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Gardening and age-related weight gain: Results from a cross-sectional survey of Denver residents

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A B S T R A C T

This study examined whether gardening modifies the association between age and body mass index (BMI). We used data from the Neighborhood Environments and Health Survey, which was conducted in Denver (N = 469) between 2006 and 2007. We fit two general linear mixed models. The base model had BMI in kg/m^2 as the outcome, and age, an indicator variable for non-gardening status and the age-by-non-gardening status interaction as predictors. The adjusted model included as covariates the potential confounders of education, ethnicity and self-reported health. We assessed self-selection bias and confounding. BMI was 27.18 kg/m^2 for non-gardeners, 25.62 kg/m^2 for home gardeners, and 24.17 kg/m^2 for community gardeners. In the base model, a statistically significant association was observed between age and BMI for non-gardeners but not for the combined community and home gardening group ($F = 9.27$, ndf = 1, ddf = 441, $p = 0.0025$). In the adjusted model, the association between age and BMI in non-gardeners was not statistically significant ($F = 1.72$, ndf = 1, ddf = 431, $p = 0.1908$). Gardeners differed on social and demographic factors when compared to non-gardeners. The results from the base model are consistent with the hypothesis that gardening might offset age-related weight gain. However, the cross-sectional design does not permit differentiation of true causal effects from the possible effects of bias and confounding. As a follow-up study, to remove bias and confounding, we are conducting a randomized clinical trial of community gardening in Denver.

1. Introduction

This study aims to explore gardens for their potential to offset age-related weight gain, a major risk factor for chronic diseases such as cancer, diabetes, and cardiovascular disease. Based on data from 2011 to 2014, the CDC reports that over 34% of adults and 17% of children are obese (Ogden et al., 2015). Moreover, cross-sectional and prospective cohort studies have found that sedentary populations tend to have increasing BMI as they age (Williams and Wood, 2005). Despite these population-level patterns of obesity, there are few proven options to ameliorate age-related increases in BMI.

Significant population-wide behavioral change is necessary to decrease the morbidity and mortality incurred by obesity and its complications (NIH Obesity Research Task Force, 2011; Luckner et al., 2012). Public health guidelines, including guidelines from the American Cancer Society, recommend maintaining healthy and active lifestyles, which includes light to moderate activities such as walking and gardening, and a high-fiber diet of fruits and vegetables (Kushi et al., 2012).

It has been repeatedly demonstrated that consuming nutrient dense, low calorie foods is effective in promoting weight loss and decreasing rates of chronic disease (Kumanyika et al., 2010; Bertoia et al., 2015; Guthrie and Lin, 2014; Ramage et al., 2013). Such changes in diet, however, may necessitate improvements in social and physical environments that influence the availability, affordability, and accessibility of healthy food and the social milieu that influences what is socially acceptable, desirable, and appropriate to eat (Brug et al., 2008). Despite this recognition, the evidence is mixed on the association between environmental factors and healthy eating (Brug et al., 2008; Belon et al., 2016).

Physical inactivity is a crucial part of the energy balance equation as it contributes to the opportunities to gain weight over time because energy intake may exceed energy expenditure (Williams and Wood, 2005). More exercise and less sitting are distinct facets of activity behaviors and both are important for weight loss and weight maintenance. Mounting evidence shows that Americans do not generally adhere to activity guidelines, and increased sedentary time is associated with development of chronic disease (Wilmot et al., 2012; Owen et al.,

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2010). According to Owen and others, sedentary behavior is not just the absence of intensive physical activity but rather a distinct set of behaviors, such as increased television viewing time, overall daily sitting time, and time spent travelling by automobile that result in prolonged sitting and consequently a range of health consequences (Owen et al., 2010, 2011).

In the United States, only 21% of adults meet federal guidelines for aerobic and strengthening activity, which is important for achieving improved physical fitness (Roger et al., 2012). Moreover, one third of the population does not engage in at least 10 min of light physical activity per day (Pearson et al., 2013). This level of inactivity is higher among women and increases across the lifespan. Moreover, non-Hispanic black and Hispanic adults are more likely to be inactive than non-Hispanic white adults (Go et al., 2013).

