Activity-Related Energy Expenditure in Older Adults: A Call for More Research

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ABSTRACT

HALL, K. S., M. C. MOREY, C. DUTTA, T. M. MANINI, A. L. WELTMAN, M. E. NELSON, A. L. MORGAN, J. G. SENIOR, C. SEYFFARTH, and D. M. BUCHNER. Activity-Related Energy Expenditure in Older Adults: A Call for More Research. *Med. Sci. Sports Exerc.*, Vol. 46, No. 12, pp. 2335–2340, 2014. The purposes of this article were to 1) provide an overview of the science of physical activity–related energy expenditure in older adults (≥65 yr), 2) offer suggestions for future research and guidelines for how scientists should be reporting their results in this area, and 3) present strategies for making these data more accessible to the layperson. This article was meant to serve as a preliminary blueprint for future empirical work in the area of energy expenditure in older adults and translational efforts to make these data useful and accurate for older adults. This document was based upon deliberations of experts involved in the Strategic Health Initiative on Aging Committee of the American College of Sports Medicine. The article was designed to reach a broad audience who might not be familiar with the complexities of assessing energy expenditure, especially in older adults. **Key Words:** PHYSICAL ACTIVITY, RESTING METABOLIC RATE, OXYGEN UPTAKE, TRANSLATION, KILOCALORIES, MET

Public health initiatives to reduce obesity and prevent chronic disease via lifestyle interventions have led government health agencies to ask for more detailed information on activity-related energy expenditure (e.g., $\dot{V}O_2$, METs). Health professionals, practitioners, and the public are calling for accurate estimates of physical activity-related *caloric* expenditure to help guide lifestyle interventions that promote maintenance of a healthy weight and strive to prevent or lessen the burden of chronic diseases. Numerous activity calculators are now publicly available to assist individuals with estimating and tracking calories expended with activity. The vast majority of these calculators estimate caloric expenditure using information provided in the Compendium of Physical Activities (1–3).

A question that arises is whether the same estimates are appropriate for use of all adults or whether estimates should be adjusted for factors known to influence physical activity energy expenditure (e.g., age, sex, body mass). In this article, we provide an overview of the science of physical activity-related energy expenditure, with a focus on older adults (≥65 yr). As a result of this review, we identified areas for future research and offer guidelines for how scientists should be reporting their results in this area. Finally, we present strategies for translating these empirical data in a way that is more accessible and useful to older adults and health professionals. We focus on the technical aspects of providing data on activity-related energy expenditure in older adults. The recommendations are based upon deliberations of experts involved in the Strategic Health Initiative on Aging Committee of the American College of Sports Medicine. The article was designed to reach a broad

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audience who might not be familiar with the complexities of assessing energy expenditure.

A REVIEW OF THE SCIENCE OF ENERGY EXPENDITURE IN OLDER ADULTS

There are two issues related to estimating energy expenditure in older versus that in younger adults: absolute energy cost (e.g., $\dot{V}O_2$ (mL·kg^{-1}·min^{-1}) and MET values. We provide a brief review of the current state of the science for each of these outcomes relative to older adults.

Absolute energy cost of physical activity in older adults. Few studies have assessed activity-related energy expenditure (e.g., $\dot{V}O_2$) in older adults (6,9,12,14,17,19). Although scarce, comparative studies show that the energetic cost (i.e., mL·kg^{-1}·min^{-1}) of walking and daily activities is higher in older adults compared with that in younger adults when both are examined at the same time under similar conditions (7,8,14–16). For example, a study by Jones et al. (8) reported that when walking speed is held constant, the energetic cost of walking is higher in older women than that in younger women. Additional evidence is provided by studies comparing measured energy expenditure in older adults with values reported in the Compendium, reporting sizeable differences in the estimated energy costs and higher energy costs in older adults (6,9,10).

Several limitations of the current literature emerged upon review. First, of the few studies that have examined the energy cost of activity in younger and older adults, many have focused on laboratory-based walking, with few studies examining activities of daily living and/or physical activities in the free-living environment. This literature is further limited by a failure to fully report $\dot{V}O_2$ data in publications. The majority of studies examining energy expenditure across age groups do not fully report energy expenditure data for each age group separately, relying instead on graphical representations of the data or aggregated-result tables, and as such are of limited use to the scientific community. A failure to fully report the demographic, biometric, and energy cost data in activity-related energy expenditure studies that compare values across groups (e.g., age, sex, obesity status) is an important and pervasive limitation of the published research. To date, the combined effect of common demographic, biometric, and functional characteristics on energy expenditure in older adult samples has received little attention. The lack of such studies limits the ability of practitioners, fitness trainers, and health promotion professionals to accurately estimate energy cost of activities in older adults.

