Daily living activities in older adults: Part I—a review of physical activity and dietary intake assessment methods

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Abstract

The aging process is expected to change advanced activities of daily living (such as employment and work activities), to basic activities of daily living (BADL; such as self-care activities, which is also considered work among older adults). In effect, older adults spend more energy on physical activities related to BADL, compared to heavy physical activity in any industrial work. Hence, accurate assessment of the type and extent of physical activity becomes critical for estimation of the activity metabolism, especially in older adults. Once an assessment of activity metabolism is made, energy balance can be quantified by comparing energy expenditure (including resting activity, and digestive metabolism) with caloric intake. Instruments and techniques available to quantify physical activity in older adults, and caloric intake in older adults are reviewed in this paper. The emphasis in this review is on questionnaire-based instruments that minimize burden on the investigator and the participant. Validity and reliability of the assessment instruments are also discussed.

Relevance to industry

Since most work activities requiring energy expenditure among older adults, especially retirees, consist of BADL, accurate assessment of activity metabolism and dietary intake is necessary for designing these work activities for older adults.

Keywords: Physical activity assessment; Dietary intake; Older adults

1. Introduction

Aging is considered a disability to the extent that it causes limitations in performance of activities. The nature of what is considered “work” activities also changes with age, especially among retired older adults—the nature of work is expected to change from being advanced activities of daily living such as heavy physically demanding work in an industrial setting, to being basic activities of daily living (BADL) such as self-care and grooming activities. Impairment in performance of activities of daily living, especially in household settings (opening a can of tomatoes, for...
example), is considered far more complex than cellular or molecular mechanisms of aging due to complex body and environmental systems involved (Clark et al., 1990; Lawton, 1990; Smith, 1990; Kumar, 1997). Surveys (Dawson et al., 1987; AARP, 2000; Pennathur et al., 2003) have shown that older adults have difficulty in performing one or more common self-care activities such as eating, using the toilet, dressing, bathing, or preparing meals in the kitchen. Other activities considered “work” related, such as walking up 10 steps, standing for 2 h, stooping, crouching or kneeling, lifting or carrying 25 pounds, etc., have been found to be difficult tasks for older adults to perform (Kovar and LaCroix, 1987; Meindl and Freivalds, 1992; Vayrynen et al., 1996; Kirvesoja et al., 2000). Older adults performing these activities of daily living have been found to need assistance when performing these activities.

Considering that the definition of “work” among older, especially retired adults, is predominantly not what would be traditionally considered “industrial work”, and given that older adults engaging in activities of daily living do expend considerable energy for performing those activities, there is very little research available in the traditional ergonomics literature on energy expenditure in daily living activities among older adults, and issues related to estimation of energy balance and metabolism among older adults. Such information is essential for optimal design of tasks and daily living activities for older adults.

People are inclined to gain weight as they age (Fitzgibbon et al., 2000; Okosun et al., 2000; Pescatello et al., 2000). Older adults tend to intake more energy in the form of calories than necessary. However, physiological need for energy and cell metabolic rate decline with aging. There is also a decrease in lean mass index (muscles, organs and skeletal tissues). Energy expenditure is directly proportional to body size and physical activity. Due to aging, a person tends to be less active and therefore experiences a gradual decline in energy expenditure. The result of consuming the same amount of calories during the aging process and less calories being required is excess calories. This excess in difference will be deposited as stored in the form of fat deposits. Over a period of time if energy intake exceeds energy output, the excess energy will be stored as predominantly adipose tissue. This accumulation of tissue leads to obesity.

Several recent recommendations from the Centers for Disease Control and the National Institutes of Health (Pate et al., 1995; National Institutes of Health, 2002) have emphasized the need for regular physical activity as being important for maintaining a healthy lifestyle, while at the same time recognizing the limitations in physical activity assessment methods, especially in relationship to caloric intake, and dietary assessment methods.

This paper, part I of a two-part paper, critically reviews instruments and techniques available for assessment of physical activity, and for assessment of caloric intake, among older adults. Section 2 presents factors that affect physical activity in older adults, and reviews techniques available for assessment of physical activity in older adults. Section 3 is a review of assessment methods available for estimation of caloric intake in older adults. The emphasis in our review is on epidemiological questionnaire-based instruments that minimize burden (both cost and ease of administration) to the researcher and the participant.

