Behavioral Determinants of Healthy Aging

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Abstract: With global trends in population aging, many nations are developing and implementing healthy aging policies to promote quality as well as years of healthy life. To broaden the evidence base for such policy development, a review of the literature was conducted to summarize the existing evidence regarding the behavioral determinants of healthy aging. Such research is needed so that the efficacy of modes of intervention can be better understood. The outcome of “healthy” or “successful” aging was selected for this review since this nomenclature dominates the literature describing a global measure of multidimensional functioning at the positive end of the health continuum in older age. Studies published between 1985 and 2003 that reported statistical associations between baseline determinants and healthy aging outcome were identified from a systematic search of medical, psychological, sociological, and gerontological databases. Eight studies satisfied the search criteria. Modifiable risk factors among the behavioral determinants included smoking status, physical activity level, body mass index, diet, alcohol use, and health practices. On the basis of these findings, effective healthy aging policies need to enhance opportunities across the life span for modification of lifestyle risk factors. Efforts to standardize concepts and terminology will facilitate further research activity in this important area.

Introduction

As the population ages, a major challenge is to consider how to increase the quality and years of healthy life. Many nations are responding to this challenge by developing and implementing policies to promote healthy aging. Healthy aging is described as a lifelong process optimizing opportunities for improving and preserving health and physical, social, and mental wellness; independence; quality of life; and enhancing successful life-course transitions. To achieve these goals, the United Nations Research Agenda on Ageing for the 21st Century outlined, as a priority, the need for research into the determinants of healthy aging so that the efficacy of preventive, curative, and rehabilitative modes of intervention could be better understood. Despite policy documents conceiving healthy aging in positive terms, empirical research has largely been based on negative aspects of mortality and morbidity. As outlined in a review, a multitude of studies have identified factors that lead to functional decline. However, interest in healthy aging requires that researchers shift their outcome measurement to focus on those persons who are aging well, since the distribution and determinants of positive health have not been studied extensively. Bryant et al. showed that some of the factors commonly associated with negative outcomes of aging showed predictive capability for positive health. However, predictors derived predominantly from existing literature that focuses on explaining disease and impairment will not be optimal for exploring healthy aging. Thus, current health and social policy, which assumes the existence of a sound evidence base for healthy aging, is not fully informed.

Research on extrinsic determinants of ill health has focused mainly on behavioral risk factors, including tobacco use, poor diet, physical inactivity, and alcohol misuse, which the World Health Organization (WHO) has estimated account for over one third of the global chronic disease burden. As a basis for policy development to promote healthy aging, a systematic review of the literature was undertaken of longitudinal studies analyzing the association of such behavioral factors with maintenance of health in older populations.

Methods

Data Sources

Published studies were identified through searches of PUBMED, MEDLINE, EMBASE, CINAHL, PSYCINFO.
The concept of “healthy aging” adopted for this review recognizes that health, as defined by the WHO, extends beyond the mere absence of disease or infirmity to include physical, mental, and social well-being. Therefore, the outcome measure “healthy aging” was defined as multidimensional functioning at the upper or positive end of the health continuum in older age. The presence of the terms healthy or successful and aging (or ageing) in the database keyword, title, and abstract information, was adopted as a preliminary search criterion, since this nomenclature dominates the literature describing positive health in older age.

Further search terms included “aged” or “elderly”; “longitudinal” or “follow-up” or “prospective”; “risk” or “predictors” or “determinants”; and “behavioral” or “lifestyle”.

Title and abstract information of articles identified by this search were entered into Endnote, version 8 (Thomson ISI ResearchSoft, Stamford, CT, 2004), and further assessed against specific selection criteria for inclusion in the review. Where necessary, full articles were obtained and appraised at this stage in the selection process.

Selection Criteria

Publications. Studies were published in peer-reviewed scientific journals reporting previously unpublished results. Unpublished studies, dissertations, theses, and non-peer-reviewed articles such as association papers and conference abstracts were not considered. Additional exclusions were book chapters, reviews, and editorials.

Study design. Selected articles were designed as primary analytic epidemiology studies with a priori aims to measure associations between behavioral determinants and healthy aging outcome as detailed below.

