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Metabolic Cost of Horticulture Activities in Older Adults

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The exercise intensity of three different horticulture activities (propagating herbs, transplanting, and making a vegetable garden) in older adults was determined. Seventeen older Korean adults (mean age 66.9±2.7 years, body mass index 26.8±3.4) that met the inclusion criteria (over 65 years in age, no uncontrolled chronic diseases, no heart and lung diseases, no pacemaker, and nonsmoking) participated in the study. The subjects visited the Konkuk University campus, Seoul, South Korea two times to complete the horticulture activities during June 2011. Propagating herbs and transplanting were completed in a glasshouse during the first visit, with each activity taking about 20 min. The third activity involved making a vegetable garden and required an average of 25 min during the second visit. Metabolic and heart rates during each activity were determined using a portable calorimetric instrument with a radiotelemetry monitor. Propagating herbs and transplanting were determined to be low intensity physical activities (2.4±0.5 metabolic equivalents (METs) and 2.7±0.5 METs, respectively) while making a vegetable garden was a moderate intensity physical activity (3.7±0.7 METs) for older adults.

Key Words: energy expenditure, physical activity, gardening, horticultural therapy, human issues in horticulture.

Introduction

The health benefits of physical activities include the prevention or decrease of chronic diseases such as Type 2 diabetes, hypertension, coronary heart disease, etc. (American College of Sports Medicine (ACSM), 1993, 1998, 2004) and the increase or maintenance of muscle strength, fitness level, aerobic capacity, and balance (ACSM, 1998; DiPietro, 2001; U.S. Department of Health and Human Services, 1996). Based on a broad range of published research, at least 30 min of moderate intensity physical activity on most days of the week is recommended for maintaining or improving the health conditions of older adults (ACSM, 1998; DiPietro, 2001; Nelson et al., 2007; Pate et al., 1995; U.S. Department of Health and Human Services, 1996).

Physical activities include a range of daily tasks such as housework and walking for transportation (Caspersen et al., 1985). The energy expenditure, which can be expressed as metabolic equivalents (METs), represents the exercise intensity of physical activities in terms of oxygen consumption per unit body mass (1 MET = 3.5 mL·O_2/kg/min) (Ainsworth et al., 2000). MET values of less than 3 indicate low intensity, 3–6 METs are moderate intensity, and above 6 METs are high intensity physical activities (Pate et al., 1995). For example, 1 MET presents a resting metabolic rate such as lying down, sitting quietly, and meditating (Ainsworth et al., 2011). Walking for pleasure is classified as a moderate intensity physical activity (3.5 METs) and jogging is a vigorous intensity physical activity (7 METs) in adults aged from 25 to 65 years (Ainsworth et al., 2011).

Gardening is a leisure-time activity that provides health benefits in older adults (Armstrong, 2000; Park et al., 2009; Reynolds, 1999, 2002; Turner et al., 2002; Walsh et al., 2001). Active American gardeners over 65 years in age spent more than 150 min per week working in their home garden and had better self-reported physical health benefits than those who did less gardening (Park et al., 2009). In one study, participation in gardening activities helped improve hand strength and pinch force (Park et al., 2009; Reynolds, 1999) since many of the common gardening tasks include a gripping motion (Park and Shoemaker, 2009). Cardiovascular fitness can also be improved due to the increased heart rate that occurs during gardening (Park et al., 2008a, b; Reynolds, 1999).

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Participation in gardening for 3 months has also been reported to improve mental health and decrease depression (Reynolds, 2002).

Park et al. (2008a, b) determined that various gardening tasks were low to moderate intensity physical activities for adults over 65 years in age. Gardening tasks that used both the upper and lower body and included weight-bearing motions (e.g., digging, raking, weeding, fertilizing, tying plants to stakes) were moderate intensity physical activities (3–6 METs) (Park et al., 2008a, 2011). Tasks that primarily used the upper body while standing or squatting (e.g., watering, washing harvesting, mixing soil, filling containers with soil) were low intensity physical activities (1–3 METs) (Park et al., 2008a, 2011). Older American gardeners in Kansas spent an average of 33 h gardening during a typical week in May and about 15 h in a typical week in June and July doing activities that were of moderate physical intensity (Park et al., 2008b).

The objective of this study was to determine the exercise intensity of three different horticulture activities (making a vegetable garden, propagating herbs, and transplanting), which are a series of horticultural tasks for older adults to develop research-based garden exercise recommendations for improved health.

