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Commentaries on Viewpoint: Expending our physical activity (measurement) budget wisely

TO THE EDITOR: The authors of "Expending our physical activity (measurement) budget wisely" (2) discussed and provided data on potential pitfalls with using self-reported physical activity (PA) to understand interactions with health. The authors rightfully suggest that despite the major efforts placed into developing reliable and valid questionnaires, they remain largely inaccurate for the majority of adults (1). The error is thought to originate from a disproportionate focus on volitional type exercise (biking, jogging, and walking), while not capturing low to moderate intensity movements that accumulate a significant proportion to total activity energy expenditure (6). However, while I agree with the author's conclusions, the use of self-reported behaviors will remain a staple in telephone-based and large epidemiological studies. We simply can't ask for objectively measured PA in such designs and we can't afford to lose this vital information for understanding demographics of PA at a global level. As an example, there are several national and international studies that will continue to use such methodology for understanding PA and health (3, 5). Therefore, improved questionnaires should be created to enhance capturing nonexercise (household chores, standing, walking for purpose) and sedentary behaviors (sitting or lying) that are uniquely associated with public health. The inclusion of such behaviors in these questionnaires will help distinguish types of activities that might have a critical role in health and potentially distinct interactions with volitional exercise. The development of such questionnaires is ongoing for these purposes (4).

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MONITORS OF PHYSICAL ACTIVITY: REPLACEMENT OF TRADITIONAL SURVEYS OR A VALUABLE SUPPORTING METHOD?

TO THE EDITOR: Physical activity is generally considered to be a central factor in the etiology, prevention, and treatment of some pathological states such as obesity. To get more insight into the benefits of daily physical activity, an accurate and reliable method for the assessment of physical activity in free-living subjects is required. The method should be suitable to measure physical activity in large populations over relatively long and representative periods, present minimal discomfort to the subjects, and be cost effective.

In their Viewpoint, Dr. Colbert and colleagues (1) highlight the advantages and disadvantages of employing traditional questionnaires, the doubly labeled water (DLW) measure of energy expenditure, and the recently developed accelerometers for measuring physical activity in subjects. Although authors clearly support the concept that the use of monitors reduces the value of traditional survey methods for most studies (2, 3), we believe that, based on the limitations of the current commercially available devices for measuring physical activity, the acquisition of physical activity data using monitors must be complemented by traditional surveys documenting the type of exercise (i.e., resistance exercise, biking, swimming, and so on) whenever possible.

We believe that combining traditional surveys and modern low-cost accelerometers will improve the quality and accuracy of the data regarding physical activity. However, there is still need for more precise monitors and more detailed questionnaires to do that task.

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TO THE EDITOR: We agree that self-reported measures of physical activity need to be improved and that objective monitoring should be incorporated into research studies. However, Colbert and Schoeller (2) overestimate the utility, functionality, and ease of objective monitoring, while underestimating the value of PAQs for measuring different activity types, patterns, domains, and contexts in which activity occurs. Objective monitoring can increase PA assessment accuracy, but is not always superior to self-report. Furthermore, self-report measures are independently associated with health-related biomarkers suggesting that they capture distinct aspects of PA (1). Hence, there is a need to examine the unique strengths of each approach.

While Colbert and Schoeller (2) compare self-report PAQs to doubly labeled water (DLW)-estimated activity energy expenditure (AEE; see Figure), it is noteworthy that none of the PAQs cited were specifically designed for AEE estimation. Similarly, in their landmark study Manini et al. (3) highlight the value of accurately and precisely ascertaining DLW-de-

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rived AEE compared with substantially lower self-reported physical activity-derived measures of AEE. Manini et al. (3) did not attempt to ascertain, by self-report, the duration and intensity of high-intensity activities that could contribute to AEE. Moreover, in our own review of DLW validation studies, we concluded that discrepancies between PAQ- and DLW-derived estimates of AEE may have been due in part to the lack of face validity of PAQs to estimate AEE (4). We therefore propose abandoning the approach of validating PAQs against measures for which they were not designed to ascertain and then generalizing their poor performance to all self-report measures.

