HortScience 59(5):718–723. 2024. https://doi.org/10.21273/HORTSCI17631-23

Exercise Intensity Assessment of Care Farming Activities in Adults

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Keywords. animal-assisted activity, energy metabolism, gardening, green care, metabolic equivalent, oxygen consumption, physical activity, social farming

Abstract. **We aimed to determine the energy expenditure, oxygen uptake, and exercise intensity of 10 care farming activities performed by adults. The study had a crossover experimental design. Participants performed 10 care farming activities for 5 minutes, including four plant- and three animal-mediated activities, and three other activities. Each participant wore a portable telemetric calorimeter during the activities, and oxygen uptake, heart rate, and exercise intensity were measured. Twenty-one adults (aged 31.5 ± 10.2 years) participated in our study. Energy expenditure, oxygen uptake, and exercise intensity differed significantly for each activity. The 10 care farming activities were regarded as light- to moderate-intensity activities. The exercise intensity, energy expenditure, and oxygen uptake for organizing a garden plot were significantly higher than those for other care farming activities. Cooking using harvests, interacting with dogs, and feeding rabbits had the lowest exercise intensity, energy expenditure, and oxygen uptake. Other activities, such as transplanting plants, harvesting, creating art, maintaining a garden, walking with a dog, and cleaning the farm, had moderate exercise intensity, energy expenditure, and oxygen uptake. Energy expenditure, oxygen uptake, and exercise intensity data could be useful when developing a care farming program suitable for the physical condition of participants in care farming interventions.**

Physical activity suitable for individual health and physical fitness provides a safe and efficient means to maximize the effects of exercise (Wilmore 1974). Even with the same exercise intervention, individual physiological responses depend on different genotypes, phenotypes, and training status (Hecksteden et al. 2015), and excessive exercise that does not consider these characteristics can increase the risk of injury (Jones et al. 1994). Exercise intensity is one of the main variables used in exercise interventions to improve individual health status and physical fitness levels (Blair 1995; Hofmann and Tschakert 2010).

Agriculture, the main purpose of which used to be production, is now used as a basis to promote human physical, mental, and social welfare by using agricultural activities and environmental resources, such as plants, farm animals, and landscapes (Relf 2006). The therapeutic use of agriculture is called care farming, a type of green care that uses agricultural farms, such as with animals, plants, gardens, forests, and landscaping, as a basis to improve quality of life and human mental and physical health (Hassink and van Dijk 2006). According to the Act on Research, Development, and Promotion of Healing Agriculture in South Korea, care farming creates social or economic value through the utilization and related activities of various agricultural and rural resources to recover, maintain, and promote people's health. In European countries such as the Netherlands, France, Italy, and Belgium, care farming has spread to provide health benefits through farming activities in a safe and restorative farm environment (Leck et al. 2014). Care farming service delivery systems take different approaches across regions and countries (Gorman and Cacciatore 2017), but collectively offer participants a range of enjoyable and purposeful activities with the possibility of learning new skills.

Care farming activities that include various body movements have the potential to improve the physical function and health of participants and, to maximize their effects, it is necessary to secure quantitative data such as exercise intensity and energy consumption of care farming activities. Gardening, a care farming activity, involves energy expenditure and consists of weight-bearing movements that use the entire body (Park et al. 2014a, 2014b). In particular, gardening activities, such as making and maintaining a garden, have been observed to be moderate- to high-intensity physical activities for adults (Park et al. 2014b). In addition, 15 sessions of gardening interventions (twice a week, 50 min per session) as low- to moderate-intensity physical activity for women aged 70 years or older were found to reduce participant's blood pressure, blood cholesterol, and gene expression levels for proinflammatory proteins (Park et al. 2017). To participate in care farming to maintain and improve the physical health of participants, it is necessary to select farming activities with an exercise intensity appropriate for the individual's condition and intervene regularly, and it is important to increase reporting of individual exercise responses (Mann et al. 2013). However, the physical effects of care farming interventions have not been identified using a quantitative approach. There are insufficient data on the energy expenditure, oxygen uptake, and exercise intensity of agricultural activities carried out using various farm resources, including animals, crafts, and other farm work on actual care farms.

We, therefore, aimed to investigate the exercise intensity and energy expenditure of plant- and animal-mediated care farming activities on a real farm to determine the activities suitable to improve physical activity in adults.

Materials and Methods

Research participants. Participants were recruited by sending leaflets to farms, nearby churches, and gymnasiums. The inclusion criteria were as follows: no personal history of metabolic or cardiovascular disease, no musculoskeletal injuries, no pregnancy, and no use of medications at the time of the study (Ruiz et al. 2009). Before the experiment, a comprehensive explanation of the purpose of the study, specifics of the care farming activities, and clinical implications of the study were provided to the participants. Written informed consent was obtained from all the participants before they participated in the experiment. Participants were required not to consume alcohol or caffeine, not to overeat, and not to engage in strenuous physical activity 12 h before starting the experiment. The participants answered a questionnaire consisting of questions about age, sex, and use of medications before starting the experiment. Height, weight, and body composition of the participants were measured using an anthropometer (Ok7979; Samhwa, Seoul, South Korea) and a body mass analyzer (ioi 353; Jawon

