# Uses of anthropometry in the elderly in the field setting
## with notes on screening in developing countries

Noel W. Solomons MD, Manolo Mazariegos MD and Ivan Mendoza MD, MSC

*Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM), research branch for the National Committee for the Blind and Deaf of Guatemala, Guatemala City.*

A field setting can be defined as any setting outside of a fixed, permanent, and sophisticated health facility or research laboratory. The most important applications of anthropometry at field level include biological anthropology, epidemiology, clinical application, and metabolic research. Data collecting in the field setting requires different levels of accuracy and precision; the standardization should also consider intra- and inter-observer variability due to the possibility of more than one observer participating in a given survey. A field setting, in contrast to the laboratory setting, involves special conditions that challenge the application of anthropometry. The required equipment is different and the conditions of data collection are less rigorous. Issues intrinsic to the target group – of education, culture and sophistication – might be limiting factors for carrying out anthropometric surveys in field settings.

Another issue is related to interpretation of the biological, nutritional and health significance of anthropometric findings in relationship to the elderly. Uncertainty regarding the accuracy of chronological age, and geography and differential survival of the elderly should be considered when designing a survey. In addition, because the majority of the elderly now live in developing countries, short stature should be a common finding in the age groups from these regions. It is in these short-stature elderly populations, that there is a problem interpreting and applying anthropometric norms or references for height or weight derived from elderly populations of developed countries.

In conclusion, although the application of anthropometry to the field setting is feasible, given its enormous importance to gerontological biology, nutrition and health, researchers should consider a series of factors and paradigms when designing and carrying out anthropometric surveys at the field level.

### Introduction

*What is a field setting?*

International research has a romantic mystique about it, and the term 'field setting' conjurs up images of Jane Goodall studying ape colonies, or some pith-helmet adorned archeologist scraping dirt from an Egyptian burial site.

Field setting should be defined by exclusion, and includes, for us: 'Any setting outside of a fixed, permanent and sophisticated health facility or research laboratory'. In a US perspective, the entire operation of the National Health and Nutrition Examination Surveys (NHANES) studies based in mobile trailers is a valid example of a field setting.

### Applications of anthropometry in the field setting

Given this broad and comprehensive definition of the field setting, a large number of applications are conceivable. Table 1 lists a series of field applications of anthropometry which could involve elderly populations.

*Biological anthropology*

The most creative and exploratory application of anthropometrics may be in the field of biological anthropology. Since this discipline has traditionally used the dimensions of mineralized structures (bones, dentition) as the subjects of study in a *living* population, the strategy would be to try to compare measurements of *comparative* indicators of the living body with skeletal and fossilized skeletal specimens. To some extent,

Table 1. Field applications of anthropometry involving elderly populations

| |
|---|
| Biological anthropology |
| Health epidemiology |
| – prevalence studies |
| – cross-sectional studies of associations |
| – longitudinal studies |
| – intervention studies |
| – surveillance and monitoring of populations |
| Clinical applications |
| – geriatric practice |
| – disease research/clinical investigation |
| Metabolic research |

Center for Studies of Sensory Impairment, Aging and Metabolism (CeSSIAM) research branch for the National Committee for the Blind and Deaf of Guatamala, Hospital de Ojos y Oidos Dr, Rodolfo Robles V; Diagonal 21 y 19 Calle, Zona 11; Guatemala City, 01011, Guatemala. Fax: +502 2 733906

*imaging* techniques such as radiology and axial tomography would provide the most precise measurements. Conventional physical measuring techniques would also contribute. Specific physical measurements would range from segmental measurements for limbs, mandible, etc., to measurements using micrometers, such as those for enamel hypoplasia of the teeth.

*Health epidemiology*
The most probable scenario for the application of anthropometry in the field setting, to the elderly or to any other age-group, is that of epidemiology. At the level of descriptive studies, cross-sectional surveys of the prevalence of specific diagnostic conditions are the most common format. The primary calling of these surveys is to produce a representative record of the distribution of anthropometric measurement in a defined population, in our case, the elderly. Using a cut-off definition for risk of obesity or chronic energy deficiency (as based on adequacy of weight-for-height or body mass index [BMI]), one can map the prevalence of these over- and underweight conditions. 'Short-stature' prevalence is yet another quality that has been of interest in population-wide studies.

Beyond quantifying, is the relationship of nutritional status and body composition to health or to the influence of environmental factors (including diet) and behavior. The next format would be cross-sectional anthropometry surveys combined with other variables from interview questionnaires, from clinical examination and/or from laboratory tests. This would be a situation in which associations among variables are sought with regression analysis or contingency tables.