Resting metabolic rate and metabolic cost of activities in older adults. Energy demands of various physical activities have also been represented by multiples of METs, that is, made relative to resting metabolic rate (RMR). The conventional definition of 1 MET = 3.5 mL·kg^{-1}·min^{-1} has long been the standard adopted by the scientific community. The prevailing practice of both the Compendium and empirical studies of energy expenditure has been to transform $\dot{V}O_2$ (mL·kg^{-1}·min^{-1}) values into METs by dividing the $\dot{V}O_2$ cost by RMR. However, several studies have shown that RMR *decreases* with age (4,5,11,12,17). In studies that have measured RMR directly from older adults, the value approximates 2.7–2.8 mL·kg^{-1}·min^{-1} (5,11,12,17); this is approximately 25% less than the 1 MET = 3.5 mL·kg^{-1}·min^{-1} assumed at baseline for all adults. A recent meta-analysis of hundreds of study estimates of RMR highlights other limitations with this conventional definition, reporting that RMR is highly variable in adults and is influenced by age, sex, and body mass (13).

Ainsworth et al. (1–3) clearly state in multiple publications that the ''Compendium was not developed to determine the precise energy cost of physical activity within individuals…does not account for differences in body mass, adiposity, age, sex, …, and individual differences in energy expenditure for the same activity can be large.'' Despite this word of caution, applying a standard MET value to all individuals continues to be a common practice in the field. This practice is unlikely to change until comprehensive comparative studies of RMR are conducted in groups of men and women by age and other defining characteristics (e.g., body mass, functional status, sex, disease status). As such, existent studies that use this conventional definition of an MET to estimate the metabolic cost of activities in older adults may be of questionable accuracy.

RECOMMENDATIONS FOR ADVANCING THE SCIENTIFIC BASIS OF ACTIVITY-RELATED ENERGY EXPENDITURE

The following are recommendations for advancing the field of energy expenditure in older adults:

1) Include sufficient numbers of older adults (≥65 yr) in research studies, which assess energy expenditure across a variety of activities, so as to allow comparison between young (20–39 yr), middle-age (40–64 yr), and older adults;
2) In studies comparing energy expenditure across age groups, evaluate potential age-related differences in metabolic costs under standard conditions (i.e., same metabolic equipment, tasks, and speeds of movement);
3) In studies comparing energy expenditure across groups, report complete demographic, biometric, and energy expenditure data (e.g., RMR, METs, $\dot{V}O_2$) for each group separately. These data would be most clearly represented in table format and supported by graphs/figures. This requires diligence on the part of journal editors, peer reviewers, and authors to ensure that the data are fully reported in the text of the report;
4) Some harmonization of measures across studies will be helpful toward gathering information on energy costs for a wide variety of activities in older adults (both healthy and those with specific diseases/combinations of diseases);

5) In studies of energy expenditure in older adults, measure activities that are common among older adults, are listed in the Compendium, and offer a spectrum of activity intensities;
6) There is a need for population-based studies that explore the singular and combined effects of common demographic (age and gender), obesity status (body mass index (BMI), fat-free mass), and health status (functional impairment, disease status) characteristics on RMR and $\dot{V}O_2$ and the effects that these factors have on estimates for energy expenditure;
7) Population-based studies that examine both laboratory-based and free-living activities are needed and are now feasible with the availability of portable metabolic systems; and
8) Studies that assess some estimate of maximal oxygen consumption to estimate the relative intensity of common activities are particularly important in older adults.

THE NEED FOR TRANSLATIONAL RESEARCH IN THE AREA OF ACTIVITY-RELATED ENERGY EXPENDITURE

As the number and quality of comparative studies of activity-related energy expenditure grow, increased effort must be made to translate these data so that they are accessible and interpretable by health professionals and the lay public. Recognizing that many public health efforts use principles of energy balance to promote healthy lifestyle, we propose that energy expenditure data be reported in units of kilocalories.

Using data from the two published studies that fully report measured energy expenditure data (i.e., $mL \cdot kg^{-1} \cdot min^{-1}$) in older adult samples (6,9), we constructed tables of caloric expenditure in older adults. These tables are presented as examples of how empirical results can be translated and presented for the public. The data from these two studies have been combined for this report. Sample characteristics can be found in the parent articles but are summarized here in Table 1. Participants' age in these two studies ranged from 61 to 90 yr, with an average age of 75.6 yr across both samples, with equal representation across genders (46% female). Both studies included adults with a range of mobility (average rapid gait speed, 1.3 $m \cdot s^{-1}$) and functional profiles and who presented with varying levels of comorbidity (0–5 chronic conditions). BMI averaged across the two samples was 27.9 $kg \cdot m^{-2}$ (range, 18.4–36.1 $kg \cdot m^{-2}$). The information provided here originates from a heterogeneous sample, with similar characteristics of community-dwelling older adults living in the United States.

