

*Original Research***Oxygen Cost of Performing Selected Adult and Child Care Activities**

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ABSTRACT

International Journal of Exercise Science 6(1) : 11-19, 2013. Little is known about the oxygen cost of caring for infants and older adults. Many people perform these activities so it is useful to know the energy cost and if the activities are of sufficient intensity to contribute to meeting physical activity recommendations. The purpose of this study was to assess the oxygen cost of four care-related activities in the Compendium of Physical Activities. Nineteen participants (n = 10 women, n = 9 men; Age = 36.4 ± 13.6 y; % Fat = 34.1 ± 10.5; BMI = 28.1 ± 4.5 kg/m²) performed four activities: 1) pushing an infant in a stroller, 2) pushing an adult in a wheelchair, 3) carrying an infant, and 4) bathing and dressing an infant. The oxygen cost was assessed using a portable metabolic unit. Activities were performed in random order for 8 minutes. The oxygen cost and heart rates, respectively, for healthy adults during care related activities were 3.09 METs and 90 ± 8 beats per minute (bpm) for pushing an infant in a stroller, 3.69 METs and 97 ± 9 bpm for pushing an adult in a wheelchair, 2.37 METs and 85 ± 9 bpm for carrying an infant, and 2.00 METs and 87 ± 9 bpm for bathing and dressing an infant. Carrying an infant and bathing an infant are light-intensity physical activities and pushing a wheelchair or a stroller are moderate intensity activities. The latter activities are of sufficient intensity to meet health-related physical activity recommendations.

KEY WORDS: Oxygen consumption, energy expenditure

INTRODUCTION

Regular physical activity is a health enhancing behavior and is recommended for weight management and to reduce the risks for several chronic diseases, disabilities, and premature mortality (11). The 2008 U.S. Physical Activity Guidelines recommend all adults perform 150 minutes of moderate intensity activity (or 75 minutes of vigorous, or an equivalent combination) per week (11). However, many adults perceive time limitations as a

barrier for performing leisure-time activities at this level. Thus, it is important to identify the intensity of activities of daily living that adults commonly perform which may have health-promoting benefits. Both men and women take care of others, however, women often bear much of the responsibility of caring for children (10) and older adults (9) and these responsibilities can be time consuming.

Using data from the 2003-2008 American Time Use Survey (ATUS), Tudor-Locke et

al. (23) showed that 16.5% of adults reported taking care of children in a usual day. The ATUS data from 2005-09 (7) showed that women spent nearly 6.7 hours per day with children under 6 years of age, of which nearly 1.1 hours were spent providing physical care activities, such as bathing, dressing, and feeding young children. Another 0.9 hours were spent performing other types of child care activities, such as: playing sports, hobbies, transporting children, and reading and talking with children (8). Little is known about the energy cost of these activities. Given that women tend to report lower levels of leisure time physical activity compared to men, it is plausible that infant care tasks may represent an unexamined aspect of their physical activity profiles.

The Compendium of Physical Activities (Compendium) provides a source to identify the oxygen cost of many activities performed on a daily basis, including caring for others. First published in 1993 (2) and revised in 2000 (3), the Compendium includes both measured and estimated MET values. A MET is a unit of movement intensity that reflects an activity metabolic rate divided by a resting metabolic rate. Recently, a second revision to the Compendium was completed to create the 2011 Compendium. The goal of the 2011 Compendium (1) was to update the activities listed and to identify MET values from published studies for as many activities as possible, and to provide citations for these activities.

Few studies have measured the oxygen costs of caring for infants. In a study with mothers of young children less than 5 years old, Brown et al. (6) measured walking with a stroller as 3.8 METs. De Guzman et al.

