Journal of Physical Activity and Health, 2011, 8, 581-586

Assigning Metabolic Equivalent Values to the 2002 Census Occupational Classification System

Catrine Tudor-Locke, Barbara E. Ainsworth, Tracy L. Washington, and Richard Troiano

Background: The Current Population Survey (CPS) and the American Time Use Survey (ATUS) use the 2002 census occupation system to classify workers into 509 separate occupations arranged into 22 major occupational categories. ***Methods:*** We describe the methods and rationale for assigning detailed Metabolic Equivalent (MET) estimates to occupations and present population estimates (comparing outputs generated by analysis of previously published summary MET estimates to the detailed MET estimates) of intensities of occupational activity using the 2003 ATUS data comprised of 20,720 respondents, 5323 (2917 males and 2406 females) of whom reported working 6+ hours at their primary occupation on their assigned reporting day. ***Results:*** Analysis using the summary MET estimates resulted in 4% more workers in sedentary occupations, 6% more in light, 7% less in moderate, and 3% less in vigorous compared with using the detailed MET estimates. The detailed estimates are more sensitive to identifying individuals who do any occupational activity that is moderate or vigorous in intensity resulting in fewer workers in sedentary and light intensity occupations. ***Conclusions:*** Since CPS/ATUS regularly captures occupation data it will be possible to track prevalence of the different intensity levels of occupations. Updates will be required with inevitable adjustments to future occupational classification systems.

Keywords: energy expenditure, physical activity, exercise

The need to address the global obesity epidemic has expanded researchers' conceptualization of physical activity modes that may contribute (positively or negatively) to energy balance. A primary concentration on leisure-time physical activity has broadened to include growing interests in transportation-related physical activity,[1] and with the emergence of a focus on the potentially detrimental effects of sitting time,[2] occupational physical activity is once again being considered.[3,4] Historically, epidemiologists have studied occupational classifications as a proxy for occupational physical activity differences. For example, Morris et al[5] compared bus drivers (who sit most of the day) to conductors (who were on their feet most of the day). In recent history, however, strenuous physical exertion has been all but eliminated from most occupations,[6] rendering earlier classification schemes obsolete, even without considering the increased offerings and wide-ranging transformations of today's occupations compared with those of 40 to 50 years ago.

The 2002 census occupation system has 509 separate occupations arranged into 22 major groups of occupational categories. The occupation classification system is publically available at http://www.bls.gov/cps/cenocc.pdf and includes "crosswalk" codes that link to earlier and other classification systems. The system groups titles describing occupations into homogeneous categories and assigns a numerical code to each category. The 2002 occupation codes are 4 digits in length, ending in 0.

Federal statistical agencies and other end users can use these codes to organize the numerous occupations in which Americans engage and to classify workers into categories for the purpose of collecting, calculating, or disseminating occupational data. For example, the Current Population Survey (CPS; http://www.bls.gov/cps), or "household" survey, is a federal survey that provides the source of the nation's unemployment rate, among other statistics. In 2003 it adopted the 2002 census occupational classification systems. The American Time Use Survey (ATUS), sponsored by the Bureau of Labor Statistics (BLS), follows the same system for classifying occupations. The ATUS is designed to collect a complete time-defined log of the respondents' activities over the course of 24 hours, thereby facilitating conclusions about population participation in specific behaviors "on any given day." Analysis of the occupational variables permits inferences about how Americans balance work and other activities with family and leisure time.

We previously published summary estimates of physical activity intensity (metabolic equivalents, or METs)

Tudor-Locke is with the Walking Behavior Laboratory, Pennington Biomedical Research Center, Baton Rouge, LA. Ainsworth and Washington are with the Dept of Exercise and Wellness, Arizona State University–Polytechnic Campus, Mesa, AZ. Troiano is with the Division of Cancer Control and Population Sciences, National Cancer Institute, Bethesda, MD.

for each of the 22 major occupation groups as part of a larger endeavor to link ATUS variables with MET values[7] from the Compendium of Physical Activities.[8] This paper describes the methods and rationale for assigning MET estimates to the 509 detailed occupations within the 2002 census occupational classification system. We also present population estimates (comparing outputs generated by analysis of the previously published summary MET estimates to the detailed MET estimates) of intensities of occupational activity using the 2003 ATUS data to illustrate a single use of this product.

