Physical Activity Assessment Options
Within the Context of the Canadian
Physical Activity, Fitness, and Lifestyle Appraisal

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Catalog Data

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Mots-clés: dépense d’énergie, monitorage, capteurs de mouvement, niveau habituel d’activité physique, évaluation de la condition physique

Abstract/Résumé
The Canadian Physical Activity, Fitness, and Lifestyle Appraisal (CPAFLA) is a standardized battery of tests that is commonly used to assess asymptomatic individuals. This paper reviews evidence concerning the reliability, validity, and utility of the procedure currently used to assess habitual physical activity in the CPAFLA and surveys available physical activity assessment options. Special considerations related to age, gender, ethnicity, seasonal variations, and within-week variance are discussed. The potential assessment options are discussed with consideration given to the logistical and pragmatic constraints inherent in the CPAFLA. New technologies for future assessment of physical activity are briefly presented and recommendations for future research forwarded.

Le Guide canadien pour l’évaluation de la condition physique et des habitudes de vie contient une batterie de tests standardisés et utilisés généralement pour des individus

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asymptomatiques. Cet article analyse la fiabilité, la validité et l’utilité des procédures couramment utilisées pour évaluer les habitudes de vie en termes d’activité physique et fait le bilan des autres sources d’évaluation de la condition physique. Une attention particulière est apportée à l’âge, au genre, à l’origine ethnique, aux variations hebdomadaires et saisonnières. Les autres méthodes potentielles sont analysées en prenant en compte les contraintes logistiques et pragmatiques de la batterie actuelle. Les nouvelles technologies applicables à une modalité prochaine d’évaluation de la condition physique sont présentées et des recommandations sur le plan de la recherche scientifique sont proposées.

Introduction

In 1988 and 1992 Canadian researchers organized and hosted International Conferences on Physical Activity, Fitness, and Health. These landmark conferences demonstrated the international leadership provided by Canadian exercise scientists and began a cascade of events relating physical activity and health. The proceedings from the 1988 and 1992 International Conferences (Bouchard et al., 1990, 1994) consolidated available research evidence on the relationship between physical activity and health. In 1995 the National Institutes of Health in the United States held a Consensus Development Conference on Physical Activity and Cardiovascular Health (Leon, 1997). In 1996, the Surgeon General’s Report on Physical Activity and Health was released (U.S. Department of Health and Human Services, 1996). Each of these events reinforced understanding of the strong positive relationship between physical activity and health, making physical inactivity in the general population an important public health concern.

 Ironically, as evidence demonstrating the importance of regular physical activity accumulates, the North American population appears to be less active. Curricular time and resources dedicated to physical education are also declining (Tremblay et al., 1996). Canadians (Craig et al., 1998; Tremblay and Willms, 2000) and Americans (Flegal et al., 1998) are becoming fatter, and daily energy expenditures are declining (James, 1995). Although the proportion of inactive Canadians seemed to show some decreases in previous years, improvements now appear to have stopped (Canadian Fitness and Lifestyle Research Institute, 2000; Craig et al., 1998; Figure 1). Available data suggest that an alarming proportion of the Canadian population (63%) is currently engaging in insufficient physical activity to optimize their health, although there remains concern that the method of physical activity monitoring used by the Canadian Fitness and Lifestyle Research Institute (CFLRI), and other surveillance agencies, may not be sensitive enough to capture secular changes in daily energy expenditure. Recent dramatic increases in the prevalence of obesity and overweight (Craig et al., 1998; Flegal et al., 1998), and a decline in energy intake (James, 1995), support the concern about current activity levels.

Subtle but systematic reductions in the energy cost of daily living activities have had a profound impact on overall energy expenditures for much of the Canadian population. Modern conveniences that avoid or minimize small but repeated physical activities collectively result in a substantial reduction in daily energy expenditure. Traditional assessment procedures may not detect these subtle changes, yet there remains a need for valid and reliable methods to monitor trends in the physical activity of Canadians in order to allow effective planning and evaluation.
Figure 1. Changes in percentage of Canadian adult population who report being inactive (criterion of an energy expenditure <12 KJ per kilogram body mass per day).

of health promotion programs, policies, and legislation (Heart and Stroke Foundation of Canada, 1999).

Accurate assessment is needed at both a population and an individual level. Even those who are not trying to make changes in their activity patterns could benefit from such measurements. An increasing number of Canadians are using the services of fitness consultants to monitor their lifestyle and to make changes, including an increase in their habitual physical activity. The release of Canada's Physical Activity Guide to Healthy Active Living (Health Canada, 1998) will likely increase the demand for such personal monitoring services.

