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Original Study

Successful Aging and Frailty: Opposite Sides of the Same Coin?

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A B S T R A C T

Objectives: Operational definitions of *successful aging* place a strong emphasis on functional capacity, and strategies for successful aging include many factors common to frailty research. We explore the hypothesis that frailty and successful aging are two sides of the same coin and that walking speed may be an objective indicator of successful aging.
Design: Observational study of two Chinese cohorts using one to define "fast walkers" and applying this criteria to another cohort to examine associated factors.
Setting: Community survey in cities in China.
Participants: A total of 1929 men and women aged 25 to 89 years of age in four cities in China and 4000 men and women 65 years old in Hong Kong SAR China.
Measurements: The top 25th percentile of walking speed for the whole cohort of 1929 men was determined, and the cutoff value was used to define "fast walkers." This value was applied to the Hong Kong Chinese population to examine factors associated with fast walking speed. These factors include age, gender, socioeconomic and lifestyle factors, medical history, quality of life, cognitive function, depressive symptoms, body mass index, body composition, and telomere length.
Results: Fast walkers had better self-rated health, lower prevalence of stroke, hypertension, cataracts, osteoporosis, and impaired cognitive function. They were more likely to be current alcohol users, more physically active, consumed more vegetables, had better physical component of health-related quality of life, and received more education. They also had lower body mass index, percentage whole body fat as well as appendicular fat, and higher appendicular muscle mass index. In multivariate analysis, the significant contributing variables were age, gender, current alcohol use, physical activity level, vegetable intake, quality of life, and appendicular fat. The area under the curve value on receiver-operating characteristic analysis was 0.77 for these seven variables.
Conclusions: Frailty and successful aging may be considered two sides of the same entity, and fast walking speed may be used as an objective indicator of successful aging.

The term *successful aging* was introduced over 20 years ago, encompassing three main factors: illness avoidance, high physical and mental functioning, and active engagement with life.[1] Subsequent discourse placed much emphasis on the presence or absence of disease, such that profiles of centenarians have been classified into "survivors," "delayers," and "escapers" based on the presence of diseases and the age of onset before or after 80 years.[2] Further research taking into account older peoples' views suggests a need to enlarge on the essentially biomedical model to include social and psychological factors.[3,4] The lay model is broader with similar characteristics to the domains of the Age-Friendly City Movement promoted by the World Health Organization in 2007.[5] Psychological components of successful aging (such as self-efficacy and resilience) were the only components in a model that predicted subsequent quality of life independently.[6] Among Chinese people, active engagement has been further subdivided into two separate constructs of caring and/or productive engagement,[7] while a social support network was the predominant factor in predicting well-being after 1 year.[8]

Studies into factors promoting successful aging examined genetic and environmental contributors. Although it is thought that genetic factors play a role, the contribution is small compared with environmental factors, but that the contribution may increase with increasing

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age.[9–11] Studies into contributors of successful aging highlighted healthy lifestyle (physical activity, nutrition), environmental enrichment and stress avoidance, and methods to preserve cognitive function by measures that promote neuronal plasticity.[12–19] The relative importance of these factors are uncertain, but a study showed that knowledge and development of a healthy lifestyle only correlated weakly with the positive aging process, compared with income and education.[20] Nevertheless, the recurrent theme from these studies suggests the importance of achieving higher levels of physical fitness through actual participation in physical activity, as well as cognitive stimulation, and that these multimodal strategies are beneficial for maintaining physical as well as cognitive function.

At the same time, the concept of frailty began to evolve, predominantly in the biomedical literature, as a phenomenon quantifying the speed of the aging trajectory. Frailty is considered a geriatric syndrome that represents age-related physiological decline in various systems that result in increased vulnerability to any external stressors. It also predicts many adverse outcomes including dependency, use of hospital services, and mortality.[21–23] Frailty also has physical, cognitive, and social components.[24–26] It would be interesting to examine whether determinants of frailty are the same as those factors associated with successful aging. Walking speed is a strong indicator of frailty, because it reflects physiological as well as pathological processes, in terms of neurodegeneration, cardiorespiratory fitness, and sarcopenia.[27] In a national survey of 1929 people aged 25 to 89 years without disabilities in four cities of China, gait speed was measured, and a percentage of people in the older age groups was found to have walking speed similar to younger age groups.[28] Using the cutoff value for walking speed in the top 25th percentile of the whole population ($\geq$ 1.39 m/s) to represent the "robust" state (as oppose to frailty), we examined the factors associated with this value of walking speed in another Chinese cohort of 4000 men and women, to determine whether these factors are similar to those described for successful aging. The objective is to explore the hypothesis that frailty and successful aging are two sides of the same coin and that walking speed above a certain value may be an objective indicator of successful aging.