TABLE 1. Sample characteristics.

Variable (*n* = 65)	Mean ± SD or *n* (%)	Range
Age (yr)	75.6 ± 7.0	61–90
Gender (male), *n* (%)	35 (53.8)	N/A
Race (White), *n* (%)	57 (87.7)	N/A
Weight (kg)	80.2 ± 15.1	47.6–125.5
BMI ($kg \cdot m^{-2}$)	27.9 ± 3.8	18.4–36.1
Rapid gait speed ($m \cdot s^{-1}$)	1.3 ± 0.2	0.43–1.88
No. of chronic conditions	1.8 ± 1.1	0–5

N/A, not applicable.

Caloric expenditure: measured versus estimated. Table 2 presents the measured caloric cost of treadmill walking and a variety of daily activities in older adults and compares these values with the estimates from an online calculator that uses the MET values reported in the Compendium. These calculations were based on an 80-kg adult (same body mass as that of the study sample average) and 30 min of activity. The final column shows the differences in caloric expenditure between measured and estimated collection methods.

The tasks in Table 2 can be conceptualized as two distinct types of tasks: those that are standardized or mechanical in which the individual is required to keep up with a predetermined pace (e.g., treadmill walking at a certain speed) and those that are self-paced in which an individual can modify effort as desired to complete a task. As indicated in Table 2, the measured caloric costs of the standardized tasks are substantially higher (approximately 30%) for older adults than the estimated caloric costs (generated by the activity calculator). The trend is reversed for self-paced or nonstandardized tasks (i.e., daily activities), such that the measured caloric cost of most of these activities is lower than the estimated caloric costs (estimated by the activity calculator).

Previous studies that report similar results attribute these differences to an age-associated decline in self-paced intensity. That is, older adults adapt the way they do a task so as to minimize the amount of effort expended, resulting in lower *absolute* energy expenditure (7,8,17–19). However, the energy cost of performing daily activities requires a substantially greater *relative* effort in old compared with that in young adults when considered as a percentage of their available maximal capacity (7). These data underscore the need to consider the energy cost of activities when making activity recommendations for older adults and the importance of considering the effect of increased daily exercise expenditure on activities of daily living.

Caloric expenditure in older adults by BMI classification. In an effort to lessen some of the variability in the measured energy expenditure data, we examined caloric cost of activities stratified by BMI (normal weight, overweight, and obese). These data are presented in Table 3. As expected, the caloric expenditure of activities increased with increasing body mass. Differences across the normal, overweight, and obese groups were substantially larger for the standardized tasks (treadmill walking) than those for the self-paced activities. Tables such as these are helpful for both individuals and health professionals because they clearly show how energy costs differ by body mass.

We recognize that the preliminary data presented in this document are based on a limited number of observations compiled from two studies of relatively small sample size (6,9). These studies did not include a comparison group of younger individuals, and therefore, whether the discordance between measured and estimated energy expenditure is due to age cannot be determined. However, these data are

TABLE 2. Caloric cost of daily activities in older adults: measured versus estimated.