(13) measured the oxygen cost of bathing children while standing as 3.48 METs. Both of these reports indicate these activities are sufficient to meet national physical activity recommendations if performed for sufficient duration. Child care activities with infants may require less intensity than those with older children. De Guzman et al. (13) reported standing and holding a child as 1.92 METs. Rao et al. (20) reported breast feeding an infant while sitting or reclining as 2.0 METs. Other studies collectively identify infant care activities at 2.0 METs (17, 5, 22) which are considered to be light-intensity (1.6 to 2.9 METs) (18). A review of the 2011 Compendium shows several child care activities for which the oxygen cost has yet to be measured. These included dressing, grooming, feeding, and occasional lifting of infants while sitting or kneeling; reclining with a baby; and walking slowly while holding an infant weighing less than 15 lbs.

With the growing aging population, adults are more likely to care for aging parents or adults with disabilities, some of whom will require assistance with the activities of daily living and rely on wheelchairs for transportation (14, 21). Such activities may include feeding, dressing, personal grooming, assisting one into and out of a wheelchair, and pushing a wheelchair. Little is known about the oxygen cost of such activities. Pushing a wheelchair has dual purposes as a household care task and an occupational task in nursing, physiotherapy, and other care-oriented professions. Pushing a wheelchair with adequate speed may be of sufficient intensity to reduce one's risks for chronic conditions while still caring for dependent adults.

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The purpose of this study was to measure the oxygen cost for care related activities listed in the Compendium that currently has only estimated MET values for these activities. We performed a laboratory study to measure the oxygen cost of four child and adult care activities: (1) pushing an infant in a stroller, (2) pushing an adult in a wheelchair, (3) walking slowly and carrying an infant, and (4) bathing and dressing an infant.

METHODS

Participants

Nineteen healthy adults ($n = 10$ women, $n = 9$ men; (mean \pm SD) age = 36.4 ± 13.6 y; % Fat = 34.1 ± 10.5 %; body mass index = 28.1 ± 4.5 kg·m⁻²) volunteered for the study. All study participants read and signed an informed consent form approved by the Arizona State University (ASU) Institutional Review Board prior to study participation. Upon completion of the tests, participants received monetary compensation for their time.

Protocol

A cross-sectional study design was used with a single 1.5 hour visit to the Healthy Lifestyles Research Center at ASU between July and October 2010. At the beginning of the visit, participants had their weight in kilograms and body composition measured using a Tanita bioelectrical-impedance scale (TBF-300, Arlington Heights, IL). Height was measured in cm using a wall mounted measuring tape. Following this a heart rate monitor (Polar, WearLink, Kempele, Finland) was placed and their heart rate was recorded in beats/min (bpm). The oxygen cost in ml⁻¹·kg⁻¹·min⁻¹ of the care related activities was assessed at rest and during each activity by measuring the

oxygen uptake (VO₂). Pulmonary gas exchange and ventilation were measured breath by breath using a portable metabolic unit to compute their VO₂ (Oxycon Mobile™, CareFusion, San Diego, CA) (19). The metabolic unit was fixed to the back of the participant via a chest harness. A flexible face mask covered the participant's mouth and nose. Care was taken to ensure that an adequate seal was achieved. The metabolic unit was calibrated using manufacturer's specifications prior to each trial.

Prior to the start of the tests, participants rested in a chair for 10 minutes to obtain resting heart rate and VO₂ values. Each test was performed for eight continuous minutes with four minutes of rest in a seated position between each activity.

Mannequins were used as test subjects to provide consistency in the test environment for each participant. An adult mannequin (height: 166 cm and weight: 75 kg) was used as the subject for the pushing a wheelchair task. The weight of 75 kg for the adult in the wheelchair was chosen using NHANES 2003-2006 data showing the mean heights and weights of males and females at varying ages (16). The mean weight was 75 kg for males and females ages 20-39 (16). There were no data available for wheelchair bound adults. An infant mannequin that was an equivalent size to a 2 month old child (length: 38 cm and weight: 5 kg, with added weights), was used for pushing a stroller, bathing and dressing an infant, and walking and carrying an infant.

