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Exercise Intensities of Gardening Tasks within Older Adult Allotment Gardeners in Wales

Abstract

Previous research has suggested that gardening activity could be an effective form of regular exercise for improving physical and psychological health in later life. However, there is a lack of data regarding the exercise intensities of various gardening tasks across different types of gardening and different populations. The purpose of this study was to examine the exercise intensity of gardening activity for older adult allotment gardeners in Wales, UK following a similar procedure used in previous studies conducted in the USA and South Korea by Park and colleagues (2008a; 2011). Oxygen consumption (VO_2) and energy expenditure for six gardening tasks were measured via indirect calorimetery using the portable Oxycon™ mobile device. From these measures, estimated metabolic equivalent units (METs) were calculated. Consistent with Park et al. (2008a; 2011) the six gardening tasks were classified as low to moderate-high intensity physical activities based on their metabolic values (1.9 - 5.7 METs).

Keywords

Physical activity, energy expenditure, metabolic cost, green exercise, human issues in horticulture

Introduction

Gardening is a prevalent form of physical activity that is popular with older populations (Chodzko-Zajko et al., 2009). One reason for this may be that gardening has the advantage of not being as stressful to the body as other forms of physical activity such as jogging and aerobic exercise (Restuccio, 1992). In addition, gardening has been shown to be a meaningful and purposeful leisure activity for older adults (Hawkins, Mercer, Thirlaway & Clayton, 2013) which may be particularly important in retirement (Dunnett & Qasim, 2000). The popularity of gardening presents an opportunity to encourage engagement in gardening activity in later life as a means of health promotion and protection.

Various international physical activity guidelines have highlighted gardening as a beneficial form of “everyday” or “recreational” activity which can strengthen muscles whilst having a very low injury risk (Department of Health, 2011; US Department of Health and Human Services, 2008). Other research has outlined potential benefits of gardening for healthy aging such as providing a long-term focus, an adaptable yet challenging workout, a method of reducing risk of falls, and a stress-busting enjoyable activity (Chen & Janke, 2012; Milligan, Gatrell & Bingley, 2004; Park, 2007; Sommerfeld, Waliczek & Zajicek, 2010). Gardening is also expected to influence an individual’s whole body bone mineral density as it involves weight-bearing motions such as pushing a mower, digging holes, pulling weeds and carrying soil and water, whilst incorporating the whole body including most upper limb muscles (Park et al., 2013; Turner, Bass, Ting, & Brown, 2002). Research suggests that whilst performing these activities over 82 percent of gardeners bend, 59 percent walk, and 47 percent lift for durations of ten seconds or longer (Park & Shoemaker, 2009). Findings from Chen & Janke (2012) indicate that gardening is associated with

better health status in terms of the number of chronic conditions and functional limitations reported by older adults. Furthermore, gardening has been associated with improvements in various other physical health outcomes such as lower total cholesterol, lower blood pressure, and lower mortality (Armstrong, 2000; Walsh, Pressman, Cauley, & Browner, 2001). For example, one study revealed that individuals who performed only gardening activities for more than 60 minutes per week had 66 percent less chance of primary cardiac arrest than individuals who were physically inactive (Lemaitre et al., 1999).

Gardening can also have beneficial effects on cognitive and psychological health. For example, gardening has also been linked to protection against cognitive decline because of the cognitively demanding mental stimulation of many gardening tasks as well as the physical activity involved (Infantino, 2005; Simons, Simons, McCallum & Friedlander, 2006). In addition, gardening has been found to be an empowering experience that can build self-esteem and relieve stress (Wakefield, Yeudall, Taron, Reynolds, & Skinner, 2007). Several studies have consistently shown that regular engagements in gardening can lead to reduced reactivity to stress (Weyerer & Kupfer, 1994), lower likelihood of depression (Teychenne, Ball, & Salmon, 2008), and decreased risk of stress-related diseases such as cardiovascular disease (Jeon, Lokken, Hu, & van Dam, 2007). More specifically, involvement in allotment gardening has been linked to enhanced health and well-being and also to sustainable behavior (Bacon, Brophy, Mguni, Mulgan, & Shandro, 2010; Hawkins, Thirlaway, Backx & Clayton, 2011). In the United Kingdom, allotment gardens are legally defined in the Allotments Acts as “a piece of land not exceeding 40 poles in extent which is wholly or mainly cultivated by the plot-holder for the production of vegetables or fruit by him/herself and family” (Allotments Regeneration Initiative, 2007). An allotment site consists of a collection of allotment plots where plot-holders

garden individually but in close proximity to one another, thus offering the opportunity for social interaction (Milligan *et al*., 2004). The new UK physical activity guidelines in particular highlight allotment gardening as an important means of being active that enables older adults to maintain independence and social engagement, which can also improve well-being (Department of Health, 2011).