The existence of associations among variables, however, tells us nothing about *causality*. To elucidate directionality to a significant association and to eliminate confounding, longitudinal observational studies or longitudinal studies with an intervention component are in order. If stature is the interesting variable such studies would have to be decades in length. Changes in weight, and lean and fat mass, can be observed over much shorter periods of time (months) in intervention studies.

From the point of view of public health, the ongoing surveillance and monitoring of sentinel populations of the elderly represents yet another option for the application of anthropometry in health epidemiology. Such surveillance is much more likely when the paradigm is the risk of acute malnutrition, as with famine brought about by war, natural disaster or climatic shifts, and would likely embrace a cross-section of all ages of the population, not just the elderly.

*Clinical applications*
Geriatric medicine can be practised in the form of mobile campaigns. In India, for instance, mass cataract extractions are made in mobile tent camps which cross rural areas with high cataract endemicity. Cataracts are an infirmity of the elderly. At a minimum, the pre-sedation work-up would involve the assessment of body weight.

Research into specific disease prevalence can be carried out in a field setting. A survey of osteoarthritis or rheumatoid arthritis prevalence or of the correlates of hypertension would involve some longitudinal and some body weight measurements, respectively.

*Metabolic research*
Although metabolic research is conventionally thought of as the enterprise of a closed, isolated metabolic in-patient unit, out-patient studies in free-living subjects are quite common, and have even been successful in subjects of advanced age[2]. One of the assumptions of metabolic studies is that weight and body composition remain stable. Thus, unless the subjects come to a common center for interval weigh-ins, out-patient metabolic studies in a dispersed population of elderly may differ in this respect.

**Collecting anthropometric data in field settings in elderly populations**

*Accuracy and precision: their implications for field research*
*Accuracy* is the ability of measurement, in this instance anthropometric, to obtain the precise answer with reference to a 'gold standard' arbiter. *Precision* is the ability of a measure to reproduce a stable, consistent result. If one has a poorly-calibrated stadiometer, one will never get the correct measurement of height. On the other hand, one can have an imprecise measure, but, if one takes enough repeated measures, the *average* may produce the correct answer.

The relative magnitude of error in weight and height measurements must be placed in perspective. For biochemical clinical measurement, such as for blood glucose, errors of +5% are considered to be very acceptable. The true detection limits for height is on the order of 0.5cm or better. For a person of 150cm in height, this represents an intrinsic precision of 0.33%. For weight, weighing scales can detect differences of 100g which represents 0.14% of the weight of a 70kg person. Variation in weight due to stool in the ampula, residual urine in the bladder and state of hydration can apply true, biological variability of 500g, which is 0.7%. Both of the basic measures of anthropometry, in terms of their measurement limits and biological variability are intrinsically precise. The kind of changes that interest us in weight are generally of the order of one kg, that is, twice the margin. However, when it comes to height *losses* associated with aging, a 0.5cm change would be of biological interest.

The margin between detectable difference and total length or thickness for circumferences and skinfolds is much smaller; thus, the kind of percentage changes detectable in height and weight are not available for the indicators of body composition.

For field studies (as distinct from the clinical setting), the implications of – and tolerance for – inaccuracy and imprecision are different. In the clinical setting, as reviewed[16], the focus is always on the *individual*. For diagnostic classification, accuracy for that patient is at a premium; for assessing response to therapy or disease, the magnitude of the changes is critical.

In many applications in the field context, it is the *population* distribution – rather than the individual – that is the quality of interest for interpretation. In general, overall accuracy, ie the correct answer for the mean and the extremes of the populations is important and that there be no *systematic* error. For descriptive statistics of population means and prevalence of abnormal conditions, the assessment can accept imprecision as long as its variability is balanced in both directions. Of course, sample-size considerations come into play. If underweight is of low prevalence in a population, a suitable number of subjects must be examined to produce a confident estimate.

*Standardization of measurements under field conditions*
When it comes to anthropometry in the clinic, the anthropometrist needs instruction and training in making the measurements. In research, standardization of the tester is called for. For anthropometry, the principles of standardization and the procedures required have been laid out in a classical text[13]. These principles and procedures are valid for measuring all age-groups, including the elderly.

The consistency of data is greatest when a single anthropometrist is involved. Intra-observer variability is intrinsically lower than the inter-observer. In the field setting, many anthropometrists will often be involved, pooling data in common statistical descriptions and analyses. Often, these testers will be at different sites and in different countries. This presents a true challenge to the standardization process. Ideally, prior to the collection of data, and at intervals throughout studies, all anthropometrists should be brought together at one site for standardization exercises[13]. The testers should be trained and standardized using the actual equipment that will be used.