The care related activities were assigned to participants in a random order to reduce the chance of systematic bias resulting from

activities being performed in the same order. Details for each task are described (1). *Pushing an infant in a stroller*: The stroller (Eddie Bauer Travel System Stroller) contained a baby mannequin that was pushed indoors on a flat firm (concrete) surface in a set, rectangular, 67 meter course. Participants walked and pushed the stroller at a comfortable pace and were timed at lap intervals and instructed to speed up, slow down, or maintain the current pace by study personnel to ensure a constant speed was maintained for 8 minutes. The average speed for pushing the stroller was 1.12 m·sec⁻¹ (4.0 km·h⁻¹) (2). *Pushing an adult in a wheelchair*: A standard hospital wheelchair (Invacare, Eylria, OH) containing an adult mannequin was pushed indoors on a flat firm (concrete) surface in a set, rectangular, 67 meter course. The mannequin was secured into the wheelchair at the chest and legs for stability. Participants walked and pushed the wheelchair at a comfortable pace and were guided by study personnel to ensure the pace remained constant for 8 minutes. The average speed for pushing the wheelchair was 1.12 m·sec⁻¹ (4.0 km·h⁻¹) (3). *Washing and dressing an infant*: A simulated baby washing protocol was used to wash and dress the infant mannequin in a diaper and clothing. Participants were supplied with a towel, soap/shampoo bottle, washcloth, and cup to simulate washing activities. Participant kneeled or sat to undress the mannequin, placed it in a tub (without water), simulated washing the infant, removed the infant from the tub, dried it with a towel, and then dressed the infant with a diaper and clothes (4). *Walking slowly and carrying an infant*: This activity was performed in a large room where the participants walked slowly and moved freely at their own speed while carrying the

infant mannequin. Each participant was allowed to carry the infant in a preferred position. The walking speed during this task was not measured.

Statistical Analysis

Data were analyzed using means and standard deviations to assess the VO₂ in ml⁻¹·kg⁻¹·min⁻¹ and the heart rate in bpm at rest and during each task. Data were averaged over a 15 second period while using minutes 3-7 for data analysis. The MET value for each activity was computed by dividing the VO₂ in ml⁻¹·kg⁻¹·min⁻¹ for each task by 3.5 ml⁻¹·kg⁻¹·min⁻¹ (4). SAS 9.2 (SAS, Cary, NC) was used for data analysis. A one-way ANOVA was used to test differences by gender in each task.

RESULTS

All participants completed each activity in their assigned sequence. Table 1 provides descriptive data on the age, weight, height, and percentage body fat for men, women, and all participants combined.

Table 1. Descriptive Statistics of Study Participants (mean ± SD).

	Total (n = 19)	Women (n = 10)	Men (n = 9)
Age (years)	38.2 ± 13.4	38.8 ± 13.5	37.6 ± 14.1
Weight (kg)	86.8 ± 17.7	76.8 ± 15.6	97.9 ± 13.0
Height (cm)	172.0 ± 9.9	167.2 ± 5.7	177.4 ± 11.1
Body Fat (%)	32.1 ± 10.2	37.9 ± 10.1	25.5 ± 5.3

Table 2 presents the steady-state heart rate in bpm during each activity for men, women, and all participants combined for each task. The resting heart rate prior to the start of the tasks was 67 ± 8 bpm (men: 66 ± 8 bpm; women: 68 ± 8 bpm). No significant

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differences were observed between men and women for heart rate at rest or during the activity.

Table 2. Steady-state Heart Rates by Task in Beats per Minute (mean \pm SD).