It has been suggested that gardening can also be adapted to various levels of physical ability and fitness level. Furthermore, a few gardening tasks have been reported as forms of moderate intensity physical activity in the literature (Ainsworth et al., 2000), there is limited research that has directly determined the exercise intensity of various gardening tasks in older adults. Park, Shoemaker and Haub (2008a) conducted one of the rare studies in this area; calculating the energy expenditure of older adults engaged in various gardening tasks. Energy expenditure was calculated by monitoring the heart rates of the participants during a number of gardening tasks and using oxygen consumption data from a laboratory-based submaximal graded exercise test on a treadmill. The metabolic equivalents (METs) of the gardening tasks were calculated in terms of oxygen consumption per unit of body mass (1 MET = 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$) (Ainsworth et al., 2011). MET values of less than 3 indicate low intensity activities, 3-6 METs are considered to be moderate intensity, while anything over 6 METs is high or vigorous physical activity (Pate et al., 1995). Park et al. showed that the gardening tasks could be classified as either low or moderate intensity physical activities. They identified gardening tasks which use both the upper and lower body such as digging and raking as moderate intensity physical activities. Whereas tasks that primarily use the upper body, such as hand weeding and transplanting seedlings, were identified as low intensity physical activity.

Park et al.'s original study (2008a) used a sample of eight American older adults to investigate gardening activity intensities on garden plots created specifically

for the research. Park, Lee, & Son (2011) have also recently replicated these findings in a sample of 20 Korean older adults aged 65 and over and expanded upon the original study by incorporating six more gardening tasks. All fifteen gardening tasks were determined to be low to moderate intensity physical activities (1.7 - 4.5 METs). This suggests that gardening may provide the same health benefits received from non-gardening forms of physical activity by contributing to an overall active lifestyle.

Despite the growing evidence surrounding the benefits of gardening for older adults' physical and mental health, there is a lack of research that specifically focuses on determining the benefits of an acute bout of gardening activity. In addition, the compendium of physical activities (Ainsworth et al., 2011) does not determine the precise energy cost of physical activity within individuals, but instead provides an activity classification system that standardizes the MET intensities of physical activity. Thus, it does not account for differences in age when performing an activity. Although Park and colleagues (Park et al., 2008a; 2011) have started to investigate exercise intensities of gardening activities in older adults as previously outlined, these were conducted with samples from the USA and Korea, and as such there is a need to validate their findings in other settings across the world. The physical activity intensities of gardening tasks may vary according to geographical location due to a number of factors, such as climate, altitude, weather and soil type. In order to gain an ecologically valid measure for an international classification of the intensity of gardening tasks it is vital that studies are conducted in different geographical settings.

The present study thus comprised a partial replication of Park et al.'s examination of exercise intensities of gardening activity (2008a; 2011). In the interest of creating a more externally valid result, participants were asked to perform the gardening tasks in the same manner they would on their own allotment rather than as

instructed by the experimenter. This way the result can be compared to everyday gardening on an allotment. An advancement on Park et al.'s (2008a) original study in the USA was also made in the method of measuring oxygen consumption during the gardening tasks. Park et al. (2008a) interpolated oxygen consumption values from a laboratory treadmill test to calculate energy expenditure of gardening tasks examined. The present study used a more sophisticated approach, in line with Park et al. (2011), by employing the use of a portable device to measure participants' oxygen consumption as they completed the gardening tasks.