As important as consistency in testing procedures, wrought through the standardization process, is the nature of the measurement apparati (stadiometers, scales, calipers, tapes) and their calibration. For scales in particular the calibration process must be repeated frequently. In field studies that involve dispersed populations, the equipment will be portable and moved continuously. This might be over asphalt highways, dirt roads, on animals, or in backpacks on the shoulders of the anthropometrists. Movement provokes the decalibration of scales. The pressure exerted by the jaws of skinfold calipers is also a factor to be standardized and maintained constant over time.

Anthropometric performance in the field setting will likely be better for an elderly population when the survey exclusively involves this age-group. This, however, is only occasionally the case. Because of the caveats and differences in approach to the elderly, eg the duration of caliper compression, an anthropometrist who is not 'specialized' in gerontological assessment will likely be less adept and consistent in the treatment of older subjects.

Geriatric concerns, which focus on the acutely or chronically ill hospitalized aged, or the homebound and bedridden frail elderly, are much less of a proportional concern in the field setting. Because of their reduced survival, in any given cross-sectional sample (except for one specifically seeking invalids) the bedbound would constitute an insignificant fraction of the total population. Hence, in most field settings the elaborate concerns for compensating for the loss of limbs or the inability to stand[4,16] are of minor relevance. From a logistical standpoint, it would make more practical sense to count the number of invalid and ultra-frail, bedridden subjects, rather than standardize the field teams in the elaborate, compensatory manoeuvers to obtain their anthropometric measures.

*Specific pitfalls to field research*
There are recognized pitfalls in obtaining anthropometric measurements in the elderly which have been reviewed by Roubenoff and Rosenberg. These include changes in elasticity and distensibility of skin, which affect the skinfold thickness determination with compression calipers. Similarly, the looseness of skin and subcutaneous tissue distorts the point for applying tapes and calipers in measuring circumferences and thicknesses. The effects of postural change must be considered in making stature measurements. Having the patient void before weight measurement is a prescription, but elderly men with prostatic enlargement may have significant – and variable – residual volumes of urine in the bladder.

However, in the field setting, other issues of inaccuracy and imprecision come into play. Surfaces of floors or open ground in field situations may not be perfectly level. The consequences for posture and the difficulties for stature measurement are obvious, but uneven ground is also an issue in measuring weight in a population that might have stability problems when standing on the platform of a scale, even under the best circumstances.

Because gravitational force is inversely proportional to the distance to the core of the earth, a sufficiently sensitive balance could, for example, detect a true difference in weight of an individual measured in Bolivia at sea-level in the Yngas Valley and at 4800 meters in the Potosi region. Many cross-national research studies involve widely dispersed geographic sites. More importantly, on this 'pear-shaped' planet, would be the greater, fixed difference in gravity between populations on the Artic Circle in Point Barrow, Alaska and those in Quito, Ecuador 80 km below the Equator. Comparisons of elderly Eskimos and Ecuadorians with the same body mass may not show them having the same body weight.

*Feasibility and execution of measurements in the elderly in field settings*
The willingness of subjects to enrol in studies and comply with the requirements of a study is critical to anthropometry in the elderly in field settings. Often, elderly populations in a developing country have low levels of formal education. Moreover, adult offspring of rural elderly may be overly protective of their aged parents. Issues of pain, inconvenience and immodesty are potential barriers to compliance with procedures or with enrolment in studies. In the clinical setting, reviewed by Roubenoff and Rosenberg[16], in which the motives and motivation for contact with anthropometry come from either self-referral or professional referral, and the basis is the patients' health, an understanding of therapy is much more conducive to compliance, even with unpleasant procedures. When the motive is one of scientific curiosity or public health, and when the initiative is on the part of the investigator, the potential barriers to compliance loom much larger.

Barriers to enrolment in the field setting ought to be familiar to investigators and solutions should be known. Openness of communication is crucial. The leaders of the communities, as well as the potential subjects and their families, must be consulted. Employing local residents as part of the study team often inspires confidence in the community. Difficulties often occur in randomized studies in which cluster samples or random-number samples are generated. It may be hard to explain to the community why one household's elders are sought while another's are not, or why the wife or the husband in a couple is to be enrolled, and the spouse is not measured. Often, if the level of invasiveness is minimum and the availability of personnel and/or time is ample, it is better to measure all persons within the age-group, and only use the pre-selected individuals' data in the analyses. Finally, ways in which the participants can realize some benefits from their participation in being measured in a field study should be considered in the planning and design.