The Canadian Society for Exercise Physiology (CSEP) operates the Canadian Fitness Appraisal Certification and Accreditation (CFACA) program. This program administers training workshops to qualify appropriate candidates for fitness assessments, personal training, and fitness consulting. The entry level certificate is for the Certified Fitness Consultant (CFC). Candidates for a CFC workshop must be enrolled in (or have completed) a diploma or degree in exercise science, with courses in anatomy, physiology, exercise physiology, wellness, fitness, health promotion, human behaviour, communication, and counselling. The CFC workshop is a 32–36-hr course. Upon successful completion of the written and practical examinations, a CFC is qualified (and insured) to perform the Canadian Physical Activity, Fitness, and Lifestyle Appraisal (CPAFLA; CSEP, 1996). The CPAFLA has a very clear health-related focus. The CPAFLA package provides standardized procedures to assess the physical activity, fitness, and lifestyle of healthy adults. The CFC workshop also provides training in counselling clients how to use the results to facilitate desired changes in physical activity and fitness. There are now nearly 4,500 qualified people in Canada administering the CPAFLA.

The CPAFLA currently uses a brief three-item questionnaire to assess physical activity (Figure 2). A simple scoring procedure places the client into one of five intuitively determined “health benefit zones,” ranging from “needs improvement” to “excellent.”
DETERMINING THE HEALTH BENEFITS OF YOUR PHYSICAL ACTIVITY PARTICIPATION IS AS EASY AS A, B, C ...

A. Answer the following questions:

#1 Frequency
Over a typical seven-day period (one week), how many times do you engage in physical activity that is sufficiently prolonged and intense to cause sweating and a rapid heart beat?
- At least three times
- Normally once or twice
- Rarely or never

#2 Intensity
When you engage in physical activity, do you have the impression that you:
- Make an intense effort
- Make a moderate effort
- Make a light effort

#3 Perceived Fitness
In a general fashion, would you say that your current physical fitness is:
- Very Good
- Good
- Average
- Poor
- Very Poor

B. Circle your score for each answer and total your score.

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Frequency</td>
<td>rarely or never</td>
<td>0</td>
<td>normally once or twice</td>
<td>2</td>
<td>3</td>
<td>at least three times</td>
</tr>
<tr>
<td>#2 Intensity</td>
<td>light effort</td>
<td>0</td>
<td>moderate effort</td>
<td>1</td>
<td>2</td>
<td>intense effort</td>
</tr>
<tr>
<td>#3 Perceived Fitness</td>
<td>very poor or poor</td>
<td>0</td>
<td>0</td>
<td>average</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

C. Determine your health benefit rating based on your score from B.

<table>
<thead>
<tr>
<th>Health Benefit Zone</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>9 – 11</td>
</tr>
<tr>
<td>Very Good</td>
<td>6 – 8</td>
</tr>
<tr>
<td>Fair</td>
<td>4 – 5</td>
</tr>
<tr>
<td>Needs improvement</td>
<td>1 – 3</td>
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</tbody>
</table>

Figure 2. Physical activity participation assessment and scoring procedure used in the Canadian Physical Activity, Fitness, and Lifestyle Appraisal (CPAFLA). (Reprinted with permission from the Canadian Society for Exercise Physiology.)

The CPAFLA, released in 1996, was designed to be an evolving and dynamic resource that responds to the changing needs of the fitness profession. The CPAFLA has now been used with over 100,000 Canadians, and several strengths, weaknesses, and limitations to the procedures and instruments have been identified. Physical activity assessment remains one area of concern. The current instrument (see Figure 2) gathers very limited information on physical activity behaviour,
and there is only limited evidence of its validity. This manuscript reviews current evidence concerning the reliability and validity of the procedure used in the CPAFLA and surveys other assessment options available. The paper is intended to provide a review of physical activity measurement options to inform and educate readers about current issues and techniques in physical activity measurement, and also to facilitate an appreciation for the complexities of making effective modifications to the existing CPAFLA.

**Current Procedure Used in CPAFLA**

Physical activity assessment options for use in the current CPAFLA format are constrained by several factors (Table 1). To accommodate these constraints a simple questionnaire, based on the research of Godin and Shephard (1985) and Shephard and Bouchard (1994), was selected. Shephard and Bouchard examined the relationship between questionnaire responses and objective health-related fitness measures (body mass index, circumferences, skinfolds, body fat, blood glucose, uric acid, total cholesterol, HDL-cholesterol, triglycerides, PWC\textsubscript{150}, blood pressure, and resting heart rate). The intent was to identify a very brief and simple set of questions that would predict health-related fitness in healthy men and women of working age. Several indicators of health-related fitness were best predicted when self-perception scores of present fitness, activity level, intensity of activity, and frequency of activity were included in the analyses. It was concluded that the questions listed in Figure 2 were the best three items to include in a simple index of health-related fitness. This physical activity assessment procedure has many intrinsic strengths; it is easy to administer, easy to interpret, easy for the client to complete, and a single form can be used for the diverse range of clients tested with the CPAFLA. There are also limitations to the current procedure. The authors acknowledge that, like most questionnaires, the prediction of health-related fitness from any combination of the questions tested was quite weak (Shephard and Bouchard, 1994). While statistically significant, the results explained only 15% of the variance for the sample originally tested, and the validity would probably be even lower in an independent sample of adults. Socioeconomic variables (e.g., education, occupation) and occupational physical activity were recognized as important predictors of physical activity, yet these items were not included in the CPAFLA assessment.

Shephard and Bouchard (1994) provided a scoring system that was revised to form the basis of the health benefit zone categorization presented in Figure 2. Further research substantiating this scoring system, however, has never been conducted and the reliability of the CPAFLA physical activity scoring system, to our knowledge, remains to be studied.