The present study aimed to expand the evidence base related to the exercise intensity of gardening tasks by recruiting experienced allotment gardeners rather than community-dwelling older adults (with no specific gardening history) as studied in Park et al.'s research. Allotment gardening may be particularly salient to the current older generation in the UK as it was originally a post-war form of welfare provision, and data now shows that it is a common leisure activity within the older population (Milligan et al., 2004). We have previously suggested that because allotment gardens are typically larger than the average home garden, allotment gardening may require more regular attendance and thus contribute larger quantities of physical activity to an individual's weekly levels (Hawkins et al., 2011). If this is the case; it is feasible to suggest that allotment gardeners may reach higher physical activity intensities when carrying out gardening tasks. Perhaps, those experienced in conducting gardening tasks may be more efficient and have higher levels of motivation to complete these.

The recommendation of allotment gardening as a leisure pursuit for promoting health and wellbeing in later life requires the extension of the existing data on exercise intensity of gardening tasks to a sample of allotment gardeners. Furthermore, in order to provide an accurate picture of the physical activity intensities

of gardening it is vital that data are gathered about the physical activity intensity levels of gardening tasks among a population who have varying levels of experience in gardening and in different settings across the world. Park and colleagues have presented key data regarding novice or non-gardeners in the USA and Korea. The aim of the present study was to determine the exercise intensity levels of a range of gardening tasks in an experienced allotment gardener population in a UK setting.

Method

Participants

The inclusion criteria for the present study required that participants were Welsh allotment gardeners currently holding a tenancy of at least one plot of land. Fifty-nine Welsh allotment gardeners had participated in a previous research study, investigating the physiological and psychological benefits of gardening, and had given consent to be re-contacted about future research studies. These 59 individuals were considered for inclusion in the present study through an anonymous search of the existing database to establish individuals that met the inclusion criteria. Consistent with Park et al.'s previous studies, the inclusion criteria required that participants: were over the age of 60, were able to attend the University for completion of the study, were non-smokers, and had no uncontrolled chronic disease, no heart and lung disease, no pace maker, ability to kneel, and had answered 'no' to all questions on the Physical Activity Readiness Questionnaire (PAR-Q; Canadian Society for Exercise Physiology, 2002). The PAR-Q is a medical screening tool for establishing safety to take part in physical activity and contains questions such as "Do you feel pain in your chest when you do physical activity?". Thirty potential participants met the inclusion criteria and were invited to take part in

the study via an invitation letter containing a full information sheet detailing the study procedures and requesting individuals to telephone or email the researcher if they wished to participate in the study. Twenty-one individuals responded to the letter; of which three declined participation in the study. The remaining 18 individuals expressed their willingness to participate and were subsequently enrolled to take part in the study.

Participants were provided with a schedule and information package providing details of experimental and ethical procedures prior to their participation in the study. Additionally, participants were advised to abstain from caffeine and a heavy meal two hours prior to participating in the study, and to wear comfortable clothing including a pair of boots suitable for gardening activity. An incentive of £10 was provided to participants upon completion of the study.

Procedure

Each session began with an explanation of the study and its requirements, after which participants had the opportunity to ask any questions before completing an informed consent form. Participants completed six of the nine gardening tasks used by Park et al. (2008a) between July and September 2012 (see Table 1 for descriptions of the tasks). The gardening tasks were selected to include activities at ground level and at a workbench with various motions such as kneeling, squatting, bending or standing. Other gardening tasks included by Park and colleagues (2008a; 2011) were not included due to their similarity to those tasks already selected and to reduce the burden on participants' time.

The gardening tasks were orally described to participants before the experiment began, and prior to each task being carried out the researcher physically demonstrated the components of the task. Participants were advised to complete

each gardening task in the same manner they would if they were at their allotment. The participants' completed each task for 10 minutes followed by a five minute resting time while sitting on a chair. Ten minutes has been established as a sufficient time to reach maximum heart rate in older adults (Park et al., 2008a). The participants were also free to take a rest during any of the gardening tasks due to fatigue; however no participants chose to do so. Participants completed all six gardening tasks in one session in the following order: weeding, raking, digging, mixing soil, filling containers with soil, and sowing seeds. The order of these tasks was based on the work of Park et al. (2008a) and was designed to replicate regular gardening.