2. Physical activity in older adults

Physical activity is defined as bodily movement produced by skeletal muscles resulting in energy expended (Caspersen et al., 1985). Physical fitness can be considered as a set of attributes that assist exercise and performance of physical activity. A lack of physical activity has been shown to be related to several adverse health outcomes as well as functional decline in older adults (Leon et al., 1987; Fletcher et al., 1992; Blair et al., 1995). On the other hand, regular physical activity and leading physically active lifestyles have been shown to be beneficial to older adults as follows; improved strength and flexibility, balance, and other physiological measures of functional performance such as aerobic capacity, reduction of fracture risk and general well-being have been shown to improve with physical fitness intervention (van der Bij et al., 2002; Carlson et al., 1999;
Department of Health and Human Services, 1996; Christmas and Anderson, 2000; Buchner et al., 1992; Green and Crouse, 1995; Province et al., 1995; Daley and Spinks, 2000; American College of Sports Medicine, 1998). Studies have also shown that the total amount of time spent engaging in physical activity declines with age (Caspersen et al., 1987; Schoenborn, 1986; Caspersen and Merritt, 1992). Studies have also shown that African Americans and other ethnic minority populations are less active than white Americans (Caspersen et al., 1986; Caspersen and Merritt, 1992; DiPietro and Caspersen, 1991).

2.1. Factors affecting physical activity

Several variables, including physiological, behavioral, and psychological variables, have been shown to affect physical activity. Among barriers to physical activity, lack of time is most commonly reported (Dishman, 1988; Sallis and Hovell, 1990; Martin and Dubbert, 1982). Studies have also shown that cigarette smokers are more likely to drop out of exercise programs than nonsmokers (Dishman and Sallis, 1994). Although body fat has not been linked to physical activity habits, studies have shown that obese persons are usually physically inactive (Bouchard et al., 1993). Godin et al. (1987) showed in their study that mere intention to participate in exercise programs, and awareness of the benefits of participating in regular physical activity programs does not result in a high degree of actual participation in physical activity and exercise programs. Older adults also have been shown to underestimate the need for regular physical activity and exercise, and exaggerate the risks associated with physical activity and exercise (Mobily et al., 1987). However, confidence in ability to be physically active and enjoyment of physical activity are strongly related to actual participation in physical activity (Sallis et al., 1989). Several studies have shown that physical activities that are low to moderate in intensity are more likely to be continued than physical activities that have high intensity and energy costs (Pollock, 1988). Studies have also shown that self-regulatory skills such as setting goals, monitoring progress in achieving goals, and self-reinforcement, all increase participation and continued performance of physical activities (Dishman, 1982). Other determinants of participation (or a lack thereof) of older adults in regular physical activity include social factors such as participation of family and friends as either role models or as exercise companions (Sallis et al., 1992), lack of an environment for physical activity and exercise such as a lack of walking paths, bicycle tracks, etc., away from traffic, inclement weather and unsafe neighborhoods (Sallis et al., 1989). Studies have also shown that excessive television viewing tends to discourage people from exercising (Tucker, 1990).

2.2. Assessment methods

Several instruments are available for assessment of physical activity such as physical activity diaries (Bouchard et al., 1983; Pols et al., 1996), mechanical or electronic activity monitoring devices (LaPorte et al., 1985), and the doubly labeled water method (Montoye et al., 1996). However, most of these methods have been found to be burdensome and expensive to administer for both participants and researchers. Therefore, several researchers have used physical activity questionnaires as the method of choice, given the comparatively low cost of administration, and the ease of administration. While several questionnaires have been developed for use with young adults (Jacobs et al., 1993; Sallis and Saelens, 2000), evidence suggests that these may be inaccurate when used with older adults (Washburn et al., 1990). The following sections provide a brief review of the instruments available.

2.2.1. Physical activity diaries

Physical activity diary methods involve the participant to keep a record of their physical activity for a typical time period. This time frame may vary from 1 day to even 1 year. The participants require keeping track of the activities they perform and also record the time period they perform those activities. This technique is not burdensome physically on the participant as compared to laboratory methods. But this method contributes to a very high error percentage in
estimating physical activity expenditure. Minnesota leisure-time physical activity was found to be more accurate compared to data from physical activity diaries kept for 4 consecutive days by the respondent (Cartmell and Moon, 1992).

2.2.2. Doubly labeled water technique

Indirect calorimetry involves measuring oxygen consumption and carbon dioxide production and relating these to the energy value of oxygen consumed and carbon dioxide produced. A recent method is the doubly labeled water technique for measuring energy expenditure in ambulatory subjects (Klein et al., 1984; Stein et al., 1987; Livingstone et al., 1992). The rate at which heavy oxygen declines relative to the decline in deuterium (which can only be excreted as water, unlike heavy oxygen which can be incorporated into carbon dioxide during metabolism or excreted as water) is used as a determinant of the metabolic rate (Lifson, 1966; Schoeller et al., 1986).