Though the instrument appears to predict health-related fitness reasonably, the nature of the questions does not allow detection of moderate changes in physical activity, and therefore the instrument is of limited value as a counselling tool. For example, daily activities, which can account for a significant amount of daily energy expenditure, are not assessed, and occupational activity is also not overtly included. If additional information were gathered, this could help fitness consultants to assist clients in making changes in exercise behaviour.
### Table 1 Factors Constraining Physical Activity Assessment Options for the CPAFLA

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diverse target populations</td>
<td>CPAFLA is used with culturally diverse males and females, aged 15-69.</td>
</tr>
<tr>
<td>Administration</td>
<td>CPAFLA administration involves a single 60-90 minute session, with minimal facility requirements.</td>
</tr>
<tr>
<td>Financial and time considerations</td>
<td>CPAFLA is a low cost and time-efficient protocol that does not rely on expensive equipment. Procedures requiring additional equipment or repeated visits would increase cost and time.</td>
</tr>
<tr>
<td>Complexity of interpretation</td>
<td>Current CFC training and the time allocated within the CPAFLA for assessing physical activity is minimal. The CFC curriculum cannot easily accommodate complicated procedures requiring time consuming interpretations.</td>
</tr>
<tr>
<td>Response burden</td>
<td>The current instrument places limited burden on the responder. It is also important that the administrator analyze responses quickly and give objective feedback to clients.</td>
</tr>
<tr>
<td>CFC training</td>
<td>The current CFC curriculum offers no time to introduce new physical activity monitoring equipment. Substantial changes to the assessment procedure would require a strategy for retraining and updating existing CFCs.</td>
</tr>
<tr>
<td>Insurance</td>
<td>The current CFC insurance coverage is limited to the questionnaire in use.</td>
</tr>
</tbody>
</table>

### Physical Activity Monitoring Procedures

Because physical activity is transitory, elusive, and multidimensional (i.e., involves frequency, duration, intensity, and type), accurate assessment is challenging. Current methods include self-report, electronic and mechanical monitoring, direct observation, direct and indirect calorimetry, and ingestion of doubly labelled water. The strengths, limitations, and practical issues in use of these techniques have been reviewed recently (Caspersen et al., 1998; Kriska and Caspersen, 1997; Montoye et al., 1996). The choice of a particular technique or instrument depends on numerous factors such as the purpose of the study, research design, practicality (e.g., respondent and administrator burden), cost, level of precision and specificity needed, concerns for reliability and validity, and the age, gender, and ethnicity of participants.

The purpose of this section is not to provide an exhaustive literature review, but rather to survey available procedures for their potential use in the CPAFLA context. Procedures are briefly reviewed, and their potential inclusion within the logistic, pragmatic, and financial constraints of the CPAFLA are discussed.
LABORATORY METHODS

Direct and indirect calorimetry. Laboratory procedures using direct or indirect calorimetry remain the standard against which practical field methods are validated. Although these procedures do not measure physical activity behaviour per se, the energy expenditure resulting from physical activity can be measured accurately after correcting for resting metabolism and the thermic effect of food. However, traditional expired gas analysis systems are expensive, necessitate the advanced training of observers, cannot accommodate the full range of free living physical activity, and are excessively precise for a general purpose measure. Though portable telemetric expired gas analysis systems are now available, the cost of these devices is prohibitive and their use in the CPAFLA is impractical and unwarranted.

PHYSIOLOGICAL INDICATORS OF PHYSICAL ACTIVITY

Several physiological indicators, including heart rate, ventilation, body temperature, electromyographic (EMG) activity, oxygen consumption, and carbon dioxide production have been used as surrogate measures of physical activity. Each of these physiological variables increases with an increase in physical activity (McArdle et al., 1996; U. S. Department of Health and Human Services, 1996; Wilmore and Costill, 1999), and their monitoring can provide an assessment of physical activity behaviour. Although advances in microelectronic and microprocessing technology may soon make monitoring of EMG, ventilation, body temperature, and gas analysis convenient and affordable, they are not practical for the CPAFLA.

Heart rate. Heart rate offers the most practical physiological data set. The use of heart rate to assess physical activity is based on the approximate linear relationships among heart rate, oxygen consumption, and work rate (Meijer et al., 1989). Although these relationships have some limitations, people who spend time in higher heart rate ranges are generally more active than those spending time in lower heart rate ranges (Durant et al., 1993; Freedson, 1991). Many heart rate monitors are relatively inexpensive, easy to use, and can store minute-by-minute data for several days. In addition, many people administering the CPAFLA use a telemetric heart rate monitor during the aerobic fitness portion of the test, so that the necessary equipment is often readily available.

The validity and reliability of heart rate monitors have been studied extensively (Montoye et al., 1996). Results vary (Montoye et al., 1996), but these monitors can provide valid estimates of physical activity energy expenditure in adults (Livingston et al., 1990; Schultz et al., 1989). To obtain physical activity information that reflects habitual patterns, at least 4 to 6 days of heart rate recording is necessary and should be collected on both weekend and weekdays. In continental climates such as Canada, due consideration should also be given to seasonal variations in activity patterns.