The materials required for the gardening tasks included a hand fork, rake, shovel, bucket, pots (approximately 65), and packets of seeds. Two gardening plots were created specifically for use in this study on the campus of Cardiff Metropolitan University, Cardiff, Wales, UK, next to a grassy area with weeds for the weeding task. Temperature and humidity were measured using a portable weather station (Orgeon Scientific) prior to the participant engaging in gardening activity, the mean outside temperature was 21.94°C (SD ±3.71) and the mean humidity was 49.57% (SD ±9.30).

Each participant wore the portable Oxycon™ device; this involved wearing a mask over their mouth while carrying a small telemetric transmitter on their back. The participant's heart rate was also continuously monitored throughout the gardening tasks using a chest strap monitor (Polar Electro, RS4000, Kemple, Finland) which recorded heart rate via radiotelemetry to the base station of the portable Oxycon™ device. Participants were advised to complete each gardening task in the same manner they would if they were at their allotment.

Measures

Sociodemographic Characteristics. In order to provide a detailed description of the sample, several sociodemographic characteristics were collected. These included: age, gender, ethnicity, hours of current gardening per week, educational attainment and employment status. Height and body mass were also measured to allow a calculation of body mass index [body mass (kg) / height^2 (m^2)], height was measured using a fixed stadiometer (Holtain LTD, Pembrokeshire, Wales) and body mass was measured using electronic weighing scales (Vogel & Halke, SECA-Model 770, Hamburg, Germany).

Exercise Intensity. A portable Oxycon™ mobile device (Jaeger, Oxycon Mobile, Warwickshire, England) was used to measure oxygen consumption (VO_2) and a measurement of heart rate when combined with a polar chest strap. The Oxycon™ mobile is a portable, wireless metabolic system measuring gas exchange breath by breath while attached to the body in a vest system. Air flow is detected by the rotation of a low resistance, bidirectional turbine connected to a face mask. Not only has the Oxycon™ mobile device been validated for use with older adults (Spruit et al., 2011) it has also been validated in comparisons with the Douglas bag method (Perret & Mueller, 2006; Rosdahl, Gullstrand, Salier-Erikkson, Johansson, & Schantz, 2010), which is generally considered to be the most accurate way to measure indirect calorimetry, and under field conditions (Salier-Eriksson, Rosdahl, & Shantz, 2011) including strong external winds and extended moderate physical activity (45 min) outdoors at low temperatures and high humidity. Via a sampling line connected to the flow sensor unit the expired air is analyzed for O_2 and CO_2 concentrations, this data is collected by an exchange unit which sends the data telemetrically to a base station connected to a computer. The portable Oxycon™ mobile device was chosen over

Park et al.'s (2008a) multi-stepped approach because it is more convenient for use outdoors without losing validity or accuracy (Rosdahl et al., 2010). After 30 minutes of warm up and immediately before data collection a 2-point (0.2 and 2.01 s^{-1}) air flow calibration was performed using the automatic flow calibrator. Gas analyzer was calibrated against room air and a certified gas mixture of 16% O_2, 5% CO_2 and 79% N_2 together with determination of measurement delay time. Before the start of data collection the face mask was checked for leakage and gas exchange values were checked to be within normal limits.

Data Analysis

MET values for each gardening task were determined from measured levels of VO_2, by dividing the measured VO_2 by 3.5 as 1 MET = 3.5 $ml \cdot kg^{-1} \cdot min^{-1}$. In order to calculate energy expenditure (EE), first the average respiratory exchange ratio (RER), which is provided by the portable Oxycon™ mobile device, was calculated for each gardening task. Using a Zuntz table (McArdle, Katch & Katch, 2001) kcal per liter of O_2 was derived from the RER, this was then multiplied by the participants measured level of absolute VO_2 ($litres \cdot min^{-1}$) to determine $kcal \cdot min^{-1}$. EE was then calculated ($kj \cdot kg^{-1} \cdot hour^{-1} = kcal \cdot min^{-1} \cdot 4.184 \cdot kg^{-1}$ of body mass).

Each participant's physiological data were recorded continuously using the portable Oxycon™ mobile device. For each gardening task the initial and final minute of data measured during the task was discarded in order to reduce noise between the end and beginning of a task. A one-way ANOVA with post hoc test Duncan's multiple range was conducted at $p < .05$ in order to compare means of physiological data and metabolic rates for the six gardening tasks. Paired t-tests were also performed to compare energy expenditure and metabolic values of gardening tasks

classified as low, moderate and high intensity activity. All data were analyzed using the Statistical Package for Social Sciences (SPSS) version 19 for Windows.