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TO THE EDITOR: Colbert and Schoeller (2) highlight an interesting point of view concerning the potential shift in physical activity (PA) monitoring. While the use of objective measures is highly encouraged, one must still recognize the limitations of such devices (3, 4) and importantly that we don't currently possess or utilize the perfect PA assessment tool. As indicated by Colbert and Schoeller (2), many studies have reported various correlations between questionnaire responses and objective monitors indicating similarities in PA assessment though the specific attributes of PA being assessed may be quite diverse. Very recently, the uniqueness of questionnaire assessment was reported in a large population study with self-reported PA suggested to identify PA aspects not concurrently assessed by accelerometers (1). Therefore, the notion that objective PA tools are more valid or accurate than nonobjective tools such as questionnaires should be considered with caution as these tools may in fact assess different aspects of PA. While the cost and size of objective monitors has been dramatically reduced recently, the use of such monitors still remains challenging for assessment of different activity modes and intensities, and for all populations, despite all good intentions. Hence, the use of simple, less intrusive tools like questionnaires will always be of relevance until the elusive, flawless PA assessment tool(s) has/have been developed. Of most importance are the identification of current PA assessment tool limitations and the development of BETTER PA assessment methodologies that exhibit high validity and applicability to a range of populations for a greater understanding of the interplay between PA and health.

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BUT WAIT—THE PA GUIDELINES INCLUDE MUSCLE-STRENGTHENING ACTIVITIES, TOO!

TO THE EDITOR: Colbert and Schoeller (1) raise important points about valid assessment of physical activity (PA) behaviors. Although they mention muscle-strengthening activities assessment, their concern/criticism is primarily directed at assessing aerobic PA. In addition to aerobic activities, the 2008 USDHHS Physical Activity Guidelines for Americans recommend ≥3 days of muscle-strengthening activities in youth and ≥2 days in adults. Musculoskeletal fitness is increasingly identified as related to mortality (4) and morbidities (2, 3). Assessment of resistance/muscle strengthening (RMS) activities and the associated measurement issues are similar to those suggested for aerobic PA, but accelerometers, pedometers, or doubly labeled water cannot assess involvement in specific RMS activities. Outside laboratory settings, RMS activities behaviors are typically assessed with self-report. Research on the nature, types, and prevalence of self-reported RMS activities is limited; the relation between self-reported RMS and health outcomes needs further investigation. We suggest that much is misunderstood about RMS activity behaviors. Research validating self-report of RMS behaviors in youth and adults is important and needed. For example, what types of activities are conducted? By whom? How often? What resistance? What relations exist? Only when the full array of PA providing health benefits is assessed can we better understand the relations between specific PA behaviors and health outcomes. Given the relatively poor quality of some PA measurements, it might well be that the true impact of PA behaviors on health outcomes and quality of life are underestimated. This might be particularly true for RMS activities as they are more difficult to measure.

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THE EXPRESS NEED FOR ACCURATELY MEASURING THE PHYSICAL ACTIVITY

TO THE EDITOR: Physical activity (PA) is established to promote health and well being in addition to preventing various types of maladies including obesity and cancers (5). Medical costs associated with obesity in the US as of 2008 are about $147 billion (2) and the National Institutes of Health estimated overall annual costs of cancer in 2008 as $228.1 billion. There is thus an express need to qualitatively and quantitatively measure PA. Among various PAs, emphasis must not only be placed on volitional PA but also on household, transport, and recreation. A reliable measurement scheme that applies to all of them, to all ages, and allows a systematic inventory thereof remains unexplored (3). It is a research challenge to devise "the best method" that combines both the objective and subjective techniques involving electronic gadgetry and PAQ-based registry. The Viewpoint of Colbert et al. (1) commends the use of gadgets and downplays the traditional self-reported questionnaires. I also believe that eliciting PA determinants from questionnaires is not easy unless they are intelligently posed. As the sensor technology is looming large today, additional strides seem possible in making gadgets that can capture very many parameters for a comprehensive picture of PA. Once their reliability and validity are ensured and they are introduced into the market on a larger scale, it is expected that their benefits outweigh cost (4). These benefits flow at both proximal and contextual levels in the causal pathway of PA awareness programs and provide objective means for institutionalization and sustainability.

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TAKING A STEP BACK: UNDERSTANDING THE UNDERLYING MECHANISMS BEFORE MOVING FORWARD WITH LARGE-SCALE EPIDEMIOLOGIC STUDIES

TO THE EDITOR: The fact that increased physical activity has beneficial effects on various conditions, including coronary artery disease, hypertension (2), obesity, diabetes mellitus, metabolic syndrome (3), and various neoplasias, is well established. As Colbert et al. (1) properly acknowledge, the interest of biomedical research is shifting its focus toward more specific questions, such as whether there is a dose-response or threshold relationship between exercise levels and their beneficial effects. Indeed, studies aiming to answer such questions would require large sample sizes and thus an affordable and effective method of quantification of exercise level. However, investigators should realize that there will always be a trade-off between validity and reliability over cost and feasibility (4). Thus, according to my opinion, the most important priority for investigators is to set clear goals in terms of how much of a difference in the physical activity level is expected for a beneficial effect in each particular setting. This is something that we should not try to address through large-scale epidemiologic studies, but instead through pilot interventional studies, meta-analyses and in vivo human basic research studies that assess the mechanisms through which exercise acts on the involved systems. Only after the exercise "dose increment" that causes a clinically relevant change is established, can we decide on the method that should be used in the setting of a large-scale epidemiologic study with hard clinical outcomes.

