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BIOLOGICAL FUNCTION, ACTIVITY AND DEPENDENCY AMONG ELDERLY SHERPA IN THE NEPAL HIMALAYAS

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Abstract—This paper considers a model contrasting the aging experience of Western and non-Western populations through consideration of the hypothesized interrelationships among four factors (biological change with age, dependency, family structure and the aging experience) in a non-Western setting. Western views of the contrast in the aging process in Western industrial and traditional pre-industrial societies include the notion that traditional societies manifest relatively slow rates of biological aging, and have extended family structures which accommodate the elderly resulting in few aging problems. On the basis of data deriving from a case study of Sherpas in Helambu, Nepal, the model appears to be an oversimplification and suggestions for revision are offered.

INTRODUCTION

Biological aging takes the form of morphological involution leading to a gradual decline in the performance of individuals[1]. The rate, causes and consequences of this involution are major questions for the science of gerontology and ones which assume ever greater importance as the numbers of people living to long chronological ages increase globally. In the quest for solutions to the aging problem in developed countries we have occasionally sought information from traditional societies. Despite a paucity of systematic study, several ideas about aging in traditional non-Western societies grew and persist. These are summarized in the model presented in Table 1. A central component of the model is the explicitly and frequently stated concept that a state of dependency is universal among the elderly[2–4]. This stems from the reasoning that physical capacity declines as aging progresses and results in a decline in an individual's capability to be a self-supporting member of society. He must then receive goods and services from others to survive, that is, become dependent. This state of dependency is viewed pejoratively and is considered the basis of many facets of the aging problem in Western society.

On the other hand, some scholars postulate that the aging process poses no problem for traditional societies. They cite two reasons. One is that people in traditional societies retain their faculties and physical fitness longer due to a slower rate of loss and lack of debility and senility that results from maintaining their productive social and economic roles and living in rugged environments[5]. A second reason argues that the traditional family structure accommodates the elderly in routine and satisfying ways since in the normal course of the family cycle, one or more adult children remain in the parental household, assume productive responsibilities, and provide needed support to aging parents. These inconsistent views require investigation and perhaps revision. The purpose of the present paper is to report some results of a study addressing these issues in a traditional society through systematic consideration of the components of the model.

MATERIAL AND METHODS

Sample

Sherpa society represents an excellent setting to examine these issues. Sherpas are a Tibetan speaking, Buddhist population inhabiting rugged mountainous areas in Nepal. The data were collected over a 6-week period during July–August 1979 in the contiguous Sherpa villages of Norbugyang and Pemagyang (pseudonyms) situated at an altitude of 2800 m, in Helambu, an area two days' walk from Kathmandu. Together these villages contained 75 households and 279 residents.

Norbugyang and Pemagyang are rural agricultural communities where the mode of subsistence and diet remain traditional. A census of the villages revealed that 28% of the residents are over 45 and 11% of the residents are over 60 years of age. It is possible to obtain accurate Western chronological age estimates from Sherpas because they use the traditional Tibetan system of naming years in a 60 year cycle. Individuals

Table 1. Western concepts of the contrast in the aging process between Western industrial and traditional pre-industrial societies

Society	Relative rate of biological aging	Degree of dependency in elderly	Family structure	Aging problems
Traditional, pre-industrial	Slow	High	Extended	No
Western, industrial	Fast	High	Nuclear	Yes

know their named birthyears which are easily transposed into a Western date of birth.

Sampling for the study began with persons aged 45 and over for two reasons. This is the youngest age at which Sherpas would have adult children upon whom they could rely if necessary. This is also the decade when many functional and anthropometric measurements begin to change with age[6]. The sample, consisting of 43 persons, represents 60% of the population over 45 and all but 5 of the 29 residents over 60. The average age of the 19 males is 61 and of the 24 females is 62 years. These subjects provided several types of information including (1) anthropometric and pulmonary functional measurements taken according to standard protocol[7], (2) activity and dietary information obtained through previous-day recall interviewing, and (3) demographic data pertaining to fertility history and household composition, and (4) cultural information concerning definitions of aging, perceptions and evaluations of the elderly's situation, and Sherpa social and economic structure.