Doubly labeled water technique estimates total energy expenditure of a person of any age group without the usual restrictions involved in a laboratory process. A known quantity of water containing known concentration of stable isotope of hydrogen (deuterium) and oxygen (oxygen-18) is consumed by the participant. Body fluids distribute these isotopes throughout the body. This process of distribution takes about 5 h. Hydrogen reacts with the body oxygen and forms water. This water leaves the body in the form of sweat, urine and pulmonary water vapor. The oxygen leaves as water and carbon dioxide. An isotope ratio mass spectrometer is used to determine the differences between elimination rates of the two isotopes relative to the normal body condition levels of carbon dioxide production estimates during the measurement period. Respiratory quotient value of 0.85 is assumed based on oxygen consumption estimated from carbon dioxide production estimates. To control the baseline values for the isotopes, the subject’s saliva or urine is analyzed prior to the intake of the doubly labeled water. Thus the name doubly labeled water technique.

Once the isotopes spread all over the body, initial saliva or urine measurements are recorded. Thereafter, the measurements are taken daily or weekly as per the study protocol. The study duration is usually 2–3 weeks. Carbon dioxide production rates are computed based on the progressive decrease in isotopes concentration.

Compared to a directly measured energy expenditure technique, the doubly labeled water technique’s accuracy is 3–5%. If the study is pertaining to physically active individuals, the error magnitude increases. This method measures total energy expenditure over prolonged periods such as bed rest and physically intense activities such as trekking, mountain climbing, space activities and swimming. This is an expensive technique, thus the sample size is usually small in studies that use this method. Hence, estimates of total daily energy expenditure obtained by other methods cannot be validated against other techniques.

There are some import assumptions that are considered in this method. The body water pool varies depending on the intensity of exercise and infancy due to the variation in body mass (Hildreth and Johnson, 1995). Only if the body mass variation is more than 15%, an error of 1–2% occurs (Schoeller, 1988). Thus total body water pool is assumed to be constant.

If a subject were to smoke three packs of cigarettes, this would contribute to increase in carbon dioxide production and contribute to 3–6% error. However, this does not affect the calculations for the elimination of oxygen and carbon dioxide is relative (Pinson and Langham, 1957). Other assumptions pertaining to isotopic spaces and isotopic fractionations are reviewed in detail in Schoeller (1988) and Wolf (1992); Schulz and Schoeller (1994), have determined the range of variation and significant determinants of energy requirements in adults using this technique.

This instrument is used more as a validation device rather than the root method to measure physical activity against other methods such as treadmill testing and physical activity questionnaires. For example, in a study by Schuit et al. (1997), the doubly labeled water technique was used to validate the physical activity scale for elderly (PASE). Results indicated a good correlation between the results of the two methods.
2.2.3. Physical activity monitors

Accelerometers are electronic devices that are used to quantify physical activity levels. Some of the most popular accelerometers are Large-Scale Integrated Motor Activity Monitor (LSI), the Coach, the Calcount and the Caltrac. Cost considerations make LSI and the Coach infeasible for clinical applications. The application of the Caltrac and the Calcount in clinical setting is attributed to their low cost and light weight. Caltrac has proved to have good reproducibility and validity in energy expenditure estimation (Balogun et al., 1988).

A Caltrac motion sensor is another instrument used to measure energy expenditure over a given period of time. It is an accelerometer worn on the waist by the subject on the left side of the body. Participants remove the sensor while performing water activities and sleeping. This gives a score in Caltrac kilocalories. The Caltrac motion sensor measures the acceleration and deceleration in the vertical position. The subjects record the readings at regular intervals for a given time frame.

This tool has been used as a validity measure against other methods that estimate energy expenditure. The Caltrac is not a very reliable tool to measure the calorie expenditure of physically active individuals such as swimmers and cyclists.

Montoye et al. (1996) used Caltrac with force plate measurements for estimating energy expenditure while performing physically intense exercises such as bench stepping and half knee bending. Many studies have used the Caltrac motion sensor to validate the energy expenditure measures. Studies of Dipietro et al. (1993) reported no significant correlation with low-intensity activities by using Caltrac count as a validation measure against the Yale Physical Activity Questionnaire.

Using accelerometers worn at the waist has a drawback. When worn in a sitting position, these instruments do not respond to moving parts distal to the center of gravity and performing arm and leg work (Montoye et al., 1983). Wearing additional Caltrac devices at the wrist can overcome this limitation and the ankle to estimate the energy expended during arm and leg work (Balogun et al., 1986).