Task	Total (n = 19)	Women n = 10)	Men (n = 9)
Pushing Stroller	90 \pm 8	91 \pm 9	89 \pm 6
Pushing Wheelchair	97 \pm 10	100 \pm 11	94 \pm 7
Carrying Infant	85 \pm 9	86 \pm 10	83 \pm 9
Bathing Infant	88 \pm 11	88 \pm 13	87 \pm 9

Table 3 presents the VO_2 in $\text{ml}^{-1}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and the associated MET values for men, women, and all participants combined for each task. The resting VO_2 was $3.7 \pm 0.7 \text{ ml}^{-1}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ (men, $3.9 \pm 0.8 \text{ ml}^{-1}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$; women, $3.5 \pm 0.5 \text{ ml}^{-1}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$). The slightly elevated resting VO_2 may have been the result of previous activity performed during the day and time of day of the testing. The VO_2 and associated MET values were similar for men and women on all activities except pushing a wheel chair, which was higher for women than for men ($p < 0.05$).

DISCUSSION

This study measured the energy cost of the commonly performed care activities of pushing a stroller and a wheelchair, carrying an infant, and bathing and dressing an infant. All activities were in the light-to-moderate intensity range. Pushing a 75 kg adult sized mannequin in a wheelchair and pushing a 5 kg mannequin infant in a stroller at $4.0 \text{ km}\cdot\text{h}^{-1}$ were

deemed moderate intensity activities at 3.7 and 3.1 METs, respectively. Carrying and bathing and dressing the infant mannequin were light intensity activities at 2.4 and 2.0 METs, respectively.

Table 3. Oxygen Uptake and Associated METs of Care Activities.

Task	Total (n = 19)	Women (n = 10)	Men (n = 9)
Pushing Stroller	10.8 \pm 2.4 (3.1 \pm 0.7)	10.9 \pm 2.5 (3.1 \pm 0.7)	10.6 \pm 2.3 (3.0 \pm 0.7)
Pushing Wheelchair	12.9 \pm 2.8 (3.7 \pm 0.8)	13.9 \pm 2.5* (4.0 \pm 0.7)	11.7 \pm 2.8 (3.3 \pm 0.8)
Carrying Infant	8.3 \pm 1.9 (2.4 \pm 0.5)	8.7 \pm 1.9 (2.5 \pm 0.5)	7.9 \pm 1.9 (2.3 \pm 0.5)
Bathing Infant	7.0 \pm 2.3 (2.0 \pm 0.7)	7.1 \pm 2.6 (2.0 \pm 0.7)	6.9 \pm 2.0 (2.0 \pm 0.6)

Data are presented as mean oxygen uptake and standard deviation in $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ with associated METs in parentheses. * Significantly different from men, $p < 0.05$.

Knowing the MET values of these care activities allows for correct classification of time spent at varying intensities and can provide a resource of suitable activities that meet U.S. physical activity guidelines. While carrying and bathing an infant are classified as light-intensity activities, their MET intensities of 2.4 and 2.0, respectively, double the caloric energy expenditure over rest. This may be beneficial in preventing inactivity-related conditions (15) and has broad implications for energy balance since 16.5% of adults reported doing physical care activities for household children in the 2003-2008 American Time Use Surveys (23). As well, pushing a stroller and a wheelchair, reported as 3.09 and 3.69 METs respectively, increase the resting metabolism nearly threefold. Just 15 minutes a day of these activities may lower

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all cause mortality by 14% (24). This is positive news for individuals that spend a significant amount of time pushing strollers and wheelchairs, such as parents of young children, and adults who care for elderly adults, as they may be more likely to meet the physical activity guidelines because of the time spent engaging in such activities.

There are several child and infant care activities listed in the Compendium including: standing and holding an infant; walking and carrying a small child or infant; bathing, dressing, and feeding an infant; pushing an infant or small child in a stroller; playing with small children; and other general child care activities. Published MET values for playing with children range from 2.2 to 5.8 METs. Moy (17) reported sitting and playing with children as 2.2 METs. Bassett and Ainsworth (5) reported walking and running while playing with children as 3.8 METs. Fischer et al. (12) reported playing tag and soccer with children aged 5 to 12 years old as 5.8 METs. These latter activities are in the moderate intensity category of 3.0 to 5.9 METs (11).