Received for publication 27 Nov 2023. Accepted for publication 4 Jan 2024.
Published online 22 Apr 2024.
This study was supported by the KU Research Professor Program at Konkuk University.
The datasets generated for this study are available on request from the corresponding author.
This work was carried out with the support of "Cooperative Research Program for Agriculture Science and Technology Development (Project No. RS-2021-RD009877)" Rural Development Administration, Republic of Korea.
The authors declare no conflict of interest.
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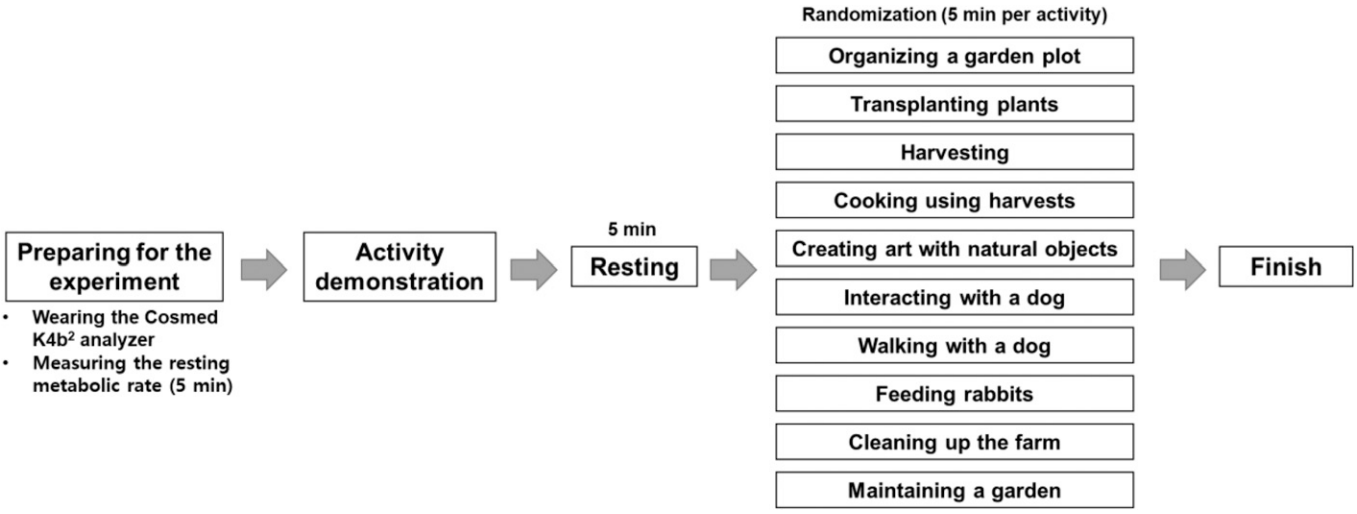

Fig. 1. The experimental protocol of this study.

Medical, Gyeongsan, South Korea). On completion of the study, the participants received $10 as a reward. This study was approved by the Institutional Review Board of Konkuk University (no. 7001355-202106-HR-442).

Experimental conditions. The experiment was conducted at a P-care farm in Sejong, South Korea, which has a variety of plant resources, such as vegetable gardens and greenhouses; animal resources, such as chickens, dogs, peacocks, and rabbits; and facility resources, such as cooking spaces and indoor classrooms. The average temperature of the farm area was 23.3 ± 2.5 °C and the average relative humidity was 81.7% ± 12.3% during the experiment.

Experimental procedure. In this crossover study, each participant performed the experimental procedure as shown in Fig. 1. The participant first sat on a chair, and their resting metabolic rate was measured for 5 min. The researchers explained and demonstrated the care farming activities before the participants performed each activity. Subsequently, the participants performed each activity for 5 min and then sat in a chair again and rested for 5 min without moving or talking. In previous studies (Park et al. 2014b, 2015), the activity time was set to 5 min to measure energy expenditure in horticulture and agricultural activities, and it was judged to be appropriate for adults to perform the activity during 5 min at the same intensity and speed in a preliminary study.

All participants performed 10 care farming activities, as described in Table 1. The care farming activities performed in the experiment were selected as those that appropriately used agricultural and rural resources, such as plants and animals of the P-care farm, and were used in the care farming program actually operated by the farm.

Measurement items. Metabolic parameters and heart rate during rest were measured while the participants rested in a chair for 5 min before the experiment using a portable telemetric calorimeter (K4b^2; Cosmed, Rome, Italy) equipped with a wireless telemetry monitor (Polar T 31; FitMed, Kempele, Finland). The Cosmed K4b^2 analyzer measures metabolic parameters such as energy expenditure, oxygen uptake, and metabolic equivalents of task (METs) through breath-by-breath measurements of gas exchange (Pinnington et al. 2001). One MET is ∼3.5 mL of oxygen consumed per kilogram of body weight per minute; 3 METs or less indicates low-intensity physical activity, 3 to 6 METs indicates moderate-intensity physical activity, and 6 METs or more indicates high-intensity physical activity (Pate et al. 1995). The K4b^2 system weighs ∼3 lb, is portable, and is worn by participants using a harness, rubber facemask, and mesh head cap with adjustable straps. The portable unit contains a galvanic fuel cell for the O_2 sensor, a digital infrared CO_2 sensor, a barometer sensor, a sampling pump, an ultrahigh-frequency transmitter, and electronics. The K4b^2 system has been verified for reliability and validity across exercise intensities in humans (Duffield et al. 2004), and its accuracy has been validated in comparison with the Douglas bag method (Pinnington et al. 2001). The K4b^2 system has also been used in previous studies to characterize exercise intensity in horticultural activities in different age groups (Park et al. 2014a, 2014b). Before the experiment, the K4b^2 system was calibrated according to the manufacturer's instructions and warmed for 1 h. The system predicts energy consumption from O_2 consumption and CO_2 production using the Weir equation (Weir 1949). The average values of the metabolic parameters extracted for each activity were calculated. To record heart rate data during the care farming activities, the participants wore a heart rate monitor under their chest via a wireless transmitter and an elastic strap (Polar T 31).

