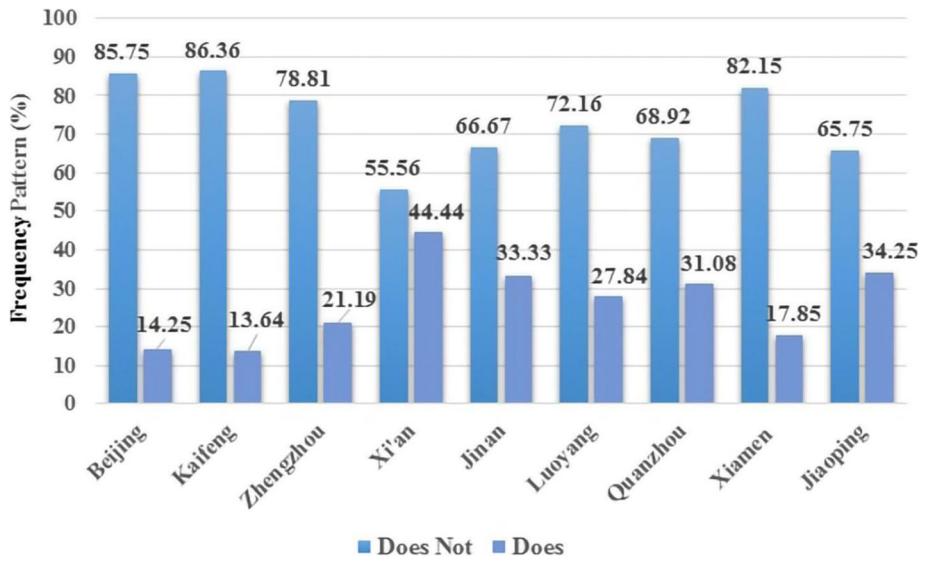

Fig. 3 Demonstrates the nine city residents' responses to the effects of the SFETV on appetite and food intake

appetite, food intake and other eating behaviors. Anecdotally, accepted but not necessarily scientifically derived conventional knowledge implies that some people would typically have less appetite for food intake when they are exposed to a hot climate. Conversely, some other people tend to experience an increased appetite for food intake due to exposure to a cold climate. To some measures, the findings of the present study have been consistent with that conventional knowledge. However, further understanding of the effect of the environmental temperature variation on appetite, food intake, and metabolic disturbances may inform the public of adopting appropriate healthy eating habits to maintain healthy body weight and reduce the risk of human biometeorology-related conditions such as obesity and eating disorders [21]. Moreover, it is important to understand how some people's appetite and food intake are predisposed to fluctuate with the changeability of environmental temperature conditions, and how this might affect their body's thermoregulation, which in turn, may lead to the suppression of appetite and unbalanced food intake. Research by Kojima et al. [20] presented epidemiological data on the effects of seasonal weather temperature variation on seasonal body weight fluctuation in humans. Further clarified that there is a

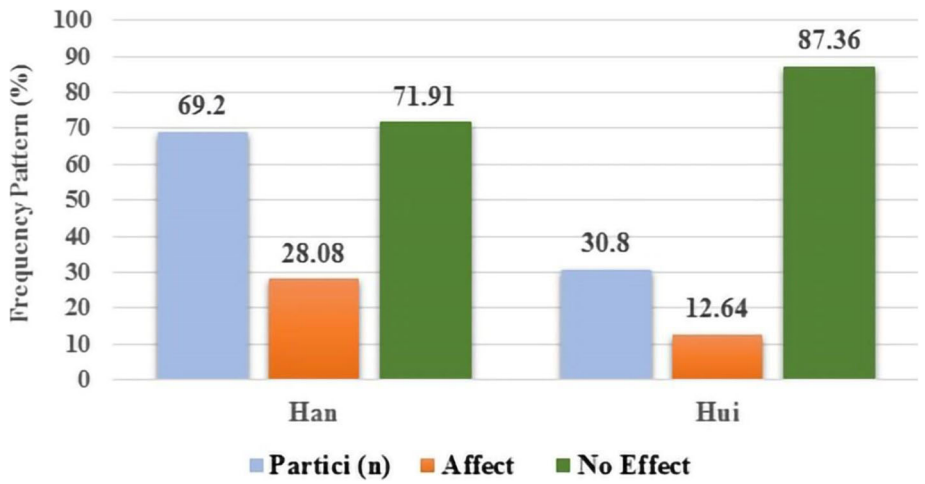

Fig. 4 Depicts the association between ethnic group affiliation (Han vs. Hui) and the SFETV effects on appetite and food intake. Key: Partici. (*n*): the number of ethnic group participants in the study. Effect: appetite and food intake affected by SFETV. No Effect: appetite and food intake not affected by SFETV

predisposition of gaining bodyweight in cold weather during the fall seasons and winter and losing it in the spring and the summer seasons. Later epidemiological studies maintained that exposure to either high or low outdoor ambient temperature has been linked to detrimental health effects on childbirth [20]. This exposure has been found to be associated with low birth bodyweight in the mid-trimester of pregnancy, as well as other adverse birth influences [22–24]. These findings can have practical applications and implications for the prevention of obesity, birth-related bodyweight problems, and other metabolic and eating disorders.