ANALYSIS

The study sought to measure biological aging by measuring a range of morphological characteristics reflecting underlying morphological involution and at some level, presumably functional capacity. A group of anthropometric measurements reflecting parameters which show age related variation among some Western populations was taken. Correlation–regression analysis permitted testing the hypothesis that these change with age in the non-Western Sherpa population. This provided a means of comparing age differences among the Sherpas with those among samples drawn from Western industrial populations.

For those measures which change with age in the Sherpa population, the percent change per decade was calculated from the regression equations. For this same set of measures, the change per decade was calculated for Western population samples by using the published sample means. The mean value of the measurement at the later age was expressed as a percent of its value at the younger age, and a rate of change was obtained by dividing the percent change by the number of decades. Western samples whose upper and lower ages were as close as possible to 40 and 80 years of age were selected so as to cover the same age span as the Sherpa sample. Relative rates rather than absolute values of change were employed in order to standardize the data for comparison between populations of very different young adult body size.

A second analytic approach measured variation in biological age within the population. It assessed an individual's (or a sub-population's) biological age relative to his chronological age peers by utilizing the standardized residual score of each of the age related variables for each individual[8]. The residual represents the individual's departure from the regression estimated population mean at that age. For negatively sloped characteristics such as height, a negative residual indicates that an individual's height lies below the population mean and in this particular context will be interpreted to indicate that the individual has a relatively greater biological age. So that older individuals have greater scores, the standardized residuals of negatively sloped characteristics were multiplied by negative one.

Applying this procedure to each of the age related characteristics for each sex, a biological age profile for an individual or a group may be constructed[8]. In this case, differences in the relative biological ages of (1) elderly people living alone, (2) elderly couples and (3) those in extended families, were examined using a one-way analysis of variance. Thus the association between an individual's biological age profile, used as

Table 2. Percent change per decade in morphological measurements significantly correlated with age ($P < 0.05$) among adult male Sherpas, Helambu, Nepal compared with those in Western samples (the regression coefficients with age and their standard errors are indicated)

Measurement	Age $b \pm SE_b$	Percent change per decade in Sherpa sample, calculated from regression equation	Percent change per decade in western samples calculated from published means	Sources
Weight	-0.42 ± 0.28	−3.3%	−1.2% to −5.4%	[10–14]
Height	-0.19 ± 0.49	−1.1%	−0.7% to −1.0%	[11–13]
Sitting height	-0.21 ± 0.07	−2.4%	−0.08 to −1.4%	[10–12]
Transverse chest diameter	-0.04 ± 0.03	−1.5%	−0.3%	[12]
Upper arm circumference (left)	-0.15 ± 0.48	−5.8%	−2.0 to −3.4%	[12, 15]
Grip strength (right hand)	-0.62 ± 0.10	−25.0%	−6.6% to −14.7%	[11 (preferred hand), 12, 16]
Grip strength (left hand)	-0.51 ± 0.13	−3.5%	−6.6% to −13.8%	[11 (preferred hand), 12, 16]
Forced vital capacity	-0.04 ± 0.02	−12.9%	−18.6%	[14]

Table 3. Percent change per decade in morphological measurements significantly correlated with age ($P < 0.05$) among adult female Sherpas, Helambu, Nepal compared with those in Western samples (the regression coefficients with age and their standard errors are indicated)

Measurement	Age $b \pm SE_b$	Percent change per decade in Sherpa sample, calculated from regression equation	Percent change per decade in western samples calculated from published means	Sources
Height	-0.44 ± 0.10	−2.8%	−0.5% to −1.5%	[10, 11, 17–20]
Sitting height	-0.22 ± 0.06	−2.7%	−1.0% to −1.7%	[10, 11, 17]
Iliac height	-0.22 ± 0.07	−2.4%		
Biacromial width	-0.08 ± 0.03	−2.5%	−1.0% to −1.1%	[10, 17]
Armspan	-0.37 ± 0.11	−2.3%	+0.5%	[18]
Grip strength (left hand)	-0.23 ± 0.07	−23.7%	−6.4% to −13.0%	[11 (preferred hand) 16, 20]

an indirect measure of functional dependency, and family structure is tested.