2.2.4. Questionnaires

Questionnaires are the preferred method for large-scale epidemiologic studies of physical activity, because of minimal burden (both cost and ease of administration and use). Questionnaires used in assessing physical activity of older adults is discussed in the following sections.

2.2.4.1. Physical activity scale for elderly (PASE).

The PASE developed by Washburn et al. (1993) assesses leisure, occupational, and household physical activity components. The PASE can be administered on the telephone, by personal interview, or self-administered through mail. A PASE score is computed based on a PASE weight assigned to different activities engaged by participants in a typical past week. Included in the PASE score are activities involving muscle strength exertion/endurance, strenuous sports activities, moderate sports, light sports, jobs involving standing or walking, walking activities, lawn care or yard care activities, caring for other persons, home repairs, heavy housework, light housework activities, and outdoor gardening activities. Activity frequencies are multiplied by activity weights (developed through regression models and principal components analysis) to obtain PASE scores. Washburn et al. (1993), in a study of the reliability of the PASE instrument among 254 men and women 65 years of age and older found that the 3–7 week test–retest reliability was high (a correlation of 0.68 for telephone administration of the PASE and a correlation of 0.84 for mail administration of PASE). Validation study of the PASE (Washburn et al., 1993) indicates that PASE scores were also found to be significantly negatively correlated with perceived health, sickness impact profile total score, and heart rate, and significantly positively correlated with grip strength, static balance, and leg strength. In a separate validation study of the PASE instrument, between 190 sedentary male and female older adults, Washburn et al. (1999) found that the PASE score was significantly correlated with peak oxygen uptake, systolic blood pressure, and balance. The PASE score did not have any significant relationship with diastolic blood pressure, resting heart rate, or percentage body fat.
2.2.4.2. Zutphen physical activity questionnaire. The Zutphen physical activity questionnaire (Caspersen et al., 1991) is a self-administered questionnaire, originally designed for retired men. The Zutphen questionnaire assesses leisure-time physical activity. The time frame of recall includes physical activity done in the past week, past month, or usual activity with no specified time period. A summary kilocalorie score expressed in kcal/kg/day is calculated based on the duration of activity for various activities (weekly estimate), and based on an intensity code for each activity based on Durrin and Passmore (1967) and the Minnesota leisure-time physical activity questionnaire (Folsom et al., 1985; Taylor et al., 1978). Based on a test–retest relationship between the first administration and a 4-month readministration in a sample of 21 Dutch men aged 70–89 years, Westerterp et al. (1992) found the Zutphen physical activity questionnaire to have a high test–retest reliability (0.93 correlation coefficient). To assess the validity of the Zutphen questionnaire, Westerterp et al. (1992) quantified the relationship between monthly total hours of activity and physical activity index (total energy expenditure) measured using the doubly labeled water divided by the resting metabolic rate. They found a significant positive (0.61 correlation coefficient) correlation.

2.2.4.3. Modified Baecke questionnaire. The modified Baecke questionnaire for older adults (Voorrips et al., 1991) assesses leisure and household physical activities. It uses the past 1 year as the time frame for recall. This questionnaire is interviewer administered. Included are questions about household activities (including light household work such as dusting, washing dishes, repairing clothes, etc., heavy housework including vacuuming, mopping, scrubbing floors, etc., food preparation activities lasting at least 10 min in duration, food service activities lasting at least 10 min in duration, dish washing lasting at least 10 min in duration, and light and heavy home repair activities). The other parts of the survey for computing time and energy expenditure summary indices include yardwork (gardening, lawn mowing, clearing walks/driveway, sweeping and raking), caretaking (adult care and child care activities), exercise activities (including brisk walking, pool exercises/yoga, vigorous activities such as aerobics, cycling and swimming), and recreational physical activities (such as leisurely walking lasting at least 10 min in duration, needlework, dancing, bowling, golf, racquet sports, and billiards). Participants report the time they spend in these activities in hours/week. The sum of all the times

