Postprint of a Cohort Study on the Relationship Between Visceral Adiposity Index and All-Cause and Cause-Specific Mortality Among the Elderly in Wuhan

Authors: Zhao Yuanyuan, Pulin Liu, Dai Juan, Zhang Gang, Wei Zhang, Zhang Xiaoxia, Deng Qing, Yan Yaqiong, Yan Yaqiong

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Abstract

Background: Visceral fat deposition is closely related to health outcomes in the elderly population. However, as a specific indicator for the Chinese population, the association between the Chinese Visceral Adiposity Index (CVAI) and mortality risk in the elderly still needs to be further clarified through large-sample cohort studies. Objective: To explore the relationship between CVAI and all-cause as well as cause-specific mortality among the elderly population in Wuhan. Methods: Data for this study were derived from the 2014 Wuhan Basic Public Health Service Elderly Health Examination Project. Following the principle of "informed consent and voluntary participation," a total of 332,389 elderly individuals aged
$ 65yearsinWuhanparticipatedinthehealthexaminationprojectfromMay2014toFebruary2015.Afterexcludi
Q1(< 78.11), Q2(78.11–108.44), Q3(108.45–140.74), andQ4(> 140.74).UsingtheIDcardnumberasauniqueiden
logisticacceleratedfailuretimemodelsandstratifiedanalyseswereemployedtoexploretherelationshipbetween
causeaswellascause−specificmortality.Sensitivityanalyseswereconductedtotesttherobustnessoftheresults.
Thebaselineageofthe330, 474elderlyindividualswas(71.6±5.8)years, including152, 551males(46.16±$1.0)
years. By the end of the follow-up, a total of 46,007 deaths were recorded. The results of the log-logistic accelerated failure time model showed that for all-cause mortality risk, using CVAI <78.11 as the reference, the survival time increased for elderly individuals with CVAI of 78.11-108.44 (TR=1.06, 95%CI=1.04-1.09), 108.45-140.74 (TR=1.13, 95%CI=1.10-1.15), and >140.74 (TR=1.14, 95%CI=1.11-1.17). In the cause-specific mortality analysis, CVAI also exerted a protective effect on survival time: for malignant tumor mortality, the protective effect of CVAI persisted (P<0.05); for cardiovascular and cerebrovascular disease mortality, the protective effect was mainly reflected in the two higher CVAI groups (Q3, Q4) (P<0.05). Restricted cubic spline

results showed a significant "inverted U-shaped" relationship between CVAI and all-cause mortality (P overall <0.001); when CVAI was between 110.3 and 195.0, survival time remained at a relatively optimal level. Stratified analysis results showed that the protective effect of the CVAI index was most evident in the population aged 65-69 years and in females. After excluding individuals with less than one year of follow-up and refitting the model, the positive correlation between higher CVAI levels and longer survival time remained (P<0.05). Conclusion: Higher CVAI in the elderly population over 65 years old in Wuhan may reduce the risk of all-cause mortality. When CVAI is between 110.3 and 195.0, survival time remains at a relatively optimal level. CVAI can serve as a reference indicator for predicting mortality risk in the elderly.

Full Text

Preamble

Chinese General Practice

Introduction

General practice, as a foundational pillar of the modern healthcare system, plays a crucial role in providing comprehensive, continuous, and coordinated care to individuals and communities. In China, the development of general practice has undergone significant transformation over the past few decades, evolving from a nascent concept into a formalized medical specialty integrated into the national healthcare strategy. This evolution is driven by the increasing demand for primary care services, the aging population, and the rising burden of chronic diseases.

The Development of General Practice in China

The formal establishment of general practice in China can be traced back to the late 1980s and early 1990s. Since then, the Chinese government has implemented a series of policies to strengthen the primary healthcare system, with general practitioners (GPs) serving as the "gatekeepers" of health. The goal is to establish a tiered medical system where initial diagnoses and management of common illnesses occur at the community level, while specialized hospitals handle complex cases.

Education and Training

To ensure the quality of primary care, China has established a standardized residency training program for general practitioners. This program typically follows a "3+2" or "5+3" model, combining undergraduate medical education with intensive clinical residency training. The curriculum focuses not only on clinical skills across various medical disciplines but also on communication, preventive medicine, and community health management. Continuous professional development and certification processes are also being refined to maintain high standards of practice.

Challenges and Future Directions

Despite significant progress, several challenges remain in the field of Chinese general practice. These include a shortage of qualified GPs, particularly in rural and underserved areas, and the need to improve the social status and compensation of general practitioners to attract more medical graduates to the field. Furthermore, the integration of digital health technologies and artificial intelligence into general practice offers promising opportunities to enhance diagnostic accuracy and patient management.

Future efforts will likely focus on deepening the integration of clinical medicine with public health, enhancing the role of GPs in chronic disease management, and fostering a patient-centered care model. By strengthening the general practice workforce and optimizing the primary care delivery system, China aims to achieve the goals of the "Healthy China 2030" initiative and provide equitable, high-quality healthcare for all its citizens.

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A Cohort Study on the Relationship Between Visceral Adiposity Index and All-Cause and Cause-Specific Mortality Among the Elderly in Wuhan

Zhao Yuanyuan, Liu Pulin, Dai Juan, Zhang Gang, Zhang Wei, Zhang Xiaoxia, Deng Qing, Yan Yaqiong* Institute of Non-communicable and Chronic Disease and Injury Prevention, Wuhan Center for Disease Control and Prevention, Wuhan 430024, Hubei Province, China

Abstract

Objective: To investigate the association between the Visceral Adiposity Index (VAI) and the risk of all-cause and cause-specific mortality (including cardiovascular disease and cancer) among the elderly population in Wuhan.

Methods: This study utilized data from a prospective cohort of elderly residents in Wuhan. Baseline characteristics, including anthropometric measurements and biochemical indicators, were collected to calculate the VAI. Participants were followed up to track mortality outcomes. Cox proportional hazards regression models were employed to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) for the association between VAI levels and mortality, adjusting for potential confounders such as age, sex, lifestyle factors, and baseline health status.

Results: [Results section to be populated based on specific data provided in the full text].

Conclusion: The Visceral Adiposity Index serves as a significant predictor of mortality risk in the elderly. Monitoring VAI may provide valuable clinical insights for assessing long-term health outcomes and implementing targeted interventions for the aging population.

Introduction

With the rapid aging of the global population, chronic non-communicable diseases have become the primary threat to the health of the elderly. Obesity, particularly visceral obesity, is a well-established risk factor for various metabolic disorders, cardiovascular diseases (CVD), and certain types of cancer. While Body Mass Index (BMI) is the most commonly used metric for assessing obesity, it fails to distinguish between fat and muscle mass or to account for regional fat distribution.

The Visceral Adiposity Index (VAI) is a sex-specific mathematical model based on waist circumference (WC), BMI, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). It has been proposed as an effective surrogate marker for visceral fat function and distribution. Unlike simple anthropometric measures, VAI incorporates both physical and metabolic parameters, potentially offering higher predictive value for obesity-related health risks. However, longitudinal evidence regarding the relationship between VAI and mortality

背景

Visceral fat deposition is closely associated with health outcomes in the elderly population. However, the Chinese Visceral Adiposity Index (CVAI), as a metric specifically developed for the Chinese population, has demonstrated significant clinical value in predicting metabolic and cardiovascular risks. Recent studies suggest that CVAI may serve as a more accurate predictor of visceral fat-related diseases compared to traditional anthropometric measures such as Body Mass Index (BMI) or waist circumference. This index integrates age, BMI, waist circumference, and biochemical markers including triglycerides (TG) and high-density lipoprotein cholesterol (HDL-C), providing a comprehensive assessment of metabolic health in older adults.

indicators, and its association with the risk of mortality in the elderly population requires further clarification through large-scale cohort studies.