While diet, physical activity and sedentary behaviors are central to disease prevention and health promotion, it is difficult to change behaviors in an environment that does not provide the necessary substrate for change (Kushi et al., 2012; Pearson et al., 2013). As such, multicomponent, multilevel interventions that influence behavior change and weight maintenance are needed (Mikkelsen et al., 2016). This is particularly salient for people of color, those of low socioeconomic position, and those that lack access to the social networks and physical amenities that support healthy living (Burke et al., 1992; Duelberg, 1992; Winkleby et al., 1999, 1998; Kimmons et al., 2009; Ogden et al., 2012; McPherson et al., 2006).

Community and home gardening present relatively scalable and affordable intervention opportunities that address active living, healthy eating, and weight maintenance (Alaimo et al., 2016). Previous studies have shown that garden participation can promote healthy eating, improve food security, and increase the availability of affordable, healthy food (Alaimo et al., 2016; Morris and Zidenberg-Cherr, 2002; Heim et al., 2009; Robinson-O'Brien et al., 2009; Johnson and Smith, 2006; Litt et al., 2011; Carney et al., 2012; Okvat and Zautra, 2011; Alaimo et al., 2008a). Garden programs also encourage physical activity and limit sedentary activity (Alaimo et al., 2016; Hermann et al., 2006; Park et al., 2009). These studies not only shed light on the direct effects of gardening on physical activity and nutrition but also on the emotional and social processes by which gardens enhance wellbeing and happiness and, in turn, influence health behaviors and health status (Segar et al., 2011). More recently, Zick and others showed that garden participation affects weight status (Zick et al., 2013). Their findings suggest that gardeners, when compared to their non-gardening siblings and non-gardening neighbors, have lower body mass index (BMI) and lower risk of being overweight or obese (Alaimo et al., 2016; Zick et al., 2013).

We aim to explore the association between garden participation, age and BMI, drawing on data from a population-based cross-sectional survey of a cohort of Denver residents.

2. Methods

2.1. Study design and sampling

The Neighborhood Environments and Health Survey was a cross-sectional, population-based survey conducted in Denver from 2006 through 2007. Survey data were collected using a multi-frame sampling design consisting of an area-based sample of the general population and a list-based census of community gardeners. The initial sampling design called for a recruitment goal of 480 total households to be randomly selected from 1454 available households in the sampling frame. Of the initial households, 655 (45%) could not be contacted due to gated and secured premises, no soliciting signs, and unrestrained dogs. Of the remaining 799 households, 473 households completed the survey (59%). 469 individuals with complete height and weight data were included in this analysis.

2.2. Measures

2.2.1. Height and weight

Data were collected through self-report during a 45-minute in-person survey. The questionnaire included items to characterize demographics, general outlook, the social environment, the physical environment, physical activity, diet and gardening activities among others. Participants were asked if they did not garden, conducted home gardening, or gardened in a community garden. *Body mass index* (*BMI*) was defined as weight (kg) divided by height (m) squared.

2.2.2. Self-rated health

A single item from the Behavioral Risk Factor Surveillance System (BRFSS) asked respondents to rate their general health on a scale of 1 (*Poor*) to 5 (*Excellent*) (Centers for Disease Control and Prevention, 2005). This item has been shown to be a reliable and valid predictor of health status (Fayers and Sprangers, 2002).

2.2.3. Gardening status

Survey items asked, “Do you garden?” Respondents who answered yes to this question were then asked whether they gardened at home (n = 215) (or at a neighbor's home) or in a community garden (n = 63).

2.2.4. Covariates

Potential covariates were identified based on their established association with body mass index, and/or relationship to gardening status. Covariates included participant age (years), highest year of school completed (some high school, high school graduate or some college, college graduate), and ethnicity/race (White, Black, Hispanic, Other). Income was not included in the analysis due to the large number of missing responses (n = 42) and the significant correlation between income and education level.

2.3. Data analysis

We used an a priori planned approach for model fitting. The first step was to find the best fitting base model to describe associations between gardening, age, and BMI. The second step was to add a set of covariates to the best fitting model, to assess if the results would be altered by the presence of covariates. The covariates, selected from the literature, included the potential confounders of education, ethnicity and self-reported health.

To find the best fitting base model, we used a planned backwards stepwise approach. We began with a mixed model that had BMI in kg/m^2 as the outcome, and age, gardening status (none, home, and community gardening), and the age-by-gardening status interaction as predictors. This is the full model in every cell (Muller et al., 2002) design matrix. The full model in every cell allows comparisons of slopes and intercepts between the gardening groups. To account for nested observations among different block groups, we included a random intercept in the model.