Materials and Methods

Subjects

Adults aged 65 years or older were recruited from the urban community in Seoul, South Korea. The registration forms describing the study were distributed directly to individuals and senior centers. Inclusion criteria were individuals 65 years or older, no uncontrolled chronic diseases, no heart and lung diseases, no pacemaker, and nonsmoking. Seventeen among the 40 volunteers met the inclusion criteria. The subjects were provided a description of the experimental procedures, a schedule, and a printed informed consent form at the initial orientation. Twelve hours prior to each session, the subjects were requested to abstain from caffeine, alcohol, a heavy meal, and physical activity. An incentive of $40 was provided to the subjects at the completion of the study.

Instruments

Height, weight, and body composition [fat (g), lean (g), and percent fat (%)] were measured using height and weight (model GL-150, G-Tech International, South Korea) and dual-energy X-ray absorptiometry (model Discovery-W, Hologic, USA) by a trained specialist at Konkuk University Medical Center prior to participating in the horticulture activities. Body mass index was calculated from weight and height data [i.e., body mass index = weight (kg)/(height (m))^2]. Resting metabolic rate and heart rate were measured using a portable calorimetric instrument (K4b^2, Cosmed, Italy) with a radiotelemetry monitor (Polar T 31, FitMed, Finland) after the participants had sat in a chair for 5 min before starting the initial activity.

Horticulture Activities

A cross-section of common gardening tasks was grouped into three different horticulture activities. A room in a glass greenhouse with a table and faucet and 17 garden plots (1 m (W) × 1.8 m (L) each) on the Konkuk University campus, Seoul, South Korea were utilized for the indoor and outdoor activities.

Table 1 describes the gardening tasks involved in each of the horticulture activities. The subjects visited the university twice: They propagated herbs and transplanted plants indoors for an average of 20 min for each activity during the first visit, and made a vegetable garden outdoors, which required an average of 25 min per person, during the second visit. Before starting the horticultural activities, the subjects rested for 5 min on a chair. This length of time was previously found to be sufficient for the heart rate to return to a resting rate (Park et al., 2008a). No rest was allowed between horticultural tasks within a session. The subjects were provided specific instructions for each task before starting a session and the time required to finish each task in each session was determined using a stopwatch. All activities were completed during June 2011 when the average temperature was 28.8 ± 3.0°C (outdoors) and 26.7 ± 2.9°C (indoors) measured using a HR-TEMP Probe attachment to a portable telemetric calorimeter (Cosmed K4b^2) the participants wore while completing the activities.

Metabolic Measurements

Each subject wore a portable telemetric calorimeter (Cosmed K4b^2) with a battery and harness that measured metabolic parameters such as oxygen uptake, energy expenditure, and METs. The subjects continuously respired through a facemask that was calibrated for oxygen and carbon dioxide analysis before starting each activity. Calibration involved using room air and a reference gas standard, and calibrating the flow turbine and the timing delay between exhalation and analysis.

Each subject wore a heart rate monitor under their breast during each task throughout the program, which allowed continuous monitoring via radiotelemetry (Polar T 31), with the data recorded by the calorimeter.

Data analysis

Descriptive information about the subjects was analyzed using Excel (Microsoft Office 2002, Microsoft Corp., USA). Respiratory data that represented 3-s averages were collected throughout the test and analyzed by Duncan's multiple range test ($P < 0.05$) using the Statistical Analysis System program (SAS Version 9 for Windows, SAS Institute Inc., USA), enabled a comparison of the total metabolic rates for each of the three activities.

Table 1. Procedure, average time, and description of three horticulture activities performed by older adults.