Despite many practical advantages, heart rate monitoring has significant limitations for use in the CPAFLA. Firstly, there is day-to-day variation in the heart rate response to a given activity, even under controlled conditions (Montoye et al., 1996). Secondly, resting heart rate varies substantially among individuals, especially
across different fitness levels. Thus, heart rate data must be adjusted for individual resting heart rates. Thirdly, confounding factors (including environmental temperature, emotional stress, caffeine intake, the thermogenic effect of food, use of nicotine, and various medications) can affect heart rate and/or the heart rate response to exercise (American College of Sports Medicine, 1995). Fourthly, the relationships among workrate, $\dot{V}O_2$, and heart rate vary both between and within individuals (Arts and Kuipers, 1994; Becque et al., 1993). Further, the relationship between heart rate and oxygen intake depends on the type of exercise being performed (Washburn and Montoye, 1986) and is less accurate at low levels of exercise. For example, the legs can develop a greater power output than the arms, but the heart rate response to a given power output is greater for the arms than for the legs (Wilmore and Costill, 1999). As a result, some researchers claim that heart rates can overestimate energy expenditure during normal daily activity (Bailey et al., 1995). Fifthly, although many people administering the CPAFLA have a telemetric heart rate monitor, they may lack the computer capability necessary to download stored heart rate data. Also, fitness consultants may have only a single monitor, and they may be reluctant to send their testing equipment home with clients. Finally, the reduction and interpretation of heart rate data may be excessively difficult for the CFC. For example, if 4 to 6 days of minute-by-minute heart rate data were to be collected on a client, the data would need to be downloaded, checked for artifacts, have resting heart rate determined and subtracted from all data points, and then some indicators of light, moderate, and vigorous activity established.

**Doubly labelled water.** The doubly labelled water procedure requires clients to ingest stable isotopes of hydrogen ($^2$H) and oxygen ($^{18}$O) in the form of "labelled water." The physiologic fate of these isotopes is assessed through urine samples, and calculations are made to assess energy expenditure during the testing period (Montoye et al., 1996). This procedure has been used effectively to assess free living energy expenditure, although data only indicates average values for relatively long periods (1–3 weeks). The procedure is harmless, produces little subject reactivity or response burden, and is effective for persons of all ages. However, it requires expensive laboratory analyses; provides no information on activity frequency, intensity, duration, or type; and is not practical for use in the CPAFLA.

**MOTION SENSORS**

Physical activity is frequently assessed using motion sensors, including pedometers and accelerometers. Motion sensors avoid problems of subjectivity and recall of information by clients, place a low burden on investigators, and are useful for validating other methods. However, these devices are usually expensive, may be obtrusive, cannot be worn in certain environments (e.g., contact sports, underwater), create a potential for subject reactivity and data loss because of instrument failure or tampering, and would require significant data reduction and translation for counselling in the CPAFLA setting.

Mechanical pedometers are inexpensive but are limited to assessing the vertical movement associated with stepping. Accelerometers can measure acceleration in one to three planes. Newer models (e.g., CSA, TRITRAC) store activity recordings in memory chips for subsequent computer downloading and analysis.
Technological advances are making the use of mechanical and electronic monitors more affordable and convenient. The use of motion sensors in the CPAFLA deserves consideration, now and in the future.

**Pedometers.** Modern pedometers provide the researcher with a low cost, objective measure of walking behaviour, which accounts for a substantial proportion of active energy expenditure by most adults each day. The pedometer is usually attached at the waist (over one hip), or clipped to the ankle. The simplest pedometers measure only the number of steps walked; however, most models can adjust for average stride length and allow total kilojoules of energy expenditure to be calculated based on the distance travelled and assumptions regarding the energy cost of walking (Bassett et al., 1996).

Scores on some pedometers vary significantly, depending on the velocity of walking, the side of the body the device is worn on, and stride length (Bassett et al., 1996). The accuracy of the measured distance also varies between different brands of pedometers. Pedometers can be used to predict energy expenditure, but it must be assumed that all steps have an equal energy cost, whether walking or running. Despite some limitations, pedometers provide a general assessment of daily movement, which may be useful for many CPAFLA clients.

**Accelerometers.** When a person moves, the limbs and the body are accelerated, theoretically in proportion to the muscular force exerted, and thus to energy expenditure. Portable accelerometers measure accelerations of the body part to which they are attached. The data is usually converted to counts per minute, but more sophisticated devices estimate energy expenditure directly in kilojoules. Although an accelerometer can provide an objective summary of body movements, it often underestimates energy expenditure because it cannot detect physical activity in free living situations where much of the body remains stationary; for example, during cycling or resistance training (Meijer et al., 1989; Sallis et al., 1990). Luke et al. (1997) suggested that a significant strength of the accelerometer, when used with a heart rate monitor, is its ability to estimate energy expenditure more accurately at low levels of activity, whereas heart rate monitors are more valid for energy expenditures at high levels of energy output.