2.2.4.4. Yale physical activity survey. The Yale physical activity survey (DiPietro et al., 1993) assesses household, exercise and recreational components of physical activity among older adults. The survey is interviewer administered and is based on participants’ recall of physical activity in a typical week in the preceding month. Three summary indices are calculated from the survey—a total time summary index, an energy expenditure index, and an activity dimensions summary index. The first section of the questionnaire intended to calculate the total time summary index and the total energy expenditure index, is divided into work activities (including shopping, stair climbing while carrying a load, laundry, light housework such as tidying the house, dusting, sweeping, indoor gardening, etc., heavy housework including vacuuming, mopping, scrubbing floors, etc., food preparation activities lasting at least 10 min in duration, food service activities lasting at least 10 min in duration, dish washing lasting at least 10 min in duration, and light and heavy home repair activities. The other parts of the survey for computing time and energy expenditure summary indices include yardwork (gardening, lawn mowing, clearing walks/driveway, sweeping and raking), caretaking (adult care and child care activities), exercise activities (including brisk walking, pool exercises/yoga, vigorous activities such as aerobics, cycling and swimming), and recreational physical activities (such as leisurely walking lasting at least 10 min in duration, needlework, dancing, bowling, golf, racquet sports, and billiards). Participants report the time they spend in these activities in hours/week. The sum of all the times
provides the summary total time index (hours/week). An intensity code (Taylor et al., 1978; McArdle et al., 1981) in kcal/min is assigned for each activity, and is multiplied by the duration (in hours/week), and summed over all activities to obtain a summary energy expenditure index. In addition to the time and energy expenditure summary indices, the Yale physical activity survey computes a vigorous activity index score, a leisurely walking index score, a moving index score, a standing index score, and a sitting index score. All these activity dimension scores are based on the duration spent in each type of activity, and the frequency of such activity. This product is then multiplied by a weight (with vigorous activity being assigned the highest weight of 5, and sitting index assigned a weight of 1) to obtain the total score for an activity dimension. The sum of all activity dimension scores is then computed as a summary activity dimension score. Several studies subsequent to the initial Yale study have attempted to quantify the reliability and the validity of the Yale physical activity survey. In their initial study of 2-week test–retest reliability, DiPietro et al. (1993) found that in a sample of 20 men and 56 women aged 60–86, the mean values for total time (hours/week) and vigorous activity dimension were significantly higher at first administration of the survey. They also validated the Yale physical activity survey by comparing the energy expenditure, and all activity dimension indices from the Yale survey with estimated maximum volumetric oxygen consumption, and Caltrac activity counts, and found moderate to high correlations between these measures. Schuler (2001) in a study of physical activity among 56 men and women aged 56–86 years using the Yale physical activity survey reported moderate to good reliability for a 2-week test–retest administration. Schuler also validated the Yale physical activity survey by comparing Yale overall measures with the average of 3 and 7 day 24-h physical activity records, predicted maximal oxygen consumption, and the sum of three skinfold measurements. Schuler found significant associations between the physical activity diary and the Yale total energy expenditure index, the Yale total time index, and the Yale total summary activity dimension index. Young et al. (2001) in a study to compare the Yale physical activity survey with other measures of physical activity, administered the Yale survey to 59 participants (45% of whom were African American, and 79% of whom were women). The Stanford 7-day physical activity recall, the estimated maximum volumetric oxygen consumption, the resting pulse rate, and the body mass index, were used as physiological validation criteria. Their results indicate that weekly energy expenditure, total time in activity, and the summary activity dimension index (all from the Yale survey) correlated with daily energy expenditure, and time spent in moderate activity (as estimated from the physical activity recall). They also found that the Yale vigorous activity index was significantly correlated with daily energy expenditure estimate, and the time spent in light, moderate, and hard/very hard activities. Also, the summary, moving, and standing indices from the Yale survey correlated with the maximum volumetric oxygen consumption, and the body mass index. In a study of the validity and reliability of the Yale physical activity survey among 108 older adults in Spain, De Abajo et al. (2001) found significant test–retest associations for total time and energy expenditure in a 2-week retest administration of the Yale survey. They also found a moderate association for all the activity dimension index scores. In their validation sub-study, they found that the total time and energy expenditure as measured from the Yale survey significantly positively correlated with the Caltrac activity units, and negatively correlated with body weight. The activity dimension summary index and the leisure walking index score, both were significantly correlated with the Caltrac units, and negatively with the percentage of body fat. The moving index score was also positively correlated with the Caltrac units. Sitting index score and body mass index were positively correlated also.