Methods

Assigning MET Codes to Census Occupational Classification System

Dr. Barbara Ainsworth, a coauthor on this paper and the lead author on the Compendium of Physical Activities[8] considered the types of movements characterizing the 509 occupations listed in the 2002 census occupation classification system to assign corresponding metabolic equivalent (MET) values using the Tecumseh Occupational Physical Activity Questionnaire classification system (TOPAQ).[9] The TOPAQ system assigns MET levels based on the considered body position (sit, stand, walk, heavy labor) and intensity (light, moderate, vigorous). A MET represents the ratio of activity metabolic rate to the sitting/resting metabolic rate. Steele and Mummery[10] have shown significant moderate correlations (ie, $r = .38$) between outputs from the TOPAQ and pedometer-determined steps/day. Resulting MET estimates are as follows: sitting activities (1.5–2.5 METs), standing activities (2.5–4.0 METs), walking activities (3.5–7.5 METs), and heavy labor activities (3.5–8.0 METs). More details are contained in Table 1. All MET values linked with each of the listed occupations were independently evaluated and verified by coauthors; discussion and consensus resolved any issues. As noted above, the summary MET estimates associated with the 22 major occupational groups were published previously;[7] they represent an aggregated value, collectively considering the underlying 509 detailed occupations. An explanation of the aggregation process has been published.[7]

2003 ATUS

Microdata from the 2003 ATUS were released in January 2005. Details about the ATUS methods are available at http://www.bls.gov/tus. Briefly, the ATUS response sample represents a subsample drawn from households that have previously completed the CPS (described above). Specifically for the ATUS, a single individual from each selected household is interviewed by telephone once (on a single, preassigned reporting day) about their personal time use over the previous 24-hour day (anchored by 4:00 AM). Both weekdays and weekend days are considered but users are advised to use ATUS constructed weights to ensure appropriate interpretation of time spent between these types of days. The actual interview is conducted (after obtaining verbal consent) using a Computer Assisted Telephone Interviewing (CATI) system to standardize progress and prompting through a combination of structured general background questions and conversational interviewing representing the designated recalled day. Responses about activities (and their durations) are captured verbatim. Structured

Table 1 Activity Codes and MET Level Estimates for Occupational Activities Based on Body Position (Sit, Stand, Walk, Heavy Labor) and Intensity (Light, Moderate, Vigorous)

Activity code	Description of body position/intensity	MET value
1	Sit, light	1.5
2	Sit, mod	2.5
3	Sit and stand, light	2.0
4	Stand, light	2.5
5	Stand, light and moderate	3.0
6	Stand, moderate	3.5
7	Stand, moderate and heavy	4.0
8	Walk, not carrying anything	3.5
9	Sit, stand, walk, not carry	2.5
10	Walk, carry < 25 lbs	4.5
11	Sit, stand, walk, carry < 15 lbs	3.0
12	Stand, walk, carry 15–25 lbs	3.5
13	Stand, walk, carry 25–50 lbs	5.0
14	Stand, walk, carry > 50 lbs	7.5
15	Carpentry	6.0
16	Heavy power tools	8.0

questions are used to update or confirm occupation data since the original CPS interview. The 2003 ATUS sample consisted of about 21,000 interviews. The ATUS is authorized by Title 13, United States Code sections 8 (population statistics) and 9 (confidentiality).

Interviewers are trained to use software to assign a 6-digit code to each ATUS primary activity based on an organizational system that classifies activities from broad categories to more specific ones using 3 hierarchical 2-digit tiers. An exception to this rule, however, is coding of occupational activities. The ATUS does not differentiate individual employment tasks necessary to assign specific MET values; almost all associated 6-digit codes related to occupational activities are exactly the same and simply indicate that the respondent was working. In other words, respondents are not asked to break down the activities they did while at their job. Details of occupational activities are omitted from the ATUS because the BLS developed the detailed time-use survey to identify nonoccupational activities and to provide a monetary estimate of time spent in such activities.[11] However, ATUS uses occupational category variables (both the major occupational group and the detailed occupation) for each respondent based on the 2002 census occupation classification system, so it is possible to get crude population estimates of occupational physical activity using the assigned MET estimates.