Data processing and analysis. To compare the metabolic rate and heart rate data according to each activity, the Kruskal-Wallis test was performed using SPSS (version 25 for Windows; IBM, Armonk, NY, USA); $P < 0.05$ was considered statistically significant. For demographic information, descriptive statistics of means, standard deviations, and percentages were obtained using Microsoft Excel (Office 2007; Microsoft Corp., Redmond, WA, USA).

Results

Demographic characteristics. Twenty-one adults aged 31.52 ± 10.18 years participated in the experiment, with six men and 15 women (men, 24.67 ± 3.27 years; women, 33.79 ± 11.01 years) (Table 2). The average body mass index was 21.59 ± 3.10 kg·m^{-2}, which was within the range of the criteria for normal.

Metabolic measurements of care farming activities. The results of oxygen intake were 10.74 ± 3.54 to 19.70 ± 4.65 mL/min/kg during plant-mediated activities, 6.91 ± 2.84 to 13.44 ± 4.46 mL/min/kg during animal-mediated activities, and 7.38 ± 1.87 to 12.51 ± 3.50 mL/min/kg during other activities on the farm. The energy expenditure results were 75.29 ± 24.86 to 140.28 ± 33.18 kcal/kg/d during plant-mediated activities, 48.42 ± 19.02 to 93.98 ± 30.89 kcal/kg/d during animal-mediated activities, and 52.04 ± 12.86 to 87.89 ± 25.01 kcal/kg/d during other activities. The descending order of exercise intensity, oxygen intake, and energy expenditure results by activity was as follows: organizing a garden plot, walking with a dog, creating art with natural objects, cleaning up the farm, planting plants, harvesting, maintaining a garden, feeding rabbits, cooking using harvests, and interacting with a dog. The energy expenditure, oxygen uptake, and exercise intensity differed significantly according to activity ($P < 0.001$).

The metabolic measurements for each care farming activity are presented in Table 3. The 10 care farming activities performed by the participants were determined to be light- to moderate-intensity physical activities (1.98 ± 0.81 to 5.63 ± 1.33 METs). When exercise intensities by each activity were analyzed, plant-mediated activities, such as organizing a garden plot, transplanting plants, harvesting, and maintaining a garden, were found to

Table 1. Care farming activities performed by the participants.

Activity	Description
Organizing a garden plot	
Digging	1) Holding the handle of a shovel (1.3 kg) with the right hand and standing with feet shoulder-width apart; 2) stepping, left foot in front of right foot, and holding the middle part of the shovel with the left hand; 3) inserting the blade into the designated position with a shovel; 4) digging up the soil and piling it up on the right side; 5) stepping back with left foot and returning to the standing position and repeating the procedure for 100 s.
Raking	1) Standing with feet shoulder-width apart and holding the tip of the garden rake with the right hand; 2) placing the left foot in front of the right foot and holding one-third of the tip of the rake (0.9 kg) with the left hand; 3) inserting the blade of the rake into the designated position; 4) scraping the soil in front of the body; 5) stepping back with left foot and returning to the standing position and repeating the procedure for 100 s.
Fertilizing	1) Standing with feet shoulder-width apart and holding the basin containing fertilizer (0.5 kg) with the left hand; 2) holding a handful of fertilizer in the right hand; 3) bending forward and extending the right arm forward to spread fertilizer in the designated area (area of 1.5 × 2.0 m); 4) returning to the standing position and repeating the procedure for 100 s.
Transplanting plants	
Planting	1) Standing with feet shoulder-width apart while holding the handle of the trowel (0.06 kg) with the right hand; 2) squatting down (bending both knees); 3) placing a trowel in the designated position; 4) digging up the soil and piling it up on the left side; 5) planting plants with both hands; 6) standing up; 7) moving one step to the right and repeating the procedure for 100 s.
Mulching	1) Standing with feet shoulder-width apart; 2) squatting down (bending both knees); 3) grabbing the rice straw in the basin with the right hand; 4) covering the straw around the seedlings in front with both hands; 5) standing up; 6) moving one step to the right and repeating the procedure for 100 s.
Setting up plant stakes	1) Standing with feet shoulder-width apart; 2) squatting down (bending both knees); 3) inserting the plant stake (0.04 kg) into the soil near the base of the plant using both hands; 4) tying the stake and plant stem with a strap at the midpoint of the plant height using both hands; 5) standing up; 6) moving one step to the right and repeating the procedure for 100 s.
Harvesting	
Harvesting crops	1) Standing with feet shoulder-width apart with a basin (0.1 kg) in the left hand; 2) checking peppers that have reached the harvest stage and moving; 3) bending the back toward the pepper to be harvested and extending the right hand; 4) picking up one pepper; 5) bringing the outstretched hand toward the body and putting it in the basin; 6) straightening the back and repeating the procedure for 100 s.
Washing crops	1) Standing in front of a table with feet shoulder-width apart while holding a basket (0.15 kg) of sesame leaves with both hands; 2) reaching the right hand to a basket of harvested peppers on the table and picking a pepper; 3) washing the pepper with water with both hands and repeating the procedure for 100 s.
Packing crops	1) Standing in front of a table with feet shoulder-width apart; 2) opening the lid of the packaging container on the table with both hands; 3) putting the washed pepper into the container with the right hand; 4) sealing the container using both hands (closing the lid) and repeating the procedure for 100 s.
Cooking using harvests	
Cutting crops	1) Standing with feet shoulder-width apart; 2) holding five sesame leaves with both hands; 3) shredding it five times and repeating the procedure for 100 s.
Trimming crops	1) Standing in front of a table with feet shoulder-width apart; 2) putting the shredded sesame leaves in a mortar on the table; 3) grasping the pestle with the right hand; 4) pounding the shredded sesame leaves in the mortar and repeating the procedure for 100 s.
Mixing crops with other ingredients	1) Standing in front of a table with feet shoulder-width apart; 2) putting the crushed sesame leaves in a mortar with a spoon into a cup with a drink on the table; 3) stirring the inside of the cup with a spoon to mix well and repeating the procedure for 100 s.
Creating art with natural objects	
Collecting natural objects	1) Standing with feet shoulder-width apart and holding a basket (0.15 kg) with the left hand; 2) checking a natural object on the ground and moving (2.0 m distance); 3) bending the back toward the object and extending the right hand to pick it up; 4) bringing the outstretched hand toward the body and straightening the back; 5) putting the object into the basket held in the left hand and repeating the procedure for 150 s.
Decorating an ornament with natural objects	1) Extending the left hand and picking up a natural object in a basket on the table while sitting on a chair in front of the table; 2) extending the right hand and grabbing the glue on the table; 3) applying glue to the natural object; 4) attaching the object to the ornament and repeating the procedure for 150 s.
Interacting with a dog	1) Placing the dog on the lap and holding it with both arms while sitting in a chair; 2) petting the dog with the right hand; 3) repeating the procedure for 300 s.
Walking with a dog	1) Standing holding the dog leash with the left hand; 2) squatting down; 3) putting the leash on the dog with both hands; 4) standing up; 5) walking; 6) continuing the procedure for 300 s.
Feeding rabbits	1) Standing with feet shoulder-width apart while holding a basket (0.15 kg) of clover with the left hand; 2) bending the back and holding clover in the basket with the right hand; 3) extending the right hand holding the clover to feed the rabbit; 4) straightening the back and repeating the procedure for 300 s.
Cleaning up the farm	1) Standing with feet shoulder-width apart while holding a broom (0.3 kg) with the right hand and a dustpan (0.2 kg) with the left hand; 2) bending the back to sweep the floor; 3) sweeping up the waste with the broom and putting it in the dustpan and continuing the procedure for 300 s.
Maintaining a garden	1) Standing with feet shoulder-width apart with a basket (0.15 kg) in the left hand; 2) checking withered leaves and moving; 3) bending the back toward the withered leaves and extending the right hand; 4) cutting the stalk of the withered leaves; 5) bringing the outstretched hand toward the body and putting it in the basket; 6) straightening the back and repeating the procedure for 300 s.