2.3. Reliability issues in questionnaire development for physical activity assessment

All physical activity assessment questionnaires presented in the earlier sections make use of self-reports from participants about the type and
extent of physical activity. These self-reports could be self-administered (from a mail survey), or could be interviewer administered. Reliability of self-reports in older adults could be hampered by trouble with recalls due to poor memory, poor cognitive information processing abilities, etc. (Baranowski, 1988). Other factors that could affect reliability of self-reports for physical activity assessment include variability in physical activity levels over time (Washburn and Montoye, 1986), and individual differences among respondents (Buchowski et al., 1999). More research is needed in integrating cognitive processes, especially with improvements to recall procedures and recall formats to enhance recalls of self-reports (Durante and Ainsworth, 1996; Sallis and Saelens, 2000). It is also possible that reliability measures for physical activity assessments may not reflect true variability in physical activity patterns unless retests cover the same time period for assessment as the initial test (Sallis and Saelens, 2000). Also, presence of many participants with no physical activity tends to inflate test–retest reliability indices (Booth et al., 1996). According to Durante and Ainsworth (1996), the high reliability in recall of high-intensity activities reported by several studies, compared to reliability in low-to moderate-intensity activities, may be due to low salience of low- and moderate-intensity activities.

2.4. Validity issues in questionnaire development for physical activity assessment

Validity of an instrument is intended to measure whether or not the instrument under consideration measures the concept it is supposed to measure. Three broad categories of validity measures are defined—content validity, criterion-related validity and construct validity. Content validity is intended to measure if the instrument includes an adequate and representative set of items to tap the concept being measured with that instrument. A minimum threshold of content validity should at least be face validity. Criterion-related validity is intended to measure whether the instrument differentiates individuals on a criterion it is expected to predict. Criterion-related validity can either be concurrent validity or predictive validity; concurrent validity is established when the instrument differentiates individuals who are known to be different. Predictive validity indicates the ability of the instrument to differentiate among individuals with respect to a future criterion. Construct validity is intended to measure if results using the instrument tap the theory around which the test or the instrument is designed. Construct validity could be convergent or discriminant. Convergent validity is established when scores obtained from two different instruments measuring the same concept are highly correlated. Discriminant validity is established when, based on a theoretical construct, if two variables are predicted to be uncorrelated, the scores obtained by using the instruments to predict these variables, indeed empirically are uncorrelated.

For physical activity assessment, since the current state of knowledge in physical activity patterns and behavior have shown that health outcomes are related to low-intensity physical activities (Anderson et al., 1998; Eaton et al., 1995), moderate-intensity physical activities (Pate et al., 1995; US Department of Health and Human Services, 1997), and vigorous-intensity activities (US Department of Health and Human Services, 1997), for any physical activity assessment questionnaire to have content validity (as defined previously), it must include assessment of low-intensity, moderate-intensity, and vigorous-intensity activities. Content validity of physical activity assessment questionnaires is important when assessing physical activity patterns among diverse demographic, cultural and ethnic populations (Sternfeld et al., 1999). Not only could the type and range of physical activity be very different among different cultural and ethnic groups (Ainsworth et al., 1999), but the reactivity to assessment instruments and methods could also be different in different ethnic and cultural groups (Warnecke et al., 1997). Content validity is context sensitive—measuring leisure-time physical activity in a population that is predominantly engaged in occupational physical activity can lead to underestimating the nature and extent of physical activity in that population (Evenson et al., 1998). Content validity of physical activity assessment instruments also needs to be revisited in light of
new technology and the sedentary behaviors, or the more vigorous-intensity sports imposed by new technology use.

Researchers have attempted to establish criterion-related validity for physical activity assessment questionnaires using both subjective (activity diaries based on self-reports), and objective (measurement of movement, energy expenditure, etc.) measures. Cardiorespiratory fitness has been shown to be weakly related to physical activity though particularly in older adults (Tager, 1998). All measures for criterion-related validity have limitations and have been documented (Ainsworth et al., 1994; Montoye et al., 1996). Validation of self-reports of the type of physical activity, frequency, intensity and duration especially among older adults is needed, particularly since accelerometers that can be used in validation permit classification of intensity minute-by-minute (Freedson et al., 1998; Nichols et al., 1999). Most criterion-related validity measures at the current time report only relative validity in the form of correlations. However, to influence health outcomes, there is a need to quantify absolute validity so that dose–response relationships can be understood. This is particularly important since most prevalence rate estimates are based on self-reports of physical activity, and several studies attempting to quantify even absolute validity of assessment techniques indicate overestimation of physical activity particularly vigorous-intensity activities (Bernstein et al., 1998; Klesges et al., 1990; Buchowski et al., 1999). Validity measures that include muscle strength, flexibility, weight-bearing activities, and sedentary behavior, are lacking at the current time (Sallis and Saelens, 2000).