RESULTS

The portion of the model contrasting relative rates of biological aging is considered using anthropometric and functional measures. Among the more than two dozen measures, 8 are significantly correlated with age among Sherpa males between the ages of 45 and 84. Several of these are themselves correlated, for example, sitting height and height. Table 2 presents the change per decade in a variable by presenting the percent difference in the anthropometric variables between individuals born ten years apart. This is calculated from the regression equations of the 8 measures: weight, height, sitting height, transverse chest diameter, left upper arm circumference, right and left hand grip strengths and Forced Vital Capacity (FVC).

Table 3 presents analogous information for the 6 measurements significantly negatively correlated with age among female Sherpas aged 45–87. These are height, iliac height, sitting height, biacromial diameter, armspan and left hand grip strength.

Some measures such as systolic and diastolic blood pressure; bi-iliac diameter, triceps and sub-scapular skinfold measurements which do change with age in other populations do not do so among the Sherpas. There is a borderline association between systolic blood pressure and age among females. Although the average female systolic blood pressure in this sample is 112 mm Hg, two females in their seventies have systolic blood pressures greater than 160 mm Hg. This yields a systolic hypertension frequency of 25% among females aged 65–74 compared with a U.S. frequency of 46.9%[9].

For those measures significantly associated with age, comparison of the percent decline per decade manifested in the Sherpa sample and in several Western population samples indicates that they are very similar (refer to Tables 2 and 3). For example, height declines between 0.7 and 1.0% per decade among several samples of Western males compared to 1.1% among Sherpa males[11–13]. Weight declines between 1.7% and 5.4% per decade among several samples of Western males compared to 3.3% among Sherpa males[11–14]. A similar pattern exists among females. In several Western samples, height declines between 0.5 and 1.1% per decade compared to 2.7% among Sherpa females[11, 15, 17–20].

With regard to the family structure aspect of the model, a striking finding is that 10 of the 75 households in these villages contained a sole person, ranging in age from 59 to 87. Among the 11 2-person households, 8 are elderly couples. 60% of the population over 60 and 73% of the population over 70 live in one or two person households. Among these, only one unmarried man and one unmarried woman (a nun) have no children. All others have at least one surviving child; 9 have surviving sons. It is therefore theoretically possible for virtually all these individuals to be living with adult children.

The hypothesis that those living in extended families are doing so because their aging processes have progressed more rapidly and they are therefore more 'dependent' due to greater loss of function is tested by examing their biological age profiles compared with elderly living alone or as a couple. Biological age profiles utilizing the age-related characteristics were constructed for 3 subpopulations of elderly Sherpas: those living in single person households, in 2-person housholds and in households of 3 or more people. These are illustrated in Fig. 1. There is no statistical difference in the average biological age among the sub-populations in any parameter comprising the profiles nor is there a consistent pattern difference.

DISCUSSION

Data examining the various components of a model contrasting the aging processes of Western and non-Western populations were presented. With regard to biological aging in Western and non-Western populations, two general results were obtained. Supporting the hypothesis that Western and non-Western aging are dissimilar, as the standard model proposed, is the finding that many of the parameters measured do not vary significantly with age among the Sherpa, for example, bi-iliac diameter, subscapular and triceps skinfolds and blood pressure. Therefore, certain features identified as normal aging on the basis of Western experience may not be inevitable concomi-