Study populations. In accord with the WHO definition of “older person,” a criterion was that study participants be aged ≥60 years at the time of outcome assessment.

Outcome measure. The study outcome was “healthy” or “successful aging,” which, in a review of studies on healthy aging, has been defined and measured as a multidimensional construct. The dependent variable was a composite measure across several domains of health to identify the subset of individuals who were functioning well in most or all measured domains. Studies measuring only one subcomponent of functional health—such as cognitive, emotional, or physical function—do not represent the multidimensional nature of healthy aging, as defined for this review. Studies of aging with disease or functional decline as the outcome were also not included, since healthy aging is not merely the opposite of aging with disease or functional impairment.

Risk/protective factors. The determinants measured in the study included behavioral factors, defined as those that can be eliminated or reduced through lifestyle or behavioral changes. The factors had to be measured as independent variables, and the association between individual baseline risk/protective factors and the dependent variable (healthy aging) had to be quantified. To overcome the possibility of reverse causation inherent in cross-sectional data, studies were restricted to those analyzing longitudinal or follow-up data. The definition of “longitudinal study” used in this paper was that exposure was measured before outcome. The relationship of predictive factors was to be quantified against global outcome and not against the domains of healthy aging (e.g., physical performance or cognitive function) analyzed separately.

Data Extraction

Abstracts and/or full papers identified by the search processes were reviewed and discussed by the authors and selected for data extraction if they met the a priori selection criteria. Using a standard form, details and results of the selected studies were extracted and synthesized.

Results

Studies Selected

A total of 341 articles met the search criteria. The systematic process of study selection from these is illustrated in Figure 1.

Eight studies met the selection criteria defined for this review as measuring associations between baseline behavioral risk factors and subsequent healthy aging in a cohort of people aged ≥60 years at outcome assessment. The studies are listed in Table 1, together with study descriptors, outcome definition, comparison groups for analysis, and determinants with effect sizes.

All the selected studies were from the United States, except for one European study. Participants in the majority of studies were representative samples of community-based older men and women, except for the Harvard Study of Adult Development, in which study participants were recruited as college sophomores and core-city adolescent men. One study recruited only men with Japanese ancestry. All studies were based on longitudinal data, with follow-up periods ranging from 2 to 60 years.

The definitions of healthy or successful aging ranged from the primarily biological, such as survival to old age with absence of disability, to the comprehensive, such as sustained well-being using a biopsychosocial model. Despite the wide-ranging approaches to the study of healthy aging, the majority of the selected studies emphasized the maintenance of functional independence, measured as ability to perform basic and/or instrumental activities of daily living. Such measures of functional independence are thought to entail preservation of physical, cognitive, and social...
functioning, and thus are considered a multidimensional measure. High functioning in tests of physical performance and cognitive ability were also included as domains of healthy aging, as well as absence of disease and psychiatric morbidity. The indicators used within the domains to measure outcome, and the way they were aggregated into summary scores, influenced the resulting proportion of healthy agers in the study population.

Determinants of Healthy Aging

The determinants of healthy aging were categorized into demographic, medical, behavioral, and psychosocial factors. The behavioral determinants shown to be significantly associated with healthy aging are described below.

Smoking Status

Being a current nonsmoker (never having smoked or having previously quit) was associated with healthy aging. For former smokers, only one study specified a minimum period of abstinence (>15 years). In the latter study, the association applied to men only, since the low number of smokers among elderly women meant that the relationship could not be investigated. A lower consumption rate (smoking <30 or <40 pack years) was also predictive of healthy aging. Effect sizes for the association of healthy aging with current nonsmoking or low tobacco consumption ranged from 1.2 to 4.5.

Alcohol Consumption

The measurement and categories of this variable differed considerably among the studies. Moderate/some alcohol consumption compared with abstinence was beneficial for healthy aging in multivariate models in one study, but not in others. In the study by Vaillant and Mukamal, absence of alcohol abuse before age 50 for the core-city cohort was an important protective factor in univariate analysis, but not in multivariate analysis, where the effect may have been masked by colinearity with smoking. With no cases of alcohol abuse in the successfully aging cohort of college men, odds ratios could not be calculated. While alcohol consumption was measured in the study by Haveman-Nies et al., it was included as part of a dietary quality score and not analyzed independently. In the one study with a significant association between healthy aging and alcohol consumption, those with a moderate intake of 60 drinks a month, compared to abstainers, were twice as likely to be healthy agers.