Results

Descriptive Data

Demographic characteristics of the study sample are summarized in Table 2. The majority of participants were of Caucasian ethnicity, were evenly split between males and females and were all retired. Age ranged from 62 to 70, with a mean of 65 years (SD ±1.93). Most participants were normal or overweight according to the World Health Organization's BMI classification systems, with a mean BMI of 25.62 (SD ±2.91). Participants reported spending anywhere between 2 hours per week to 23 hours per week gardening in the current season, with a mean of 11 hours per week (SD ±6.71).

Exercise Intensities of Gardening Tasks

The six gardening tasks completed by participants ranged from low to high intensity physical activities (Table 3). Digging had a mean of 5.7 METs (SD ±1) and was therefore classed as a high-moderate intensity activity (~6 METs). Raking (4.6 ±0.8), weeding (4.6 ±0.8), and mixing soil (3.2 ±0.5) were all classed as moderate physical activities (3-6 METs). Filling containers (2.3 ±0.6) and sowing seeds (1.9 ±0.5) were both classed as low intensity activities (1-3 METs). The results of independent t-tests showed that there were no significant differences between male and female participants for any of the metabolic measurements on all six gardening tasks.

As seen in Table 4, energy expenditure during high-moderate intensity gardening tasks (M = 24.33, SE = 1.19) was found to be significantly greater than energy expenditure during both moderate intensity gardening tasks (M = 19.80, SE =

1.19), $t(13) = -4.84$, $p<.0001$, $r = .80$, and low intensity gardening tasks (M = 9.85, SE = 0.61), $t(13) = -10.44$, $p<.0001$, $r = 0.94$. Furthermore energy expenditure during moderate intensity gardening tasks (M = 20.01, SE = 0.77) was significantly greater than energy expenditure during low exercise intensity gardening tasks (M = 9.1, SE = 0.46), $t(24) = -12.26$, $p<.0001$, $r = 0.93$.

MET values for high-moderate intensity gardening tasks (M = 5.7, SE = 0.27) were found to be significantly different to MET values for both moderate intensity gardening tasks (M = 4.6, SE = 0.26), $t(13) = -5.10$, $p<.0001$, $r = 0.82$, and low intensity gardening tasks (M = 2.1, SE = 0.14), $t(13) = -10.41$, $p<.0001$, $r = 0.94$. MET values for moderate intensity gardening tasks (M= 4.6, SE = 0.17), were also found to be significantly different from MET values of low intensity gardening tasks (M = 2.1, SE = 0.11), $t(24) = -12.47$, $p<.0001$, $r = 0.93$.

Discussion

The aims of this study were to partially replicate the work of Park and colleagues (2008a; 2011) in a sample of Welsh older adult allotment gardeners in order to determine whether gardening is an effective form of exercise for this population. All six gardening tasks were determined to be low to high-moderate intensity physical activities based on their metabolic values (1.9 - 5.7 METs).

As noted at the outset little attention has focused on determining the exercise intensities of various gardening tasks in older adults, despite the well documented benefits of gardening on older adults' physical, psychological, mental and social wellbeing. In two previous studies Park and colleagues (2008; 2011) have concluded that a variety of gardening tasks provide low to moderate intensity physical activity for healthy older adults in America and Korea. By exploring the exercise intensities of gardening tasks in a Welsh allotment gardening population the present study has

provided further empirical support for gardening as an effective form of physical activity in older adults that can contribute to the achievement of public health recommendations.

Out of the six gardening tasks measured in adults over the age of 60 digging was found to be the most intensive with a MET value of 5.7 (SD ±1.0), and as such was classified as a high-moderate intensity physical activity. Raking, weeding, and mixing soil were identified as moderate physical activity (4.6 ±0.8 METs, 4.6 ±1.0 METs , and 3.2 ±0.5 METs respectively) while filling containers with soil and sowing seeds were identified as low intensity physical activity (2.3 ±0.6 METs, and 1.9 ±0.5 METs respectively). No significant differences were observed between male and female participants across all gardening tasks on any of the metabolic measurements. It is worth noting that this lack of a gender difference might be specific to the sample of experienced allotment gardeners of this study. It would be interesting to determine whether there are gender differences in the metabolic cost of gardening activities amongst a non-experienced population.