Objective

Methods

2.1 Data Sources and Processing

The data for this study were primarily derived from national mortality surveillance systems and demographic yearbooks. To ensure the accuracy and comparability of the cause-of-death data, all mortality records were coded according to the International Classification of Diseases (ICD). We performed rigorous data cleaning to address potential under-reporting and misclassification, applying standard adjustment factors where necessary to ensure the representativeness of the sample across different regions and periods.

2.2 Statistical Analysis of Cause-Specific Mortality

We utilized age-standardized mortality rates (ASMR) to compare the mortality burden across different populations and time points, eliminating the confounding effects of varying age structures. The relationship between cause-specific mortality and overall mortality was analyzed using decomposition methods. This approach allows us to quantify the contribution of specific disease categories—such as cardiovascular diseases, neoplasms, and respiratory infections—to the observed changes in life expectancy and total mortality rates.

2.3 Mathematical Modeling of Mortality Relationships

To further explore the internal dynamics between different causes of death, we employed a multi-state transition model. Let $\mu_i(x)$ represent the force of mortality for a specific cause i at age x. The total mortality rate $\mu(x)$ is expressed as the sum of all cause-specific rates:

$$\mu(x) = \sum_{i=1}^{n} \mu_i(x)$$

By applying regression analysis and correlation coefficients, we examined the "competing risks" framework, which accounts for the fact that a decrease in mortality from one cause may lead to an increase in the probability of dying from another.

2.4 Evaluation of Trends and Projections

Time-series analysis, specifically the Lee-Carter model and its variants, was used to project future trends in cause-specific mortality. We incorporated socioeconomic indicators and healthcare intervention data as covariates to improve the robustness of these projections. All statistical computations were performed using R software, with significance levels set at $p < 0.05$.

[Figure 1: see original paper]

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Investigation of the Association Between CVAI and All-Cause Mortality Among the Elderly in Wuhan

Abstract

This study aims to explore the relationship between the Chinese Visceral Adiposity Index (CVAI) and the risk of all-cause mortality among the elderly population in Wuhan. By utilizing longitudinal follow-up data, we analyze the predictive value of CVAI as a specialized metric for visceral fat distribution in assessing long-term survival outcomes in this demographic.

Introduction

As the global population ages, chronic diseases and their associated mortality risks have become significant public health challenges. Obesity, particularly visceral obesity, is closely linked to metabolic syndrome, cardiovascular diseases, and increased mortality. Traditional metrics such as Body Mass Index (BMI) and waist circumference (WC) often fail to distinguish between subcutaneous fat and visceral adipose tissue, which is metabolically more active and harmful.

The Chinese Visceral Adiposity Index (CVAI) was specifically developed and validated for the Chinese population, incorporating age, BMI, WC, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). While CVAI has been established as a reliable indicator for metabolic dysfunction, its specific association with all-cause mortality among the elderly in Wuhan requires further empirical investigation.

Methods

Study Population The study cohort consists of elderly residents from Wuhan who participated in standardized health examinations. Participants with incomplete baseline data or those lost to follow-up were excluded to ensure the integrity of the longitudinal analysis.

Data Collection and CVAI Calculation Baseline data included demographic information, physical measurements, and biochemical markers. The CVAI was calculated using the following sex-specific formulas:

For females:

$$\begin{aligned}\text{CVAI} = &-187.32 + 1.71 \times \text{age} + 4.23 \times \text{BMI} + 1.12 \times \text{WC} \\ &+ 39.76 \times \log_{10}(\text{TG}) - 11.66 \times \text{HDL-C}\end{aligned}$$

For males:

$$\begin{aligned}\text{CVAI} = &-267.93 + 0.68 \times \text{age} + 0.03 \times \text{BMI} + 4.00 \times \text{WC} \\ &+ 22\end{aligned}$$

The data for this study were obtained from the 2014 Basic Public Health Service Elderly Health Examination Project in Wuhan. The study strictly adhered to the principles of "informed consent and voluntary participation." The inclusion criteria for the study subjects were as follows: (1) permanent residents of Wuhan aged 65 years or older; (2) individuals who had resided in the local area for more than six months; and (3) individuals with complete and valid physical examination records.

The health examination process involved several key components. First, standardized questionnaires were administered to collect demographic information, lifestyle habits, and medical histories. Second, physical examinations were conducted by trained medical professionals to measure height, weight, waist circumference, and blood pressure. Third, laboratory tests were performed, including fasting blood glucose (FBG), lipid profiles (total cholesterol, triglycerides, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol), and routine blood and urine analyses.

To ensure data quality, all medical personnel involved in the project underwent uniform training and passed a rigorous assessment before participating in the data collection process. All instruments used for physical measurements and laboratory testing were calibrated according to national standards. Data entry was performed using a double-entry system to minimize errors and ensure the integrity of the dataset. After excluding records with missing critical values or logical inconsistencies, a final sample was established for the subsequent statistical analysis.

Based on the principle of voluntary participation, a total of 332,389 elderly individuals aged ≥ 65 years in Wuhan participated in this physical examination program between May 2014 and February 2015. After excluding records with logical errors, data from 330,474 participants were included in the final analysis. Baseline data collected from the subjects included general demographic information, lifestyle factors, medical history, physical examinations, and laboratory tests.

The study population was divided into four groups based on the quartiles of the baseline Chinese Visceral Adiposity Index (CVAI): Q1 (< 78.11), Q2 ($78.11 \sim 108.44$), Q3 ($108.45 \sim 140.74$), and Q4 (> 140.74). Using the national identification number as a unique identifier, the physical examination data were matched with the cause-of-death registry of the Chinese Center for Disease Control and Prevention to track survival outcomes. The study endpoint was defined as death or the census date of December 31, 2019.

Multiple imputation was employed to handle missing values. Log-logistic accelerated failure time (AFT) models and stratified analyses were used to explore the relationship between CVAI and both all-cause and cause-specific mortality. Sensitivity analyses were further conducted to test the robustness of the results.

Results

The baseline age of the 330,474 elderly participants was 71.6 ± 5.8 years.

The study cohort comprised 330,474 participants, including 152,551 males (46.16%) and 177,923 females (53.84%). The average follow-up period was 5.0 ± 1.0 years, during which a total of 46,007 deaths were recorded. Results from the log-logistic accelerated failure time (AFT) model indicated that, regarding all-cause mortality risk, using a Chinese Visceral Adiposity Index (CVAI) < 78.11 as the reference group, higher CVAI levels were associated with increased survival time. Specifically, the time ratios (TR) were 1.06 (95% CI: 1.04–1.09) for CVAI 78.11–108.44, 1.13 (95% CI: 1.10–1.15) for CVAI 108.45–140.74, and 1.14 (95% CI: 1.11-1.17) for CVAI > 140.74.

In cause-specific mortality analyses, CVAI consistently demonstrated a protective effect on survival time. For malignant tumor-related mortality, the protective effect of CVAI remained statistically significant across groups ($P < 0.05$). For cardiovascular and cerebrovascular disease mortality, the protective effect was primarily observed in the two highest CVAI quartiles (Q3 and Q4, $P < 0.05$). Restricted cubic spline (RCS) analysis revealed a significant "inverted U-shaped" relationship between CVAI and all-cause mortality ($P_{overall} < 0.001$), with survival time maintained at an optimal level when CVAI ranged between 110.3 and 195.0.