Activity[z]	Procedure[y]	Average time (min)	Description
Making a vegetable garden (outdoor)	1. Digging	5	Digging a 1 m (W) × 1.8 m (L) garden plot with a shovel (1.3 kg).
	2. Fertilizing	3	Spreading fertilizer from a bucket with a shovel (1.3 kg) on the garden plot and then mixing it into the soil using a shovel.
	3. Raking	3	Raking the garden plot with a hand rake (0.9 kg).
	4. Making furrows	2	Making furrows using a hand rake (0.9 kg).
	5. Transplanting	5	Transplanting lettuce plants into the garden plot using a hand trowel (0.1 kg).
	6. Watering with a hose	2	Watering the plants using a hose.
		(Total 20 min)	
Propagating herb plants (indoor)	1. Putting soil in a bucket	4	Putting soil into a bucket (68 L) using a hand trowel (0.1 kg).
	2. Filling a watering can	1	Running water into a watering can (6 kg).
	3. Carrying water	5	Moving the watering can (6 kg) to the bucket and adding water to the soil.
	4. Mixing soil		Mixing soil and water in the bucket by hand.
	5. Filling tray with soil	4	Filling trays with 72 holes by hand with soil from the bucket.
	6. Making stem cuttings	9	Cutting rosemary stems and placing them on a tray.
	7. Making a name tag		Writing the date and plant and subject names on a plastic label using a pen.
	8. Transferring the tray to a bench	2	Transferring the tray with stem cuttings onto a bench.
		(Total 25 min)	
Transplanting (indoor)	1. Filling a bucket with soil	4	Putting soil in a bucket (68 L) using a hand trowel (0.1 kg).
	2. Filling a watering can	1	Running water into a watering can (6 kg)
	3. Moving the watering can	10	Moving the water (6 kg) and adding it to the soil in the bucket.
	4. Mixing the water into the soil		Mixing the water into the soil by hand.
	5. Filling a planter with soil	3	Placing soil from the bucket into the planter (0.6 m (W) × 0.4 m (L) × 0.2 m (H)) using a hand trowel (0.1 kg).
	6. Transplanting	2	Transplanting two tomato plants into the planter.
	7. Tying the plants	2	Tying the plants to a support stake with wire.
	8. Running water into a can	2	Running water into a small watering can (2 kg)
	9. Watering		Watering the plants using a watering can (2 kg).
	10. Labeling the plants	1	Writing the date and the name of the subject and plant on a plastic tag.
		(Total 25 min)	

[z] The subjects rested for 5 min on a chair before starting the horticulture activities (Park et al., 2008a).
[y] No rest was allowed between horticultural tasks within a session.

Results

Descriptive characteristics of the subjects

The 17 Korean adults who participated in the study had an average age of 66.9 ± 2.7 years and body mass index of 26.8 ± 3.4 (ranging from normal to overweight) (Table 2).

Exercise intensities of the horticulture activities

The horticulture activities were low to moderate in physical intensity for older Koreans (Table 3). Making a vegetable garden was moderate intensity (3.7 ± 0.7 METs) and was different from propagating herbs and transplanting, which were found to be low intensity physical activities (2.4 ± 0.5 METs and 2.7 ± 0.5 METs, respectively) (Table 3).

Discussion

Determining the MET values for a physical activity is based on the amount of oxygen intake by the body during the activity. One MET represents 3.5 mL·O_2/kg/min. Less than 3 METs indicate low intensity, 3–6 METs are moderate, and above 6 METs are vigorous intensity (Pate et al., 1995). To measure the oxygen intake, indirect calorimetry is used more than direct calorimetry because it is simpler and less expensive (McArdle et al., 2007).

Table 2. Characteristics of older adults (n = 17) that participated in a study to assess the exercise intensities of three horticulture activities.

Variable	Mean	SD
Age (years)	66.9	2.7
Height (cm)	154.0	6.9
Body weight (kg)	63.8	9.9
Body composition		
Body mass index ($kg \cdot m^{-2}$)	26.8	3.4
Fat (g)[z]	21307.8	5813.3
Lean (g)[z]	39875.7	6234.1
% Fat (%)[z]	33.6	5.7
Resting metabolic rate[y]		
Resting metabolic equivalents (METs)	1.1	0.3
VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	3.8	0.9
$Kj \cdot kg^{-1} \cdot h^{-1}$	4.4	1.4
Resting HR (beats/min)	79.6	9.8
Age-adjusted HRmax (beats/min)[x]	153.1	2.7

[z] Measured via dual-energy X-ray absorptiometry.
[y] Measured when the subjects were sitting on a chair for 5 min.
[x] Age-adjusted maximum heart rate (HRmax) = 220—age in years.

Table 3. Average metabolic measurements for 17 older adults taken while completing three horticulture activities.

Horticulture activity	Mean[z]	SD	Range
Making a vegetable garden			
METs[y]	3.7[a]	0.7	2.8–5.7
HR (beats/min)	108.4[a]	11.4	91.0–126.8
VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	13.1[a]	2.5	9.8–20.0
$Kj \cdot kg^{-1} \cdot h^{-1}$	9.8[a]	1.9	7.1–13.6
Propagating herb plants			
METs	2.4[b]	0.5	1.8–3.5
HR (beats/min)	85.1[b]	10.7	63.9–107.2
VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	8.5[b]	1.7	6.4–12.1
$Kj \cdot kg^{-1} \cdot h^{-1}$	7.8[b]	1.9	4.9–13.0
Transplanting			
METs	2.7[b]	0.5	2.0–3.7
HR (beats/min)	88.3[b]	11.1	64.2–109.5
VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	9.3[b]	1.7	7.1–12.9
$Kj \cdot kg^{-1} \cdot h^{-1}$	8.3[b]	1.9	5.4–13.9

[z] Means sharing a common letter are not significantly different by Duncan's multiple range test at $P = 0.01$.
[y] MET represents the exercise intensity of physical activity in terms of oxygen consumption per unit body mass (1 MET = 3.5 $mL \cdot O_2/kg/min$) (Ainsworth et al., 2000). Less than 3 METs indicate low intensity, 3–6 METs are moderate intensity, and above 6 METs are high intensity physical activity (Pate et al., 1995).