Three of the care activities measured in this study had estimated MET values in the 2000 Compendium of Physical Activities (3). One motivation for measuring the oxygen cost of these care activities was to have measured MET values in the 2011 Compendium (1). Interestingly, the 2000 Compendium estimated MET values were similar to the measured values for bathing an infant (Compendium code 05185; estimated 2.5 METs vs. measured 2.0 METs) and for pushing a wheelchair (Compendium code 17105; estimated 4.0 METs vs. measured 3.69 METs). The 2000 Compendium estimated MET value was

lower for pushing a stroller (Compendium code 17100; estimated 2.5 METs vs. measured 3.09 METs). Carrying an infant (Compendium code 05183) was a new activity added to the 2011 Compendium with a measured value of 2.37 METs.

It should be noted that the MET values published in the 2011 Compendium may differ from those published in this study. For ease of presentation, the Compendium MET values are rounded to significant digits of 0, 3, 5, and 8. Also, the 2011 Compendium MET values reflect the mean METs of studies that have published measured MET values for similar activities. For example, in 2001, Brown et al. measured the VO_2 of women pushing a stroller at $5.0 \text{ km}\cdot\text{h}^{-1}$ reported as 4.9 METs (6). This MET value is higher than the value measured in this study (3.09 METs) and may be due to participants pushing the stroller at a faster pace than the pace used in the current study ($4.0 \text{ km}\cdot\text{h}^{-1}$). Also, the Brown et al. (6) study included only women who pushed their own children who were on average 2.3 years old and weighed more than the 5 kg infant mannequin used in the current study. Because the 2011 Compendium averages MET values across the different studies published, averaging the Brown et al. study (4.9 METs) and the current study (3.09 METs) resulted in a 2011 Compendium MET value for pushing a stroller of 4.0 METs.

The U.S. Physical Activity Guidelines recommend adults engage in 150 minutes of moderate-intensity activity per week ranging from 3.0-5.9 METs, or 75 minutes of vigorous-intensity activity per week, ≥ 6.0 METs (11). As noted earlier, pushing a child in a stroller and pushing adults in a wheelchair are moderate intensity activities

that can contribute to meeting the Physical Activity Guidelines. By classifying these activities as moderate intensity, more individuals may meet the Physical Activity Guidelines. It is important for activity intensity to be properly classified to assess individual and national activity levels.

One limitation for this study was that participants were required to walk at a 4.0 km·h⁻¹ pace for pushing the wheelchair and the stroller and were guided by study personnel to maintain that speed. Participants had a tendency to increase speed throughout the duration of the activities, and were timed at lap intervals and instructed to speed up, slow down, or maintain the current pace by study personnel to ensure a constant speed was maintained for the activity duration. This may have limited the speed at which participants performed the activity and altered the VO₂ of the pushing activities. Another limitation related to the pushing activities was the amount of friction generated by the stroller and wheelchair. A low rolling resistance may have not have made a significant contribution to the oxygen cost of these activities. Additionally, participants with infant children who engaged in the activities measured in this study may have been more familiar with the activities and exhibited a movement economy that could have lowered their VO₂ in selected activities. The simulated washing of a mannequin, rather than washing an infant, may also have resulted in a change in the energy cost of this activity. Holding a live infant and pouring water may affect the oxygen cost of this activity.

We measured the oxygen cost of four care-related activities to show that pushing a

wheelchair and a stroller are classified as moderate-intensity activities and carrying and dressing an infant are classified as light-intensity activities. Knowing the MET values for these care activities provides useful information that may help better quantify physical activity in mothers with small children and care givers for wheelchair bound persons. We also reported measured MET values for the 2011 Compendium of Physical Activities that replaced previously estimated values from the 2000 Compendium of Physical Activities.

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