3. Dietary intake assessment in older adults

Several dietary intake assessment methods have been developed for assessment of dietary intake in humans, each with its advantages and disadvantages. Several factors determine the method to use in a specific study (Bazzare and Myers, 1980; Bingham, 1987; Block, 1982; Dwyer, 1988; Medlin and Skinner, 1988). The most important among these factors are (1) whether the goals of the study are to assess average intake of a group or whether the assessment goal is individual intake; (2) level of detail needed in the dietary intake assessment (food groups and nutrients needed for the analysis); (3) degree of precision needed in determination of food amounts (4) cost of administration of the assessment method, including the burden on the respondents. Accuracy and reliability of dietary assessment methods in the study population, and adequate training of data collection personnel are also important considerations in choosing the dietary intake assessment methods for specific studies. The most common methods used to assess individual intakes are food records and dietary recalls—these two methods are reviewed further.

3.1. Food record method

The food record method requires participants to measure and record types and amounts of all food and drinks consumed in a specified period of time (Bazzare and Myers, 1980). Foods consumed could be weighed to record the amount, or in some other studies, standard measuring cups and spoons are used to assess amounts. Food models, volume models and photographs of serving sizes have also been used in conjunction with food records to estimate amounts and portions. There are several disadvantages to the food record method, however. Since this method requires respondents to keep a record of the foods consumed, it requires cooperative, motivated, and literate respondents, as well as trained personnel to code and perform nutrient analysis once respondents complete food records. Respondents may also alter their diets to facilitate recording, and consequently, the reported intake may not accurately reflect the usual intakes. Weighing foods that are eaten at restaurants may also pose problems, and hence recall of these intakes for recording into the food records may not be accurate. Because this procedure is burdensome on participants, participation rates may typically be very low (Bazzare and Myers, 1980). Because this procedure is time consuming for respondents and investigators, with this method, it may be difficult to obtain representative large samples for epidemiological studies. Although
food record methods are cumbersome to administer, they have been found useful in pilot studies (Bingham, 1987). Studies have also shown that actual intakes are typically under-reported with this method (Mertz and Kelsay, 1984). An important variable of interest is the number of days of food record to maintain for purposes of dietary analysis. This depends upon the nutrients of interest and the sample size available—for example, if nutrient analysis information is desired for highly variable nutrients such as vitamin A, it is essential to maintain more extensive food records, than for overall energy values (Basiotis et al., 1987). In their study, Basiotis et al. (1987) estimate that they would have needed an average of 31 days of intake data to predict an individual's usual intake of energy (with 29 adults keeping records for 1 year), whereas an average of 433 days of record would have been required to predict an individual's usual intake of vitamin A. The mean food energy intake of the group could have been estimated just with 3 days of food record data, and the mean group vitamin A intake would have needed only 41 days of data. Other researchers (Sorenson, 1982; Bingham, 1987) have also concluded that to estimate the mean intake of a group, 3-day records are sufficient, provided they account for day-of-the-week variations (such as food eaten on a week-day versus a week-end day).

3.2. Dietary recall method

A 24-h diet recall is another method used for estimating food intake (Beaton et al., 1979; Block, 1982; Todd et al., 1983). Administration time is small in this method, and hence, the cost is also low. Some disadvantages of this method include poor accuracy due to failure to recall foods and portion sizes consumed, high day-to-day variability in the nutrient intake (which may not be captured with few administrations of a 24-h recall), large biases in recall due to a desire to please the interviewer, and reluctance to report consumption of food that may be construed unhealthy by the interviewer (such as alcohol and chocolates). Researchers suggest that, while a single 24-h recall may be valuable in assessing mean intake of a group (Gersovitz et al., 1978; Madden et al., 1976; Sorenson, 1982), it is also important to compare the accuracy of this method with other methods such as a diet record (Bingham, 1987). Checks for validity against measures such as 24-h urinary nitrogen as a reflection of protein intake, can increase accuracy and confidence in food intake analyses obtained by 24-h recalls (Block, 1982). Several researchers have used multiple administrations of the 24-h diet recalls from the same participants over several months to increase accuracy of their estimates, especially for highly variable nutrients (Bazzare and Myers, 1980; Liu et al., 1978; Rush and Kristal, 1982).