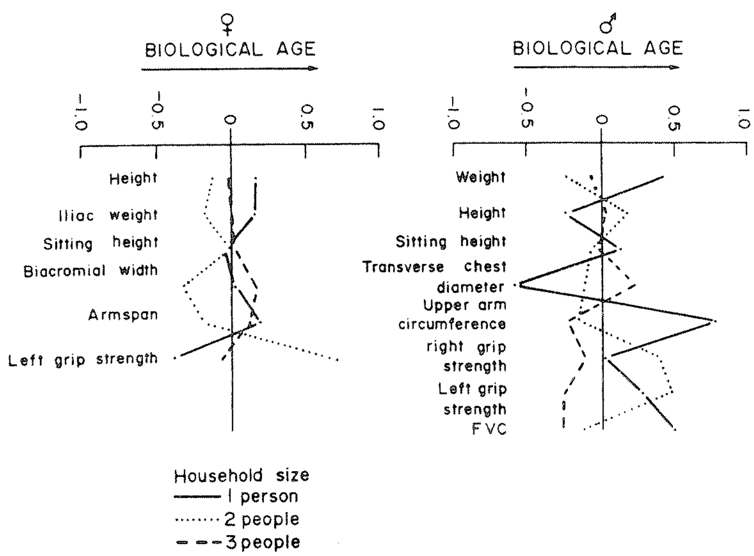

Fig. 1. Biological age profiles of elderly Sherpa living in households of one, two and three or more people.

tants of the passage of time. This demonstrates the need for future research to measure a wide range of phenomena cross-culturally in order to uncover patterns of association and constellations of features which change together or independently within and between different populations.

Arguing against the hypothesis that non-Western and Western aging is dissimilar is the finding that among the variables which do change with age such as height and sitting height, the change occurs among the Sherpas at about the same rate per decade after the age of 40 as Western samples. The somewhat greater age related decline among the Sherpas reported in Tables 2 and 3 may reflect the different method of calculating the percent decline. Since the rate of aging accelerates with age[6, 21] the slightly older Sherpa sample may also account for this finding. It is the case that the oldest age categories for many of the published Western samples were in the 70's.

The change in some characteristics may be an artifact of secular trend rather than aging. Separating the possible effects of aging from secular trend is problematic in a cross-sectional sample. One approach relies on the observation that long bone length does not shorten with age and does reflect secular trend[18–21]. Two measures available for this sample, iliac height and armspan, reflect primarily long bone length. The lack of age differences in these two measures among male Sherpas is indirect evidence that secular trend may not have occurred. The decline in sitting height which contributed to the statural decline therefore may be a time related phenomenon reflecting shrinking of the intervertebral discs[6, 21].

The situation differs among female Sherpas. The greater armspan and iliac heights among younger Sherpa women may reflect secular trend in length of the long bones. However, the decline in biacromial width also contributed to the decline in armspan among Sherpa women. One may speculate that both aging and secular trend are manifested by female Sherpas. Larger samples of women including younger women and more detailed knowledge of local history to ascertain changes which could have produced a secular trend are necessary to strengthen the argument which in any case remains indirect so long as it rests on a cross-sectional sample.

While the rough techniques used for comparison in this paper require refinement in future research, overall the Sherpa findings suggest both similarities and contrasts between the experience of biological aging in Western and non-Western populations.

The model in Table 1 includes a dependency component which is considered in detail in Beall and Goldstein[22]. This component will be examined briefly here from the biological perspective. Two sets of data are available to examine the idea that dependency increases with age. These are the biological age profiles and recall activity interviews. An important issue is to determine to what extent age related biological change affects the ability to provide for oneself. It is possible that those biologically the oldest have lost function to the degree that they must depend on others for goods and services (see [22]). Alternatively, aging people may simply lose their reserves of function above that normally used so that while function declines with age, it does not result in dependency, i.e. it does not require receipt of goods and services and residence with children or others. The data show that on the basis of the biological aging profiles, it is not the case that those living alone or with a spouse are the youngest biologically. Conversely, those who are living with other family members are not the oldest biologically.