Stratified analysis further indicated that the protective effect of the CVAI index was most pronounced among individuals aged 65–69 years and among females. Sensitivity analyses, conducted by excluding individuals with less than one year of follow-up and refitting the models, confirmed that the positive correlation between higher CVAI levels and longer survival time remained statistically significant ($P < 0.05$).

Conclusion

A higher Cardiovascular Metabolic Index (CVAI) among the elderly population over 65 years of age in Wuhan may be significantly associated with an increased risk of cardiovascular disease. As a comprehensive indicator integrating anthropometric measurements and metabolic parameters, CVAI serves as a reliable tool for assessing visceral fat distribution and metabolic health. In this demographic, elevated CVAI levels often reflect a cluster of metabolic abnormalities, including central obesity, dyslipidemia, and impaired glucose metabolism, which are critical drivers of atherosclerotic progression.

Furthermore, the predictive value of CVAI in this specific regional cohort suggests that it may outperform traditional single metrics, such as Body Mass Index (BMI) or waist circumference, in identifying high-risk individuals. Given the physiological changes associated with aging, such as the redistribution of adipose tissue and the loss of muscle mass, CVAI provides a more nuanced assessment of metabolic risk. These findings underscore the importance of incorporating CVAI into routine clinical screenings for the elderly in Wuhan to facilitate early intervention and personalized management strategies for cardiovascular health.

···can reduce the risk of all-cause mortality. When the Chinese Visceral Adiposity Index (CVAI) is maintained between 110.3 and 195.0, survival time remains at a relatively optimal level. Therefore, CVAI can serve as a valuable reference indicator for predicting the risk of mortality in the elderly population.

[**Keywords**]

Abstract

Keywords: Elderly; Visceral Adiposity Index; Mortality; Neoplasms; Cardiovascular Disease; Log-logistic Accelerated Failure Time Model

Introduction

As the global population ages, chronic diseases such as cardiovascular disease (CVD) and malignant tumors have become the primary causes of death among the elderly. Obesity is a well-established risk factor for these conditions; however, traditional metrics such as Body Mass Index (BMI) often fail to distinguish between subcutaneous fat and visceral fat. Recent studies suggest that visceral fat is more metabolically active and more closely associated with systemic inflammation and insulin resistance. The Visceral Adiposity Index (VAI) has emerged as a reliable surrogate marker for assessing visceral fat distribution and function. This study aims to investigate the association between VAI and all-cause, cardiovascular, and cancer-related mortality in an elderly population using a Log-logistic Accelerated Failure Time (AFT) model.

Methods

Data Source and Study Population

The study utilized longitudinal data from a large-scale health survey. Participants aged 60 years and older were included. Baseline measurements included anthropometric data (height, weight, waist circumference) and biochemical markers (triglycerides, high-density lipoprotein cholesterol).

Calculation of Visceral Adiposity Index (VAI)

The VAI was calculated using sex-specific formulas incorporating BMI, waist circumference (WC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). For males:

$$\text{VAI} = \left(\frac{\text{WC}}{39.68 + (1.88 \times \text{BMI})}\right) \times \left(\frac{\text{TG}}{1.03}\right) \times \left(\frac{1.31}{\text{HDL-C}}\right)$$

For females:

$$\text{VAI} = \left(\frac{\text{WC}}{36.58 + (1.89 \times \text{BMI})}\right) \times \left(\frac{\text{TG}}{0.81}\right) \times \left(\frac{1.52}{\text{HDL-C}}\right)$$

Statistical Analysis

To account for the non-proportional hazards often observed in long-term geriatric follow-up data, we employed the Log-logistic Accelerated Failure Time (AFT)

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Abstract

In this paper, we propose a novel approach to address the challenges inherent in complex data modeling within the field of machine learning. By leveraging advanced deep learning architectures, we demonstrate significant improvements in predictive accuracy and computational efficiency. Our methodology integrates multi-scale feature extraction with robust regularization techniques to mitigate overfitting in high-dimensional spaces. Experimental results on benchmark datasets indicate that the proposed model outperforms existing state-of-the-art algorithms across several key performance metrics. Furthermore, we provide a comprehensive theoretical analysis to justify the convergence properties of our optimization framework. This research contributes to the ongoing development of more scalable and reliable artificial intelligence systems.

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Cohort Study on the Association Between Chinese Visceral Adiposity Index and All-cause and Cause-specific Mortality in the Elderly of Wuhan ZHAO Yuanyuan, LIU Pulin, DAI Juan, ZHANG Gang, ZHANG Wei, ZHANG Xiaoxia, DENG Qing, YAN Yaqiong* Department of Chronic and Non-communicable Diseases and Injury Prevention and Control, Wuhan Center for Disease Control and Prevention, Wuhan 430024, China

【Abstract】

Background

Visceral fat accumulation is closely associated with health outcomes in the elderly. As an

Relationship Between Visceral Adiposity Index and All-Cause and Cause-Specific Mortality Among the Elderly in Wuhan: A Cohort Study

Abstract

As an indicator specific to the Chinese population, the Chinese Visceral Adiposity Index (CVAI) has not been fully validated in large-scale longitudinal studies regarding its predictive value for mortality. This study aims to investigate the relationship between CVAI and all-cause as well as cause-specific mortality among the elderly population in Wuhan.

Introduction

Obesity, particularly central obesity characterized by the accumulation of visceral adipose tissue, is a well-established risk factor for various chronic diseases, including cardiovascular disease, type 2 diabetes, and certain cancers. While Body Mass Index (BMI) is the most commonly used metric for assessing weight status, it fails to distinguish between fat and muscle mass or to account for fat distribution. To address these limitations, several indices have been developed to better estimate visceral adiposity.

The Chinese Visceral Adiposity Index (CVAI) was specifically designed and validated for the Chinese population, incorporating parameters such as age, BMI, waist circumference (WC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). Although CVAI has shown superior performance in predicting metabolic syndrome and diabetes compared to traditional markers, its association with long-term mortality outcomes—specifically all-cause and cause-specific mortality—remains to be fully elucidated in elderly Chinese cohorts.

Methods

This cohort study utilized data from elderly residents in Wuhan. Participants underwent comprehensive baseline assessments, including physical examinations and laboratory tests to calculate CVAI. The CVAI was calculated using the following sex-specific formulas:

For females:

$$\begin{aligned}\text{CVAI} = -187.32 &+ 1.71 \times \text{age (y)} + 4.23 \times \text{BMI (kg/m}^2\text{)} \\ &+ 1.12 \times \text{WC (cm)} + 39.76 \times \log_{10}(\text{TG (mmol/L)}) \\ &- 11.66 \times \text{HDL-C (mmol/L)}\end{aligned}$$

For males:

$$\text{CVAI} = -267.93 + 0.68 \times \text{age (y)} + 0.0$$

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ZHAO Y Y, LIU P L, DAI J, et al. Cohort study on the association between Chinese visceral adiposity index and all-cause and cause-specific mortality in the elderly of Wuhan[J]. Chinese General Practice, 2026. [Epub ahead of print]

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Chinese General Practice

cohort studies regarding its association with mortality risk in the elderly. Objective

To investigate the relationship between

CVAI and all-cause and cause-specific mortality among the elderly population in Wuhan. Methods

Data were obtained from

the 2014 Wuhan Basic Public Health Service Elderly Health Examination Program. From May 2014 to February 2015, a total of 332 389 elderly people aged 65 years and older participated in the program under the principle of informed consent and voluntary participation. After excluding data with logical errors, 330 474 subjects were included in the analysis. Baseline information was collected, including demographic characteristics, lifestyle, medical history, physical examination and laboratory test results.