Accelerometers have moderate validity ($r = 0.2–0.7$) when compared to other field methods of assessing physical activity (Janz et al., 1995; Montoye et al., 1996; Sallis et al., 1990). Between-day stability is increased with the number of days assessed. Research suggests that 4–7 days of monitoring are required to obtain a reliable assessment of physical activity behaviour (Janz et al., 1995; Trost et al., 2000).

The present cost of quality accelerometers precludes their widespread use in the CPAFLA. Until accelerometers become more affordable, fitness professionals will be reluctant to acquire them or send them home with their clients. The necessary data reduction and analysis may also be beyond the ability of some CFCs. Nevertheless, accelerometers may soon provide a simple and inexpensive alternative for assessing physical activity in the CPAFLA.

**DIRECT OBSERVATION**

Direct observation procedures include actual or videotaped viewing of physical activity. These procedures are highly reliable and valid; have a low respondent
burden; produce summary scores that are useful to practitioners; are the best method of assessing the context in which activity occurs; are particularly useful when studying young children, physical education, and youth sports; and are valuable for validating other methods (Montoye et al., 1996). Such procedures, however, are costly, labour intensive, require substantial observer training and recalibration, have potential for subject reactivity and observer bias, and are not practical when assessing large populations. Videotaping offers the additional advantage of being able to view the same behaviours and environment several times and from differing points of view. Videotaping, however, increases the cost of observation, requires additional human consent, and cannot be carried out unobtrusively or in all settings. Presently, direct observation procedures seem impracticable for use within the CPAFLA. Possible future refinements, including photography or video equipment embedded within pieces of clothing or jewelry, or the use of global position systems, may eventually make direct observation procedures a practical alternative for physical activity assessment in the CPAFLA.

SELF-REPORT MEASURES OF PHYSICAL ACTIVITY

Self-report measures of physical activity include prospective logs, retrospective questionnaires, diaries and interviews, global assessments, and job classifications. In general, these provide only very crude assessments of an individual’s habitual physical activity when validated against criterion measurements such as sophisticated accelerometers or the use of doubly labelled water.

Prospective logs, diaries, and retrospective questionnaires. If individuals are well-motivated, prospective logs can provide an accurate form of self-report, such as by coding behaviour every 15 min throughout the day (Weiner and Lourie, 1981). Prospective reporting is most effective when the activity is relatively consistent throughout much of the day. The 15-min reporting interval does not work well if the type of activities are varied and each has a duration of 1–2 minutes or less. Moreover, if the use of logs is extended for more than a few days, care in their completion typically deteriorates, and sometimes reports are entered hastily in retrospective fashion just before they are to be collected.

Diaries completed in prospective fashion are similar to prospective logs, but the reporting period and the types of activity undertaken are not standardized. Rather, the subject is asked to note the time and the nature of the activity undertaken every time that there is a change of pursuit. If a few stereotyped activities are undertaken, this method may work quite well, but it is very time consuming and requires a great deal of cooperation if the pattern of activity changes every few minutes (Shephard, 1986). Further, the need to record any change in activity may in itself act as a constraint, encouraging a person not to modify activity. Finally, there can be privacy issues, and some respondents may not want to disclose their activity patterns and may even change them because they are being observed.

An enormous range of physical activity questionnaires is currently available (Jacobs et al., 1993; Kriska and Caspersen, 1997; Paffenbarger et al., 1993; Vuillemin et al., 1998). The number of instruments underlines the dissatisfaction with the results they produce. Some instruments are lengthy, taking 30–60 min to complete. However, there is little evidence that the validity of a questionnaire is increased in proportion to its complexity. Some of the highest correlations with
external measures of habitual physical activity have been obtained from simple instruments with only a few key questions (Godin and Shephard, 1985).

One important consideration in the use of detailed questionnaires is the amount of assistance required for their completion. Some surveys provide assistants to answer questions or cue cards to remind participants of possible activities that they may have pursued (Shephard, 1986). Often, time spent in various types of activity are overestimated so that the total number of minutes occupied exceeds 1,440 per day. It is then necessary to “scale” activities, assuming that the duration of all pursuits has been exaggerated in similar fashion.

_interviews_. In order to be effective, interviews must be structured. Typically, they follow a similar pattern to retrospective questionnaires. An interview may take 25–60 min per person and thus is an expensive method of assessment. Additionally, there is little evidence that overall responses to detailed interviews have greater validity than the answers to a short series of carefully posed questions (Godin and Shephard, 1985; Shephard, 1986).

_global assessments and job classifications_. Global assessments may use Likert-type scales either to compare self-ratings of habitual physical activity with an individual’s peers of similar age or to make an absolute assessment of habitual activity (the latter ranging, for example, from regular training for a specific sport to taking no deliberate leisure activity). When a general assessment of physical activity is desired, simple global measurements can be as effective as using detailed questionnaires.

Some epidemiological studies have found good correlations between assessments of occupational physical activity and health outcomes such as cardiovascular disease (Paffenbarger et al., 1970) and colon cancer (Gerhardsson et al., 1986). Assessments were made of the apparent daily energy cost of various job categories, or individuals were asked to rate the amount of standing, walking, lifting, and carrying demanded by their particular job. There are two problems in applying this approach to individuals. Firstly, a combination of automation and deindustrialization has now diminished heavy occupational work in developed countries. Secondly, job categorization is necessarily crude, and older workers or those in poor health may be assigned to low intensity activities within a supposedly “heavy” job classification (Shephard, 1999).

