## Effect of the interaction with informal green space on physical activity? An analysis of potted street gardens in Tangier, Morocco.

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## Abstract

**Objectives:** Accumulating research findings shows that encouraging exposure to urban greenspaces (UGS) can be a strategic and far-reaching way to increase physical activity (PA). However, most UGS–PA studies have focused on formal green spaces rather than on informal ones, even though parks and public gardens are not equitably distributed, and research shows that informal UGS are spontaneously used by urban communities to cope with UGS scarcity, especially in dense residential neighborhoods. The objective of this research was to study the correlation between PA duration and ownership of potted street gardens (PSG), an informal UGS, in a densely populated Moroccan neighborhood.

**Study design:** Cross sectional study.

**Methods:** Data were collected using a face-to-face survey conducted in January 2019 in Tangier, Morocco. Participants were selected using a systematic random sampling method. We measured weekly walking duration and data were analyzed using weighted linear regression (WLS).

**Results:** There was no significant difference between PSG owners and nonowners in weekly walking duration.PSG ownership moderated the association between weekly walking duration and social capital (F(1,334) = 5.624, p < .05. R² change = .008). Among PSG owners, one year increase in PSG age was associated with 6 minutes decrease in weekly walking duration (b=-.54, CI=-.90/-.18; p < .01), one minute increase in weekly care duration was associated with a ½ minute increase in weekly walking duration (b=.40, CI = -.038/.75; p < .05), and an addition of in the diversity of recreational activities (eating, siting, chatting with neighbors, etc.) done next to PSG was associated with 17 minutes increase in weekly walking duration in the neighborhood (b=16.91, CI=1.08/32.75; p < .05). High neighborhood satisfaction and social capital score were associated with longer weekly walks in the neighborhood but only People without PSG.

**Implications**: PSG’ owners that had more social and gardening activities next to their PSG walked significantly longer than others. Owners with higher social capital walked less, possibly because they spend more time next to their PSG, chatting or socializing. PSG as a gardening venue may be used to encourage PA.

**Key words**

Physical activity, potted street gardens, public health, informal urban green space.

## Introduction

According to the WHO (WHO, 2010), PI is the main cause for more than a quarter of all breast and colon cancers and diabetes, and is responsible for 6% of deaths globally, making it the fourth leading mortality risk factor in the world. However, despite these alarming statistics, PI is still increasing in both developed and underdeveloped countries, in part because of the increasing urbanization of the world population (Assah et al., 2011; Ojiambo et al., 2012). A consistent body of Research highlighted the importance of built environments in defining PA levels, the availability of UGS in particular was linked to an increase in PA (Akpinar, 2016; Schipperijn et al., 2013), in addition to an increase in neighborhood safety perception (Bennett et al., 2007; Garvin et al., 2013; Gorham et al., 2009), neighborhood life quality satisfaction (Stronegger et al., 2010; Zhang et al., 2017), and social capital (Fu et al., 2018; Jennings & Bamkole, 2019). Therefore, creating new UGS may be an effective way to increase PA levels. However, the mechanisms of this association are still unclear as UGS use as a venue for outdoor activities can’t fully explain alone this association (Hillsdon et al., 2006; Luo et al., 2020; Mytton et al., 2012). Furthermore, UGS is still not evenly distributed through urban environments between communities of different socioeconomic levels, especially in developing countries, mainly because UGS perception as an expensive luxury (Wolch et al., 2014) and the unavailability of vacant-land in dense neighborhoods with no UGS.

In this study we investigated the correlation between ownership of PSG, an informal, low cost, and easy to implement informal UGS, and weekly walking duration as a moderate PA.

PSG presence in residential neighborhoods was associated with an increase in neighborhood greenery perception and UGS scarcity (Aoki & Yuasa, 1993), which suggests that PSG may also have the same positive impact as formal UGS on PA levels.

The majority of PSG related studies focused on its connection with community life, territoriality and depression levels and most of these studies were performed in Japan. Findings showed PSG correlation with community space organization (Aoki & Yuasa, 1993; Ikkai et al., 1999; Masuda & Hino, 2018; Takahashi et al., 2005), and with higher depression levels (Afrad & Kawazoe, 2020). To our knowledge, no study investigated PSG associations with PA as a form of UGS.