be moderate-intensity physical activities (3.07 ± 1.01 to 5.63 ± 1.33 METs), animal-mediated activities, such as interacting with a dog, walking with a dog, and feeding rabbits, were determined to be light- to moderate-intensity physical activities (1.98 ± 0.81 to 3.84 ± 1.27 METs), and other activities, such as cooking using harvests, creating art with natural objects, and cleaning up the farm, were determined to be light- to moderate-intensity physical activities (2.11 ± 0.53 to 3.58 ± 1.00 METs).

Discussion

The energy expenditure, oxygen uptake, and exercise intensity were statistically significantly different for each activity (Table 3). The 10 care farming activities in healthy adults

Table 2. Descriptive information of participants who participated in the study.

Variable	Mean ± *SD*
Age (y)	31.52 ± 10.18
Height[i] (cm)	166.56 ± 8.85
Body weight[ii] (kg)	60.20 ± 11.41
Body mass index[iii] ($kg \cdot m^{-2}$)	21.59 ± 3.10
Body composition	
Fat (kg)	15.28 ± 7.02
Lean (kg)	43.12 ± 8.48
Resting metabolic rate[iv]	
VO_2 (mL/min/kg)[v]	5.48 ± 1.55
Energy expenditure (Kcal/kg/d)	38.79 ± 10.72
Resting MET[vi]	1.57 ± 0.44
Resting heart rate (beats/min)[vii]	76.76 ± 14.93
Age-adjusted HRmax (beats/min)[viii]	189.48 ± 10.34

[i] Height was measured using an anthropometer (Ok7979; Samhwa, Seoul, South Korea) without wearing shoes.
[ii] Body weight was measured using a body fat analyzer (ioi 353; Jawon Medical, South Korea).
[iii] Body mass index was calculated using the formula [weight (kg)]/[height $(m)^2$].
[iv] Measured by a portable calorimetric instrument (K4b^2; Cosmed, Rome, Italy) while the participant sat on a chair for 5 min.
[v] Oxygen uptake; 1 $mL \cdot kg^{-1} = 0.0277$ $inch^3$/lb.
[vi] 1 metabolic equivalent (MET) = 3.5 $mL \cdot kg^{-1}$ (0.0969 $inch^3$/lb) oxygen per minute (Norton et al. 2010).
[vii] Heart rate by a radiotelemetry monitor (Polar T 31; FitMed, Kempele, Finland) while the participant sat on a chair for a 5-min rest.
[viii] Age-adjusted maximum HR (HRmax) = 208–0.7 × age (Tanaka et al. 2001).

were light- to moderate-intensity physical activities (1.98 ± 0.81 to 5.63 ± 1.33 METs). The exercise intensity, energy expenditure, and oxygen uptake for organizing a garden plot was found to be significantly higher than those for other care farming activities (5.63 ± 1.33 METs). The activities with the lowest exercise intensity, energy expenditure, and oxygen uptake were cooking using harvests, interacting with dogs, and feeding rabbits (1.98 ± 0.81 to 2.48 ± 0.84 METs). Other activities, such as transplanting plants, harvesting, creating art, maintaining a garden, walking with a dog, and cleaning the farm, were found to have moderate exercise intensity, energy expenditure, and oxygen uptake.