We then followed a planned model reduction strategy to find the most parsimonious model which best explained the data. The strategy involved a cascade of tests, which stops for any significant result. We tested for a difference in the slopes of three gardening groups, and conducted secondary tests to identify whether we could combine the groups. We assessed whether the slopes in age were equal to zero, a finding that if true, would indicate that BMI did not change with age for one or more groups. We tested for a difference in the intercepts between the three gardening groups. We performed general linear hypothesis tests using a Wald F-test with Kenward-Roger degrees of freedom and a Type I error rate of 0.05.

As is common in observational studies, possible associations between gardening and age-related increase in BMI may in fact be confounded by other measured or unmeasured variables.

Table 1
Respondent characteristics.

	Non-gardeners (N = 191)	Gardeners (N = 215)	Community gardeners (N = 63)	Total (N = 469)
Age				
N	190	215	62	467
Mean (SD)	41.3 (16.59)	48.1 (14.48)	53.6 (13.98)	46.1 (15.88)
Median	37.5	48	53	46
Q1, Q3	28, 51	37, 57	44, 63	33, 56
Min, Max	18, 94	22, 92	31, 88	18, 94
Sex				
Male	65 (34.0%)	67 (31.2%)	21 (33.3%)	153 (32.6%)
Female	126 (66.0%)	148 (68.8%)	42 (66.7%)	316 (67.4%)
BMI				
N	178	208	60	446
Mean (SD)	27.18 (5.972)	25.62 (5.215)	24.17 (3.801)	26.05 (5.462)
Median	25.67	24.69	23.49	24.96
Q1, Q3	23.03, 30.55	21.79, 27.93	21.78, 25.64	22.24, 28.69
Min, Max	16.64, 49.12	17.37, 54.09	17.75, 39.33	16.64, 54.09
Education				
No high school	40 (20.9%)	10 (4.7%)	2 (3.2%)	52 (11.1%)
HS graduate or some college	82 (42.9%)	55 (25.6%)	11 (17.5%)	148 (31.6%)
College graduate	69 (36.1%)	150 (69.8%)	50 (79.4%)	269 (57.4%)
Ethnicity				
White	71 (37.2%)	151 (70.2%)	49 (77.8%)	271 (57.8%)
Black	45 (23.6%)	20 (9.3%)	5 (7.9%)	70 (14.9%)
Hispanic	71 (37.2%)	40 (18.6%)	8 (12.7%)	119 (25.4%)
Other	4 (2.1%)	4 (1.9%)	1 (1.6%)	9 (1.9%)
Race				
Non-white	120 (62.8%)	64 (29.8%)	14 (22.2%)	198 (42.2%)
White	71 (37.2%)	151 (70.2%)	49 (77.8%)	271 (57.8%)
Self-reported health				
Poor	9 (4.7%)	5 (2.4%)	0 (0.0%)	14 (3.0%)
Fair	48 (25.1%)	23 (10.7%)	7 (11.1%)	78 (16.6%)
Good	53 (27.7%)	49 (22.8%)	17 (27.0%)	119 (25.4%)
Very good	45 (23.6%)	85 (39.5%)	26 (41.3%)	156 (33.3%)
Excellent	36 (18.8%)	52 (24.2%)	12 (19.0%)	100 (21.3%)
Missing	0 (0.0%)	1 (0.5%)	1 (1.6%)	2 (0.4%)

Variables can only act as confounders if they are associated with both the predictors and the outcomes. To assess the association between potential confounders and the outcome of BMI, we explored the univariate relationships between gardening and the covariates of interest. We assessed the association between potential confounders and BMI using ANOVA. We assessed the association between ordinal categorical confounders and gardening status using the Cochran-Mantel-Haenszel row mean score differ statistic. We assessed the association between non-ordered categorical confounders and gardening activity using chi-squared tests of association.

Confounders change the association between the exposure of interest and the outcome when added to the model. To assess whether education, ethnicity and self-reported health, we added those covariates to the best fitting reduced base model. In the adjusted model, we again tested for the association between gardening status and BMI, and noted the change in the parameter estimates.