PSG can be categorized as an UGS according to its definition by the WHO as "all urban land covered by vegetation of any kind, this covers vegetation on private and public grounds, irrespective of size and function." (WHO, 2017). However, most PSG-related research has focused on it being private property, and acting as a territorial tool, dividing areas of public ground between neighbors.

PSG are a private property present on public space, cleaned, watered, and protected from vandalism mainly by owners, these characteristics and routines may have an impact on behaviors and perception of the neighborhood’s physical and social characteristics.

Therefore, our objective is to measure the impact of PSG ownership on PA levels (both direct association and moderation effects), when controlling for the demographic characteristics of the sample population, and three aspects of neighborhood life associated with PA levels; perceived safety (Gonyea et al., 2018), life satisfaction (Julien et al., 2012), and social capital (Fu et al., 2018)

We extend prior research on UGS associations with PA among disadvantaged communities to explore:

(a) PSG ownership association with PA levels

(b) PSG ownership moderation effect and its impact on the relationship between PA levels and neighborhood safety, life quality satisfaction, and social capital

(c) PSG perceived publicness and routines related to SPGs ownership impact on PA levels.  
In line with our literature review, we advance the following hypotheses:

**Hypothesis 1**: PSG ownership, neighborhood safety, life quality satisfaction, and social capital are associated with PA.

**Hypothesis 2**: PSG ownership moderates the association between PA levels and neighborhood safety, life satisfaction, and social capital.

**Hypothesis 3**: PSG-related daily routines and PSG perception are associated with PA levels.

## Methodology

### **2.1 Data**

A face-to-face survey (N=388) was conducted in January 2019, in the Beni-Makada district of Tangier (Morocco). The district houses more than 40% of Tangier’s population (RGPH, 2014), but is also the most disadvantaged neighborhood (La Cava et al., 2012) in the city, with a poverty rate of 14 % (Alvarez, 2015), the lowest (0.27m2 ) per capita of green space (OPEMHT, 2016).

During the 22nd conference of parties (COP22) organized in 2016 in Morocco, the study area attracted media attention in part because of the abundance of PSG in its narrow streets. The local government made efforts to encourage PSG ownership in other districts in Tangier trough the organization of competitions between neighborhoods, and by providing funding’s nongovernmental organizations.

There are approximatively 93.737 households in Beni-Makada, 87% live in individual patio houses (RGPH, 2014). All PSG in the area are owned and maintained by local community and situated on the streets in front of owners’ houses, visible and accessible to all.

The questionnaire was tested with focus groups and a certified translator fluent in the local Arabic dialect before being implemented. The study was approved by the ethics committee of the University of Tokyo. In addition, we received oral informed consent and parental permission for minors before each interview. Adulthood was defined according to its legal definition in Morocco (≥18 years).

A sample size of a minimum of 384 (one individual from each household) was calculated to achieve a significance level of α=0.05**,** and a 95% confidence interval (CI). About 80% agreed to participate in the survey. After four weeks, we obtained 388 valid questionnaires.

The interviews were conducted by four male survey conductors fluent in the local dialect. All interviews were conducted in private.

### **2.2 Measures**

weekly walking duration was measured in minutes using the product of two questions. “How many times a week do you have a walk in your neighborhood”, measuring frequency with responses ranging from “(0) Never” to “7 times a week”, and “How much time does every walk last” measuring duration in minutes.

Life satisfaction was measured using a satisfaction index summing participant’s answers to two questions: “How satisfied or dissatisfied are you with life quality in your neighborhood” with responses “(1) Not satisfied at all”, “(2) Not satisfied”, “(3) Average”, “(4) Satisfied”, and “(5) Very satisfied”. And “How proud are you to live in this neighborhood” with responses “(1) not proud at all,” “(2) not proud,” “(3) average,” “(4) proud,” and “(4) very proud”. The summed score ranged from 1 to 10. The internal consistency of the items was good (Cronbach’s α=.88).