The majority of the MET values for gardening tasks in this study were slightly higher than those previously reported by Park and colleagues' (2008a; 2011) American and Korean samples. For example digging was found to be a higher intensity physical activity within our sample with an average of 5.7 METs (SD ± 1.0), than the 3.6 METs (SD ± 0.8) reported in Park's American study (Park et al., 2008a) and the 4.5 METs (SD ± 1.2) reported in Park's Korean study (Park et al., 2011).

Park et al. (2011) explain that differences between gardening intensities for similar gardening tasks may be due to how the task is performed; gardening tasks can be performed using different tools (e.g., type, weight), methods, or with different conditions (e.g., compactness of soil, garden size). Thus the differences reported here may be due to the participants being able to complete the tasks in the same

manner as they would on their allotment plot, rather than following the demonstration of a researcher as was the case in Park et al.'s studies. It is possible that the participants' previous experience of cultivating an allotment plot may have been implicated in the higher MET values observed in this study when compared with Park et al.'s findings. The exercise intensity required to dig over a large allotment plot may be greater than is typical of the domestic gardening of a community-dwelling older adult population as studied by Park et al. According to Gunn et al. (2004; 2005) exercise intensity of gardening tasks can also be influenced by variables such as environment and participant characteristics (e.g., age, participant's physical fitness). As such the observed differences between MET values may have occurred as a result of the lower average age of this study's sample (65.2 ±1.9 years old) compared to that of Park's American (77.4 ±4.1 years old) and Korean (67.3 ±2.7 years old) samples. It is also unknown whether participants exercised at a different intensity than usual as a consequence of being measured and observed. However attempts were made to reduce this issue by regularly reminding participants that all gardening tasks should be performed at the same intensity as if they were on their allotment and not being measured by the researcher. It is also possible that allotment gardeners exercise at a greater intensity due to their presumed higher motivation to engage in these tasks as compared with the non-gardener samples in Park et al.'s research.

In order to determine MET values for physical activity Park et al. (2008) measured oxygen uptake (VO_2) through a submaximal graded exercise test (GXT) on a treadmill based on the heart rate measurements from the gardening tasks. This indirect method of estimating exercise intensity is based on a linear relationship between heart rate and VO_2 during daily activities, work and sports (Park et al., 2011). Unlike Park et al. (2008a) this study has used a portable and lightweight

metabolic measurement system, the Oxycon™ Mobile. This method of indirect calorimetry also has the advantage of being simple to use and less time consuming for participants. The Douglas bag method is generally considered to be the most accurate method of indirect calorimetry. Although the Douglas bag method may be used for measurements in an outside environment, its limitations in sampling duration as well as measurement resolution means the Oxycon™ mobile was more suited to the study's aims. Furthermore, the bags restrict freedom of movement and can impose additional air resistance (Rosdahl et al., 2010).

In their previous studies Park and colleagues (2008a; 2011) have identified gardening tasks that use a combination of the upper body and lower body, such as digging, turning compost, raking, mulching and fertilizing to be moderate intensity physical activities for older adults (3-6 METs). Whereas tasks that use primarily the upper body such as mixing soil, filling container with soil, sowing seeds and transplanting seeds have been identified as low intensity physical activity (1-3 METs). Correspondingly, results from the current study suggest that gardening tasks which involve weight-bearing motions and combine both upper and lower body muscle strength are classed as moderate to high intensity physical activity. For example, digging over soil with a shovel uses both upper and lower body muscles while incorporating weight-bearing motions (Park & Shoemaker, 2009; Restuccio, 1992). Weight bearing motions such as the ones used during gardening are expected to influence whole body bone mineral density (Turner et al., 2002) as well as incorporating many important elements of accepted exercise regimes such as strength and stance, repetition and movement, and even resistance principals similar to those seen in weight training (Park & Shoemaker, 2009). Therefore an activity program that incorporates gardening tasks of moderate-high intensity physical

activity can be expected to improve or maintain the health of older adults (Armstrong, 2000; Park & Shoemaker, 2009; Reynolds 1999; 2002; Turner et al., 2002).