Age and traditional culture interact to define adverse attitudes towards anthropometric measurement procedures. Different regions find elderly, traditional, rural women in different dress: *sarongs* (Bali); *kaftans* (Morocco); *saris* (India); and *cortes* (Guatemala). Issues of modesty would not be likely to impede a same-sex anthropometrist from exposing enough bare skin to make reliable (standardized approach) measurement of suprailiac skinfolds, calf measurements, or waist or hip circumferences. On the other hand, issues of cultural modesty might not allow testers to expose women in the latter three costumes in order to obtain access to the measurement sites. In the same vein, if subjects cannot be weighed nude or in a paper gown as recommended, an adjustment for the 'average' weight of clothing is applied. In societies with *kaftans* and *cortes* the magnitude of the adjustment is large, and individual-to-individual variability in clothing weight is substantial. In these circumstances, a more accurate individual weight might be obtained by measuring the actual garments of each female subject.

To the extent that bioelectrical impedance analysis (BIA) is a measurement of body composition worthy of consideration, connection to an electrical apparatus – no matter how innocuous – may simply be unacceptable, especially to the elderly with more of a traditional grounding in local superstitions.

*How stable can anthropometric measures in the elderly be?*

In Guatemala, we simulated a field setting, although this was not a mobile survey. In a congregate feeding center constructed in a suburb of Antigua Guatemala in the interior of the Republic, 50 km from the capital city, we conducted serial measurements of anthropometric indices on 29 occasions in 24 elderly subjects, all over 60 years of age. There were 15 women and 9 men. Subjects were measured by the same anthropometrist, one of the co-authors (I.M.), over seven consecutive weeks. The circumstances were conducive to biological stability, as during this time the subjects were on constant physical activity patterns and consumed 2440 kcal of energy. Seven common anthropometric measurements were involved: weight (kg); tricipital, bicipital, subscapular, suprailiac skinfolds (mm); amd mid-arm and mid-calf circumferences (cm). As an example, the matrix for serial measurements of weight are shown in Table 2[15].

The coefficients of variation (relative standard deviations) for within-individual measures ranged from lows of 0.8% (calf circumference) and 0.9% (weight), to highs of 9.8% and 7.0% for bicipital and suprailiac skinfolds, respectively. None exceeded 10%. Intra-class correlation coefficients ranged from 0.97 to 0.99. For the group of longitudinally-followed, free-living elderly on a stable energy intake and expenditure, the means and distributions of all seven anthropometric measures were virtually stable over time. Although more instability would have been expected if the anthropometrist had gone house-to-house with the equipment, ours represents the kind of situation that would obtain in a rural survey center. We can see that extraordinary reproducibility of anthropometric measures is possible in an older population. In fact, the observed precision is such under the field conditions of this study as to give high probabilities of a sensitivity in anthropometry in the elderly that picks up small – but real – changes over time with interventions or changing environmental, dietary or health conditions in the population.

Table 2. Variability of inter- and intra-individual weight on repeated measurement in Guatemalan elderly from a suburban area.

| | Global mean weight (kg) | Average standard deviation (kg) | Average coefficient variation % |
|---|---|---|---|
| Inter-individual parameters ($n$=29 subjects) | 48 | 5.8 | 11.8 |
| Intra-individual parameters ($n$=7 repetitions) | 48 | 0.4 | 0.9 |

**Constructing indicators and making diagnostic interpretations of anthropometric data from field studies of the elderly**

Primary anthropometric measurements are just that: measurements. They have no meaning or interpretation unless they can be used for diagnosis and classification. This can be done (1) by comparing the measurement to a normative distribution; or (2) by combining measurements into indicators that pretend to reflect the composition of the body, eg the Quetlet body mass index constructed from weight and height determinations, the mid-arm muscle or fat areas determined from upper arm circumference and triceps skinfold thickness; or (3) through a combination of the two.

It matters little that we can make an accurate, precise and non-invasive anthropometric measurement, if its interpretation is flawed. That would be a formula for self-deception with little chance to advance biological understanding. The validity of a measure is its ability to represent what we assume and interpret it to mean. That is, validity refers to whether a diagnostic measure or a composite index means what we assume it to mean. If the assumptions for their interpretation are not valid, the interpretation and the diagnostic classifications will suffer and, with it, the potential to gain useful information from the collection process.

The study of the elderly, and field studies in different locations and across different sites introduce additional dimensions on validity. Is an interpretation suitable to a young adult population still valid in the elderly? Is an interpretation suitable to a reference population still valid in a population of another ethnic/racial group? A series of validity issues related to anthropometry in the elderly in field settings, especially when *developing country* populations are the subjects of study, are worth analysing.

