Numerous changes in body composition occur after the seventh decade of human life. Decreased bone mass, changes in the size of body organs, decreases in skeletal muscle and body water, and changes in body fat may be singly or jointly responsible for losses in lean and fat body mass. Age-related decline in stature is a common observation, but its physiological or clinical importance to health outcomes is unknown (1). Although there are few reports on population-based longitudinal studies of anthropometric measures in elderly men and women (2), it has been observed that weight changes after age 50 are generally associated with deterioration in nutritional and overall health (3–5) and mobility (5).

Data on the evolution of anthropometric parameters in the elderly population are equivocal. Among healthy elderly subjects recruited for the New Mexico Aging Process Study (APS), which began in 1979, and the Toulouse Aging Project recruited for the New Mexico Aging Process Study, which started in 1991, investigators have reported (3–5) and mobility (5).

In the New Mexico APS participants, height declined with age, both cross-sectionally and over time, but weight did not change over time in men. Among women, weight decreased at the rate of 0.14 kg/year (8). In the EC/Euronut Survey in Europe on Nutrition and the Elderly, a Concerted Action (SENECA) study of healthy elderly men and women (2), average body weight showed only small mean differences over time, but weight did not change over time in men. Among elderly Canadian CSHA participants, particularly in the very old and those with dementia. Such longitudinal anthropometric data are needed along with information on dietary intakes, and medical, cognitive, and functional measures to plan interventions geared to maximizing nutritional and overall health in the elderly population, whatever their cognitive status.

Conclusions. Body weight and stature declined with aging among elderly Canadian CSHA participants, particularly in the very old and those with dementia. Such longitudinal anthropometric data are needed along with information on dietary intakes, and medical, cognitive, and functional measures to plan interventions geared to maximizing nutritional and overall health in the elderly population, whatever their cognitive status.
found to be protective for both men and women, and mortality was linked to factors associated with unintentional weight loss (10). Losonczy and colleagues (4) found that weight lost between middle and older age increased mortality risk after the age of 70. They proposed that low weight was indicative of poor health and decline in health led to an increased mortality risk. Yaari and Goldbort (11), looking at weight changes and mortality among Israeli men, found that all-cause mortality linked to weight loss was greatest among the initially leanest individuals. Unlike Meltzer and Everhart (10), Yaari and Goldbort’s results (11) appear to indicate a possible increase in mortality risk related to attempts to alter weight. Willett (9) has suggested that diminished lean body mass (contributing to weight loss) leads to poor health, whereas decreased fat mass (also leading to weight loss) would, in contrast, be associated with improved health. Thus, numerous authors urge investigators to consider weight history and weight change when undertaking analyses of body weight and health risks in those older than 70 years of age (3–4,9).

To our knowledge, longitudinal data on height and weight have not previously been published in a cohort of elderly Canadians. This study documents and examines correlates of anthropometric characteristics and their evolution over a 5-year period in a subsample of elderly Canadians who had taken part in both phases the Canadian Study of Health and Aging (CSHA) (12). Such information can aid in identifying high-risk target groups who could benefit from nutritional intervention. The data were examined separately for community-dwelling and institutionalized participants and explored age, gender, and two measures of cognitive status as correlates of anthropometric changes. Given the literature on body weight and dementia, we expected that decreases in weight and in BMI from the two phases of the CSHA, CSHA-1 to CSHA-2, would be greater in elderly individuals with dementia compared with those individuals who were cognitively intact.

METHODS AND MATERIALS

CSHA

The CSHA was conducted in two phases, with a nationwide prevalence study of dementia in 1991–1992 (CSHA-1), and a longitudinal follow-up phase in 1996 (CSHA-2) designed to assess the incidence of dementia in the aging Canadian population (12). People aged older than 65 years were randomly selected using recruitment procedures that differed for those living in the community (n = 9008) and in institutions (n = 1255). Briefly, 36 sample areas defined by feasibility criteria (e.g., accessibility to study centers) were designated across Canada. This sample frame covered around 60% of Canadians aged older than 65 years living in cities and their surrounding rural areas. The community-dwelling sample was recruited from provincial health insurance databases, except in Ontario, where electoral lists were used. The institutionalized sample was made up of a stratified representative sample of nursing homes, chronic care facilities, and collective dwellings from which residents were randomly selected and then recruited.