Furthermore, knowing the intensities of various gardening tasks can help to formulate activity programs suitable for older adults according to their health conditions or level of physical ability. For example, Park, Lee, Son and Shoemaker (2012) have tested a range of horticultural therapy programs for exercise intensity. They found that creating a vegetable garden consists of a range of moderate physical activity gardening tasks, resulting in the overall activity, 'making a garden', being classified as a moderate intensity physical activity. Whereas completing activity programs like propagating herbs or transplanting seedlings were found to be low intensity physical activities and would therefore be suitable for individuals that require a lower level of physical activity or have other special needs.

Gardening has the advantage of being a directed and long term focus activity (Restuccio, 1992) as it involves the responsibility of taking care of a garden continuously (Relf, 1981) and this may promote regular and long-term involvement. In addition, gardening can help maintain motivation and interest, which has proven to be difficult with physical activity in older adults (Brawley et al., 2003). As a result, gardening activity may be a particularly beneficial form of exercise to promote for the goal of healthy ageing, enabling older people to live healthier lifestyles for longer. According to Welmer, Mörck, & Dahlin-Ivanoff (2012) older adults do not view physical activity as a separate activity but rather as a part of other leisure activities often rated as more important than the physical activity itself. As an activity that is already popular with older adults in the UK, allotment gardening therefore can be seen as a form of leisure activity that provides exercise intensity levels that can meet government recommendations. In this study, allotment gardeners reported average weekly gardening activity levels of 10.97 hours a week (±6.71). Thus, even at the

lowest levels of participation, allotment gardening provided a level of physical activity to contribute significantly to the achievement of current public health recommendations (i.e. 150 minutes of moderate to vigorous intensity activity per week).Whilst it could be argued that domestic gardening may not require as frequent participation as tending to an allotment garden plot, this activity would still contribute to an overall active lifestyle and achievement of weekly physical activity recommendations when combined with other active leisure pursuits. The importance of incremental daily physical activities for reducing the risk of cardiovascular morbidity and all-cause mortality in later life has recently been highlighted by researchers in Sweden (Ekblom-Bak et al., 2013). In addition, other work by Park, Shoemaker and Haub (2008b) suggests that domestic gardening can require high levels of participation at certain times of the year.

It should be noted that healthy, non-smoking participants were deliberately selected to participate in this study in order to replicate Park et al.'s previous studies, and that this presents a possible bias in the findings. Different intensity values may have been observed with a less healthy sample. Additionally, participants were self-selecting and may have been more highly motivated to promote the benefits of gardening. Future replication of this research with clinical populations is warranted to examine any differences in intensity levels of gardening tasks across specific conditions. Unlike in Park et al.'s previous work (Park et al., 2011; 2012), resting metabolic rate was not measured in this study. Therefore it is not possible to compare the metabolic equivalents of the gardening tasks reported here to the participants' metabolic rate when at rest.

An additional limitation of this research is the small sample size, which replicates but does not improve upon the sample sizes of previous work (Park et al., 2008a; 2011). Future research that expands on this study should aim to recruit a

larger sample. Additional research is also needed in order to determine the effectiveness of physical activity programs incorporating gardening activities for older adults, particularly low intensity activity programs in adults with low levels of physical ability. Longitudinal studies could be particularly useful in determining the health benefits of low or moderate intensity gardening tasks over time.

In conclusion, the present study indicates that a range of gardening tasks provide low to high-moderate intensity physical activity (1.9 - 5.7 METs) for healthy older adults. In addition, we have partially-replicated the findings of Park et al. (2008a; 2011) in a sample of Welsh allotment gardeners and found that some activities were conducted at a higher intensity than the non-allotment gardener participants of Park et al.'s studies. The range of MET values observed for the various gardening tasks studied is comparable to the MET values provided for walking activity in the Compendium of Physical Activities (Ainsworth et al., 2011). For example, slow walking at less than a 2 mph pace (2.0 METs) is comparable to sowing seeds (1.9 METs) and walking at a more vigorous pace of 4-4.5 mph (5-6 METs) is comparable to digging activity (5.7 METs). This highlights the relevance of gardening as a valuable resource for disease prevention and health promotion in older populations. The introduction of gardening as an integral component in older adults' physical activity programs may have significant physical and psychosocial benefits for the health in later life.