Physical Activity

Physical activity measures differed by type, frequency, intensity, and life stage at which measures were taken. However, there was general consensus that high levels of physical activity (based on frequency of participation or energy expenditure in a range of household, leisure, or exercise activity) was associated with healthy aging in univariate models and multivariate models. Examples of level of exercise required to achieve healthy aging were participating several times a week in walking, gardening, and/or vigorous exercise, or expending energy at a rate of >500 kilocalories per week. Effect sizes for the association of healthy aging with high levels of physical activity ranged from 1.27 to 3.09.

Obesity

As measured by body mass index, or by weight alone being in the normal range, not being overweight or obese predicted subsequent healthy aging. Effect sizes for the association of healthy aging with having normal body weight ranged from 1.58 to 3.05.
<table>
<thead>
<tr>
<th>Author, yearref</th>
<th>Study, site, population descriptors</th>
<th>Outcome definition and comparison groups in analysis</th>
<th>Determinants and effect sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haveman-Nies, 2003[^1^9]</td>
<td>SENECA Study, 19 European towns, n=2200 community-dwelling men and women aged 70 to 75 at baseline. Follow-up 10 years.</td>
<td><strong>Healthy aging</strong> defined as maintenance of health at old age (being alive and remaining functionally independent)</td>
<td><strong>OR (90% CIs)</strong></td>
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<tr>
<td></td>
<td></td>
<td>Comparison of outcome groups:</td>
<td>Men</td>
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<tr>
<td></td>
<td></td>
<td>● Becoming dependent: 35 men; 41 women</td>
<td>1.9 (0.9–3.9)</td>
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<tr>
<td></td>
<td></td>
<td>● Remaining independent: 175 men; 206 women</td>
<td>1.0 (0.5–2.2)</td>
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<tr>
<td>Newman, 2003[^2^2]</td>
<td>Cardiovascular Health Study, four sites in U.S., n=2992 community-dwelling men and women aged ≥65 at baseline. Follow-up 8 years.</td>
<td><strong>Successful aging</strong> defined as remaining free of major, life-threatening disease and having normal physical and cognitive functioning. Multivariable analyses using accelerated failure/time models for outcome groups:</td>
<td>Proportion of successful years with 95% CIs</td>
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<td></td>
<td></td>
<td>● Remaining successful: 1408 (48%)</td>
<td>Smoking (current vs never/former) (&lt;40 vs none)</td>
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<td></td>
<td></td>
<td>● Developed disease or disability: 1524 (52%)</td>
<td>Physical activity (highest quintile vs lowest)</td>
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<td>Vaillant, 2001[^2^0]</td>
<td>Harvard Study of Adult Development, U.S. A. College male sophomores, n=237 B. Core-city male adolescents n=332 Follow-up 60 years.</td>
<td><strong>Successful aging</strong> defined as survival to older age with a high level of well-being in domains of physical, mental, and social functioning. Multivariate models contrasted most (happy-well) and least successful agers (sad sick and prematurely dead)</td>
<td><strong>OR (95% CIs)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Happy-well: 62 (26%) A; 95 (29%) B</td>
<td>Smoking (&lt;30 vs 30 to 90 pack years) Cohort A</td>
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<tr>
<td></td>
<td></td>
<td>● Sad-sick: 40 (17%) A; 48 (14%) B</td>
<td>Alcohol (No abuse vs abuse) Cohort B</td>
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<td></td>
<td></td>
<td>● Prematurely dead: 60 (25%) A; 75 (23%) B</td>
<td>Some regular exercise (&gt;500 kcal/week vs less)</td>
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<tr>
<td>Ford, 2000[^2^3]</td>
<td>Survivors of previous survey; Cleveland, n=487; non-institutionalized men and women aged ≥70 at baseline. Follow-up 2 years.</td>