*Age validity issues*

The issues of the question of validity in exptrapolating from assumptions about the meaning of anthropometric measures has been reviewed thoroughly by Roubenoff and Rosenberg[16]. With the exception of the discussion on the consequences of height reduction in aging (see below), we shall not repeat the points made.

*Ethnic validity issues*

In field settings, especially in multicenter studies involving Third World countries. The EURONUT-SENECA study[5] measured 2600 elderly men and women, but they were relatively homogenous in racial heritage, and hence in body habitus. Compare this to the yet-to-be-published data from the 'Dietary Habits of the Elderly: a Multicentre Study' of the Committee on Ageing and Nutrition of the International Union of Nutritional Sciences. This has included Swedes, Greeks, and Anglo-Celts settled in Australia (comparable to the EURONUT-SENECA population) along with Chinese, Australian Aborigines, Filipinos, and Indigenous and *meztizo* Guatemalans[19].

Biological anthropoligsts have described the basic variation among ethnic groups in terms of fat distribution, limb length and proportion of body segments. We know, for instance, that there are polar contrasts between the relative proportions of height contributed by the trunk and the legs in blacks (short-waisted; long-legged) and in whites or Amerindians (long-waisted, short-legged). Fat distribution in the gluteal fat pads is obviously different for the Kalahari Desert bushmen than for most other ethnicities.

These racial differences have potential implications – albeit not fully explored or understood – for the validity of anthropometric indices. The body mass index (BMI) is a case in point. Given that lower limbs constitute 3 inches more of the stature of blacks, and trunk and abdomen 3 inches less than in whites, what is the comparative validity of assessment of 'obesity' from BMI with this differential composition of length?

*The interaction of short stature and the validity of anthropometric measures*

As can be seen from the tables of Launer and Harris (1992)[11], there is an overriding trend in the developing countries of Latin America, Asia and Africa: populations tend to be *short* in stature. Guatemalan rural males had a mean height of 155cm whereas the women had a mean height of 143cm. As a facile nutritional interpretation, this retardation in stature in Third World populations, relative to distributions such as the NCHS used as standards, has been interpreted as evidence of 'chronic malnutrition'[20].

What should the height be of adult populations in developing country and why do they remain so short? With regard to the former question some students of human growth, such as Martorell[14] feel that all humankind has the same genetic potential for linear growth and that nutritional insult is the cause of short stature. Others argue that a more durable genetic component is involved in the short stature of ethnic groups in the developing world. As to the *mechanism* (pathogenesis) of short stature, we feel that the term 'chronic' malnutrition poorly applies, both as a definition and as a concept. Recent work from a number of populations has shown that most of the deficit in height is determined within the first 24 months of life. That is, newborns in developing countries, born with a relatively adequate body length, rapidly begin to decline with respect to the Z-scores of the NCHS curve until the median can be at −2 Z-scores by 18 to 24 months. Weight adequacy also declines but in proportion to length, or often less so, giving the infants and toddlers Z-scores for weight-for-height on the order of +0.5, ie slightly *over*weight for their lengths.

When longitudinal data are followed into later childhood, the children cease losing ground to the reference population curves and grow parallel to – but below – the lower percentiles with no further decline in Z-score. There is little tendency toward recuperation of height status; that is, there is no catch-up linear growth, but the velocity of growth relative to the height is identical to that of those in the 50th percentile of the reference population. Rather than seeing these populations as *chronically malnourished* in an enduring process, we should see it as an early and distinct insult. The origins are not exclusively dietary, as breastmilk is the major food during most of the stature-loss period, and recurrent infections and continuous activation of the systemic acute-phase response need to be included in the complex that leads to short stature[1].

There is a *technical* problem in simply transforming anthropometric data for short-stature populations. This was pointed out in a classic article by Geissler and Miller[9], who were interested in calculating weight-for-height adequacy for short individuals. They observed that if one extrapolated *upwards* from the childhood weight-for-height relationships into the height ranges of short adults, or if one extrapolated *downwards* from the WHO adult weight-for-height relationships, the two curves did *not* connect. They performed a *mathematical* computerized 'smoothing' of the weight-for-height which allowed one to determine an estimation of adequacy of weight-for-height in short-statured adults. The Geissler and Miller curve (1985) is 'unisex' without differentiation across genders. For Guatemalan elderly, to estimate the appropriateness of weight for 40% of the men and well over half of the women, one is operating in the smoothed portion of the Geissler–Miller curve.