The principal aim of this study was to examine the effect of environmental temperature variation on appetite and food intake patterns in Chinese adults residing in eight urban cities and one rural town located in six geography and climatically diverse provinces in China (Fig. 1). In the present study, the term "appetite" is described as a subjective desire to consume food that is initiated by voluntary "hunger." A voluntary hunger sensation is referred to as a more objective deprivation state of prolonged lack of food intake. Several previous studies suggested that, in humans, food intake can be affected by the intersection of a myriad of key influential factors, including outdoor environmental temperature variation, physiological, psychological, emotional, cultural, thermogenesis, food caloric content information, and sensory signals for food intake. Other environmental factors such as circadian rhythms, altitude and latitude factors may also contribute to increasing or decreasing the consumption volume of food intake [10, 15, 24–28]. This confluence of influences on human appetite and food intake demonstrates the level of complexity and multidimensionality of appetite and eating behavior, especially if all or some of them occur concurrently. The complex nature of appetite and food intake was supported by research findings by [29]. The findings of this research confirmed that appetite and food intake regulatory system may be overwhelmed by social or psychological influences, as well as the thermogenic response to a variable energy input may play a critical role in the energy regulatory system. Later research by Pilgrim et al. [30] reported similar effects of high environmental temperatures on the rise of core body temperature, which affected the digestive system activity, and consequently appetite. Similarly, high environmental temperatures were found to produce an increased level of negative emotions that affected appetite and food intake [31]. In addition, the psychological factors played a significant role in the development of some symptoms of indigestion and loss of appetite [32].

Figure 5 compares the findings of the effect of SFETV on appetite and food intake across the sociodemographic factors (e.g., gender, marital status, employment status, ethnic group affiliation). The findings reveal a consistent pattern of effects and no effects across the board. Despite the wide diversity of the climate and weather variation in the eight cities and one rural town where the data were collected, there is a noticeable pattern of proximate similarities in responding to the study question, which is whether appetite and food intake of the respondents is affected by SFETV. The noteworthy findings exist between the differences in sociodemographic and ethnic groups. Concerning the effects of SFETV, the scores range are between 69.57% on the lower end and 87.36% on the upper end. On the other hand, they are between 12.64% on the lower end and 30.43% on the upper end in which the respondents subjectively indicated that the environmental temperature variation affects their appetite and food intake. These findings suggest that even with the varied weather temperature conditions where the respondents reside, the appetite and food intake of greater proportions of them are not affected by the environmental temperature variation (hot or cold). However, these findings are not entirely aligned with the findings obtained from earlier research by Sloan [21] who contended that people living in a warm weather climate may be affected by experiencing an elevated risk for developing eating disorders. According to one theory, it seems that environmental heat alone is not enough to affect human appetite. Study findings by Beller [33] maintained that environmental heat combined with high humidity can have a greater effect on suppressing appetite than dry heat exclusively. This theory may explain the different findings from the present study in which humidity was not included as a factor. In agreement with Beller [33], findings from earlier similar studies that also arrived at different results than the present study similarly considered humidity as a factor which in addition to heat, it might have played a major role in suppressing appetite and food intake [10, 34].

Another notable finding of the present study is related to the gender factor. With a high degree of similarity, the appetite and food intake of the male and female respondents are not affected by the seasonal weather temperature variation (hot or cold). However, this finding regarding the gender factor is not in line with that of Burse [35] who purported that the physiological and appetite responses of males and females are influenced in different ways due to the exposure to heat and cold stresses. According to Burse [35], physiologically, when exposed to above-average hot or cold conditions, females are facing unfavorable conditions that can affect them more than their male counterparts in similar conditions. Fewer females than their males can be effectively acclimatized to environmental heat or cold. Consequently, this can affect their appetite and food intake. Juxtaposed with the present study findings, research by Herman and Vaccarino [34] suggested that an intense level of psychological stress induced by environmental heat stress has