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THE KEY POINT IS TO MEASURE AND INCREASE $\dot{V}O_{2max}$

TO THE EDITOR: I agree with Colbert and Schoeller (1) that the major research issue is now to solve questions regarding the effectiveness of training interventions, i.e., not to increase the quantity of physical activity but firstly to increase maximal aerobic capacity. Research has shown that a one MET increment in maximal aerobic capacity was associated with a 13–15% decrement in all-cause mortality, and this association appears consistent across disease condition, gender, and age (3). The difficulty is to be sure that $\dot{V}O_{2max}$ is valid and then that implies to yield a $\dot{V}O_{2max}$ plateau and it has been proved that this plateau can be extended to 16 min, irrespective of individual fitness, using a variable pace protocol (4, 5). Before starting any effect-dose research a real personal training must be proposed knowing the indi-

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vidual's metabolic scope. This self-pace exercise protocol (4, 5) can be also performed using walking for certain persons (senior or obese individuals) who have a maximal aerobic speed <8 km/h (5 miles/h) that is the transition between walking and running (2). This variable pace exercise gives new insights and new perspectives for improving cardiorespiratory fitness thanks to more pleasant and feasible protocols increasing subject adherence, which must also be accurately measured. The democratization of heart rate and speed data collection by internet in an interactive training log is the future key to success for validating the effectiveness of individual training program to improve maximal aerobic capacity improvement.

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TO THE EDITOR: In the context of growing health care cost, Colbert and Schoeller (2) recently stated that the development of accurate, compact, and affordable devices to monitor physical activity is a valuable asset to obtain objective monitoring of progresses. Our team recently validated the Polar AW200 (1), a device consisting of a watch equipped with an accelerometer allowing calculation of energy expenditure (EE). We observed a good interchangeability with indirect calorimetry. We also emphasized its usefulness not only for recreational trekkers but also for rehabilitation program notably because of its pedometer function. While interpreting EE scores can be complex for some, counting the number of steps is straightforward and has been proposed to correlate with exercise intensity (3). However, we faced the same restrictions as mentioned by Colbert and Schoeller (2) in terms of the type of activity allowed and also noticed that for an accurate EE calculation, anthropometric information need to be updated. For instance, if the user is carrying a bag, this extra weight should be implemented into the watch (1). Nevertheless, an asset of this type of technology is that it can precisely estimate the activity during nonconventional exercises, such as domestic activities, an important component to limit cardiovascular mortality (4). To us, the important remaining questions to further determine the benefit of monitors vs. questionnaires are to estimate *1*) the long-term adherence once the excitement of the novelty fades away and *2*) the easy and ergonomic access to daily EE data allowing positive feedback to the subjects.

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HOW TO KEEP TRACK OF ONE'S PHYSICAL ACTIVITY BUDGET USING PERVASIVE TECHNOLOGIES

TO THE EDITOR: Modernization of society increases prevalence of sedentary lifestyle. Automation of movement (e.g., escalators, cars) and built environments unfavorable for walking or cycling reduce physical activity related energy expenditure levels (5). In parallel, a new mobile computing and communication era emerges. Beyond their classic use as telephones, smartphones can provide many other functions, including monitoring of movement patterns (2). Exploiting the in-built accelerometer and GPS of smartphones we proof the feasibility of this idea, monitoring daily movement patterns, including locations and times of activities. Activity Level Estimator (ALE) is an Android-based smartphone application, running unobtrusively in the phone's background allowing estimating physical activity related energy expenditure (PAEE) (3). We assessed a first ALE prototype against a BodyMedia SenseWear device (4). ALE was 86% accurate for different modes of walking but underestimated PAEE by 23% in 24 h (3). Further refinement and validation against indirect calorimetry and DLW of ALE-type apps will likely lead to increasingly precise estimations of PAEE. We therefore anticipate realization of the vision of accurate and timely assessment of physical activity "in the wild," as strove for by Colbert and Schoeller (1). Recent developments indicate further potential, since a combination of smartphones equipped with GPS and accelerometers and ANT+ capable sensors (heart rate, temperature, etc.) will allow increasingly precise monitoring of daily physical activity patterns and energy expenditure estimations. In a not so distant future, anybody will thus be able to track one's physical activity budget and get instant feedback on its appropriateness for health purposes.

