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SPECIAL ARTICLE

Dietary Intake and Physical Activity Assessment: Current Tools, Techniques, and Technologies for Use in Adult Populations

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Accurate assessment of dietary intake and physical activity is a vital component for quality research in public health, nutrition, and exercise science. However, accurate and consistent methodology for the assessment of these components remains a major challenge. Classic methods use self-report to capture dietary intake and physical activity in healthy adult populations. However, these tools, such as questionnaires or food and activity records and recalls, have been shown to underestimate energy intake and expenditure as compared with direct measures like doubly labeled water. This paper summarizes recent technological advancements, such as remote sensing devices, digital photography, and multisensor devices, which have the potential to improve the assessment of dietary intake and physical activity in free-living adults. This review will provide researchers with emerging evidence in support of these technologies, as well as a quick reference for selecting the "right-sized" assessment method based on study design, target population, outcome variables of interest, and economic and time considerations.

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INTRODUCTION

Accurate assessment of dietary intake (DI) and physical activity (PA) is essential for quality research in the fields of public health, nutrition, and exercise science. However, consistent and accurate estimation of both remains one of the largest challenges in these fields. Several subjective and objective measures of DI and PA assessment exist, each with its own limitations and biases.

Capture of DI in healthy adult populations is intricate and multidimensional, thus making accurate quantification challenging. DI is traditionally assessed using self-report measures, including food frequency questionnaires (FFQs), diet records, and recalls.[1–3] Such self-report measures have been shown to underestimate energy intake by approximately 11%–35% (more prevalent among obese individuals) compared with direct measures like doubly labeled water.[4–7] Reporting error that includes bias, also known as systematic error, misestimation, and

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random error, and error related to nutrient databases for foods being reported are a few of the current criticisms that have questioned the adequacy of self-report DI measures as the basis for scientific conclusions regarding the link between DI and health.[8–11] From the findings in studies with doubly labeled water, researchers have suggested that self-report measures should not be used to estimate energy intakes, but that they are useful to estimate usual intakes of other nutrients and food groups and their densities, inform nutrition policy, and assess diet and disease associations.[12] Several recent reports suggest that investigators should work to improve and apply newer methods of DI assessment suitable for use in free-living individuals, such as biomarkers,[4,13,14] remote sensing devices,[15,16] or digital photography,[17] rather than continue to rely solely on self-report methods.

PA is typically assessed using both self-report measures and devices. Self-report measures of PA include administration of questionnaires and completion of detailed diaries or logs. Device-based measures include motion sensors, such as accelerometers, pedometers, heart rate (HR) monitors, and multisensor devices.[18] Because of the complex and multidimensional nature of PA, precise quantification can be difficult.[19] Improvement and innovation are needed to provide low-cost, accurate measures of PA for use in both large and small samples of free-living healthy adults.

The use of technology for individualized DI and PA assessment has expanded rapidly over the past decade.[20–24] Although technology has brought about some advances in diet and PA assessment methodology, many limitations and challenges remain. The purpose of this paper is to review the current science and challenges in the assessment of DI and PA for healthy adults and to identify current gaps and future needs.

DIETARY INTAKE ASSESSMENT

Methods of DI have been assessed using several objective and subjective tools, each with its inherent strengths and limitations. Selection of the right tool for use in research varies, depending on the study design, nutrients of interest, target population, and economic and time resources available. Some caution the adequacy of self-report DI measures as the basis for scientific conclusions regarding the link between DI and health outcomes.[8–10] However, traditional DI assessment measures (FFQs, diet records, and recalls) remain the mainstay in the field based on their cost and familiarity, as well as lack of consensus among more objective methods capable of providing the complex output required. Although these measures may be criticized for not being precise, such data remain useful for population guidance in maintaining healthy eating practices, comparison across populations, informing nutrition policy, and elucidating the associations between diet and disease.[12] Additional information on traditional DI methods and the controversy can be found in recent reviews by Farshchi et al.,[25] Dhurandhar and colleagues,[9] Archer et al.,[10] Shim and colleagues,[26] and Kirkpatrick et al.[27] Additionally, researchers are encouraged to utilize the Dietary Assessment Primer by National Cancer Institute (NCI) to help them determine the best way to assess diet for any study in which estimates of group intakes are required.[28]

Current Dietary Intake Technology

Recent advances in technology have led to the development of several automated dietary assessment tools that have overcome some limitations of the traditional subjective tools, while striving to meet time and cost efficiency. Although modern DI methods are attractive, researchers should consider that these methods often do not differ in errors associated with underreporting and reactivity as compared with traditional methods. Current examples of modern methods include automated 24-hour recalls and food records,[29,30] automated and graphic FFQs, photo-assisted dietary assessments (PADAs),[31–38] and image-based dietary assessments (IBDAs).[39–45] Table 1 summarizes the current and emerging DI assessment tools using technology.

The NCI introduced a modified version of the U.S. Department of Agriculture's Multiple-Pass 24-Hour Recall Method enabling 24-hour recalls to be self-administered by a respondent (ASA24) and used over multiple days as a food record.[46] Multiple versions (i.e., languages) have since been released and are detailed elsewhere.[47] The ASA24 improves on the limitations of traditional 24-hour recalls, including lack of reliance on trained interviewers, reduced time and economic burden to the researcher, and reduced respondent burden.[48] Because of the need for a high-speed Internet connection and familiarity with Internet or web-based tools, the use of the ASA24 may be limited in some populations.

In an effort to limit the issues with paper-based traditional FFQs,[49] a number of innovative web-based self-administered FFQs have been developed to automate the tool, such as the NCI Block questionnaire developed by Nutrition Quest,[50] NCI's Diet History Questionnaire (DHQ) III,[51] and the Fred Hutchinson Cancer Research Center FFQ.[52] All are web based and contain 100 or more questions on food items, purchasing, and preparation, with variations in layout design and analysis (e.g., food lists and databases) with NCI's DHQ III free for use by researchers. A novel alternative, VioScreen, offers a graphical FFQ option that addresses limitations of traditional FFQs by utilizing