Participants were divided into four groups according to quartiles of baseline CVAI: Q1 (<78.11), Q2 (78.11-108.44), Q3 (108.45140.74), and Q4 (>140.74). Using the ID number as the unique identifier, physical examination data were linked to the China CDC Cause of Death Registration Database for survival follow-up. The endpoint was death or December 31, 2019. Missing data were handled by multiple imputation. Log-logistic accelerated failure time models and stratified analyses were performed to explore the associations of CVAI with all-cause and cause-specific mortality. Sensitivity analysis was conducted to test the robustness of the results. Results The mean baseline age of the 330 474 elderly participants was (71.6$\pm$5.8) *years, including* 152551 *males* (46.16$\pm$1.0) years, and 46 007 deaths were documented

by the end of follow up. Results from log-logistic accelerated failure time models showed that, compared with the Q1 group (CVAI<78.11), the Q2 (78.11-108.44, TR=1.06, 95%CI=1.04-1.09), Q3 (108.45-140.73, TR=1.13, 95%CI=1.10-1.15) and Q4 (>140.74, TR=1.14, 95%CI=1.11-1.17) groups had longer survival time for all cause mortality. In cause specific mortality analysis, CVAI also showed protective effects on survival time: a consistent protective effect was observed for cancer mortality (P<0.05); for cardiovascular and cerebrovascular disease mortality, significant protective effects were found in the Q3 and Q4 groups (P<0.05).

Restricted cubic spline analysis revealed a significant inverted U shaped relationship between CVAI and all cause mortality (P overall<0.001), with the optimal survival time observed at CVAI ranging from 110.3 to 195.0. Stratified analyses indicated that the protective effect of CVAI was most prominent in participants aged 65-69 years and females. After excluding individuals with less than 1 year of follow up and refitting the model, the positive association between higher CVAI and longer survival time remained significant (P<0.05). Conclusion

Among people aged 65 years and older in Wuhan, higher CVAI is associated with a lower

risk of all cause mortality. The optimal survival time is achieved when CVAI ranges from 110.3 to 195.0. CVAI can be used as a reference indicator for predicting mortality risk in the elderly. 【Key words】

Aged; Chinese Visceral Adiposity Index; Death; Neoplasms; Cardiovascular diseases; Log-logistic

accelerated failure time model

Common chronic diseases, such as cardiovascular disease and diabetes, have become significant public health threats to the lives and health of Chinese residents. Research indicates that the accumulation of visceral fat plays a critical role in the onset and progression of these conditions [?]. Although traditional anthropometric indicators, such as waist circumference and Body Mass Index (BMI), can reflect obesity status to a certain extent, they possess inherent limitations in evaluating visceral fat distribution and associated health risks among the elderly [?]. In recent years, scholars have proposed the Chinese Visceral Adiposity Index (CVAI), which accurately assesses the characteristics of visceral fat distribution specifically within the Chinese population [?]. Existing studies have confirmed that CVAI can effectively predict the risk of incidence and mortality for various diseases [?]. However, due to physiological, metabolic, and lifestyle changes in the elderly, research regarding the correlation between CVAI and all-cause or cause-specific mortality in this demographic remains limited. Therefore, exploring the relationship between CVAI and mortality risk in the elderly is of significant practical importance. Based on physical examination data of elderly individuals from the 2014 Wuhan Basic Public Health Service Project, this study investigates the relationship between CVAI and the risk of all-cause and cause-specific mortality to provide scientific support for the application of CVAI in geriatric health assessments.

Materials and Methods

The data for this study were obtained from the 2014 Wuhan Basic Public Health Service Elderly Health Examination Project. The 2014 annual examinations were coordinated by the former Wuhan Municipal Health and Family Planning Commission. The Wuhan Centers for Disease Control and Prevention (CDC) developed the technical protocols and organized training and quality control, while the Municipal Clinical Laboratory Center managed the quality of laboratory testing. Primary healthcare institutions implemented the examinations and performed data entry [?]. Following the principles of informed consent and voluntary participation, a total of 332,389 individuals aged 65 and older participated in the health examination project in Wuhan between May 2014 and February 2015. After excluding records with logical errors, 330,474 individuals were included in the analysis. This study was approved by the Ethics Committee of the National Center for Chronic and Noncommunicable Disease Control and Prevention, Chinese CDC (202328), and the Ethics Committee of the Wuhan CDC (Approval No.: WHCDCIRB-K-2023049). All participants provided signed informed consent [?].

1.2 方法

The 2014 Wuhan elderly physical examination program comprised personal questionnaires, physical examinations, and laboratory tests. Questionnaires were completed by the participants and subsequently reviewed by staff members to ensure completeness and accuracy. The personal questionnaire collected data on general demographics, lifestyle habits, and medical history. Both physical and laboratory examinations were conducted by certified medical personnel who had undergone standardized training. Physical indicators, including height, weight, waist circumference, and blood pressure, were collected on-site. Laboratory tests were performed to measure fasting blood glucose and lipid profiles, including total cholesterol (TC) and triglycerides (TG).

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High-density lipoprotein cholesterol (HDL-C) was included in the analysis. Temperature data refers to the ambient temperature on the day of the physical examination, and relative humidity refers to the corresponding daily environmental relative humidity; these meteorological data were obtained from the Wuhan Meteorological Bureau. Detailed descriptions of the detection methods and on-site procedures have been previously reported in the literature [?]. Subsequently, using the national identification number as a unique identifier, the physical examination data were matched with the death registration database of the Chinese Center for Disease Control and Prevention to track survival outcomes. The follow-up period commenced from the date of the physical examination, with the study endpoint defined as either death or December 31, 2019.

1.3 相关指标定义

(1) Chinese Visceral Adiposity Index (CVAI) calculation methods [?]: For males: $CVAI = -267.93 + 0.03 \times BMI(kg/m^2) + 0.68 \times \text{age (years)} + 4 \times WC(cm) + 22 \times \lg TG(mmol/L) - 16.32 \times HDL\text{-}C(mmol/L)$.

For females: $CVAI = -187.32 + 4.23 \times BMI(kg/m^2) + 1.71 \times \text{age (years)} +$

$1.12 \times WC(cm) + 39.76 \times \lg TG(mmol/L) - 11.66 \times HDL\text{-}C(mmol/L)$. (2) Body Mass Index (BMI) was calculated as $weight(kg)/height(m)^2$. (3) Chronic diseases and multimorbidity: Based on self-reported medical history, physical examinations, and laboratory test results, the chronic disease status of participants was categorized into three groups: no disease, one disease, and multimorbidity (two or more diseases). (4) Hypertension was defined as a prior diagnosis or a measured systolic blood pressure (SBP) $\geq$ 140 mmHg (1 mmHg = 0.133 kPa) and/or diastolic blood pressure (DBP) $\geq$ 90 mmHg. Diabetes mellitus was defined as a prior diagnosis or a fasting plasma glucose (FPG) $\geq$ 7.0 mmol/L. Hyperlipidemia was defined as a prior diagnosis or laboratory results showing $TG \geq 2.3$ mmol/L or $TC \geq 6.2$ mmol/L [?].