Participants and Methods

Establishment of the Top 25th Percentile of Walking in a Chinese Population of All Ages

A cross-sectional survey was conducted in four urban cities of China from September 2013 to December 2014. One thousand nine hundred twenty-nine people aged 25 to 89 years without physical disabilities were recruited. Approximately half were from Northern and half from Southern China. Forty-five percent were women, and 53% were 60 years of age and older.

Participants were requested to begin walking at their usual pace from a starting point and to continue on a straight course of 7 meters. The total time taken from the starting point to the first footfall over the 6-meter line was measured using a stopwatch. Gait speed was calculated by dividing the distance in meters by the time taken in seconds (m/s). The mean standard deviation (SD) walking speed for the cohort was 1.55 (0.18) m/s. The cutoff value for the top 25th percentile was $\geq$ 1.39 m/s.

Chinese Population Studied

Subjects were participants of a cohort study examining the risk factors for osteoporosis in Hong Kong.[29] Four thousand Chinese men (n = 2000) and women (n = 2000) aged 65 years of age or older living in the community were recruited in a health survey between August 2001 and December 2003 by recruitment notices and talks in community centers and housing estates. Participants were volunteers and were able to walk or take public transport to the study site. They were recruited using a stratified sampling method so that approximately 33% would be in each of these age groups: 65 to 69, 70 to 74, and 75+.

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of the Chinese University of Hong Kong. Written informed consent was obtained from all subjects.

Questionnaire

A standardized, structured interview was performed to collect information on age, education level, smoking habits, and alcohol use. Information on the duration and level of past and current use of cigarettes, cigars, and pipes was obtained. Smoking history was classified in terms of former smoking (at least 100 cigarettes smoked in a lifetime), current smoking, or never smoking. Subjects were also asked about their alcohol use, and drinking status was defined as never, former, or current. The presence of known chronic disease was also recorded, and participants were also asked to rate their health status into five categories from poor to excellent. Cognitive function was assessed by the Mini-Mental Status Examination[30] according to the original osteoporosis study protocol.[31] Health-related quality of life was evaluated by the 12-Item Short Form Health Survey (SF-12). It derives summary scores from specific items from the eight domains of the SF-36, with physical component summary score (summary of physical functioning, physical role, bodily pain, and general health) and the mental component summary score summary of vitality, social functioning, emotional role, and mental health,[32] being highly correlated with that of the SF-36 (0.951 and 0.969, respectively). Depressive symptoms were assessed using the Geriatric Depression Scale[33] with a score $\geq$8 representing depressive symptoms, validated in elderly Chinese subjects.[34]

Self-rated SES was assessed by asking participants to place a mark on a picture of an upright ladder with ten rungs, with the top rung representing people who have the most money, the most education, and the most respected jobs and the bottom rung representing people at the other extreme (SES ladder). This is a subjective measure of social status developed by the John D. and Catherine T. MacArthur Research Network on Socioeconomic Status and Health. It has been associated with key health outcomes in various population surveys of different cultural and ethnic groups[35] and had been applied in the Hong Kong population to examine gender differences in socioeconomic status.[36]

Dietary intake was assessed at baseline using a validated semi-quantitative food frequency questionnaire.[37] A trained interviewer asked each participant to report the frequency and the usual amount of consumption of each food item over the past year. Portion size was explained to participants using a catalogue of pictures of individual food portions. The daily amount of consumption of major food groups including cereal, egg and egg products, fish and shellfish, fruits and dried fruits, legumes/nuts/seeds, meat and poultry, milk and milk products, and vegetables was calculated. Mean daily nutrient intake was calculated using food tables derived from McCance and Widdowson[38] and the Chinese Medical Sciences Institute.[39]

Measurements and Methods

Body weight was measured with subjects wearing a light gown, using the Physician Balance Beam Scale (Health o meter, McCook, IL). Height was measured using the Holtain Harpenden stadiometer (Holtain Ltd, Crosswell, Crymych, Pembs, Wales). Body mass index (BMI) was calculated as (body weight in kg/[height in m^2]). BMI was divided into different categories to represent underweight ($<$18.5 kg/m^2), normal weight (18.5 to $<$ 23 kg/m^2), overweight (23 to 24.9 kg/m^2), obesity I (25 to 29.9 kg/m^2), and obesity II ($\geq$30 kg/m^2), using Asian criteria.[40] Blood pressure was measured after a 5-minute