Exercise intensity is determined by the body's ability to generate energy through the uptake and utilization of oxygen (Costill and Fox 1969). The MET is an objective measure of the ratio of a person's energy expenditure to their mass while performing physical activity (Ainsworth et al. 2000). One MET is ~3.5 mL of oxygen consumed per kilogram of body weight per min.

The results of this study showed that care farming activities performed by adults were light to moderately intense. First, for plant-mediated activities, such as organizing a garden plot, transplanting plants, harvesting, and maintaining a garden, the exercise intensities were identified as moderate for all participants. In previous studies, gardening and horticultural activities performed by adults were identified as physical activities with light- to vigorous-intensity exercise. In the ascending order of exercise intensity, they are as follows: walking and applying fertilizer (2.5 METs), watering plants (2.5 METs), planting transplants (3.5 METs), mixing growing medium (3.6 METs), raking a lawn or leaves (3.6 METs), watering using a hose (3.9 METs), garden maintenance (3.9 METs), harvesting (4.2 METs), sowing (4.3 METs), hoeing (4.4 METs), mulching (4.5 METs), making a vegetable bed (5.0 METs), weeding (5.0 METs), raking (5.4 METs), digging the soil (6.3 METs) (Aguilar-Farias et al. 2019; Ainsworth et al. 2000; Park et al. 2014b, 2015). Gardening activities, such as digging holes, pushing a mower, and carrying soil or other gardening items, involve weight-bearing motions (Turner et al. 2002). Kinematic and kinetic analyses have shown that gardening activities comprise complex tasks that involve various motions (Lee et al. 2016). Participation in plant-mediated activities for 50 min twice a week has been shown to increase the participants' muscle mass and aerobic endurance and had a positive effect on oxidative stress, blood lipid profiles, and levels of inflammatory markers in the blood (Park et al. 2016, 2017). These activities are helpful in maintaining and promoting the health of participants because, as confirmed in our study, plant- and animal-mediated activities are low- to moderate-intensity physical activities.

For animal-mediated activities, such as interacting with a dog, walking with a dog, and feeding rabbits, exercise intensities were identified as light- to moderate-intensity for all participants, regardless of sex. Ainsworth et al. (2000) also reported that the exercise intensities of activities with animals were light- to moderate-intensity; in the ascending order of exercise intensity, they were as follows: feeding animals (2.5 METs), playing with animals in a sitting position (2.5 METs), and walking the dog (3.0 METs). As the animal-mediated activities performed in this study consisted of sitting, standing, and walking lightly while caring for farm animals, the exercise intensity was considered to be less than moderate. Previous research has suggested that animal-assisted activities may improve cardiovascular health, including increased moderate-intensity physical activity and reduced systolic blood pressure and plasma triglycerides; however, no definitive scientific basis has been provided (Anderson et al. 1992; Reeves et al. 2011; Temple et al. 2011; Wright et al. 2007). Animal interventions have focused on improving human health and well-being through interventions involving domestic animals. Previous studies on animal-mediated interventions have mainly focused on pets, especially dogs; however, farm animals are becoming more important with the increased interest in care-related activities in green care using farm animals (Berget and Grepperud 2011; Haubenhofer et al. 2010). Olsen et al. (2016) reported that animal-mediated activity could be effective in improving a patient's physical health, such as improving balance and preventing falls but noted that few studies exist on the physical effects of animal-mediated interventions. Therefore, to improve our understanding of the therapeutic value of green care, it is necessary to obtain statistically significant findings using quantitative data on the various effects of care farming activities using farm animals (Haubenhofer et al. 2010).

Table 3. Metabolic measurements of adults during 10 care farming activities to determine exercise intensities (N = 21).

Variable	MET[i]	VO_2 (mL/min/kg)[ii]	Heart rate (beats/min)	Energy expenditure (kcal/kg/d)	HRmax (%)[iii]
			Mean ± *SD*		
Organizing a garden plot	5.63 ± 1.33	19.70 ± 4.65	106.28 ± 21.23	140.28 ± 33.18	56.14 ± 11.15
Transplanting plants	3.38 ± 0.77	11.84 ± 2.68	95.54 ± 11.65	83.65 ± 18.99	50.43 ± 5.53
Harvesting	3.12 ± 0.69	10.93 ± 2.41	96.57 ± 13.24	76.91 ± 17.05	51.02 ± 6.86
Cooking using harvests	2.11 ± 0.53	7.38 ± 1.87	90.10 ± 11.37	52.04 ± 12.86	47.59 ± 5.78
Creating art with natural objects	3.58 ± 1.00	12.51 ± 3.50	94.12 ± 8.83	87.89 ± 25.01	49.86 ± 5.88
Interacting with a dog	1.98 ± 0.81	6.91 ± 2.84	83.07 ± 12.00	48.42 ± 19.02	43.86 ± 6.16
Walking with a dog	3.84 ± 1.27	13.44 ± 4.46	102.88 ± 25.67	93.98 ± 30.89	54.20 ± 12.46
Feeding rabbits	2.48 ± 0.84	8.69 ± 2.94	87.48 ± 11.05	61.32 ± 20.30	46.21 ± 5.64
Cleaning up the farm	3.40 ± 0.98	11.89 ± 3.43	91.81 ± 15.08	84.10 ± 24.00	48.54 ± 8.03
Maintaining a garden	3.07 ± 1.01	10.74 ± 3.54	93.94 ± 15.52	75.29 ± 24.86	49.60 ± 8.08
Significance	0.000***	0.000***	0.000***	0.000***	0.000***