Social capital was measured using a social capital index summing participants’ answers to two questions “How would you describe the neighbors relationship in your neighborhood” with responses “(1) very bad”, “(2) bad”, “(3) neutral”, “(4) good ” and “(5)very good”, and “How many of your neighbors do you know” with responses “(1) none of them”, “(2) few of them”, “(3) half of them”, “(4) most of them,” and “(5) all of them”. The summed score ranged from 1 to 10. The internal consistency of the items was good (Cronbach’s α=.79).

Perceived neighborhood safety was measured using the question: “How safe is your neighborhood?” with responses “(1) very unsafe”, “(2) unsafe”, “(3) neutral”, “(4) safe”, and “(5) very safe”.

PSG age was measured in months using the question “Since when there are potted plants in front of your house”.

PSG size was measured in number of pots using the question “How many pots are in your garden”.

PSG daily care duration was measured in minutes using the question “How much time do you spend taking care of your garden daily”.

Weekly care frequency was measured using the question “How many times a week do you take care of your plants” with responses ranging from “(0) Never” to “7 times a week”.

Diversity of recreational activities done next to PSG was assessed using the question “What kind of activities do you have next to your pots” a check-All-That-Apply question, with responses, (0) “nothing”, “(1) sitting or standing”, “(1) eating”, “(1) chatting”, “(1) smoking”, and “(1) other”. The number of checked items is added to form the answer.

Weekly frequency of recreational activities next to PSG was measured using the question “On average, how many times a week do you have activities next to your pots”, with responses ranging from “(0) Never” to “7 times a week”

And PSG publicness was measured using the question “Do you think that your potted garden is” with responses “(1) private”, “(2) both private and public”, and “(3) Public”.

We controlled for demographic covariates including age, gender, household size, House ownership (yes/no), car ownership (yes/no), marital status (single/married/widowed/divorced), educational level (Less than high school /vocational training/ high school/ bachelor/Masters/PhD/ other), duration of residence (time lived at current address in years).

### **2.3 Analysis Plan**

Participants were divided into two groups, PSG owners and non-owners. We then used descriptive statistics, to define the sociodemographic characteristics of participants to compare the variance in depression scores between the two groups. Afterwards, we conducted moderated weighted least squared regressions (WLS) using standard deviation (SD) function to reweight the observations in the data set using SPSS 25, because of the presence of heteroscedasticity in the data (the Breusch-Pagan test was significant for all Models; p < .001). In model 1 we tested the relationship between PA and our independent variables. In model 2 we added the interaction terms between PSG ownership and perceived safety, life satisfaction and social capital. Finally, in model 3 we conducted a WLS regression for PSG owners’ group only, adding variables related to PSG ownership; perceived publicness, size, age, daily care duration, weekly care frequency, activity diversity, and activity frequency).

## Results

**3.1 Descriptive Statistics**

Table 1 shows the characteristics of the sample and the comparison between the two groups, with without PSG. The average WEEKLY WALKING DURATION of survey participants is 111.47 minutes (SD=135.50), which is below the 150 minutes of moderate PA recommended by the WHO (Who, 2010), although some studies suggest 15 minutes are enough to start benefitting from PA (Wen et al., 2011). Overall, only 27.6% of our sample walked more than 150 minutes a week. Two thirds of our population (68%) reported owning a PSG. The average score for social capital index is M=7.98 (range 1–10; SD=1.41). The average score for neighborhood safety is M=3.91 (range 1-5; SD=0.771), with 82% of participants perceiving their neighborhoods as “safe/very safe”. The average life satisfaction score was 8.04 (range 1–10; SD=1.14).