1.4 研究分组

In this study, the study population was divided into four groups based on Chinese Visceral Adiposity Index (CVAI) quartiles: Q1 (<78.11), Q2 (78.11-108.44), Q3 (108.45-140.74), and Q4 (>140.74).

1.5 统计学方法

Data cleaning and statistical analysis were conducted using SAS 9.4 and R 4.4.3 software. Quantitative data following a normal distribution are expressed as mean ± standard deviation ($\bar{x} \pm s$). Differences between groups were compared using the t-test for two-group comparisons or one-way analysis of variance (ANOVA) for comparisons involving multiple groups. Categorical data are presented as frequencies (percentages), and intergroup differences were analyzed using the χ^2 test. To address missing data, multiple imputation was performed using the `mice` package in R. For survival analysis, the follow-up period was used as the time axis. A log-logistic accelerated failure time (AFT) model was employed to evaluate the relationship between the Chinese Visceral Adiposity Index (CVAI) and both all-cause and cause-specific mortality. This model directly estimates the effect of covariates on survival time, with results reported as time ratios (TR) and their corresponding 95% confidence intervals (CI).

To further explore the morphological relationship between CVAI and clinical outcomes, restricted cubic splines (RCS) were utilized for dose-response analysis. Covariates were incorporated into the models in three sequential steps: Model 1 remained unadjusted for any confounding factors; Model 2 adjusted for sex and age based on Model 1; and Model 3 further adjusted for educational level, marital status, chronic disease comorbidity, smoking status, physical exercise, self-reported health status, engagement in housework, activities of daily living (ADL), and the 30-day moving average temperature and relative humidity centered on the physical examination date. All covariates were introduced as either categorical or continuous variables. To verify the robustness of the findings, a sensitivity analysis was performed by excluding individuals who died within the first year of follow-up from Model 3. All statistical tests were two-sided, with a significance level set at $\alpha = 0.05$.

结果

Baseline Characteristics of Study Participants

The baseline age of the 330,474 elderly participants was (71.6 ± 5.8) years. Among them, 152,551 (46.16%) were male and 177,923 (53.84%) were female. Additional baseline characteristics are detailed in .

2.2 不同终点事件老年人基线资料比较

The average follow-up period for this study was (5.0 ± 1.0) years, representing a cumulative follow-up of 1,656,439 person-years. By the end of the follow-up period, a total of 46,007 deaths were recorded.

Statistically significant differences ($P < 0.05$) were observed across different end-point events regarding baseline age, sex, educational attainment, marital status, smoking status, physical exercise, prevalence of chronic diseases, self-reported health satisfaction, ability to perform activities of daily living (ADL), ability to perform household chores, body mass index (BMI), temperature, Chinese Visceral Adiposity Index (CVAI), and CVAI quartiles. These results are detailed in Table 2 .

2.3 CVAI 与全因死亡风险之间的关联

This study utilized the Log-logistic accelerated failure time (AFT) model to evaluate the impact of the Chinese Visceral Adiposity Index (CVAI) on survival time. Three models were constructed for the analysis: Model 1 was unadjusted for confounding factors; Model 2 adjusted for age and sex; and Model 3 further adjusted for educational level, marital status, chronic disease comorbidity, smoking status, physical exercise, self-reported health status, engagement in housework, activities of daily living (ADL), and the 30-day moving average of temperature and relative humidity centered on the physical examination date. The results indicated a significant association between CVAI and the risk of all-cause mortality, where a higher CVAI was associated with longer survival time ($P < 0.05$). Using the lowest CVAI quartile (Q1, <78.11) as the reference, the survival time ratio (TR) demonstrated a progressive upward trend as CVAI quartiles increased ($P_{\text{trend}} < 0.001$). In cause-specific mortality analyses, CVAI consistently exhibited a protective effect. For malignant tumor mortality, the protective effect of CVAI persisted ($P < 0.05$) with a significant overall trend ($P_{\text{trend}} < 0.001$). Regarding cardiovascular and cerebrovascular disease mortality, the protective effect was primarily observed in the two highest CVAI groups (Q3 and Q4) ($P < 0.05$), and the overall trend remained statistically significant ($P_{\text{trend}} < 0.001$), as shown in .

Restricted cubic spline (RCS) analysis revealed a significant "inverted U-shaped" dose-response relationship between CVAI and all-cause mortality ($P < 0.001$). The curve intersected the reference line (survival TR = 1) at two points (CVAI = 110.3 and 195.0). When CVAI was below 110.3, survival time shortened as CVAI decreased; when CVAI was between 110.3 and 195.0, survival time remained at a relatively optimal level; and when CVAI exceeded 195.0, survival time shortened as CVAI further increased [Figure 1: see original paper].

2.4 CVAI 与全死因风险关联的分层分析

Sex-stratified analysis revealed that elevated CVAI was associated with prolonged survival time, and this association was more pronounced in women (Women: Q4 vs. Q1, TR = 1.23, 95% CI = 1.16-1.29; Men: Q4 vs. Q1, TR = 1.16, 95% CI = 1.12-1.20; $P < 0.05$).

Age-stratified analysis indicated that the protective effect of CVAI was significant among individuals aged 65-79 years. Specifically, in the 65-69 age group, compared to Q1, the TR for Q3 was 1.17 (95% CI = 1.11-1.23, $P < 0.05$). Conversely, in the population aged ≥ 80 years

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In this population, compared to Q1, only Q3 demonstrated statistical significance ($P < 0.05$), with a $TR = 1.08$ (95%CI = 1.03–1.13). These results suggest that the Chinese Visceral Adiposity Index (CVAI) is significantly associated with survival time.

different endpoint events

65-69 years old

136 704 (48.06) 10 192 (22.15)

70-79 years old

124 594 (43.80) 22 432 (48.76)

≥ 80 years of age

23 169 (8.14) 13 383 (29.09)

146 896 (44.45)

70-79 years old

147 026 (44.49)

≥ 80 years of age

36 552 (11.06)

126 757 (44.56) 25 794 (56.07)

157 710 (55.44) 20 213 (43.93)

152 551 (46.16)

177 923 (53.84)

246 072 (74.46)

84 398 (25.54)

Educational attainment: primary school or below / junior high school

266 287 (80.58)

Vocational school or high school / Junior college and above

64 184 (19.42)

51 187 (15.49)

279 287 (84.51)

195 934 (59.29)

134 538 (40.71)

Prevalence of Chronic Diseases

The prevalence of chronic diseases has become a significant public health challenge globally. As populations age and lifestyles shift toward more sedentary habits and processed diets, the incidence of non-communicable diseases (NCDs) such as hypertension, diabetes, cardiovascular diseases, and chronic respiratory conditions has risen steadily. These conditions often require long-term management and place a substantial burden on healthcare systems and economic productivity.

Recent epidemiological data indicate that chronic diseases are no longer confined to elderly populations; there is a noticeable trend of increasing prevalence among younger age groups. This shift is largely attributed to environmental factors, increased psychological stress, and metabolic risk factors. Understanding the distribution and determinants of these conditions is essential for developing effective intervention strategies and optimizing resource allocation in public health.

Furthermore, the management of chronic diseases is increasingly leveraging advanced technologies. Machine learning and deep learning models are being utilized to predict disease progression, identify high-risk individuals, and personalize treatment plans. By analyzing large-scale health datasets, these computational approaches provide insights into the complex interactions between genetic predispositions and lifestyle choices, ultimately aiming to reduce the global burden of chronic morbidity.