Population Estimates of Occupational Physical Activity

As a simple illustration of the utility of this product, we studied the 20,720 ATUS respondents, 5289 (2902 males and 2387 females) of whom were ≥ 15 years of age and reported working 6+ hours at their primary occupation on their assigned reporting day. Specifically, we compared proportions of the sample working at sedentary, light, moderate, or vigorous intensity using the summary MET values published previously[7] and the detailed estimates. The corresponding MET levels for the 3 intensity categories, respectively, are commonly expressed as < 3 METs, 3 to 6 METs, and vigorous, or > 6 METs.[12] Recently, however, consensus was reached that 6 MET activities (previously categorized as moderate intensity) should be classified as vigorous intensity;[13] this update was used herein. Further, following the growing interest in the potential deleterious effects of sedentary behaviors[2] we segmented the light intensity category into sedentary (<2METs) and light (2–2.9 METs) intensities.

Results

Table 2 presents activity codes and MET values assigned to the 2002 census occupational classification system. Left to right, the first column contains the 2002 census

Table 2 Activity Codes and MET Values Assigned to 2002 Census Occupational Classification System

Occupation group title from 2002 Census Occupational Classification System	2002 census codes	Range of assigned activity codes	Range of assigned MET values	Summary MET values*
1 Management	0010—0430	1–5	1.5–3.0	1.73
2 Business and financial operations	0500—0950	1–11	1.5–2.5	1.67
3 Computer and mathematical	1000—1240	1–9	1.5–2.5	1.58
4 Architecture and engineering	1300—1560	1–9	1.5–2.5	1.64
5 Life, physical, and social science	1600—1960	1–9	1.5–2.5	2.03
6 Community and social services	2000—2060	1–9	1.5–2.5	2.08
7 Legal	2100—2150	1	1.5	1.50
8 Education, training, and library	2200—2550	1–9	2.5	2.50
9 Arts, design, entertainment, sports, media	2600—2960	1–9	1.5–3.5	2.13
10 Healthcare practitioner and technical	3000—3540	1–11	1.5–3.0	2.22
11 Healthcare support	3600—3650	3–11	2.0–4.0	2.83
12 Protective service	3700—3950	3–12	2.0–5.0	2.56
13 Food preparation and serving related	4000—4160	4–9	2.0–3.5	2.58
14 Building and grounds cleaning and maintenance	4200—4250	9–11	2.5–4.5	3.58
15 Personal care and service	4300—4650	1–12	1.5–3.0	2.53
16 Sales and related occupations	4700—4960	1–9	1.5–2.5	2.00
17 Office and administrative support	5000—5930	1–11	1.5–4.5	1.83
18 Farming, fishing, and forestry	6000—6130	5–16	2.5–8.0	3.67
19 Construction and extraction	6200—6940	2–16	2.5–8.0	4.29
20 Installation, maintenance, and repair	7000—7620	1–16	1.5–8.0	3.19
21 Production	7700—8960	1–9	1.5–4.0	2.69
22 Transportation and material moving	9000—9750	1–14	1.5–7.5	2.68

* Published previously[7].

occupation title category; the next column captures the associated range of 2002 census codes; next, the assigned activity codes (taken from Table 1) capturing body position and/or intensity of the occupation; next, the estimated range of MET values associated with the occupation category; and finally, the previously published[7] associated summary MET values. Tables 3 to 24 present the details for each of the 22 major occupations and 509 detailed occupations and may be viewed online at http://riskfactor.cancer.gov/tools/ocs-met/.

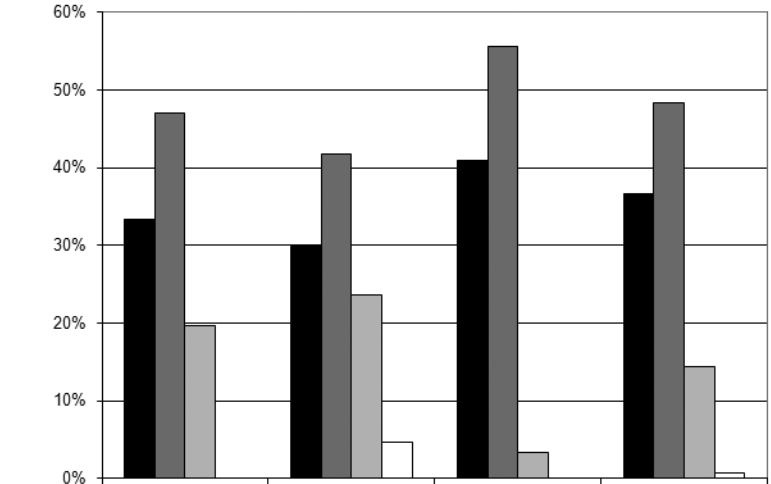
Figure 1 presents the prevalence (using summary vs. detailed MET estimates) of those respondents reporting sedentary, light, moderate, and vigorous intensity occupations, by sex. The detailed estimates are more sensitive to identifying individuals who do any occupational activity that is moderate or vigorous in intensity, resulting in fewer workers in sedentary and light intensity occupations.