<td><strong>Successful aging</strong> defined as sustained independent living in the community. Logistic regression contrasted outcome groups:</td>
<td><strong>OR (95% CIs) for:</strong></td>
</tr>
<tr>
<td></td>
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<td>● Sustained independence: 98 (20.1%)</td>
<td>Smoking (current nonsmokers vs smokers)</td>
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<td></td>
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<td>● Dependent: 389 (79.9%)</td>
<td>Alcohol (current nondrinkers vs drinkers)</td>
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<td>Leveille, 1999</td>
<td>Established Populations for the Epidemiologic Study of the Elderly (EPESE) U.S., n=1097 community-based men and women aged &gt;65 at baseline. Follow-up 2 to 8 years (mean, 6.1 years)</td>
<td>Aging successfully defined as living to an advanced old age and having little or no disability prior to death. Logistic regression contrasted outcome groups: ● Aged successfully: 442 (40%) ● Aged unsuccessfully: 655 (60%)</td>
<td>OR (95% CIs) for: Smoking (current vs never) 1.04 (0.63–1.69) Alcohol (≥1 oz/day vs &lt;1 oz/day) 0.83 (0.41–1.66) Activity level (high vs low) 1.86 (1.24–2.79) BMI (&gt;27 vs 21 to 27) 0.63 (0.44–0.89)</td>
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<td>Reed, 1998</td>
<td>Honolulu Heart Program, n=3154 population-based men of Japanese ancestry aged 45 to 68 at baseline. Follow-up 28 years.</td>
<td>Healthy aging defined as surviving to late life free of major life-threatening illnesses and maintaining the ability to function physically and mentally. Multivariate models contrasted healthy aging with outcome group: ● Healthy aged: 610 (19%) ● Illness and impairment: 1279</td>
<td>OR (95% CIs) for: Smoking pack years (continuous, decreasing) 0.52 (0.39–0.70) Physical activity NS Alcohol intake NS BMI (continuous, decreasing) 0.44 (0.32–0.59) Japanese Diet Score, % (continuous, decreasing) 0.76 (0.59–0.97)</td>
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<td>Strawbridge, 1996</td>
<td>Human Population Laboratory Alameda Country Study, U.S., n=356 population-based men and women aged ≥65 at baseline. Follow-up 6 years.</td>
<td>Successful aging defined as having minimal interruption of usual functioning in basic activities and physical performance measures. Logistic regression contrasted outcome groups: ● Aging successfully: 125 (35%) ● Not aging successfully: 231 (65%)</td>
<td>OR (95% CIs) for: Smoking (past/never vs current) 3.0 (1.8–5.1) Alcohol consumption (1 to 60 drinks/month vs none) 2.1 (1.1–4.1) Weight (moderate vs other) 2.3 (1.1–4.9) Hours of sleep (7 to 8 hours vs &lt;7 or &gt;8) 0.9 (0.5–1.7)</td>
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<tr>
<td>Guralnik, 1989</td>
<td>Human Population Laboratory Alameda County Study, U.S., n=841, population-based men and women aged 46 to 70 at baseline. Follow-up 19 years.</td>
<td>Healthy aging defined as surviving to late life with a high level of functioning. Multiple logistic models contrasted high functioning with low/moderate functioning including deaths. Outcome groups: ● Healthy aged: 107 (12.7%) ● Nonhealthy aged: 734 (589 low/moderate function 46.3%; 345 deaths 41%)</td>
<td>OR (95% CIs) for: Smoking (past/never vs current) 3.0 (1.8–5.1) Alcohol consumption (1 to 60 drinks/month vs none) 2.1 (1.1–4.1) Weight (moderate vs other) 2.3 (1.1–4.9) Hours of sleep (7 to 8 hours vs &lt;7 or &gt;8) 0.9 (0.5–1.7)</td>
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BMI, body mass index; CI, confidence interval; NS not significant; OR, odds ratio.
Diet intake was not measured in many of the selected studies. Lower values for a Japanese diet score (based on the ratio of intake of Japanese food to total intake) were associated with healthy aging, but having a low-quality diet (a low intake of quality foods based on a Mediterranean diet) was not related to maintenance of health status in the European study. No significant association was found for variables concerned with frequency of eating breakfast or snacking (eating between meals).