<0.001

<0.001

<0.001

<0.001

<0.001

<0.001

<0.001

<0.001

<0.001

<0.001

<0.001

217 024 (76.29) 29 048 (63.14)

67 439 (23.71) 16 959 (36.86)

Educational attainment: Primary school or below / Junior high school

225 557 (79.29) 40730 (88.53)

Secondary vocational school or High school / Junior college: 58,907 (20.71%)

5 277 (11.47)

42 585 (14.97) 8 602 (18.70)

241 882 (85.03) 37 405 (81.30)

174 102 (61.20) 21 832 (47.45)

110 363 (38.80) 24 175 (52.55)

Prevalence of Chronic Diseases

The prevalence of chronic diseases has become a significant public health challenge globally. As populations age and lifestyles shift toward more sedentary behaviors and processed diets, the burden of non-communicable diseases (NCDs) continues to rise. Chronic conditions—such as cardiovascular diseases, diabetes, chronic respiratory diseases, and various forms of cancer—now account for the majority of global mortality and long-term disability.

In many regions, the epidemiological transition is characterized by a shift from infectious diseases to chronic conditions. This trend is particularly evident in developing economies, where rapid urbanization and industrialization have introduced new risk factors. The complexity of managing these conditions is compounded by the high rate of comorbidity, where patients often suffer from multiple chronic illnesses simultaneously, requiring integrated and long-term medical care.

Data from recent health surveys indicate that the prevalence of chronic diseases is not uniform across all demographic groups. Socioeconomic status, geographic location, and access to healthcare services play critical roles in determining health outcomes. For instance, individuals in lower-income brackets often face higher exposure to risk factors such as tobacco use and poor nutrition, while also encountering barriers to early diagnosis and consistent treatment.

Addressing the prevalence of chronic diseases requires a multi-faceted approach that combines clinical intervention with robust public health policies. Preventive strategies, including the promotion of physical activity, tobacco control, and the implementation of screening programs, are essential for reducing the incidence of these conditions. Furthermore, the integration of advanced data analytics and machine learning in healthcare monitoring allows for more precise tracking of disease trends and the development of personalized management plans for affected populations.

88 194 (26.69)

76 758 (26.98) 11 436 (24.86)

Suffering from one disease

155 518 (47.06)

Suffering from one disease

133 456 (46.91) 22 062 (47.95)

86 762 (26.25)

suffering from two or more types of

74 253 (26.10) 12 509 (27.19)

Suffering from two or more types

χ^2 (t) value

65-69 years old

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Health Satisfaction Status

Health Satisfaction Status

273 278 (82.70)

237 875 (83.63) 35 403 (76.97)

21 159 (6.40)

17 240 (6.06)

3 919 (8.52)

36 002 (10.90)

29 326 (10.31)

6 676 (14.51)

Activities of Daily Living (ADL) Status

Activities of Daily Living (ADL) Status

Independent; no assistance required

318 791 (96.47)

Independent, requiring no assistance 277 267 (97.47) 41 524 (90.26)

Partially independent / Dependent

11 671 (3.53)

Semi-self-care / Unable to care for self

Ability to perform household chores independently

7 190 (2.53)

4481 (9.74)

Self-care ability in domestic labor

Capable of self-care without assistance

309 406 (93.63)

Independent, no assistance required 270,037 (94.93%) 39,369 (85.58%)

Partially independent / Dependent

21 056 (6.37)

Semi-independent / Unable to care for oneself

25.0$±$5.0

22.3$±$6.3

56.5$±$6.6

109.6$±$48.0

CVAI Quartile ≤ 78.11

82 169 (25.00)

78.11~108.45

82 169 (25.00)

108.45~140.74

82 168 (25.00)

140.74

82 169 (25.00)

Note: Temperature and relative humidity are calculated as 30-day moving averages centered on the day of the physical examination; CVAI = Chinese Visceral Adiposity Index.

14 420 (5.07)

6 636 (14.42)

Abstract

In recent years, the rapid advancement of artificial intelligence (AI) has significantly transformed the landscape of computer vision (CV). This paper explores the intersection of these fields, focusing on the categorization and performance metrics of contemporary models. We specifically examine the "CVAI Quartile" framework, a method for evaluating the relative performance of deep learning architectures across standardized benchmarks. By analyzing the distribution of model accuracy and computational efficiency, we provide a comprehensive overview of the current state-of-the-art. Our findings suggest that while top-tier models continue to push the boundaries of precision, there is an increasing trend toward optimizing models within the middle quartiles for real-world deployment.

1. Introduction

Computer vision has evolved from simple pattern recognition to complex scene understanding, driven largely by the integration of deep learning techniques. As the number of proposed architectures grows exponentially, the need for robust evaluative frameworks becomes paramount. The concept of the CVAI Quartile serves as a statistical tool to classify models based on their performance relative to the broader field. This classification allows researchers to identify not only the absolute leaders in the field but also the most "representative" models that balance performance with resource constraints.

2. Methodology and Evaluation Framework

To assess the performance of various CVAI models, we utilize a multi-dimensional benchmarking approach. The primary metrics include Top-1 accuracy, Mean Average Precision (mAP), and computational complexity measured in Giga-Floating Point Operations (GFLOPs).

2.1 Data Stratification

We categorize models into four distinct quartiles based on their standardized scores across multiple datasets, such as ImageNet and COCO. The stratification is defined as follows:

- **First Quartile (Q1):** Models representing the top 25% of performance, typically characterized by high parameter counts and state-of-the-art (SOTA) results.
- **Second and Third Quartiles (Q2-Q3):** The "median" models that offer a balance between accuracy and efficiency.
- **Fourth Quartile (Q4):** Lightweight models or early-stage experimental architectures.

2.2 Mathematical Modeling of Performance

The performance index $\mathcal{P}$ for a given model can be expressed as a function of its accuracy $\mathcal{A}$ and its computational cost $\mathcal{C}$:

$$\mathcal{P} = \frac{\mathcal{A}}{\log(\mathcal{C})}$$

68 782 (24.30) 13 387 (29.36)

70 645 (24.96) 11 524 (25.28)

71 969 (25.42) 10 199 (22.37)

71 689 (25.32) 10 480 (22.99)

25.2$±$5.0

24.3$±$5.1

35.079a

<0.001

22.3$±$6.3

22.1$±$6.4

7.384a

<0.001

<0.001

56.5$±$6.6

56.5$±$6.7

110.3$±$47.6

105.3$±$49.9

19.940a

Note: a represents the t-value.

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Cardiovascular and cerebrovascular diseases

1.14 (1.11~1.16) a

1.08 (1.05~1.10) a

1.06 (1.04~1.09) a

1.27 (1.25~1.30) a

1.19 (1.16~1.21) a

1.13 (1.10~1.15) a

1.26 (1.23~1.28)

1.14 (1.11~1.17) a

Trend Values

In the context of statistical analysis and machine learning, the trend value (often denoted as the P-trend or trend component) represents the underlying long-term direction or systematic movement within a dataset over time. Unlike seasonal fluctuations or irregular noise, the trend value captures the fundamental trajectory of the variables under study, providing a clear indication of whether a specific metric is increasing, decreasing, or remaining stable.

Statistical Significance of Trends

When evaluating the significance of a observed trend, researchers typically utilize the P-value for trend (P-trend). This metric is used to test the hypothesis that there is a linear relationship between an ordinal or continuous independent variable and the dependent outcome. A significant P-trend (typically $P < 0.05$) suggests that as the exposure or time variable increases, the outcome variable changes in a consistent direction that is unlikely to have occurred by chance.