Analysis using the summary MET estimates resulted in 4% more workers in sedentary occupations, 6% more in light, 7% less in moderate, and 3% less in vigorous compared with using the detailed MET estimates. The greatest single difference was observed in females. The summary MET estimates resulted in 3.4% engaged in moderate intensity occupations vs. 14.4% when the detailed MET estimates were used. Scrutinizing the vigorous-intensity occupations revealed 152 respondents who were classified differently. For example, 64 individuals were classified as Laborers and Freight, Stock and Material Movers, Hand (census code 9620) at a detailed MET value of 7.5, but were included within Transportation and Material Moving (category 22) at a summary MET value of 2.68. Forty-seven were classified as Carpenters (census code 6230) and 32 individuals were classified as Construction Laborers (census code 6260), both at a detailed 6.0 METs, but were included within Construction and Extraction (category 19) at a summary value of 4.29 METs. To emphasize, use of the detailed MET values put these individuals (and 9 others not detailed above) into vigorous intensity occupations whereas use of the summary MET values coded them as moderate intensity.

Discussion

Assigning MET values to occupational classification systems provides an inexpensive and feasible approach to studying occupational physical activity. The resulting MET values indicate, that on any given day in 2003, the majority (78% based on detailed estimates vs. 88% based on summary estimates) of American workers were engaged in sedentary or light intensity occupations (ie, <3 MET).

Regardless of whether a summary or detailed MET estimate is used, however, limitations to this approach to estimating occupational intensity include within-job variability, intensity misclassification, seasonal and secular changes in job requirements, and possible selection bias.[14] Collection of data in this manner cannot replace more



	Males		Females	
	Summary	Detailed	Summary	Detailed
Sedentary	33.29%	29.9%	41.0%	36.6%
Light	47.04%	41.7%	55.6%	48.3%
Moderate	19.68%	23.7%	3.4%	14.4%
Vigorous	0.00%	4.7%	0.0%	0.7%

Figure 1 — Prevalence (using summary vs. detailed MET estimates) of those respondents reporting sedentary, light, moderate, and vigorous intensity occupations by sex.

detailed and individualized estimates obtained with valid and reliable questionnaires targeting occupational physical activity.[15] That being said, Steele and Mummery[10] demonstrated significant differences in mean steps/day across occupational categories defined with the Australian Standard Classification of Occupations as professional (2835 steps/day), white-collar (3616 steps/day), and blue-collar (8757 steps/day). Further, because occupation data are regularly collected as a matter of course with the CPS and linked with the ATUS, it behooves us to capitalize on this large and representative resource.

Eighteen of the 22 occupation groups presented in Table 2 have summary MET values that are less than moderate intensity, compared with 8 groups with similarly classified detailed MET estimates. Therefore a shift from sedentary and light occupational activities to moderate or vigorous activities has to be expected when using detailed versus summary MET values. Specifically, the use of the detailed MET values identified 152 more individuals (out of 5289 ATUS respondents working 6+ hours at their primary occupation on their assigned reporting day) engaged in vigorous intensity occupations than did the summary estimates. It is difficult to believe that any individual can perform an 8.0 MET activity as an occupation typically lasting 8 hours a day, 5 days a week, for weeks on end. Some of the highest MET values in the Compendium are assigned to athletic pursuits, which we assume last shorter durations and are not likely undertaken day in and day out. An exception that comes to mind are the high-level cyclists engaged in the Tour de France, who ride (between 8 to 12 METs according to the Compendium) for 4 to 5 hours a day for a few weeks during the competition. It is more likely that workers who engage in vigorous intensity tasks intersperse these with moderate, light, and sedentary activities to sustain their output and prevent injury. Considering this, a summary moderate MET value is probably more conservatively representative of overall occupational energy expenditure. However, analysts might choose to use the detailed MET estimates as a means of identifying those individuals in occupations with at least some vigorous intensity activities. The detailed MET values also identified 7% more individuals in moderate-intensity activities, which may be useful when examining the association of occupational activity with body weight, to name but 1 health outcome of interest. It is not within the scope of this article to test the relative utility of the 2 MET classification systems in this manner. Further, we are not able to make comments on the relative validity of either approach to classifying occupation activity; no criterion standard is currently available for this purpose.