Activity	*n*	Measured Calories Burned per Minute (kcal) Mean ± SEE	Measured Calories Burned per 30 min (kcal) Mean ± SEE	Estimated Calories Burned per 30 min[a] (kcal)	Mean Difference[b] (kcal)
Treadmill walking[c]					
1.5 mph	20	4.1 ± 0.3 Range, 2.5–7.5	124.1 ± 8.3	Not available	—
2.0 mph	20	4.8 ± 0.3 Range, 2.8–8.9	145.4 ± 9.8	100.5	+44.9
2.5 mph	20	5.5 ± 0.3 Range, 3.5–9.5	163.7 ± 9.5	Not available	—
3.0 mph	20	6.5 ± 0.4 Range, 3.9–11.3	194.2 ± 12.1	132.7	+61.5
3.5 mph	19	7.7 ± 0.4 Range, 5.1–10.8	232.0 ± 12.1	152.8	+79.2
Self-paced walking[c]					
Leisurely[c,d]	63	4.4 ± 0.80 Range, 1.6–7.8	132 ± 24	Not available	—
Brisk[c,d]	58	5.7 ± 0.95 Range, 2.2–9.8	171 ± 28.5	Not available	—
Fast	19	7.2 ± 0.42 Range, 4.1–10.4	216 ± 12.6	Not available	—
Daily activities[d]					
Standing	30	1.3 ± 0.08 Range, 0.7–2.5	39 ± 2.4	48.2	−9.2
Gardening	40	3.1 ± 0.14 Range, 1.4–5.3	93 ± 4.2	160.9	−67.9
Playing cards	32	1.4 ± 0.07 Range, 0.7–2.8	42 ± 2.1	Not available	—
Sweeping and vacuuming	41	4.1 ± 0.17 Range, 2.3–7.0	123 ± 5.1	140.7	−17.7
Washing windows	41	2.8 ± 0.12 Range, 1.3–5.4	84 ± 3.6	120.6	−36.6
Ironing	40	2.4 ± 0.10 Range, 1.1–4.7	72 ± 3.0	92.5	−20.5
Lying in bed	28	1.1 ± 0.05 Range, 0.6–2.1	33 ± 1.5	36.2	−3.2
Making the bed	44	3.8 ± 0.17 Range, 2.1–6.5	114 ± 5.1	80.4	+33.6
Doing laundry	43	3.1 ± 0.14 Range, 1.8–5.7	93 ± 4.2	Not available	—
Computer work	40	1.4 ± 0.06 Range, 0.7–2.4	42 ± 1.8	60.3	−18.3
Grocery shopping	45	3.3 ± 0.14 Range, 1.5–5.3	99 ± 4.2	92.5	+6.5
Preparing and serving food	45	2.1 ± 0.09 Range, 1.1–3.7	63 ± 2.7	80.4	−17.4
Washing dishes	45	2.2 ± 0.09 Range, 1.1–3.7	66 ± 2.7	Not available	—
Raking leaves	45	3.5 ± 0.14 Range, 1.8–5.6	105 ± 4.2	172.9	−67.9
Stair climbing	40	6.0 ± 0.30 Range, 2.9–11.8	180 ± 9.0	Not available	—

[a]Estimates were generated from an online calculator based on the Compendium.
[b]Defined as "measured − estimated".
[c]From Hall et al. (6).
[d]From Knaggs et al. (9).

presented as an example of how activity-related caloric expenditure data could be presented for the public.

RECOMMENDATIONS FOR TRANSLATING THE SCIENCE OF ACTIVITY-RELATED ENERGY EXPENDITURE

The following are recommendations for advancing translational research in the area of activity-related energy expenditure in older adults:

1) Report energy expenditure data in units familiar to the lay public and those that can be easily used by health promotion professionals. We recommend kilocalories (per minute of activity and for sustained periods of activity) as an ideal unit for reporting;
2) Studies reporting measured caloric expenditure across activities should also report variance statistics (i.e., SD and range) to show how well an average value applies to a given individual;
3) If multiple age groups are examined, report complete demographic, biometric, and caloric cost data for each group separately;
4) Measure and report caloric cost of activities that are common among older adults, are listed in the Compendium, and offer a spectrum of activity intensities;

TABLE 3. Caloric cost of daily activities in older adults stratified by BMI.