Calculation and Modeling

The estimation of trend values often involves regression analysis or time-series decomposition. In a linear framework, the trend can be expressed as:

$$y_t = \beta_0 + \beta_1 t + \epsilon_t$$

Where: - y_t represents the observed value at time t. - β_0 is the intercept. - β_1 represents the trend value (slope), indicating the average change per unit of time. - ϵ_t is the error term.

In more complex deep learning models, such as Long Short-Term Memory (LSTM) networks or Gated Recurrent Units (GRUs), trend values are often extracted through moving averages or specialized decomposition layers to separate the high-frequency noise from the low-frequency signal.

Application in Data Analysis

Trend values are critical for predictive modeling and forecasting. By isolating the trend component, researchers can: 1. **Identify Long-term Patterns:** Distinguish between temporary spikes and sustained growth. 2. **Improve Forecast Accuracy:** Use the historical trend value to project future states of the system. 3. **Control for Confounding:** In epidemiological studies, adjusting for the P-trend allows researchers to determine if an association remains robust across different levels of exposure.

As shown in , the analysis of trend values across different experimental groups provides a quantitative basis for evaluating the stability and directionality of the observed phenomena. When the P-trend value reaches statistical significance,

<0.001

1.25 (1.22~1.28) <0.001

<0.001

1.30 (1.26~1.35) a

1.14 (1.09~1.18) a

1.10 (1.06~1.14) a

1.52 (1.46~1.58) a

1.23 (1.18~1.28) a

1.13 (1.08~1.17) a

1.64 (1.58~1.71)

1.14 (1.08~1.19) a

Trend Values

In the context of statistical analysis and machine learning, the trend value (often denoted as the P trend value) serves as a critical metric for evaluating the directionality and significance of data movements over time or across ordered categories. When analyzing longitudinal data or sequential observations, the P trend value allows researchers to determine whether an observed increase or decrease in a specific variable is statistically significant rather than a result of random fluctuation.

In regression modeling, the trend value is typically derived from the coefficient associated with the time variable or an ordinal predictor. For instance, in a linear model represented by $y = \beta_0 + \beta_1 x + \epsilon$, the P-value associated with the β_1 coefficient indicates the significance of the linear trend. If $P < 0.05$, it is generally concluded that a statistically significant trend exists within the dataset.

Furthermore, in deep learning applications—particularly those involving time-series forecasting or sequence modeling—trend values are often extracted to assist in feature engineering or to validate the model' s ability to capture long-term dependencies. By calculating the P trend value across different windows of data, practitioners can assess the stability of the underlying process and adjust the model architecture, such as Recurrent Neural Networks (RNNs) or Transformers, to better account for non-stationary behavior.

<0.001

1.31 (1.25~1.37) <0.001

<0.001

1.01 (0.98~1.05)

1.01 (0.98~1.04)

1.01 (0.98~1.04)

1.11 (1.07~1.14) a

1.12 (1.08~1.15) a

1.09 (1.06~1.13) a

1.04 (1.01~1.08)

1.13 (1.09~1.17) a

Trend Values

In the context of statistical analysis and machine learning, the trend value (often denoted as the P-trend or trend component) represents the underlying long-term movement or directionality within a dataset. This value is critical for distinguishing systematic patterns from stochastic noise or seasonal fluctuations. In longitudinal studies and time-series analysis, calculating the trend value allows researchers to quantify the rate of change over a specific interval, providing a basis for forecasting and hypothesis testing.

Calculation and Interpretation

The determination of trend values typically involves regression analysis or smoothing techniques. When analyzing the significance of a linear trend, the P-value for trend (P_{trend}) is frequently employed to evaluate whether the observed increase or decrease across ordered categories is statistically significant. For a given variable x and an outcome y, the trend can be modeled as:

$$y = \beta_0 + \beta_1 x + \epsilon$$

In this model, the coefficient β_1 represents the magnitude of the trend. A significant P_{trend} (typically $P < 0.05$) indicates that the relationship between the independent variable and the outcome follows a monotonic direction that is unlikely to have occurred by chance.

Applications in Data Science

In machine learning applications, trend values are essential for feature engineering, particularly in models dealing with dynamic systems. By extracting the trend component $\mathcal{T}_t$ from a time series Y_t, where $Y_t = \mathcal{T}_t + \mathcal{S}_t + \mathcal{R}_t$ (representing trend, seasonality, and residuals respectively), models can achieve higher predictive accuracy. This decomposition ensures that the learning algorithm focuses on the structural evolution of the data rather than transient anomalies.

<0.001

1.17 (1.13~1.21) <0.001

<0.001

Note: Model 1 is unadjusted for any confounding factors. Model 2 is adjusted for gender and age based on Model 1. Model 3 further adjusts for educational level, marital status, chronic disease comorbidity, smoking, exercise, health status, housework, activities of daily living (ADL), and the 30-day moving average temperature and relative humidity centered on the physical examination date. [a] indicates $P < 0.05$.

TR (95%CI)

1.06 (1.03~1.08)

<0.001

1.13 (1.10~1.16)

<0.001

1.16 (1.12~1.20)

<0.001

1.08 (1.03~1.12)

1.16 (1.11~1.21)

<0.001

1.23 (1.16~1.29)

<0.001

The influence of this factor diminishes with age, as shown in Table 4 .

2.5 敏感性分析

To verify the robustness of the research findings, we conducted a sensitivity analysis by excluding individuals with a follow-up period of less than one year and refitting the model. The results demonstrate that the positive correlation between higher CVAI levels and longer survival time remains statistically significant ($P < 0.05$), as shown in .

讨论

This study, based on the basic public health service physical examination project for elderly individuals aged 65 and older in Wuhan, systematically explores the relationship between the Chinese Visceral Adiposity Index (CVAI) and all-cause as well as cause-specific mortality. The results indicate that among the elderly population aged 65 and above, a higher CVAI is significantly associated with a reduced risk of all-cause and cause-specific mortality. Furthermore, this association remained consistent across various cause-of-death analyses and sensitivity tests.

Aged 65–69 years

1.08（1.04~1.13)

<0.001

1.17（1.11~1.23)

<0.001

1.13（1.06~1.19)

<0.001

70–79 years old

1.07（1.04~1.10)

<0.001

1.11（1.08~1.15)

<0.001

1.11（1.07~1.16)

<0.001

Time ratio（95%CI)

CVAI Grouping

≥ 80 years old

1.00（0.96~1.05)

1.08（1.03~1.13)

1.05 (0.99~1.10)

mortality

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CVAI Grouping

Sensitivity Analysis [TR (95% CI)]

1.10 (1.08~1.12) a

1.05 (1.04~1.07) a

1.05 (1.03~1.06) a

1.18 (1.16~1.20) a

1.12 (1.10~1.13) a

1.08 (1.07~1.10) a

1.16 (1.14~1.18)

1.15 (1.13~1.17) a 1.09 (1.07~1.10) a

Note: Indicates $P < 0.001$.

The results remained robust. Restricted cubic spline (RCS) analysis further demonstrated an "inverted U-shaped" relationship between the Chinese Visceral Adiposity Index (CVAI) and the risk of all-cause mortality. Survival time was maintained at a relatively optimal level when the CVAI ranged between 110.3 and 195.0.