Cognitive Status

Community-dwelling participants were screened by interviewers for cognitive impairment using the modified Mini-Mental State Examination (3MS) (13), a clinical tool for grading patients’ cognitive status modified from the Mini-Mental State Examination (MMSE) (14). It has a 16-item grid addressing memory, mental processes, temporal orientation, spatial orientation, word associations, semantic associations, and ability to follow instructions. The maximum score is 100. Patients are scored as normal (≥78), having mild cognitive impairment (66–77), declining cognitive abilities (50–65), or severe cognitive difficulties (<50). The untestable, those patients testing positive for dementia, and a random sample of control subjects (having a reference person willing to complete study instruments designed for proxy respondents) underwent a clinical examination. All institutionalized participants who met inclusion criteria (spoke English or French, and lived in the study area) took part in the clinical examination. The 3MS was readministered by a nurse during this clinical assessment. The final cognitive diagnosis was reached by consensus of the clinician, another physician, and a neuropsychologist, aided by the nurse who had administered the clinical questionnaire, using criteria from the Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition (15). Participants who were not consistent with dementia criteria, but who manifested cognitive impairment, were termed “cognitively impaired, not demented” (CIND), by exclusion.

Participants and Measures

Following the clinical exam recruitment procedure described previously, height and weight were measured in the CSHA-1 in 1464 (16.3%) community-based participants and 963 (76.7%) institutionalized participants. In CSHA-2, 728 community-dwelling subjects and 298 institutionalized subjects were reassessed in clinics, and height and weight were remeasured in 521 (71.6%) and 160 (53.7%) participants, respectively. These measurements were carried out during the clinical examination by nurses who were trained to follow procedures described in the nurse’s study manual. It should be noted that different nurses might have obtained these measurements, as some study personnel changed in the 5-year interval from CSHA-1 to CSHA-2. Participants were lost to follow-up in phase 2, mainly due to death (38.5%, community; 65.5%, institutions) or refusal/noncontact (11.7%, community; 3.5%, institutions; Figure 1).

Data Handling and Analyses

As with the CSHA-1 data (16), all CSHA-2 analyses were conducted separately for community-dwelling versus institutionalized participants to reflect the different recruitment strategies used. Data were stratified by sex, age group, 3MS score (obtained by the nurse during the clinical exam), and cognitive diagnosis. Subcategories of dementia (mainly Alzheimer’s dementia, as well as vascular or Parkinson’s dementia, or another unknown etiology) were tested for differences (none were found) before being grouped into a single category. Because White and colleagues (17) have suggested that weight loss differences in older men and women may not reflect a differential effect of cognitive decline by
gender, it was decided not to further stratify age and cognitive status analyses by gender. Although cultural or ethnic origin may influence anthropometric values, 99% of participants were Caucasian, and 45% identified themselves simply as “Canadian,” almost 30% as “French Canadian,” and the remaining 25% were distributed into around 15 different groups. This made ethnic subgroup analyses untenable.

The distribution of independent variables was examined in the subsamples (institution and community). A systematic review by clinicians and researchers verified height and weight data for plausibility. As a result, 54 participants with unacceptable values (increase in height from CSHA-1 to CSHA-2, substantial and implausible divergence in height and/or weight from CSHA-1 to CSHA-2, or unlikely weight for gender or height) were excluded from this set of analyses. BMI (weight [kg]/height [m$^2$]) was calculated. The significance of changes in the dependent variables of height, weight, and BMI from CSHA-1 to CSHA-2 was tested in each sample using paired t tests, and the extent of differences within and interactions across categories (independent variables of gender, age, 3MS score, and diagnosis) was assessed by repeated-measures multivariate analysis of variance (MANOVA), testing separately for 3MS score and cognitive diagnosis. Analyses were conducted using the SPSS V8 software package (SPSS, Inc., Chicago, IL).

**Results**

Participants in CSHA-2 retained the recruitment status (institution or community) established in CSHA-1, whatever their residence situation at the time of this second phase of the CSHA. Body weight was available for 249 institutionalized and 603 community-dwelling subjects. Of these, 237 (95.2%) in institutions, and 584 (96.8%) community-dwelling participants had plausible data at both phases. Height was measured in fewer subjects, limiting the calculation of BMI to those with both measurements. Approximately 18% of institutionalized subjects and 44% of community-dwelling participants were diagnosed as cognitively intact; 50% and 27%, respectively, were diagnosed with dementia; and the remaining were CIND (data not presented). Means and SDs, along with the 10th, 50th, and 90th percentiles, stratified by age, sex, 3MS score, and cognitive diagnosis, were used to present changes in weight (Table 1) and height (Table 2) from CSHA-1 to CSHA-2 in community-dwelling participants. Age, screening, and diagnosis variables reflected values in CSHA-2.