The Douglas bag method is considered as the most accurate for indirect calorimetry but it is impractical in an outside setting such as a garden. However, the Cosmed K4b^2 is a portable system that can be used outdoors for measuring the energy cost of free movements and the validity and accuracy equals the Douglas bag method (Kawakami et al., 1992).

Making a vegetable garden was found to be a moderate physical activity (3.7 ± 0.7 METs) for adults over the age of 65 while propagating herbs and transplanting were found to be low intensity physical activities (2.4 ± 0.5 METs and 2.7 ± 0.5 METs, respectively) (Table 3). In previous studies (Park et al., 2008a, 2011), gardening tasks that used both the upper and lower body (e.g., digging, raking, fertilizing) were found to be moderate intensity physical activities for older adults (3–6 METs), while tasks that used mainly the upper body while sitting or squatting (e.g., transplanting, harvesting, watering) were low intensity physical activities (1–3 METs). In this study, making a vegetable garden consisted of tasks such as digging (4.5 ± 1.2 METs), fertilizing (4.0 ± 0.9 METs), raking (3.4 METs ± 0.8 METs), making furrows (no published data, assumed to be moderate intensity because it uses both upper and lower body), transplanting (2.9 ± 0.9 METs), and watering with a hose (2.4 ± 0.8 METs) (Table 1) (Park et al., 2011), which were moderate intensity physical activities because the tasks almost used both the upper and lower body. Therefore, the overall activity, making a vegetable garden, was also determined to be moderate in physical intensity. Gunn et al. (2005) reported that some regular activities at home were moderate intensity physical activities in Australian men aged from 55 to 65 years (e.g., sweeping, 3.9 ± 0.6 METs; window cleaning, 3.8 ± 0.6 METs; vacuuming, 3.0 ± 0.6 METs; lawn mowing, 5.3 ± 0.7 METs; walking, 3.9 ± 0.6 METs). These regular activities are also related to the usage of both the upper and lower body.

An activity program with moderate intensity physical tasks can be used to improve or maintain the health condition of older adults (Armstrong, 2000; Park et al., 2009; Reynolds, 1999, 2002; Turner et al., 2002; Walsh et al., 2001). Recommendations for at least 30 min of physical activity of moderate intensity offer health benefits that are thought to prevent or reduce chronic diseases and help to maintain the ability of older adults to live independently. Health benefits include: a reduction of hypertension, anxiety and depression; a reduced prevalence of chronic diseases, coronary heart disease, type 2 diabetes, osteoporosis, ischemic stroke, and cancers; and improved fitness level, muscle strength, aerobic capacity, balance and bone mineral density (ACSM, 1993, 1998, 2004; DiPietro, 2001; Galloway and Jokl, 2000; Hui and Rubenstein, 2006; Lee et al., 1991; Powell et al., 1987; U.S. Department of Health and Human Services, 1996). Similar health benefits for older adults are obtained from non-gardening forms of physical activities, although gardening provides a number of additional benefits (e.g., aesthetic pleasure, sense of purpose, reduced food costs).

Indoor horticultural activity programs that included low intensity tasks (e.g., mixing soil, filling containers with soil, and watering) (Park et al., 2011) were found to be collectively of low physical intensity. Compared to these horticultural activities, various home activities involving little effort, such as cleaning or washing dishes, and conditioning exercises such as yoga or mild

stretching, are reported as a low intensity physical activity in adults aged from 25 to 65 years old (Ainsworth et al., 2011). Activity programs (e.g., propagating herbs, transplanting) that primarily used the upper body while standing are better suited to individuals that require a lower level of physical activity or have special needs in a horticultural therapy program.

Future study to determine the exercise intensity of various horticultural activities that are a series of indoor or outdoor horticultural tasks will be required to develop a garden exercise program or horticultural therapy program for health in older adults. It would be interesting to apply a long-term horticultural activity program utilizing low or moderate intensity physical gardening tasks to assess the health benefits to older adults.

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