This technical hitch in the published reference curves, however, raised for us a much more profound *conceptual* issue with regard to the validity of the assumption of a linear proportion of weight to stature. Some structures, ie the skull, and some organs, ie the brain, are not closely related to stature, and seem to correspond more to a state of adult maturity. Are there other organs or systems in the adult human which reach a constant, absolute size rather than one proportional to the frame? If so, there would be a basic 'minimum package' of adult tissues and organs to be respected, no matter how short the frame.

Research into the possible non-linearity of body mass and body composition with extreme variation in stature for adults, and aging adult populations, is long overdue. The validity of many of our fundamental assumptions based as they are on NCHS-sized adult populations under 75 years of age, are called into question by the phenomenon of generalized short stature as they apply to the majority of countries in the Developing world.

In the Third World's elderly, we have short populations made shorter with the passage of years. If the logical reasoning (above) suggests a non-linear paradigm of weight relationship to height, a specific focus on *body composition* in relation to stature needs to be pursued. But, the shortness of elderly in developing countries has dual components. It can be attributed to the desiccation of the intervertebral, cartillagenous disks, considered a 'senescent' process of tissue 'settling', and vertebral body compression, a 'pathological' process of osteoporotic 'fracturing'. Both processes can lead, moreover, to curvature of the thoracic spine: both scoliotic and kyphotic.

What these processes produce is an elderly person with standing height (stature), diminished with respect to the *maximal* adult height achieved in the second or third decade of life. The contribution of genetics, diet and environmental stresses shape a person's statural attainment of X cm at its peak. What we measure in older age, however, is a stature of X-Y, with Y being the height lost due to senescent and osteoporotic processes. A question with both philosophical and *practical* consequences is: which of the heights – X or X-Y – is most relevant and appropriate to the biology and physiology of the older person?

At CeSSIAM, we have concluded on a working speculation that X, or the maximal adult height, is the more appropriate. With analogy to a sausage casing being stuffed by a traditional sausage maker: should he put any *less* meat in a casing that is curved that one that is perfectly straight? Most consumer-protection inspectors would consider such a practice to be *short-weighting* the customer. Indeed, we may be short-weighting older adults by referring their anthropometric indices to their *current* stature, rather than correcting back to their point of maximum standing height[17].

Since long bones do not lose length with aging, several potential options are open to estimate back to an original adult height. Knee-height can be conveniently measured with a specially devised caliper[3]. This technique was originally described for the geriatric concerns of bed-ridden elderly. Could it be adapted, through a nomogramic relationship to younger adults, to predict young-adult stature? In fact, work in Boston using the knee-height measurement as a free-standing index (Roubenoff: unpublished findings) shows its promise in making better predictions for elderly body composition than when the Chumlea formula, or any equation, is applied.

Armspan is another option that involves long bones. The use of this measure would inherently extrapolate back to young adult height, as shown by Dequeker et al. (1969)[6]. These Belgian physicians have confirmed an observation that, at the cessation of linear growth, the height/span ratio is 1.0 as a population average. They assert that the regression of height/span index over time gives a probable epidemiologic gauge of the burden of spinal osteoporosis. Belgian women lost 1.5cm per decade from the fourth to the tenth decade. We find in Guatemala, a nation of short-statured people with pure or mixed Mayan descendency and exposed several of the putative *protective* factors against osteoporosis (eg low animal protein intake, high calcium intake, abundant vitamin D-forming sun exposure, high activity, weight-bearing on the axial skeleton, and increased weight-for-height), that the regression of height/span with age of both men and women is virtually flat. It has been stated that restricted mobility of the shoulder or sternoclavicular joints may limit the ability of older – potentially arthritic – individuals to give appropriate maximal lateral extension of the arms for the armspan measurement. In both urban[17] and rural[11] Guatemalan populations, we have not encountered this problem. The life-style factors (above) may themselves facilitate the preservation of joint mobility, permitting accurate assessments of span in later life.

Finally, options for 'correcting' actual stature to reflect maximal stature in the elderly are potentially available in any of the imaging techniques from radiography to tomography. The lesser hazard of ionizing radiation exposure in the elderly, moreover, eliminates objections to such procedures. Mathematical models and nomogramic relationships to make the back calculation of height in early adulthood from total body or segmental imaging should be explored.

Obviously, if one uses a 'corrected' stature, as compared to the observed height, it will alter the magnitude of composite anthropometric indices[17]. BMI, with its height-squared term in the denominator, will be *reduced* when span is substituted for height in the formula. The biological 'proof of the pudding' for the validity and utility of the alternative use of corrected – rather than actual – height will be based on the reasonableness of its prediction of the distribution in elderly populations of such expressions as the body mass index, the Harris-Benedict equation of basal energy expenditure, or the formular for energy requirements of the elderly using the approach of the FAO/WHO/UNU (1985)[7] Expert Committee.