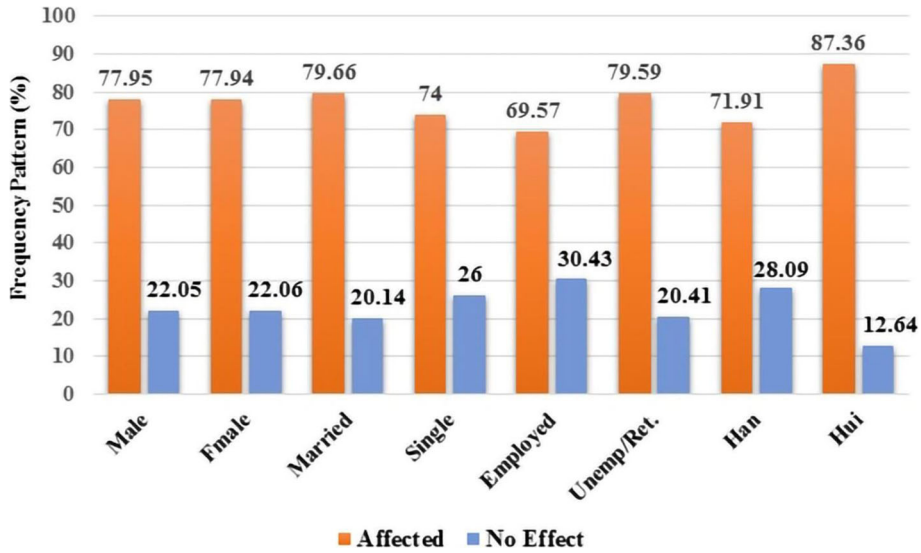

Fig. 5 Illustrates the sociodemographic and ethnic groups' responses to the effects of SFETV on appetite and food intake

been shown to decrease the appetite and food intake of apparently healthy individuals. Findings from earlier field research by Zifferblatt et al. [36] found that at lunchtime where the outdoor temperature was significantly rising in a major workplace staff cafeteria, the workers were viewed to reduce their purchases of warm cooked vegetables, soups, and starchy foods, in the meantime, they were also observed increasing their purchases of cooler food items such as yogurt, cottage cheese, salads, and fruits. These findings suggested a change in appetite for certain food selection was influenced by the rising temperature as a characteristic adaptive mechanism to the intensifying environmental temperature and thermogenesis in the cafeteria. These findings are supported by more recent research conducted on Chinese college students employing a visual analog scale (VAS) for a subjective rating of appetite. The findings revealed that during eating lunch, the appetite of the study participants was significantly diminished by high outdoor weather temperature, as the appetite and prospective food intake at 36 °C (96.8 °F) were found to be significantly lower than those at 32 °C. (89.6 °F). It seems that environmental heat coupled with body heat load leads to affecting energy and water metabolism. Consequently, this affected the appetite and digestive system functions of the participants causing decreased consumption of food intake [37].

Conclusions and future research recommendations

Founded on the results obtained from the present study, with the only exception of the responses of the participants from the eight cities and one rural town, all other responses to the effect of SFETV (hot or cold) on appetite and food intake did not produce significant differences across the sociodemographic and ethnic group factors. However, a significant difference was found in the education level between the married and single cohorts. Nonetheless, this significant difference in the level of education between the two marital status groups seems not to affect their respective responses to the effect of SFETV. Furthermore, the other significant difference found in the combined responses of the participants from the eight cities and one rural town. This can be reasonably explained to occur as a result of the greater climatic and geographical diversity in the eight cities and one rural town. These results suggest that the effect of environmental temperature variation on appetite and food intake regulation is comparatively inconclusive among the study population. Other studies have reinforced the common theory that human appetite is likely to suffer when it is affected by environmental heat conditions leading to decreasing food intake, therefore, curtailing appetite and food intake. Conversely, environmental cold conditions can contribute to promoting increased food intake, consequently, enhancing appetite and food intake. Both functions occur as a result of adaptive responses of the homeostatic mechanisms of the thermic effect of food and the body's thermoregulation.

For future research, further investigations are recommended to better understand whether seasonal environmental temperature variation has a causal-effect relationship on human appetite and food intake under different conditions. The following areas of research are recommended: First, research on the effect of environmental heat on appetite and food intake with humidity factored in as a major variable. Second, research on the effect of environmental heat and cold conditions on appetite and food intake with variable altitudes and latitudes as

major variables. Third, research on the effect of environmental heat and cold conditions conducted separately in the summer and winter seasons. Fourth, research on the effect of environmental heat and cold condition on appetite and food intake with food selection as a major variable. Fifth, research on the effect of environmental heat and cold conditions on appetite and food intake with a hunger scale employed as a major variable.

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Author's contributions
The author read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

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