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Table 1 **Descriptions of Gardening tasks to be performed**

Gardening Tasks	Description
Hand Weeding	With a standard hand fork (wood and stainless steel), squatting or sitting in a grassy area with weeds, some moving as they complete an area.
Raking	Raking a 2 m x 2.5 m garden plot with a standard soil rake (wood and stainless steel), including the removal of stones, weeds, and bark form the surface.
Digging	Digging over a 2 m x 2.5 m garden plot with a standard digging shovel (wood and stainless steel). Participants were informed not to dig a big hole.
Mixing Soil	Mixing and moving soil between two buckets (30 cm diameter) with their hands, performed while the bucket was standing on a table (table dimensions: 110 cm x 55 cm x 76 cm).
Filling Containers with Soil	Filling 6 cm fiber pots with previously mixed soil from a bucket (30 cm diameter) by hand, performed while the bucket was standing on a table (table dimensions: 110 cm x 55 cm x 76 cm).
Sowing Seeds	Creating a small hole in previously filled pots with either finger or a small stick and then sowing beetroot seeds (Beta vulgaris) and covering over.

Table 2 Descriptive Characteristics of the Participants

Variable	*M* ± SD	%
Age (years)	65.21 ± 1.93	
Gender: Male		50
Ethnicity: Caucasian		92.9
Body Mass (kg)	70.96 ± 12.23	
Height (m)	1.66 ± 0.08	
Body Mass Index ($kg \cdot m^{-2}$)	25.62 ± 2.91	
Gardening Activity*	10.97 ± 6.71	
Education:		
Undergraduate		71.4
Graduate		21.4
Postgraduate		7.1
Employment Status:		
Retired		100

Note. *hours per week, N =18.

Table 3 Metabolic measurements for six different gardening tasks

Task	VO^2 ($mL \cdot kg^{-1} \cdot min^{-1}$)	EE ($kj \cdot kg^{-1} \cdot h^{-1}$)	METs	HR ($beats \cdot min^{-1}$)
Digging	19.8 [a] ± 3.5	24.3 [a] ± 4.4	5.7 [a] ± 1.0	111 [a] ± 14
Raking	16.2 [b] ± 2.9	20.1 [b] ± 3.7	4.6 [b] ± 0.8	102 [a] ± 17
Weeding	16.1 [b] ± 3.4	19.8 [b] ± 4.4	4.6 [b] ± 1.0	100 [a] ± 17
Mixing Soil	11.1 [c] ± 1.9	13.6 [c] ± 2.5	3.2 [c] ± 0.5	91 [b] ± 16
Filling Containers	8.1 [d] ± 1.9	9.8 [d] ± 2.4	2.3 [d] ± 0.6	83 [b] ± 10
Sowing Seeds	6.8 [d] ± 1.6	8.3 [d] ± 2.0	1.9 [d] ± 0.5	77 [b] ± 8

Note. Values are *M* ± SD, a, b, c, and d: means sharing one common letter are not significantly different by Duncan's multiple range test at p=.05. VO_2 = oxygen consumption; EE = energy expenditure; METs = metabolic equivalents; HR = heart rate.

Table 4 Classifying six gardening tasks as low, moderate, or high intensity physical activity

	Exercise Intensity			t	df
	Gardening Tasks Low Intensity	Gardening Tasks Moderate Intensity	Gardening Tasks High Intensity		
EE ($Kj \cdot kg^{-1} \cdot h^{-1}$)	9.10 ± 2.30	20.01 ± 3.83		-12.26*	24
	9.85 ± 2.27		24.33 ± 4.44	-10.44*	13
		19.80 ± 4.46	24.33 ± 4.44	-4.84*	13
METs	2.1 ± 0.5	4.6 ± 0.8		-12.47*	24
	2.3 ± 0.5		5.7 ± 1.0	-10.41*	13
		4.6 ± 1.0	5.7 ± 1.0	-5.10*	13

Note. Values are *M ± SD*, *= *p* <.0001.