### *Interpreting the biological nutritional and health significance of anthropometric findings in relationship to the elderly*

The foremost issue in interpreting the biological, nutritional and health significance of anthropometric studies is to be firmly grounded in the fundamentals of *aging biology*. Recognizing the distinctions between aging and *non*-aging in the interpretation of data, specifically cross-sectional data[9,21]. The validity of anthropometric indices, and the challenge to conventional interpretations that can be raised by virtue of age or ethnicity (above) must be considered. However, the reliability of all *other* (non-anthropometric) variables, and the validity of their assumptions must also be considered. That 'a chain is only as strong as its weakest link' has never had a more appropriate application than in reference to a data-set from an older population in exploring aging biology.

*Uncertainty regarding the accuracy of chronological age*
All aging research is predicated on age classification of the individuals. Eligibility to be classified as 'elderly' is based on a cut-off criterion: >60 years is the convention of
the World Health Organization[21]. Moreover, most studies subdivide the elderly into age-groups. In developed countries, this could be the 'young old', 'old', and 'old old'; in developing countries, this would be 60–70 years. Classification errors in the assigning of groups will result from inaccurate age data. Most crucial for the use of chronological age are those analyses in which regression analysis will be used against other measured, individual variables, eg age versus height/armspan ratio. A dramatic attenuation of association in regression analysis is introduced by classification errors[18].

To respond to all of the above, accurate determination of chronological age is essential. The absolute arbiter of age is the birth record. In both developed countries, due to wars, and in developing countries, for a host of reasons, birth records may not be available. Under these circumstances, self-reported age must be used. In developing countries, a host of barriers to obtaining accurate age data are present. In illiterate, rural populations,, birth records may never have been taken, or if taken, they could be registered in church ledgers which may not have withstood the strains of time. It has been our experience in Guatemala, that mothers make up to one-year errors in reporting age of preschool children. This can be exaggerated with the passage of years. In developed countries, contemporary investigators use historical events to refine and validate the self-reported age of the elderly. 'Were you born before or after the outbreak of World War One?'. The response to this for an elderly European will differentiate those around a 78 year cut-off point. For developing countries, such catastrophic events may not be known to contemporary investigators. Political events are of marginal relevance for rural population; among the older women of San Pedro Ayampuc, a rural community only 23km from Guatemala City, less than half had ever visited the capital[11]. Sometimes, natural disasters such as floods, earthquakes, volcanic eruptions, or epidemics can be used as reference dates even in illiterate, rural populations to refine the accuracy of self-reported age.

There is yet another caveat in chronological age assessment, applicable to *comparative*, cross-cultural aging studies, is the culture conventions for reporting age. The Chinese date life from the data of conception; Chinese are one year old when they are born. Central Americans report the age to be completed on their *next* birthday, ie their ordinal year in life, rather than that of their *last* birthday, ie their cardinal years. Both of these conventions make the mean reported age of a Chinese or Central American population one year older than one computed from actual birthdates.

*Geography and differential survival of the elderly*
Even when accuracy of age is assured, other issues of chronology intercede in the interpretation of aging research. A recognized, major confounder of aging research based on cross-sectional data is selective mortality (differential survival) of the populations of a given birth cohort. For comparative, cross-national studies, this differential survival raises another question: what is a comparable age-group in country X to compare with in country Y? To date, most studies use *chronological* age as the criterion, but often raise the ill-defined term of comparable 'biological' age. In a planned, multicenter study of the IUNS Committee on Ageing and Nutrition[19], the protocol called for enrolling 200 subjects over 70 years of age. Among a settlement of Australian Aborigines, only a few individuals were found who had survived seven decades. What is the aged population of these Aborigines compared with other sites?

One approach is to take a certain upper percentage of the age-pyramid, for instance, the oldest 6%. This suffers from the difficulty that mortality in the *current* youngest age-groups determines the size of whole population. A potentially valide criterion for cross-comparison would be populations with the *same number of remaining years of life-expectancy*. This projection can be made with some representative longitudinal data[8]. In any event, the current state-of-the-art for comparison of groups with differential life-long survival pressures is uncertain, and requires some creative exploration.

**Remaining uncertainties and recommendations related to the use of anthropometry in the elderly in the field setting**

In both developed and developing countries, there has been little experience in the anthropometric study of the elderly in field settings. For instance, the ceiling age in the first two National Health and Nutrition Examination Surveys (NHANES) has been 74 years, with too few subjects in the older bracket for nation-wide representation for the US young-elderly population. The present NHANES III survey, currently underway is over-sampling for the elderly, and extending the upper range.