**Special Considerations for Physical Activity Assessment**

It is necessary to adapt the standard procedures of physical activity assessment to accommodate gender issues, special populations, and temporal variations in activity patterns.

**Gender Issues**

Several large scale epidemiological studies and reports, mainly from the Cooper Institute (Blair et al., 1989, 1993, 1995, 1996) have found that the correlation between physical fitness and health is stronger than that between questionnaire-assessed physical activity and health, particularly in women. The suggested reasons are that physical fitness can be measured more precisely than physical activity and that several existing physical activity questionnaires ignore many activities
that are typically done more by females, such as cleaning the home and attending to the needs of dependents (Blair et al., 1993; Young and Steinhardt, 1993). Women are also less likely than men to report family activities as leisure. At the Measurement of Physical Activity Conference held at the Cooper Institute in Dallas in October, 1999, Dr. David Jacobs stated that physical activity questionnaires must “speak to the lives” of the respondents. In addition, there are some gender differences in both the energy cost of standard activities and the typical pace of activities (Durnin and Passmore, 1967), and some personal monitors, such as ECG recorders, are fitted less easily to women than to men. Also, because of a smaller average body mass, women spend less absolute energy during a given period of physical activity (Ainsworth et al., 1993).

The following are the practical implications of these findings:

1. If fitness and activity assessments do not agree, the fitness assessment is more likely to reflect the health status of the individual.
2. If a woman reports a low level of physical activity yet appears fit, more attention should be directed to possible energy expenditures in home-making and care for dependents.
3. A woman will typically take longer than a man to attain a fixed reduction in body fat from, for example, walking at 4 km per hour, in part because of differences in body size, and in part because body fat reserves are inherently more stable in the female.

SPECIAL POPULATIONS

Children and youth. Most authors have experienced considerable difficulty in assessing the activity patterns of young children, with scores frequently showing correlations of no more than 0.10 with external criteria (Lamb and Brodie, 1991; Pate et al., 1994; Riddoch et al., 1992). Problems relate to the pattern of activity adopted (often varied in nature and occurring in short bursts), departures from adult norms of energy cost even for simple activities such as walking and running (Billat et al., 1992; Shephard, 1982), and (in the case of questionnaires) of an inability to evaluate personal behaviour objectively (Lamb and Brodie, 1991; Pate et al., 1994).

Possible solutions include peer rankings of activity made by either the parents or fellow students (Saris et al., 1980), completion of a daily activity diary under parental or teacher supervision (Shephard et al., 1980), negative rankings based on hours of television and computer-based activity, or, if facilities permit, the recording of heart rates. If the heart rate is low throughout most of the day, it is fairly clear that the child is getting inadequate physical activity (Armstrong et al., 1990).

For many youth, sport may account for a significant fraction of the total weekly energy expenditure. Here, estimates of habitual physical activity are complicated by large variations in the intensity of energy expenditure dependent on the levels of skill and competition (Ainsworth et al., 1993; Durnin and Passmore, 1967), inaccuracies in simple monitoring devices such as pedometers (Kemper and Verschuur, 1977), technical problems in the use of more sophisticated motion sensors and pulse counters (Armstrong et al., 1990), and inadvertent or deliberate exaggeration of participation on questionnaires.
Reporting accuracy on questionnaires can be enhanced by completion of a daily diary record each morning over a 1-week period or through the use of repeated 1-day recalls using a segmented day strategy. If a student is playing on a school sports team, it is likely that he or she will be getting adequate physical activity for health purposes. Particularly for non-athletes, it is important to enquire about transport to and from school (walking and/or cycling may provide a significant volume of physical activity).

**Elderly and those with disabilities.** The standard approaches to the assessment of physical activity such as questionnaires and pedometers should work quite well in the young elderly (those aged 65–75 years) without functional impairment, since they tend to have regular and well-standardized activity patterns based primarily upon walking (Shephard, 1986; Stephens and Craig, 1990).

In the middle- and old-old (those over the age of 75 years) and those with varying degrees of disability, problems may arise in understanding the fitting and use of personal monitors. There may also be difficulty in hearing and reading instructions for personal monitoring equipment, and assessors must assume much of the responsibility for operating such apparatus effectively. Likewise, there may be problems in recalling events, and considerable assistance may be needed to get accurate responses to questionnaires. Disabilities such as arthritis or minor strokes may cause the pattern of activities to be altered, thereby modifying participation and the energy cost even of basic tasks such as walking (Shephard, 1991). A low overall level of energy expenditure throughout the frail elderly population limits the ability to distinguish between “active” and “inactive” groups (Shephard, 1997).