The second set of data derives from recall activity interviews with 30 different people over the age of 50 obtained on 15 different days during the peak agricultural season which yielded a total of 69 person-days of activity observations. Heavy labor, defined as load carrying or field work is undertaken at least once on 91% of the male and 87% of the female person-days of observation. The work pattern does not vary with age into the 80's. Thus one reason for the lack of association between biological age profiles and household composition may be a high degree of functional capacity in nearly everyone. These elderly Sherpa maintain activity, control the means of production, have wealth, influence, and relatively good health, and do not appear to be dependent from the standpoint of various dimensions of dependency. Since mortality during adulthood is low prior to the ages of about 60 or so even in traditional societies such as this, it is unlikely that these elderly represent a group of survivors subjected to heavy selection in adulthood[23–25]. The possible influence of high infant and child mortality acting to screen out individuals during childhood who might otherwise survive to become decrepit adults is not known. These findings support the argument that sustained physical and useful economic activity create a situation where the elderly retain their physical abilities, i.e. age without "debility and senility"[5]. It also supports the theory that life in rugged mountainous environments such as those in Helambu is especially associated with sustained physical exertion and thus the maintenance of physical abilities[5].

Leaf[5, p. 84] however, also argues that psychological factors are significant in aging without debility and senility. In turn, this is related, he postulates, to the degree to which the elderly "continue to work and to participate in the economy and social life". There is no retirement in traditional societies as in the West, and although the "vigor of the activity may be curtailed, ... activity remains nonetheless". Leaf also comments on the significance of social status, of how the society and the young regard the elderly, for the maintenance of physical and mental abilities. The Sherpa data indicate a more complex situation wherein physical and psychological factors are separable. Despite their physical capability, the absence of senility and debility, and their continuation of productive economic activities, most of the elderly Sherpas were unhappy and dissatisfied with their personal situation, particularly those living alone. Physical capability, economic resources and self-reliance do not in and of themselves produce psychological and emotional well-being for the elderly. The dynamics of this situation are examined elsewhere[22].

The final component of the model in Table 1 refers to the presence or absence of an aging problem in Western and traditional societies. Whether or not an aging problem exists may depend upon the perspective with which the situation is viewed. In Helambu, from the observer's point of view, the 'etic' perspective, there is little problem—people are physically and mentally capable of supporting themselves by their own labors and do so. They are self-reliant. From the Sherpa participants' point of view, the 'emic' perspective, cultural expectations associated with family life are not being met and consequently there is an aging problem. A great deal of the confusion in cross-cultural studies of aging may derive from the fact that ethnologists generally report the emic view and physical anthropologists the etic.

CONCLUSION

The Helambu Sherpa do not experience the age related changes in some physical characteristics that Western samples experience. Some Sherpa characteristics do change with age and do so at about the same rate as among Western samples. There is no apparent association between the relative biological ages of Sherpas and their household compositions. That is, the declines with age in some physical and functional characteristics apparently do not result in physical dependency (as inferred from household composition). Despite this lack of physical and economic dependency and despite the maintenance of economic productivity, the Sherpa express unhappiness over their personal situations.

The postulated components of the standard model contrasting non-Western and Western aging include the rate of loss of function, dependency, family structure and the existence of an aging problem. Clearly the standard model requires revision on the basis of these Sherpa data. It is difficult to present alternatives at sufficient levels of generalization to cover all possibilities. It appears that the contrasts are overdrawn and some of the concepts are oversimplified and ethnocentric. Looking at each component of the model in turn, a revised model should ideally consider individual and population variation in the change of specific physical characteristics, the associations among biological characteristics, and their rate of loss and the factors influencing these. It should incorporate more dimensions into the concept of dependency in order to separate physical, economic, emotional, demographic, etc. aspects, consider their interactions and examine their relationship with biological aging on the one hand and sociocultural factors on the other. The family structure component of the model may be at too specific a level. Sociocultural factors including expectations and current conditions may be a more appropriate level of generalization within which factors such as family structure and sociocultural expectations may be included. The evaluation of the presence or absence of an aging problem also requires examination of more accurately specified factors. Incorporation of the emic/etic contrast frequently utilized by anthropologists will be helpful in constructing more useful conceptual frameworks and in evaluating issues such as dependency and aging as discussed in this paper.

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