Worldwide, developing countries contain an increasing proportion of the elderly. There has not been a high priority for aging research in nations dominated by a concern for maternal child health. The topic of anthropometric 'screening' of elderly populations in developing countries has been raised, and with it a series of heretofore unresolved issues. Screening implies the filtering of a population to classify them into categories, and calculate the prevalence of 'conditions' of health or nutritional interest. The preparation for and logistics of the field activities necessary for a survey of elderly in developing countries has been addressed. That cultural barriers to obtaining some measures exist, and the value of recalibrating equipment, has been emphasized. It is important to point out, however, that the traditional paradigm of the *rural* poor is giving way, through migration and urbanization in developing countries, to paradigms of the urban poor. This offers advantages to the realization of data collection, but introduces additional issues about the selective nature of the elderly population samples.

The overriding anthropometric reality of the Third World is short-stature populations. Not the accuracy nor the precision, but the *validity* of interpretation of anthropometric measures and indicators is called into question when considering the interaction between the lower extreme of height and body mass and composition. Simple linear extrapolation from current industrialized country reference populations is likely to be inappropriate. More to the point for creating reference populations of short stature, however is developing a fundamental understanding of the human biology and physiological imperatives of adult maturity with reduced height. Only then, can appropriate and valid classifications be developed, and only then does *screening* for deficits, excesses and imbalances of body composition have a legitimate rationale. In the final analysis, this is more of a task for an emphasis on body composition relationships than on normative distribution. Our challenge in field anthropometry of the elderly is to refine the interpretation fo physical measures in terms of fat mass, lean tissue, their distribution, their interrelationship, and their predictive significance for further function, good health and survival.

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**Uses of anthropometry in the elderly in the field setting**

Noel W. Solomons, Manolo Mazariegar and Ivan Mendoza.

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## 老年人體測量的應用

### 摘要

本文介紹了發展中國家老年人群的人體測量及一系列尚未解決的問題。本文并討論了發展中國家老年人測量所需要的后勤補給措施。作者强調了再校準儀器的價值和文化屏障對某些測量數據的影響。第三世界人群身材矮小，這是主要的人體測量數據，當考慮到身高，體重和體組成最低值之間的相互關系時，對人體測量的尺度和指標的正確解釋就出現了問題。但并非精確度和精密度問題。而是應以身材矮小的人群爲基準，建立一個基本和一致的身材矮小成人的生物和生理指標。只有這樣，才能建立適當和有效的分類，只有這樣，才能表達身體組成的不足，過多和不平衡的合理的理論基礎。

Un ambiente de investigacion a nivel de campo puede ser definido como cualquier ambiente fuera de las estructuras físicas fijas y permanentes de un laboratorio sofisticado de investigación. Las aplicaciones de la antropometria a nivel de campo incluyen antropología biológica, epidemiología, clínica e investigación metabólica. La colección de datos a nivel del campo requiere diferentes niveles de exactitud y precisión; la estandarización debe considerar la variabilidad intra e inter-observadores dada la posibilidad de que mas de un investigador pueda participar en el estudio. Un ambiente de campo, en oposición al de un laboratorio de investigación, representa un reto a la antropometría. El equipo requerido es diferente y las condiciones de la colección de datos debería considerar una serie de factores que faciliten su interpretación, dado que la rigurosidad podría ser comprometida. Otros aspectos instrinsicos a la poblacion de interes – bajo nivel de educación, asociado a factores culturales y poca sofisticación contemporánea –, podrían limitar la ejecución de encuestas antropométricas a nivel del campo.

Otro aspecto esta relacionado a la interpretación del significado biológico, nutricional y de salud de los hallazgos antropométricos. La incertidumbre con respecto a la edad cronológica, geografía y supervivencia diferencial del anciano, debe ser considerado al planificar y Ilevar a cabo estudios. Además, debido a que la mayoría de los ancianos viven actualmente en países en desarrolo, el hallazgo de baja estatura debería ser un hallazgo muy común en las poblaciones envejecidas de estas regiones. La baja estatura en poblaciones ancianas de países en desarrollo hace resaltar la limitación de aplicar normas o referencias antropometricas (de peso y talla), derivadas de poblaciones ancianas de países desarrollados.

En conclusión, aunque la aplicación de antropometría en al anciano a nivel de campo es factible, dada la enorme importancia a la biología gerontológica, nutrición, y salud, los investigadores deben considerar una serie de factores y paradigmas al diseñar y ejecutar encuestas antropométricas a nivel de campo, principalmente en paises en desarrollo.