Activity	n	Measured Calories Burned per 30 min, Normal Weight (BMI, 18.5–24.9 kg·m^{-2}) (kcal) Mean ± SEE	Measured Calories Burned per 30 min, Overweight (BMI, 25–29.9 kg·m^{-2}) (kcal) Mean ± SEE	Measured Calories Burned per 30 min, Obese (BMI, ≥ 30 kg·m^{-2}) (kcal) Mean ± SEE
Treadmill walking[a]				
1.5 mph	20	88.6 ± 11.2 n = 2	117.7 ± 7.8 n = 12	148.9 ± 19.1 n = 6
2.0 mph	20	103.6 ± 17.5 n = 2	134.8 ± 7.6 n = 12	180.5 ± 22.9 n = 6
2.5 mph	20	126.7 ± 13.9 n = 2	149.9 ± 7.2 n = 12	203.7 ± 20.5 n = 6
3.0 mph	20	155.5 ± 23.2 n = 2	177.5 ± 11.0 n = 12	240.3 ± 25.4 n = 6
3.5 mph	19	213.3 ± 61.8 n = 2	219.5 ± 47.2 n = 11	261.1 ± 20.7 n = 6
Self-paced walking[a]				
Leisurely[a,b]	63	97.0 ± 16.2 n = 16	137.2 ± 18.1 n = 32	148.4 ± 25.9 n = 15
Brisk[a,b]	58	143.2 ± 16.7 n = 14	167.1 ± 28.8 n = 30	197.0 ± 31.2 n = 14
Fast[a]	19	197.8 ± 49.0 n = 2	193.0 ± 15.1 n = 11	259.5 ± 14.6 n = 6
Daily activities[b]				
Standing	30	30.6 ± 2.4 n = 9	38.1 ± 2.7 n = 14	46.5 ± 7.0 n = 7
Gardening	40	81.6 ± 7.1 n = 12	101.4 ± 5.9 n = 20	92.7 ± 10.6 n = 8
Playing cards	32	36.9 ± 3.8 n = 8	44.1 ± 2.0 n = 16	46.2 ± 6.0 n = 8
Sweeping and vacuuming	41	106.8 ± 8.8 n = 13	129.6 ± 6.6 n = 20	131.1 ± 14.1 n = 8
Washing windows	41	72.6 ± 5.1 n = 13	88.2 ± 4.68 n = 20	87.0 ± 11.2 n = 8
Ironing	40	60.0 ± 4.0 n = 13	76.5 ± 3.9 n = 19	83.4 ± 9.7 n = 8
Lying in bed	28	28.5 ± 1.6 n = 12	34.2 ± 2.1 n = 8	41.7 ± 3.9 n = 8
Making the bed	44	105.0 ± 6.3 n = 14	113.4 ± 8.3 n = 21	135.9 ± 8.9 n = 9
Doing laundry	43	82.8 ± 4.8 n = 14	97.2 ± 7.0 n = 20	101.1 ± 6.7 n = 9
Computer work	40	34.5 ± 2.1 n = 13	41.7 ± 2.6 n = 19	49.8 ± 3.4 n = 8
Grocery shopping	45	80.1 ± 6.3 n = 15	103.8 ± 5.5 n = 21	120.9 ± 6.7 n = 9
Preparing and serving food	45	57.3 ± 4.3 n = 15	63.3 ± 3.9 n = 21	75.9 ± 5.3 n = 9
Washing dishes	45	58.8 ± 4.8 n = 15	69.3 ± 3.7 n = 21	78.0 ± 4.7 n = 9
Raking leaves	45	98.4 ± 7.4 n = 15	105.0 ± 6.3 n = 21	114.0 ± 8.2 n = 9
Stair climbing	40	159.6 ± 11.5 n = 14	188.1 ± 16.2 n = 18	203.4 ± 16.6 n = 8

[a] From Hall et al. (6).
[b] From Knaggs et al. (9).

5) Offer kilocalorie estimates for older adults by gender and relative weight groups. These results may need to be further stratified by other individual-level factors (e.g., disease status, functional status) as determined by empirical studies (see recommendation 6 for scientific basis, as previously mentioned).
6) Efforts to amass a database of energy expenditure ($\dot{V}O_2$) and caloric cost of common activities in older adults by pooling data from the literature would benefit the field and be a valuable resource for older adults and health professionals, in essence creating a caloric compendium of activities that could be used for health promotion efforts.
7) As new information on energy expenditure of activities in older adults is gathered, new physical activity interventions may need to be developed. Any differences in energy costs of activities should influence the design of new exercise/physical activity interventions for older adults in terms of intensity and possibly duration and frequency. The differences in energy costs of activities will factor into study design, depending on whether the target population is healthy older adults (i.e., prevention study) or older people living with a given chronic condition or multiple chronic conditions (i.e., rehabilitation or treatment study).

SUMMARY AND CONCLUSIONS

Our review of the science on activity-related energy expenditure highlights the need for comprehensive comparative studies that examine the influence of age and other factors (e.g., sex, obesity status, functional impairment, disease status) known to affect RMR and energy expenditure. Studies that examine the combined effects of these factors will be particularly beneficial because they would approximate group characteristics normally encountered in public health efforts and could inform lifestyle interventions that promote healthy aging. Accurate information on the energy costs of daily activities is important to public health initiatives aimed at preventing or lessening the burden of chronic diseases.

It is the hope of the authors that recommendations in this article for moving the science forward serve as a preliminary blueprint for future studies of activity-related energy expenditure, particularly in older adults. Previous empirical studies exist, which likely have the requisite data to contribute to this effort, although not fully reported in the literature. Ideally, such data could be analyzed and reported like the guidelines provided in this article.

This field of study is ripe for translational research, and we provide an example of how empirical data on energy expenditure may be reported for the public. Efforts to translate activity-related energy expenditure for use of older adults and health professionals are of great public health importance, and these studies may inform the design of new tailored physical activity interventions for older adults.

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