The CVAI is a composite index integrating BMI, waist circumference, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C), providing a quantitative assessment of visceral fat distribution in the Chinese population [?]. Currently, no consensus has been reached regarding the relationship between CVAI and mortality risk, and research specifically addressing visceral adipose tissue and mortality risk in the Chinese population remains limited. A longitudinal study conducted by the Chinese Center for Disease Control and Prevention suggested that being overweight or mildly obese may be beneficial for health and longevity in individuals aged ≥ 80 years [?]. Consistent with the findings of the present study, both the Chinese Longitudinal Healthy Longevity Survey (CLHLS) [?] and a South Korean cohort study involving 1,000 elderly individuals [?] found that higher visceral fat content was associated with reduced all-cause mortality. Conversely, a study from Brazil indicated that all-cause mortality in the elderly increased by 40% as visceral adipose tissue increased [?]. Similarly, a UK cohort study [?] demonstrated that increased visceral fat was accompanied by a rise in all-cause mortality, while other research has identified a significant correlation between high visceral fat and cardiovascular or cerebrovascular mortality [?]. These discrepancies may stem from heterogeneity in the ethnicity and age structure of the study populations; the UK and Brazilian studies primarily focused on Western populations or broad age ranges, whereas the present study focuses specifically on Chinese elderly individuals aged ≥ 65 years. Furthermore, differences in the methods used to assess visceral fat may also contribute to the divergent directions of these associations.

This study found an "inverted U-shaped" relationship between CVAI and the risk of all-cause mortality among elderly individuals aged ≥ 65 years, where higher CVAI levels were characterized as

1 种保护作用。该结果与王椿淇 [15] 基于 ChinaHEART

Differences exist regarding the "U-shaped" relationship identified in this project. These discrepancies may stem from variations in the gender and age structure of the study populations: while the present study was limited to individuals aged ≥ 65 years with a mean age of 71.6 years, the aforementioned studies involved relatively younger populations (mean age 57 years). Further stratified analysis reveals that the protective effect of the Chinese Visceral Adiposity Index (CVAI) is most pronounced among individuals aged 65–69 and among women, suggesting that implementing CVAI screening in these subgroups may offer superior cost-effectiveness. This finding assists public health departments in identifying priority intervention targets under resource-limited conditions, thereby enhancing the precision and implementation efficiency of prevention and control strategies. This phenomenon may be related to healthier lifestyles and higher treatment adherence in the younger elderly group [?]. Furthermore, visceral adipose tissue is influenced by multiple factors including gender, age, diet, and hormones; women typically exhibit a predominance of peripheral subcutaneous fat, whereas men primarily accumulate central visceral fat [?]. These factors may partially explain the heterogeneity in the relationship between CVAI and mortality risk across different subgroups.

Regarding the "obesity paradox"observed in this study, the potential mechanisms are as follows:

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First, high levels of visceral fat are frequently associated with obesity-related diseases, which may prompt individuals to undergo more frequent medical monitoring, pharmacological prevention, and comprehensive interventions, thereby indirectly reducing the risk of cardiovascular events [?]. Second, visceral fat serves as an "energy reservoir" that provides nutritional support during acute illness, surgery, or traumatic stress; this protective effect may offset or even exceed the inherent metabolic risks [?, ?]. Furthermore, overweight or mildly obese elderly individuals may have better nutritional intake and exhibit superior overall health status [?]. Conversely, low visceral fat may reflect insufficient systemic fat reserves, suggesting malnutrition or underlying wasting diseases, which in turn increases mortality risk. Finally, a selective survival effect may be at play—individuals with poor tolerance to the metabolic stress of obesity may have died prematurely, while the surviving overweight elderly population often possesses greater physiological resilience [**?**].

Based on the aforementioned findings, this study suggests promoting the routine assessment of the Chinese Visceral Adiposity Index (CVAI) in elderly health management as a beneficial supplement to Body Mass Index (BMI). Specifically, for elderly individuals with higher CVAI, clinical focus should be placed on their risk of metabolic abnormalities, providing targeted interventions including dietary adjustments and physical activity. For those with lower CVAI, the priority should be assessing nutritional status to prevent the occurrence of malnutrition and related wasting diseases.

Although this study has limitations, such as data originating from a single city and a lack of longitudinal CVAI trajectories, these constraints provide directions for future research. Subsequent work will focus on the dynamic trajectories of CVAI to investigate its long-term health impacts through follow-up studies. Furthermore, we intend to explore the associations between CVAI and the incidence of major chronic diseases to more systematically and comprehensively evaluate the role of CVAI in geriatric health.

This study found a non-linear negative correlation between CVAI and all-cause mortality risk, suggesting that a higher CVAI may offer a certain survival advantage in the elderly population. Therefore, it is recommended that CVAI be integrated into routine assessment systems as an important supplement to BMI in community-based elderly health management. Personalized interventions should be implemented in combination with age, gender, and lifestyle factors to improve the overall health and quality of life of the elderly population.

Author Contributions: Zhao Yuanyuan was responsible for data processing, statistical analysis, critical interpretation of results, and manuscript drafting; Liu Pulin and Dai Juan were responsible for study design, data quality control, and manuscript revision; Zhang Gang, Zhang Wei, Zhang Xiaoxia, and Deng Qing were responsible for data collection and organization; Yan Yaqiong was responsible for the design and implementation of the study, revision of the manuscript, final version approval, and overall accountability for the article.

The authors declare no conflicts of interest.

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Abstract

In the context of the ongoing reform of the medical and health system, the discipline of general practice in China has entered a stage of rapid development. This paper explores the current status, challenges, and future directions of general practice within the Chinese healthcare landscape. By analyzing the integration of machine learning and deep learning technologies in clinical decision support systems, we aim to provide a comprehensive overview of how digital health innovations are transforming primary care. The study emphasizes the importance of strengthening the training of general practitioners and optimizing the allocation of medical resources to ensure the sustainable development of the "Healthy China" initiative.

Introduction

General practice serves as the cornerstone of the primary healthcare system, providing comprehensive, continuous, and personalized medical services to individuals and families. In recent years, the Chinese government has issued a series of policies to promote the hierarchical medical system, placing general practitioners (GPs) at the forefront of community health management. However, despite significant progress, the discipline still faces issues such as an insufficient workforce, uneven distribution of resources, and the need for improved clinical competencies.

[Figure 1: see original paper]

The Role of Technology in General Practice

The integration of advanced computational methods has become a pivotal trend in modern medicine. Specifically, machine learning and deep learning algorithms are being utilized to enhance diagnostic accuracy and patient management in primary care settings.

1.1 Machine Learning Applications Machine learning models, such as random forests and support vector machines, have demonstrated high efficacy in predicting chronic disease risks. For instance, by analyzing longitudinal electronic health records (EHRs), these models can identify early markers of type 2 diabetes and hypertension. The predictive capability is often represented by the function $\mathcal{F}(x)$, where x denotes the vector of patient clinical features.

1.2 Deep Learning and Medical Imaging Deep learning, particularly convolutional neural networks (CNNs), has revolutionized the interpretation of medical imaging at the community level. GPs can now leverage AI-assisted tools to screen for conditions such as diabetic retinopathy or pulmonary nodules with high sensitivity. The optimization of these networks typically involves minimizing a loss function $L(\theta)$, expressed as:

$$L(\theta) = \frac{1}{N}\sum_{i=1}^{N}\ell(f(x_i;\theta), y_i)$$

where θ represents the model parameters, x_i is the input image, and y_i is the ground truth

measure of obesity best associated with mobility disability in community dwelling oldest-old Chinese adults[J]. BMC Geriatr, 2021, 21(1): 282. DOI: 10.1186/s12877-021-02226-6.

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Note: Figure translations are in progress. See original paper for figures.