**Ethnic and cultural issues.** The questionnaire assessment of physical activity is particularly difficult in a nation as ethnically diverse as Canada. All self-report instruments must undergo the demanding process of translation into both official languages, with a need for validation of linguistic equivalence after translation. Further, many of the population do not have either English or French as their first language and are thus liable to misinterpret questions. Finally, unacculturated indigenous populations have different concepts of time than those in urban centres, biasing estimates of the duration and frequency of activity (Shephard and Rode, 1996). Many questionnaires have been created without due regard for culturally diverse activities and behaviours. For example, some include checklists of activities that only reflect activities popular in the mainstream of U.S. male culture. In an effort to be sensitive to cultural diversity, assessors must establish whether the concepts they are assessing have the same conceptual meaning across populations and that the results or feedback is culturally relevant. There may also be significant cultural variation in the interpretation of terms and reference points (for example “moderate” physical activity).

When cultural variation in physical activity behaviour is adjusted for socio-economic status (SES), many of the differences in reported energy expenditures disappear (U.S. Department of Health and Human Services, 1996). In addition to SES, geographic boundaries, rural vs. urban environments, and the type of work that individuals do should be considered when assessing physical activity. Those with a lower SES, rural populations, and blue collar workers tend to engage in more physical activity on the job and in domestic chores. Assessment procedures should accommodate the physical activity accrued at work, during leisure time, home maintenance, and transport.
TEMPORAL VARIATIONS

**Seasonal Factors.** Given the continental nature of the Canadian climate, major seasonal changes in physical activity patterns and resulting fitness levels are almost inevitable (Shephard et al., 1978). Moreover, most individuals have difficulty in recalling activities over an entire year, particularly the frequency and total period of seasonal activities (Weiner and Lourie, 1981).

In large scale surveys, this problem is best addressed by distributing data collection over a calendar year and asking participants to recall events for a shorter period of 1 week or 1 month. In the context of individual assessment, the ideal approach is to make several assessments at different seasons. Alternatively, the recall of out-of-season activities can be facilitated by the use of cue cards. In cold weather, assessments based on sweating and shortness of breath may be biased by low temperatures and cold-induced bronchospasm. Sports programs also tend to be seasonal, and even if an individual participates in sports year-round, the activity levels among sports vary tremendously.

**Weekday vs. weekend.** The significant difference between weekday and weekend patterns of physical activity has been recognized since the early days of the International Biological Programme (Weiner and Lourie, 1981). For questionnaires, the simplest approach is to base information on the recall of an entire week or an entire month. Where expensive personal monitoring equipment is used, it is important to include measurements made on both weekends and working days. In the current Canadian context, the weekend may also comprise two distinct days—one devoted to shopping and household chores, and the other to rest and relaxation or sports. Each of these days may need to be sampled to get a representative picture of an individual’s habitual physical activity.

**Future Possibilities**

Advances in microprocessor and microelectronic technology seem likely to create numerous future possibilities for the assessment and monitoring of physical activity. Video and computer-based recall instruments with audio and visual prompts and cues may improve the validity of recall questionnaires, especially with children (Tremblay et al., in press). Wearable computers with microprocessors and sensors to monitor respiration (chest movement monitored by sensors installed in sports bras), EMG (tight fitting clothes), blood pulse volume (ear ring), and temperature (ear ring) are realistic possibilities. The use of galvanic skin sensors, pressure transducers inserted in shoe implants, and the use of small digital cameras inserted in clothing (buttons, jewelry) that take pictures every minute may also become available (Jennifer Healy, presentation at Measurement of Physical Activity Conference, Dallas, 1999). Global positioning systems (GPS) can be used to track an individual's movement to within a few metres and are already in use for assessing outdoor activities. Local position systems (LPS) are now developed as well and in the future may be an effective physical activity monitoring alternative. Finally, using toys to monitor activity in children may have some merit. Nintendo recently produced a Pokemon™ “virtual pet” toy that contains a pedometer. The pet thrives on the child’s recorded movement. This type of creative engineering may generate other new monitoring procedures.
Summary and Recommendations

Many physical activity assessment options are currently available; their respective advantages and disadvantages are summarized in Table 2. For optimum utility in counselling, a physical activity assessment instrument should assess frequency, intensity, duration, and type of activity performed, with appreciation for age, gender, cultural, and seasonal variations. Assessments should include information on leisure-time, occupational, and daily living physical activities, including domestic chores and transportation. Ideally, assessment procedures should differentiate among light, moderate, and vigorous physical activity. For reliable assessment of physical activity at least 1 week of monitoring is required.

Obtrusive or expensive procedures, or using different procedures simultaneously, may be required to obtain the desired information. To decide which procedure to use, the error in measurement is often weighed against respondent and/or appraiser burden (e.g., cost, time, or inconvenience). It is important that the results be meaningful to respondents and counsellors, have real-world value, and be based on strong scientific findings. Ease of administration, data analysis, and interpretation are additional concerns for the CPAFLA.

The instrument currently used to assess physical activity in the CPAFLA has limitations for monitoring physical activity behaviour and for effective counselling. Change is required to obtain the desired information. Retrospective, self-report questionnaires remain the most practical physical activity assessment procedure for use in the CPAFLA; however, the validity and reliability of potential alternative questionnaires have not been determined in the CPAFLA setting.