[i] 1 metabolic equivalent (MET) = 3.5 $mL \cdot kg^{-1}$ (0.0969 $inch^3$/lb) oxygen per minute (Norton et al. 2010).
[ii] Oxygen uptake; 1 $mL \cdot kg^{-1} = 0.0277$ $inch^3$/lb.
[iii] Maximum heart rate (HRmax) = 208–0.7 × age (Tanaka et al. 2001).
***Significant at $P < 0.001$ using Kruskal-Wallis test.

For other farm activities, such as cooking using harvests, creating art with natural objects, and cleaning up the farm, exercise intensities were identified as light- to moderate-intensity for all participants. Similar activities were identified as light- to moderate-intensity physical activity in the study by Ainsworth et al. (2000), which were as follows in the ascending order of exercise intensity: arts and crafts while sitting (light effort: 1.5 METs, moderate effort: 2.0 METs), baking (2.5 METs), and general cleaning (3.5 METs). The activities were identified as light to moderate in intensity because the other farm activities performed in this study consisted of standing or light walking activities. Care farming activities are provided within farming production and care activities, and can be divided into various forms depending on the participants and context (Hine et al. 2008). Most care farming activities are based on agricultural activities, such as growing crops, gardening, and caring for livestock, and include other activities on farms, such as cooking, crafts, and maintenance of care farming facilities (Hine et al. 2008). Because the inclusion of off-farm activities within the category of care farming activities is essential, it is necessary to continuously classify the types of off-farm activities and identify their therapeutic effects.

According to the American College of Sports Medicine exercise guidelines (Garber et al. 2011), a regular exercise program is essential for adults to improve and maintain fitness and health, and encourages them to engage in exercise to achieve a total energy expenditure of 500 MET/min/week or more. Therefore, according to the results of this study, it is recommended to conduct care farming activities two to three times a week for 1 h per session, including organizing a garden plot activity, which is a high-intensity exercise. For individualized exercise prescription, moderate- to vigorous-intensity exercise is recommended for most adults, and light- to moderate-intensity exercise may benefit deconditioned individuals (Garber et al. 2011). In this study, care farming activities were identified as physical activities of various exercise intensities of light- to moderate-intensity or higher; therefore, with care farming activities it may be possible to adjust the exercise intensity to suit each participant in terms of exercise prescription.

Care farming activities are physical activities of light to moderate intensity, which are body movements generated by skeletal muscles that result in higher energy consumption than at the resting level (US Department of Health and Human Services 1999). Participation in planned, structured, and repetitive care farming activities, that is, participation in the care farming program, could be an "exercise" (Caspersen et al. 1985). Performing physical activities in a natural environment, such as a farm, is called "green exercise" (Pretty et al. 2003), which not only has physical health benefits but also greater health benefits, such as psychological effects resulting from exposure to the natural environment (Gladwell et al. 2013). Accordingly, continuous participation in care farming programs could have a long-term positive effect on mental health and improve individual physical function and fitness.

To do so, the goals of the care farming program should be developed with goals set according to the participants' physical function, daily physical activity, health status, and preference in terms of exercise prescription. This is because when prescribing exercise, it is important not only to consider the amount and intensity of exercise, but also to maximize the efficiency of the exercise intervention by considering interindividual heterogeneity (Gronwald et al. 2020; Lehtonen et al. 2022). In particular, in the case of general exercise prescriptions, it is very important to encourage unmotivated clients to maintain exercise participation because lack of personal motivation leads to lack of participation in exercise intervention (Lucini and Pagani 2021; Wackerhage and Schoenfeld 2021). In this respect, farming activities can provide constant motivation by allowing participants to be in constant contact with nature and interact with various living things. In addition, "caring" for organisms such as plants and animals can provide participants with additional benefits, such as psychological stability and a sense of accomplishment, as well as physical effects.

This study could be used to support therapeutic mechanism of physical aspects of care farming interventions and fills this gap in knowledge. However, the limitation of this study is that it is difficult to generalize the results because of the small sample size. Follow-up study should be conducted with a larger number of participants to ensure that the results of this study can be applied to a broader population.

In conclusion, we evaluated the exercise intensity of the activities in a program operated in an actual care farm and collected the basic data necessary for the development of a care farm program for the improvement of physical function in adults. Because we attempted a field study to measure energy metabolism when activities on the actual farm were performed, the results of this study can be practically used to develop a care farming program at various farm sites in the future. In the future, it will be necessary to organize various physical effects of care farming activities using measurements of physical effects as well as exercise intensity and to develop and disseminate care farming programs to improve physical health suitable for the participants' goals of care.

References Cited

Aguilar-Farias N, Brown WJ, Skinner TL, Peeters GG. 2019. Metabolic equivalent values of common daily activities in middle-age and older adults in free-living environments: A pilot study. J Phys Act Health. 16(3):222–229. https://doi.org/10.1123/jpah.2016-0400.

Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, O'Brien WL, Bassett DR, Schmitz KH, Emplaincourt PO, Jacobs DR Jr, Leon AS. 2000. Compendium of physical activities: An update of activity codes and MET intensities. Med Sci Sports Exerc. 32: S498–S516. https://doi.org/10.1097/00005768-200009001-00009.

Anderson WP, Reid CM, Jennings GL. 1992. Pet ownership and risk factors for cardiovascular disease. Med J Aust. 157:298–301. https://doi.org/10.5694/j.1326-5377.1992.tb137178.x.

Berget B, Grepperud S. 2011. Animal-assisted interventions for psychiatric patients: Beliefs in treatment effects among practitioners. Eur J Integr Med. 3(2):e91–e96. https://doi.org/10.1016/j.eujim.2011.03.001.

Blair SN. 1995. Exercise prescription for health. Quest. 47(3):338–353. https://doi.org/10.1080/00336297.1995.10484162.

Caspersen CJ, Powell KE, Christenson GM. 1985. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. Public Health Rep. 100(2):126–131. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1424733/.

Costill DL, Fox EL. 1969. Energetics of marathon running. Med Sci Sports. 1:81–86. https://doi.org/10.1249/00005768-196906000-00005.

Duffield R, Dawson B, Pinnington H, Wong P. 2004. Accuracy and reliability of a Cosmed $K4b^2$ portable gas analysis system. J Sci Med Sport. 7:11–22. https://doi.org/10.1016/S1440-2440(04)80039-2.

Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Nieman DC, Swain DP. 2011. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. Med Sci Sports Exerc. 43:1334–1359. https://doi.org/10.1249/mss.0b013e318213fefb.

Gladwell VF, Brown DK, Wood C, Sandercock GR, Barton JL. 2013. The great outdoors: How a green exercise environment can benefit all. Extrem Physiol Med. 2(1):1–7. https://doi.org/10.1186/2046-7648-2-3.

Gorman R, Cacciatore J. 2017. Cultivating our humanity: A systematic review of care farming & traumatic grief. Health Place. 47:12–21. https://doi.org/10.1016/j.healthplace.2017.06.006.

Gronwald T, Törpel A, Herold F, Budde H. 2020. Perspective of dose and response for individualized physical exercise and training prescription. J Funct Morphol Kinesiol. 5(3):48. https://doi.org/10.3390/jfmk5030048.

Hassink J, van Dijk M. 2006. Farming for health: Green-care farming across Europe and the United States of America; Springer: Berlin/Heidelberg, Germany. https://books.google.co.kr/books?hl=ko&lr=&id=jzbY4NisxckC&oi=fnd&pg=PR9&dq=Farming+for+Health:+Green-care+farming+across+Europe+and+the+United+States+of+America&ots=bd1z5hIwq-&sig=IB4w63bsdqaPIMbcZS7MHkq6f4g#v=onepage&q=Farming%20for%20Health%3A%20Green-care%20farming%20across%20Europe%20and%20the%20United%20States%20of%20America&f=false.

Haubenhofer DK, Elings M, Hassink J, Hine RE. 2010. The development of green care in western European countries. J Sci Heal. 6:106–111. https://doi.org/10.1016/j.explore.2009.12.002.

Hecksteden A, Kraushaar J, Scharhag-Rosenberger F, Theisen D, Senn S, Meyer T. 2015. Individual response to exercise training—A statistical perspective. J Appl Physiol. 118:1450–1459. https://doi.org/10.1152/japplphysiol.00714.2014.

Hine R, Peacock J, Pretty J. 2008. Care farming in the UK: Contexts, benefits, and links with therapeutic communities. Ther Commun. 29:245–260. http://www.soczem.webobce.cz/www/soczem/fs/journal-of-therapeutic-communities.pdf#page=29.

Hofmann P, Tschakert G. 2010. Special needs to prescribe exercise intensity for scientific studies. Cardiol Res Pract. 2011:209302. https://doi.org/10.4061/2011/209302.

Jones BH, Cowan DN, Knapik JJ. 1994. Exercise, training and injuries. Sports Med. 18:202–214. https://doi.org/10.2165/00007256-199418030-00005.

Leck C, Evans N, Upton D. 2014. Agriculture—Who cares? An investigation of 'care farming' in the UK. J Rural Stud. 34:313–325. https://doi.org/10.1016/j.jrurstud.2014.01.012.

Lee AY, Park SA, Kim JJ, So JM, Son KC. 2016. Kinematic and kinetic analysis of upper limb motions during horticultural activities. Korean J Hortic Sci Technol. 34:940–958. https://doi.org/10.12972/kjhst.20160097.

Lehtonen E, Gagnon D, Eklund D, Kaseva K, Peltonen JE. 2022. Hierarchical framework to improve individualised exercise prescription in adults: A critical review. BMJ Open Sport Exerc Med. 8(2):e001339. https://doi.org/10.1136/bmjsem-2022-001339.

Lucini D, Pagani M. 2021. Exercise prescription to foster health and well-being: A behavioral approach to transform barriers into opportunities. Int J Environ Res Public Health. 18(3):968. https://doi.org/10.3390/ijerph18030968.

Mann T, Lamberts RP, Lambert MI. 2013. Methods of prescribing relative exercise intensity: Physiological and practical considerations. Sports Med. 43:613–625. https://doi.org/10.1007/s40279-013-0045-x.