3. Results

The demographic characteristics of the 469 study participants are presented in Table 1. There were 191 non-gardeners, 215 home gardeners and 63 community gardeners surveyed for the study. There were 23 missing BMI measurements, 2 missing age measurements and 2 missing self-reported health measurements. The majority of the study participants were female, white, and college-educated. The average age of the study participants was 46.1 years. Non-gardeners (mean = 41.3 years) were on average younger than those performing gardening activities, with community gardeners (mean = 53.6 years) being slightly older than home gardeners on average (mean = 48.1 years). Gardeners reported more college education (75.2%) compared to those that did not garden (36.1%). All community gardeners and 60% of home gardeners reported growing fruits and vegetables. Moreover, 60% of home and community gardeners reported over 10 years of gardening experience.

There was no statistically significant association between age and BMI for individuals participating in home or community gardening. There was, however, a statistically significant association between age and BMI for those individuals not participating in gardening activities ($F = 9.27$, $ndf = 1$, $ddf = 441$, $p = 0.0025$). On average, BMI increased by 0.03 (kg/m^2) for every year of age increase for those who did not garden.

Non-gardeners, on average, had a higher BMI (27.18 kg/m^2) than home gardeners (25.62 kg/m^2) and community gardeners (24.17 kg/m^2) ($F = 8.31$, $DF = 2$, $p = 0.0003$). Analysis showed that education, ethnicity and self-reported health may be possible confounders of the association between BMI, age and gardening activity. For example, educational attainment was associated with BMI ($F = 21.46$, $DF = 2$, $p < 0.0001$). Those who had not completed high school had a BMI (28.72 kg/m^2), which was, on average, higher than that of both high school graduates (27.70 kg/m^2) and college graduates (24.70 kg/m^2). Higher levels of education were associated with increased gardening activity (Cochran-Mantel-Haenszel, $\chi^2 = 60.33$, $p < 0.0001$). Additionally, there were significant associations between self-reported health and gardening (Cochran-Mantel-Haenszel, $\chi^2 = 22.87$, $p = 0.0001$), ethnicity (White/Non-White) and gardening activity ($\chi^2 = 58.62$, $p < 0.0001$), ethnicity and BMI ($F = 27.29$, $df = 3$, $p < 0.0001$), and between self-reported health and BMI ($F = 21.39$, $df = 4$, $p < 0.0001$). Gender was not significantly associated with gardening activity ($p = 0.8120$) or BMI ($p = 0.1673$).

The adjusted model included the additional covariates of education, ethnicity and self-reported health. Following adjustment for education, ethnicity and self-reported health, there was no statistically significant association between age and BMI in non-gardeners ($F = 1.72$, $ndf = 1$, $ddf = 431$, $p = 0.1908$). Table 2 presents a comparison of the association between age and BMI in both the adjusted and unadjusted best fitting model.

Table 2
Relationship between age and BMI for non-gardeners in the adjusted and unadjusted linear models, Denver, Colorado 2006–2007.

	Estimate	95% CI	p-Value
Un-adjusted			
Non-gardeners	0.034 (kg/m^2)	(0.012, 0.055)	0.0025
Adjusted			
Non-gardeners	0.014 (kg/m^2)	(− 0.007, 0.035)	0.1980
Ethnicity			
White	− 3.264	(− 6.517, − 0.010)	0.0499
Black	0.249	(− 3.161, 3.659)	0.8863
Hispanic	− 0.640	(− 4.015, 2.735)	0.7070
Other	(*Reference*)		
Education			
Less than HS degree	0.424	(− 1.509, 2.357)	0.6676
HS degree	0.038	(− 1.182, 1.259)	0.9509
College degree	(*Reference*)		
Self-reported health			
Poor	7.831	(4.900, 10.762)	< 0.0001
Fair	3.448	(1.857, 4.671)	< 0.0001
Good	3.341	(2.010, 4.671)	< 0.0001
Very good	1.445	(0.218, 2.673)	0.0215
Excellent	(*Reference*)		

4. Discussion

The unadjusted results of this study show a significant association between age and BMI for non-gardeners, but not for those who garden at home or in a community plot. Among non-gardeners, BMI increased by 0.03 kg/m^2 per year. This is consistent with other reports about global trends in body mass index that show increases of 0.4 to 0.5 kg/m^2 per decade among men and women (Johns et al., 2014).