Combined and Other Health Behaviors
There were significant associations for protective factors in combination in two studies. Past and never smokers with a high level of physical activity were two and a half times more likely to age successfully compared with sedentary counterparts. There was a dose–response relationship according to number of positive responses on factors of not often being depressed, having five or more personal contacts, and often walking for exercise. Those having two or more of these factors were three times more likely to age successfully than those with none. Evidence of impact of sleep patterns was inconclusive. Number of hours of sleep was not independently associated with healthy aging in one study, although not usually taking naps was associated with successful aging in cross-sectional analysis.

Discussion
Main Findings
This systematic review of the literature aimed at documenting the evidence for modifiable behavioral risk factors that predict healthy living in older cohorts. Determinants for which there was evidence of an association with healthy aging included not smoking, being physically active, maintaining weight within normal ranges, and moderate alcohol consumption. Combining positive health behaviors of high physical activity with not smoking enhanced the chances of healthy aging. The evidence in these studies for the effects of type of diet on healthy aging was less conclusive. Nonsignificant results for smoking in two studies were explained because smokers may have died or quit before reaching old age. Lack of significant associations in studies of alcohol consumption were attributed to low incidence of alcohol abuse in the cohort, masking by colinearity with smoking, or lack of variability as reported previously in the cardiovascular health study of Newman et al. The potentially protective effect of alcohol may reflect a survival bias since the impaired group who drank may be under-represented due to excess mortality and nonparticipation. Lack of independent association for physical activity in two studies was attributed to the exclusion of those with illnesses, which could have confounded the association between physical activity and health, or was due to controlling for health status in a population with a limited range of exercise. One study did not examine physical activity as a predictor because it was part of the outcome measure.

Implications
Evidence of robust predictors has emerged from the accumulated results of the studies on healthy aging. The evidence linking global health outcomes to behavioral risk factors identified in this review supports the focus of interventions for lifestyle modification to be included in healthy aging policy. Since these precursors to health have their genesis in early ages and are cumulative in their impact, healthy aging interventions based on lifestyle modification should take a population-based, life-course perspective. To be most effective, interventions aimed primarily at addressing smoking, alcohol misuse, inadequate exercise, and poor nutrition should target young and middle-aged populations, although health promotion interventions for older adults targeting individual behavioral risk reduction also benefit health and support the motto that “it’s never too late.”

Methodologic Issues
In the studies identified using the selection criteria, methodologic differences in study design, follow-up periods, populations sampled, and definition of the outcome influenced the proportion of the study population designated as “healthy agers,” and thus the comparison groups used in analysis. Because of the considerable heterogeneity in the studies, it was not possible to pool results for meta-analysis. While a detailed critique of the quality of the evidence presented in these selected studies is beyond the scope of this paper, a number of study factors, which affected results, are discussed.

In the selected studies, length of follow-up varied from 2 to 60 years, depending on age at entry. Three studies were based on cohorts recruited and followed from adolescence or middle age. For the other five studies, participants were aged ≥65 years at study entry. Studies established specifically to study aging, by beginning in late life, have the disadvantage of not including those who die prematurely, and do not allow examination of lifestyle factors measured during mid-life, which are associated with the maintenance of health during late adult years. Alternately, if the time interval between baseline and follow-up is too long, valuable data may be lost due to high mortality, or...
because of potential changes over time in baseline measures.24

Lack of consistent results among studies may be attributed to different nomenclature and measurement of the explanatory variables, such as in the measurement of alcohol use and abuse. The United Nations Research Agenda on Ageing for the 21st Century8 highlighted these methodologic issues in seeking improved definitions of healthy aging, and the adaptation and development of research methods and instruments that yield findings that are comparable across and valid within settings.

Conclusions

Epidemiologic evidence of behavioral determinants of healthy aging such as those presented in this review is essential in the preparation of effective measures of health promotion and disease/disability prevention in global planning for the well-being of the elderly.30 A major challenge is to discover the best ways to apply this evidence to encourage people to adopt and maintain healthy lifestyles.31 Further research in this area needs to concentrate on appropriate models/definitions of health determinants and outcomes, as well as analytic techniques in studies of healthy aging.

References