Norton K, Norton L, Sadgrove D. 2010. Position statement on physical activity and exercise intensity terminology. J Sci Med Sport. 13:496–502. https://doi.org/10.1016/j.jsams.2009.09.008.

Olsen C, Pedersen I, Bergland A, Enders-Slegers MJ, Ihlebæk C. 2016. Effect of animal-assisted activity on balance and quality of life in home-dwelling persons with dementia. Geriatr Nurs. 37:284–291. https://doi.org/10.1016/j.gerinurse.2016.04.002.

Park SA, Lee AY, Kim JJ, Lee KS, So JM, Son KC. 2014a. Electromyographic analysis of upper and lower limb muscles during gardening tasks. Korean J Hortic Sci Technol. 32:710–720. https://doi.org/10.7235/hort.2014.14059.

Park SA, Lee AY, Lee KS, Son KC. 2014b. Gardening tasks performed by adults are moderate-to high-intensity physical activities. HortTechnology. 24(1):58–63. https://doi.org/10.21273/HORTTECH.24.1.58.

Park SA, Lee AY, Park HG, Son KC, Kim DS, Lee WL. 2017. Gardening intervention as a low-to moderate-intensity physical activity for improving blood lipid profiles, blood pressure, inflammation, and oxidative stress in women over the age of 70: A pilot study. HortScience. 52:200–205. https://doi.org/10.21273/HORTSCI11232-16.

Park SA, Lee AY, Son KC. 2015. A comparison of exercise intensity between two horticultural and four common physical activities among male adults in their 20s. Hort Sci Technol. 33:133–142. https://doi.org/10.7235/hort.2015.14084.

Park SA, Lee AY, Son KC, Lee WL, Kim DS. 2016. Gardening intervention for physical and psychological health benefits in elderly women at community centers. HortTechnology. 26:474–483. https://doi.org/10.21273/HORTTECH.26.4.474.

Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC, Kriska A, Leon AS, Marcus BH, Morris J, Paffenbarger JM Jr, Patrick K, Pollock ML, Rippe JM, Sallis J, Wilmore JH. 1995. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA. 273:402–407. https://doi.org/10.1001/jama.1995.03520290054029.

Pinnington HC, Wong P, Tay J, Green D, Dawson B. 2001. The level of accuracy and agreement in measures of FEO2, FECO2 and VE between the cosmed K4b^2 portable, respiratory gas analysis system and a metabolic cart. J Sci Med Sport. 4:324–335. https://doi.org/10.1016/S1440-2440(01)80041-4.

Pretty J, Griffin M, Sellens M, Pretty C. 2003. Green exercise: Complementary roles of nature, exercise and diet in physical and emotional well-being and implications for public health policy. Colchester: University of Essex. https://scholar.google.co.kr/scholar?hl=ko&as_sdt=0%2C5&q=Green+Exercise%3A+Complementary+Roles+of+Nature%2C+Exercise+and+Diet+in+Physical+and+Emotional+Well-Being+and+Implications+for+Public+Health+Policy.+&btnG=.

Reeves MJ, Rafferty AP, Miller CE, Lyon-Callo SK. 2011. The impact of dog walking on leisure-time physical activity: Results From a population-based survey of Michigan adults. J Phys Act Health. 8:436–444. https://doi.org/10.1123/jpah.8.3.436.

Relf PD. 2006. Agriculture and health care—The care of plants and animals for therapy and rehabilitation in the United States, p 309–343. In: Hassink J, van Dijk M (eds). Farming for health. Springer, Dordrecht, The Netherlands. ISBN 978-1-4020-4540-0.

Ruiz JR, Silva G, Oliveira N, Ribeiro JC, Oliveira JF, Mota J. 2009. Criterion-related validity of the 20-m shuttle run test in youths aged 13–19 years. J Sports Sci. 27:899–906. https://doi.org/10.1080/02640410902902835.

Tanaka H, Monahan KD, Seals DR. 2001. Age-predicted maximal heart rate revisited. J Am Coll Cardiol. 37:153–156. https://doi.org/10.1016/S0735-1097%2800%2901054-8.

Temple V, Rhodes R, Wharf Higgins J. 2011. Unleashing physical activity: An observational study of park use, dog walking, and physical activity. J Phys Act Health. 8:766–774. https://doi.org/10.1123/jpah.8.6.766.

Turner LW, Bass MA, Ting L, Brown B. 2002. Influence of yard work and weight training on bone mineral density among older us women. J Women Aging. 14:139–148. https://doi.org/10.1300/J074v14n03_09.

US Department of Health and Human Services. 1999. Physical activity and health: A report of the Surgeon General. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Atlanta, GA. http://www.cdc.gov/nccdphp/sgr/pdf/sgrfull.pdf. [accessed 10 Oct 2010].

Wackerhage H, Schoenfeld BJ. 2021. Personalized, evidence-informed training plans and exercise prescriptions for performance, fitness and health. Sports Med. 51(9):1805–1813. https://doi.org/10.1007/s40279-021-01495-w.

Weir JB. 1949. New methods for calculating metabolic rate with special reference to protein metabolism. J Physiol. 109:1–9. https://doi.org/10.1113/jphysiol.1949.sp004363.

Wilmore JC. 1974. Individual exercise prescription. Am J Cardiol. 33:757–759. https://doi.org/10.1016/0002-9149(74)90217-3.

Wright JD, Kritz-Silverstein D, Morton DJ, Wingard DL, Barrett-Connor E. 2007. Pet ownership and blood pressure in old age. Epidemiology. 18(5):613–618. https://doi.org/10.1097/Ede.0b013e3181271398.