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TO THE EDITOR: The Viewpoint written by Colbert and Schoeller (3) highlights the importance of objective physical activity assessment over the self-report survey approach. Objective assessment is critical for understanding health risk and the effect of interventions on improving health status. The authors also discuss the limitations of current pedometer and accelerometer technology for meeting research goals. I agree with their position; however, I think another technology is available for objective assessment—the heart rate monitor (HRM).

Heart rate is a classic parameter used to establish exercise prescription, as well as to evaluate acute exercise and postexercise recovery. HRMs are now more widely available, cost-efficient, and user-friendly. Unlike pedometers, HRMs are not as limited by mode of exercise. The modern HRM features: *1*) memory storage for exercise sessions, *2*) time for exercise duration, and *3*) activity and session-level heart rate parameters for exercise intensity. These features are key if complex physical activity interventions, e.g., high intensity interval training (2, 5), are to be accomplished unsupervised. HRMs also allow measurement of postexercise heart rate recovery, which is an independent predictor of all-cause mortality (4), but goes undetected when using pedometer/accelerometer-based approaches. When accelerometer and HRM technologies are combined they provide a valid approach to assess total energy expenditure (1). Therefore, the HRM offers a classical assessment of heart rate to accomplish a modern goal—to quantify physical activity and recovery in larger target populations with the intent to examine mechanisms of action and provide recommendations for improving health status.

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EMERGING TRENDS IN ESTIMATING ENERGY EXPENDITURE

TO THE EDITOR: The Viewpoint by Colbert and Schoeller (1) eloquently highlights the growing concern surrounding physical activity (PA) assessment of large cohorts. Given the limited validity of self-reported PA and the inability of objective measurement tools to capture all types of PA (2), a hybrid approach may be optimal for future PA assessments. Indeed continuous advancements in the technology of objective PA assessment tools combined with online self-reported PA data collection are likely to lead the way in the following years toward a modernized and, potentially, more accurate and comprehensive estimation of PA. For this to work effectively, the existing self-reported PA assessment tools must be refined to improve their accuracy. Nevertheless, self-reported PA in the future is likely to move toward serving a supporting role to the newer and more accurate objective tools. In this light, until the accuracy and precision of PA surveys is improved, the use of self-reported PA as a primary assessment tool should be limited and the results should be interpreted with caution. Instead, more time should be spent on the development and validation of cost-efficient PA objective measurement tools. For example, existing pedometers have a heart rate measurement function which provides useful information on PA duration and intensity. Reducing subject number and increasing cost for the sake of accuracy and precision in this case is widely important. Particularly when you consider the compelling evidence supporting that cardiorespiratory fitness (an objective measure of habitual physical activity) is an independent predictor of all-cause and cardiovascular disease mortality (3).

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A WISE (MEASUREMENT) BUDGET INCLUDES BOTH INCREASED PRECISION AND LARGE SAMPLE SIZE

TO THE EDITOR: In their Viewpoint in the Journal, Colbert and Schoeller (1) compellingly argue that we have reached "a tipping point," implying that researchers should strive for substituting self-report methods with objective methods for assessing physical activity (PA). The rationale is that this will reduce sample sizes and possibly costs.

The importance of increased measurement precision of PA has previously been acknowledged (3), and we agree that self-reported PA is not sufficiently accurate for quantifying "caloric" activity outcomes, for which purpose objective methods are better suited. However, rather than substituting self-reports with objective methods, we suggest that both should be included in future studies. In addition, for questions that remain unanswered in the field of PA epidemiology, the importance of *large sample sizes in combination with increased accuracy* should not be overlooked. Despite the finding from the Health ABC (2), which did in fact have sufficient statistical power, when the outcome is rare (e.g., cause-specific mortality and rarer diseases) large sample sizes are needed. Indeed, population representativeness is easier achieved with larger samples, which may have profound implications if the confounding structure for the research question is complex. Similarly, it is likely that the combination of a large sample size and increased precision is required when examining gene-lifestyle interactions and for unraveling the genetic determinants of PA (4). Therefore, we agree that we should "expend" our measurement budget wisely and, for some questions, this means "expanding" it by inclusion of objective monitoring in very large observational studies.

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