Among the 584 community-dwelling participants retained in these analyses, of whom 74% were aged 80 years or older (Table 1), a mean weight loss of around 2 kg ($p < .001$) was noted, and there were statistically significant weight losses in each level of the stratification categories (gender, age, screening score, and diagnosis). MANOVA demonstrated significant interactions between gender and age, and inspection of the marginal means (not presented) showed weight losses to be most pronounced in community-dwelling subjects aged 70 to 79 years with dementia (3 kg; $p < .001$). Among those diagnosed as cognitively intact, weight loss was greater in those under 90 years ($p < .01$). In general, average weight loss in community-dwelling participants ranged from 1.5 to 3 kg ($p < .01$ to $p < .001$). Similarly, among 237 institutionalized participants (73% aged 80 or older), an average weight loss of around 2 kg ($p < .001$) occurred in the 5-year period from CSHA-1 to CSHA-2. Most institutionalized subgroups had statistically significant weight losses, ranging from 1.8 kg ($p < .05$) in those with 3MS scores ≥78, to 4 kg ($p < .001$) in patients aged

![Figure 1. Canadian Study of Health and Aging (CSHA) anthropometric measures, phases 1 and 2.](https://academic.oup.com/biomedgerontology/article-abstract/56/8/M483/578070)
90 years or older, but there were no significant differences or interactions when compared across categories by MANOVA (data not presented).

Community-dwelling participants measured in both phases of the CSHA (Table 2) had an average height loss of 1.4 cm ($p < .001$). Although statistically significant losses in height were recorded in all stratification categories, there were no differences in the extent of height loss within groups. There was also a decrease in height of 2 cm ($p < .001$) in the 148 institutionalized participants and statistically significant height losses in most levels of the stratification categories. Repeated-measures MANOVA showed the height loss in institution-dwelling participants to be greatest in men aged 90 years or older ($p < .005$; data not presented).

The calculation of changes in BMI was limited to those individuals with both height and weight data in CSHA-1 and CSHA-2. Thus, BMI was determined for 140 institutionalized participants and 487 of those in the community. Overall average BMI was 24. Despite BMI changes in some stratification categories, among institutionalized participants, the average BMI did not change from phase 1 to phase 2, while in community-dwelling participants, the small mean decrease in BMI from CSHA-1 to CSHA-2 was without clinical importance (data not shown).

**Discussion**

The present series of analyses in a cohort of elderly Canadians showed a decline in body weight and stature with aging (more pronounced among the very old and persons diagnosed with dementia), partially confirming the findings of other longitudinal studies in elderly cohorts (2,8). Our findings thus support the age-related decline in stature reported in the longitudinal phase of the SENECA study of healthy

### Table 1. Weight Changes From CSHA-1 to CSHA-2 for Subjects Designated as Community Dwelling CSHA-1

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>3MS Score</th>
<th>Age (y)</th>
<th>Weight, CSHA-1 (kg)</th>
<th>Weight, CSHA-2 (kg)</th>
<th>Weight Difference, CSHA-2 − CSHA-1 (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td></td>
<td>$&lt;78$</td>
<td>16.2 ± 9.8 (152.0, 163.0, 175.0)</td>
<td>14.6 ± 4.5 (149.0, 160.0, 175.0)</td>
<td>$-1.6 ± 4.3 (7.4, -10.3, 3.7)$***</td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td>$≥78$</td>
<td>157.3 ± 6.7 (150.0, 157.0, 166.0)</td>
<td>155.6 ± 6.7 (148.0, 154.0, 165.0)</td>
<td>$-1.7 ± 4.8 (7.9, -17.3, 3.9)$***</td>
</tr>
<tr>
<td>CIND</td>
<td></td>
<td>$&lt;78$</td>
<td>157.3 ± 6.7 (150.0, 157.0, 166.0)</td>
<td>155.6 ± 6.7 (148.0, 154.0, 165.0)</td>
<td>$-1.7 ± 4.8 (7.9, -17.3, 3.9)$***</td>
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<td></td>
<td>$≥78$</td>
<td>157.3 ± 6.7 (150.0, 157.0, 166.0)</td>
<td>155.6 ± 6.7 (148.0, 154.0, 165.0)</td>
<td>$-1.7 ± 4.8 (7.9, -17.3, 3.9)$***</td>
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<tr>
<td>Dementia</td>
<td></td>
<td>$&lt;78$</td>
<td>157.3 ± 6.7 (150.0, 157.0, 166.0)</td>
<td>155.6 ± 6.7 (148.0, 154.0, 165.0)</td>
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**Notes:** Values are mean ± SD. Numbers in parentheses reflect 10th, 50th, and 90th percentiles, respectively. Age, 3MS score, and diagnosis reflect CSHA-2 status.