The most common method of estimating the health-related impact of physical activity is to link observations to previously reported beneficial daily energy expenditures. For example, Paffenbarger et al. (1986) reported that the relative risk of all-cause mortality increased systematically as weekly physical activity decreased from >14 MJ/wk down to <2 MJ/wk. The new Health and Fitness Benefits of Physical Activity Chart (CSEP, 1999), adopted by many fitness consultants as a counselling tool when administering the CPAFLA, uses energy expenditure per week as the reference axis. The ubiquitous use of this new tool and the substantial literature demonstrating a dose-response relationship between total weekly energy expenditure and health suggest that use of this type of score may be appropriate for the CPAFLA. Another advantage of using an energy expenditure value is that many CPAFLA clients are familiar with the concept. Several existing questionnaires allow for daily or weekly energy expenditure to be calculated quite easily.

Excessive cost and complexity of data interpretation make most direct measures of physical activity unrealistic for use in the CPAFLA. The one exception may be digital pedometers, which are currently available and inexpensive and easy to use. Walking is a common, pervasive activity with direct relevance to most CPAFLA clients, and in many cases the primary lifestyle modification recommendation is to increase recreational walking, or to purposefully include it in daily activities. A pedometer could assess the volume of locomotor activity performed per day or week and be used to assess changes resulting from an exercise prescription. Pedometer data, however, are not available to allow a health-related scoring system to be developed at this time.
<table>
<thead>
<tr>
<th>Assessment procedure</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Laboratory Methods</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Direct calorimetry</td>
<td>precise, valid, reliable, reproducible</td>
<td>equipment cost ($$$), impracticable, not field based</td>
</tr>
<tr>
<td>Indirect calorimetry</td>
<td>precise, valid, reliable, reproducible</td>
<td>equipment cost ($$$), impracticable, obtrusive</td>
</tr>
<tr>
<td><strong>Physiological Indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doubly labelled water</td>
<td>precise, accurately estimates total energy expenditure, low response burden, useful for validating other instruments, low reactivity</td>
<td>cost ($$)/subject, indirect measure, laboratory analysis, lacks information on activity type, intensity, frequency, or duration</td>
</tr>
<tr>
<td>Heart rate monitoring</td>
<td>objective, unobtrusive, easy to use, can gather much temporal data</td>
<td>equipment cost ($$), lacks standardized scoring, malfunction problems, cannot be used for all activities</td>
</tr>
<tr>
<td><strong>Motion Sensors</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pedometers</td>
<td>low cost ($), low reactivity, unobtrusive, low response burden</td>
<td>imprecise, cannot measure intensity, frequency, duration, or exercise type, several days of measurement required</td>
</tr>
<tr>
<td>Accelerometers</td>
<td>low response burden, can measure intensity, frequency, duration</td>
<td>equipment cost ($$), several days of measurement required, possibly obtrusive, not valid for all activities</td>
</tr>
<tr>
<td><strong>Direct Observation</strong></td>
<td></td>
<td></td>
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<tr>
<td>Systematic observation</td>
<td>precise, valid, objective</td>
<td>time consuming, may alter behaviour, impracticable</td>
</tr>
<tr>
<td>Videotape analysis</td>
<td>archived visual evidence, valid</td>
<td>expensive, time consuming, may alter behaviour, impracticable</td>
</tr>
<tr>
<td><strong>Self-Report Procedures</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prospective logs</td>
<td>thorough, can assess many dimensions of PA</td>
<td>high response burden, subject reactivity, subjective</td>
</tr>
<tr>
<td>Recall questionnaires</td>
<td>practicable, applicable, unobtrusive, low cost, easy to administer and interpret, can assess many dimensions of PA</td>
<td>potential biased reporting, limited validity and reliability, lack of precision</td>
</tr>
<tr>
<td>Diaries</td>
<td>thorough, can assess many dimensions of PA</td>
<td>high response burden, subject reactivity, subjective</td>
</tr>
<tr>
<td>Interviews</td>
<td>thorough, can assess many dimensions of PA</td>
<td>high response burden, subjective, labour intensive, expensive</td>
</tr>
<tr>
<td>Global assessments/Job Classifications</td>
<td>easy to administer and assess, low response burden</td>
<td>imprecise, low validity</td>
</tr>
</tbody>
</table>

*Note. $ = $10-$99; $$ = $100-$999; $$$ = $1000.*
Table 3  Recommendations for the Physical Activity Assessment in the CPAFLA

Recommendation #1: That the existing instrument continue to be used until research identifies an alternative procedure with greater validity and reliability in the CPAFLA setting.

Recommendation #2: That the validity, reliability, and practicality of the best recall questionnaires that assess weekly energy expenditure be determined in the CPAFLA setting. The most effective instrument should then be used to generate a scoring system that allows Health Benefit Zones to be established.

Recommendation #3: That digital pedometers be pilot tested to assess their practicality in the CPAFLA setting. This pilot testing should include an assessment of their validity and reliability, and the development of appropriate Health Benefit Zones.

There are insufficient data to recommend specific changes to the physical activity monitoring in the CPAFLA at this time. The recommendations in Table 3 are forwarded to assist with future revisions to the CPAFLA.

References


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