Because the association between age and BMI was non-significant in a model that included education, ethnicity and self-reported health, it is possible that the results of the study were due to confounding. Education, ethnicity and self-reported health were all related both to the decision to garden, and to the outcome of BMI (McLaren, 2007; Clarke et al., 2009; Okosun et al., 2001). Because education, ethnicity and self-reported health were so tightly confounded with the decision to garden, no stratification efforts can remove the confounding. While regression models can measure association between variables, holding other variables constant, the approach does not resolve questions of selection bias (Hammer et al., 2009), nor confounding (Richiardi et al., 2013). In this observational, cross-sectional study, one cannot distinguish between the possibilities that gardening ameliorates the age-related increase BMI or whether this apparent effect is in fact due to confounding.

Obesity and overweight are influenced by many factors from genetics to broader policy and physical environments and thus interventions that aim to influence weight-related outcomes should be multicomponent, multilevel, and behaviorally-based (e.g., targeting diet and physical activity) (Ramage et al., 2013; Johns et al., 2014). Qualitative and quantitative studies demonstrate that gardens have the potential to influence eating and physical activity behaviors critical for better health (Alaimo et al., 2016; Litt et al., 2011; Litt et al., 2015; Alaimo et al., 2008b; Blair et al., 2013).

Garden environments may support behavior changes needed to maintain weight over time. Moreover, the garden context warrants further investigation as a public health intervention because of its cultural lever, allowing people to grow food that reflects their cultural heritage (Hale et al., 2011).

Our previous research has shown that people garden because it makes them feel good. People garden because they like to get their hands dirty, they love it, and it allows them to escape the stressful parts of their lives (Hale et al., 2011). The garden presents individuals with a variety of activities that are satisfying and can generate a sense of purpose by tending to and caring for plants and foster reciprocity between individuals and the landscape (Blair et al., 2013; Hale et al., 2011). These emotional processes are crucial for igniting the processes necessary for sustainable behavior change (Comstock et al., 2010) and are important drivers behind participation. Self-determination theory informs these observations in that it suggests that the energy and motivation behind behavior change largely originate from within an individual (Segar et al., 2011; Patrick and Williams, 2012; Ryan and Deci, 2000). Adherence to behavioral regimens is critical to the maintenance of a healthy weight and intrinsic motivation is crucial for adherence (MacLean et al., 2015). Because the motivations for gardening are largely intrinsic (e.g., "I do it because I love it"), they give important insights into why gardeners continue to garden over time. Furthermore, gardens have their own patterns of growth and activities based on changing weather across the seasons, changing day lengths, and changing characteristics of the soil and the plants in the garden. Each season, accordingly, necessitates tasks that require different activities and different time commitments. This variety of tasks over time protects against the potential monotony that may compromise the effectiveness of other weight loss and weight maintenance interventions (MacLean et al., 2015).

4.1. Limitations

Several issues should be considered when interpreting the study results. Self-reported height and weight data were used to derive body mass index, the metric used as our primary outcome. Reliance on self-reported height and weight to calculate body mass index has been shown to underestimate average body mass index and the proportion of the population in higher body mass index categories in population surveys although the measure has been validated among adults (Gregory et al., 2008; Gorber et al., 2007; Stommel and Schoenborn, 2009).

The degree of bias attributed to self-selection is unknown due to the cross-sectional design of this study. That is, we do not know whether the differences we observed between gardeners and non-gardeners were due to participation in community gardening or to other factors that varied by gardener status. We also do not know, for example, whether people who joined a community garden already tend to engage in more active and healthy lifestyles, factors that could bias our estimates.

Confounding is the central concern when establishing causality. In this study, the association between age and BMI for people who do not garden may be due to unaddressed confounding, which reflects a bias inherent in cross-sectional studies. Only an experimental study design can begin to overcome this inherent bias by distributing potential confounders equally across treatment and control groups. In observational studies, it is likely that education and ethnicity will result in confounding because they can be associated with the exposure (gardening) and the outcome of interest (body mass index). A randomized controlled trial of community gardening funded by the American Cancer Society is now underway to test these associations among low income and minority residents in Denver, Colorado (NCT03089177). This study is designed to ensure that the gardening intervention is not offered disproportionately to those with more education and in higher income groups.

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