In summary, this paper extends earlier work,[7] which focused on linking ATUS activity variables with Compendium of Physical Activities[8] MET values. It provides detailed MET estimates for the 509 occupations listed in the 2002 census occupational classification system. Despite the admitted limitations of using job titles to represent intensity of occupational activity, users of the ATUS data now have the opportunity to choose between summary and detailed MET estimates. The detailed estimates provide resolution to distinguish individuals with different work-related physical activity demands within an occupational category. The opportunities for using these data are widely varied. For example, because CPS regularly captures occupation data it will be possible to track prevalence (and demographic correlates) of the different intensity levels of occupations. Further, because beginning in 2006, ATUS captured self-reported height and weight (allowing calculation of BMI), it will be possible to explore the association of occupational activity (or inactivity) in addition to nonwork activity with body weight status. We stress that these estimates are intended for epidemiologic study only and should not be used to justify fitness requirements to perform listed occupations. Updates to this database will be required with anticipated inevitable adjustments to future occupational classification systems.

References

1. Kruger J, Ham SA, Berrigan D, Ballard-Barbash R. Prevalence of transportation and leisure walking among U.S. adults. *Prev Med.* 2008;47:329–334.
2. Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. *Diabetes*. 2007;56(11):2655–2667.
3. Brown WJ, Miller YD, Miller R. Sitting time and work patterns as indicators of overweight and obesity in Australian adults. *Int J Obes Relat Metab Disord*. 2003;27(11):1340–1346.
4. Mummery WK, Schofield GM, Steele R, Eakin EG, Brown WJ. Occupational sitting time and overweight and obesity in Australian workers. *Am J Prev Med*. 2005;29(2):91–97.
5. Morris JN, Heady JA, Raffle PA, Roberts CG, Parks JW. Coronary heart-disease and physical activity of work. *Lancet*. 1953;265(6796):1111–1120 concl.
6. Sobolski JC, Kolesar JJ, Kornitzer MD, et al. Physical fitness does not reflect physical activity patterns in middle-aged workers. *Med Sci Sports Exerc*. 1988;20(1):6–13.
7. Tudor-Locke C, Washington TL, Ainsworth BE, Troiano RP. Linking the American Time Use Survey (ATUS) and the Compendium of Physical Activities: Methods and rationale. *J Phys Act Health*. 2009;6:347–353.
8. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. 2000;32(9, Suppl):S498–S504.
9. Ainsworth BE, Richardson MT, Jacobs DR, Jr, Leon AS, Sternfeld B. Accuracy of recall of occupational physical activity by questionnaire. *J Clin Epidemiol*. 1999;52(3):219–227.
10. Steele R, Mummery K. Occupational physical activity across occupational categories. *J Sci Med Sport*. 2003;6(4):398–407.
11. Shelley K. Developing the American Time Use Survey activity classification system. *Mon Labor Rev*. 2005; (June):3–15.
12. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273(5):402–407.

13. Physical Activity Guidelines Advisory Committee. *Physical Activity Guidelines Advisory Committee Report, 2008*. Washington, D.C.: U.S. Department of Health and Human Services; 2008.
14. LaPorte RE, Montoye HJ, Caspersen CJ. Assessment of physical activity in epidemiologic research: problems and prospects. *Public Health Rep*. 1985;100(2):131–146.
15. Reis JP, Dubose KD, Ainsworth BE, Macera CA, Yore MM. Reliability and validity of the occupational physical activity questionnaire. *Med Sci Sports Exerc*. 2005;37(12):2075–2083.