The diet history method typically used to obtain dietary intake information for longer periods of time than with diet records or 24-h recalls, seasonal variations can also be taken into account. However, an accurate diet history is very expensive to obtain and takes skilled interviewers. An alternative that has gained widespread use is the food frequency assessment method with questionnaires that are easy to administer and less expensive. These methods however often do not provide information on the amounts or portion sizes consumed; they provide information just on the frequency of food consumption—this may be useful for ecological studies that do not need high accuracy (Chu et al., 1984). Diet histories have been shown to produce higher estimates of intakes than food records (Bazzare and Myers, 1980; Bingham and Cummings, 1985; Block, 1982; Dwyer, 1988; Jain et al., 1980; Sorenson, 1982). Repeatability of the diet history methods have also been shown to be good (Hankin et al., 1983; Nomura et al., 1976). Diet histories and food frequency questionnaires are subject to recall biases (when participants consistently remember their intake of food as higher or lower than it actually was) and errors due to misreporting. Recent approaches that are semi-quantitative in nature seem promising (Willet et al., 1985; Block et al., 1986).

3.3. Food frequency questionnaires

In order to attain valid and reliable results, researchers also use food frequency questionnaires to assess dietary intake. These questionnaires
contain specific foods relevant to the area of focus of the study consumed is a given time frame. This time may vary from a day to a year. These can be self-administered, interviewer administered or can also be mailed. The duration of the interview also varies depending on the intensity of the contents, which are of interest. Block et al. (1986) developed a diet questionnaire. The portion sizes, the food list and the nutrient values were developed using dietary data from 11,658 participants from the NHANES study. In studies aiming at a particular population, data collected using a dietary instrument modified based on local knowledge and expert advice proved more valid compared with instruments developed using population data (Retzlaff et al., 1997).

Food frequency questionnaires have been found to provide reliable results by Morgan et al. (1978). Kolonel et al. (1977) investigated the accuracy of the responses and found good agreement between spouses at an intensity comparable to that found on repeated administrations to the same participant.

The food frequency questionnaire method is easy to administer for large sample sizes. This method, however, does not yield good results when precision of the nutrients is to be studied (Block, 1982). In studying the relationship between diet and disease, valuable data regarding food intakes of the elderly can be obtained from food frequency questionnaires. In food frequency questionnaires, recall of the intake in the past does not give appropriate data especially with older adults. This method is not appropriate for studying macronutrient intake, as this information requires longitudinal data and it is impractical to use a questionnaires for such long time where recalling dietary intakes for the past 1 year or more for older adults is not feasible.

3.4. Reliability and validity of dietary intake assessment instruments

Several errors in dietary intake assessment methods may affect the accuracy of the dietary data (Bingham, 1987). These include sampling errors, reporting errors, and errors due to large day-to-day variation in intake. Small samples may provide highly unrepresentative estimates of food intakes by populations even when individual data may be accurate, resulting in large sampling errors. When participation rates are low in a dietary intake study with random samples, a serious nonresponse bias could be introduced if those who refuse to participate in the study differ in their dietary intake substantially from the ones who participate in the study.

Several classes of reporting errors have already been discussed in the previous paragraphs, and all these relate to how cooperative, honest, motivated, and literate respondents who participate in dietary intake studies are. Errors caused due to day-to-day variations in food and nutrient intake can considerably affect estimates of the dietary intake. Interviewer bias due to poorly trained interviewers may affect results. Errors in dietary intake estimation may also occur due to inherent errors in food composition tables used for nutrient analysis (Bazzare and Myers, 1980; Bingham, 1987). Use of biological markers such as 24-h urinary sodium excretion as a validation criterion for sodium intake (Fregly, 1985), 24-h urinary nitrogen as a measure of protein intake (Bingham and Cummings, 1985; Isaksson, 1980), the use of toenail levels of selenium to assess selenium intake (Morris et al., 1983), and use of adipose tissue concentrations of fatty acids to assess types of fatty acids consumed (Beynen et al., 1980), can be used as validation criteria for dietary intake estimates.

Validation is a technique that supports the intent of measurement. This requires the knowledge of truth to verify the results. Studies determining dietary intake over a period of time confront practical difficulties. This requires skilled and experienced persons to observe the dietary intake of individuals over a period of time.

Validating 24-h dietary recall or diet history methods are possible by observing and measuring the food intake of the participant. But if the period is longer then it is practicality questionable. For such validation studies there is no perfect solution. The outcomes may vary from period to period. The solution can never be satisfactory and depends on the criteria used to analyze the data. The results may vary each time a validation study is
performed for the dietary intake varies widely from time to time. Again there is no standard rule to follow for validation studies. Again, the more the time frame of the study, the more cumbersome it is for both the participants and the researcher.

4. Summary

This paper reviewed instruments used in epidemiological research to assess physical activity and dietary intake in older adults. Accurate estimation of the types and extent of physical activity and dietary intake will enable accurate quantification of energy balance in older adults—this is important for design of work for older adults.

References