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The present series of analyses in a cohort of elderly Canadians showed a decline in body weight and stature with aging (more pronounced among the very old and persons diagnosed with dementia), partially confirming the findings of other longitudinal studies in elderly cohorts (2,8). Our findings thus support the age-related decline in stature reported in the longitudinal phase of the SENECA study of healthy

### Table 2. Height Changes From CSHA-1 to CSHA-2 for Subjects Designated as Community Dwelling in CSHA-1

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Height, CSHA-1 (cm)</th>
<th>Height, CSHA-2 (cm)</th>
<th>Height Difference, CSHA-2 − CSHA-1 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>162.9 ± 9.8 (152.0, 163.0, 175.0)</td>
<td>149.9 ± 8.1 (147.0, 158.0, 168.0)</td>
<td>$-3.0 ± 4.8 (7.9, -17.3, 3.9)$***</td>
</tr>
<tr>
<td>CIND</td>
<td>157.3 ± 6.7 (150.0, 157.0, 166.0)</td>
<td>155.6 ± 6.7 (148.0, 154.0, 165.0)</td>
<td>$-1.7 ± 4.8 (7.9, -17.3, 3.9)$***</td>
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elderly men and women (2). However, they differ from most of the SENECA study sites’ ponderal data, as well as the APS observation of relatively stable body weights over time (2,6–7). It must be remembered that the APS (6–7) and the SENECA (2) cohorts were assembled from healthy community-dwelling volunteers, while the Canadian study design was built around the objective of studying cognitive impairment in community- and institution-dwelling elderly persons. In addition, the CSHA participants were older, on average, than members of the former cohorts. These basic differences render comparisons difficult.

Changes in BMI over time can result from alterations in stature or body weight, or both, and the latter is largely dependent on a number of potential changes in body composition (1). Statistically significant decreases in BMI, observed in some subgroups of CSHA community-dwelling subjects (data not shown), were too small to have clinical significance. Indeed, they may have resulted from measurement or statistical artifact. Still, an examination of temporal changes in this parameter may provide valuable information about the evolution of nutritional status in elderly persons, in spite of controversy over the usefulness of BMI in elderly individuals, because of the loss of stature and other age-related changes in body composition (2). Loss of height could reflect the consequences of specific conditions or illnesses (e.g., hip or vertebral fracture resulting from osteoporosis) on skeletal integrity, or may result from the elderly person’s inability to fully extend hip or knee joints. Other conditions (e.g., sarcopenia resulting from diminished mobility) may be responsible for the weight differences observed in CSHA-2 compared with CSHA-1.

Concerns relating to the data must be addressed, particularly because this study reports on secondary data analyses. Although initial overall sampling was representative of the Canadian elderly population, only those CSHA participants undergoing clinical examination were weighed and measured. In addition, a substantial proportion was lost to follow-up (see Figure 1), mainly due to death. Still, there is no reason to suspect bias in the selection of those for whom data were available. The present analyses did not consider CSHA-1 decedents. Rather, the data presented here reflect anthropometric values in the surviving members of the cohort and, as such, can be said to represent survivors of the 5-year follow-up period. Since subjects in the oldest age categories were oversampled in the community, the community-dwelling cohort may not be strictly representative of the home-dwelling elderly population. Health status at the time of these analyses was not considered. Therefore, we could not distinguish between age-related decreases in anthropometric parameters and those caused by illness (e.g., cancer-related weight loss or osteoporosis leading to diminished stature), which may be masked since anthropometric data were gathered at only two time points. Finally, it must be cautioned that some statistically significant differences may be attributed to chance, which increases when numerous statistical tests are performed. Despite these concerns, the present analyses provide much-needed and useful data on anthropometric values in elderly Canadians, adding cognitive status to the more commonly reported correlates of age and gender.

To increase our understanding of changes that occur with successful, useful, or pathological aging, elderly populations should be studied longitudinally, and data collected on key anthropometric measurements along with relevant health and functional variables. The CSHA was designed to assess the prevalence and incidence of dementia and related issues in elderly Canadians. Although there is substantial controversy on this issue, it has been suggested that the weight loss typically associated with cognitive disorders, such as Alzheimer’s disease, may not be an automatic feature of the disease. Persons afflicted with this type of dementia may therefore benefit from early dietary interventions designed to improve or maintain their nutritional status and slow the onset of malnutrition, which leads to weight loss and attendant complications, including increased mortality (18,19).

The present compilation of data on longitudinal changes in basic anthropometric characteristics in a cohort of elderly Canadians suggests the need for expanded nutrition research. This should include information on dietary and nutritional intakes, well-being and environmental predictors, as well as medical, cognitive, and functional status, in order to plan interventions geared to preserving nutritional and overall health in the elderly population, whatever their cognitive status.

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