**Table 1**. Descriptive Information on the Analytic Sample (N=388)

|  |  |  |  |
| --- | --- | --- | --- |
| Response | Whole sample | No PSG | With PSG |
| **PSG ownership** |  |  |  |
| Yes | 264 (68%) |  |  |
| No | 124 (32%) |  |  |
| **Weekly walking duration** | M=111.47; SD=135.50 | M=111.21; SD=157.40 | M=111.6; SD=124.21 |
| **SPGs age** |  |  | M=30.34; SD=32.168 |
| **SPGs size** |  |  | M=7.65; SD=4.621 |
| **Daily care (min)** |  |  | M=17.26; SD=13.63 |
| **Weekly care frequency** |  |  | M=2.40; SD=1.44 |
| **Weekly care (min)** |  |  | M=47.26; SD=48.41 |
| **SPGs publicness** |  |  | M=2.14; SD=0.76 |
| **Perceived Safety** | 3.91 (0.771) | 3.90 (0.712) | 3.91 (0.798) |
| Not safe at all | **2** | **0.8%** | **0.4%** |
| Not safe | **27** | **6.6%** | **7.2%** |
| Neutral | **40** | **5.8%** | **12.5%** |
| Safe | **250** | **75.2%** | **60.5%** |
| Very safe | **65** | **11.6%** | **19.4%** |
| **Life satisfaction (range 1-10)** | M=8.04; SD=1.14 | **M=7.7; SD=1.08** | **M=8.20; SD=1.13** |
| **Social Capital (range 1-10)** | M=7.98; SD=1.41 | M=7.91; SD=1.67 | M=8.01; SD=1.26 |
| **Gender** |  |  |  |
| Male | 271 (69.8%) | 92(74.2%) | 179(67.8%) |
| Female | 117(30.2%) | 32(25.8%) | 85(32.2%) |
| **Age category** |  |  |  |
| less than 18 | 10 (2.6%) | 3 (2.4%) | 7 (2.7%) |
| 18-35 | 219 (56.4%) | 76 (61.3%) | 143 (54.2%) |
| 36-50 | 110 (28.4%) | 30 (24.2%) | 80 (30.3%) |
| 51-65 | 37 (9.5%) | 13 (10.5%) | 24 (9.1%) |
| More than 65 | 12 (3.1%) | 2 (1.6%) | 10 (3.8%) |
| **Education level** |  |  |  |
| Less than high school | 82 (21.1%) | 29 (23.4%) | 53 (20.1%) |
| Vocational training | 32 (8.2%) | 10 (8.1%) | 22 (8.3%) |
| High school graduate | 78 (20.1%) | 20 (16.1%) | 58 (22.0%) |
| Bachelor’s degree | 77 (19.8%) | 31 (25.0%) | 46 (17.4%) |
| Master’s degree | 64 (16.5%) | 19 (15.3%) | 45 (17.0%) |
| Doctorate degree | 2 (.5%) | 1 (.8%) | 1 (.4%) |
| **Marital status** |  |  |  |
| Single | 49.7% | (65) 52.8% | (126) 47.7% |
| Married | 40.6% | (47) 38.2% | (109) 41.3% |
| Widowed | 4.9% | (6) 4.9% | (13) 4.9% |
| Divorced | 2.3% | (4) 3.3% | (5) 1.9% |
| **Years in neighborhood** | M=23; SD=10.83. | M=23.75; SD=11.45 | M=23.25; SD=10.55 |
| **Homeownership** |  |  |  |
| Yes | 56.1% | 56.5% | 55.7% |
| No | 43.9% | 42.7% | 44.3% |
| **House hold size** | M=4.92; SD=1.70 | M=4.86; SD=1.79 | M=4.95; SD=1.64 |
| **Car ownership** |  |  |  |
| Yes | 257 (66.8%) | 87 (70.2%) | 170 (65.1%) |
| No | 128 (33.2%) | 37 (29.8%) | 91 (34.5%) |

### Boldface indicates p<.05 for PSG owners compared to those with no PSG.

Two thirds (69.8%) of our sample were male, of whom 56.1% owned their home. The average age group was 2.54 (SD = .82), which corresponds to ages between 18 and 35 years. The average level of education was between vocational training and high school graduate (M=2.68; SD=1.68; range 0–6). The average household size was 4.92 (SD=1.70), and the average duration participants lived at their current address was 23 years (SD=10.83).

### **3.2 Bivariate Analysis**

We used bivariate analyses (t tests and χ2 tests) to identify significant differences between our two groups (see table 1).

There is no significant difference between those with and without PSG in terms of weekly walking duration or social capital. However, participants with PSG were less likely to perceive their neighborhoods as safe, and reported higher life quality satisfaction than those without PSG.

There were no significant differences between our two groups of PSG owners and nonowners in terms of gender, age, education, marital status, house or car ownership, years lived in current address, or household size.

Spearman’s correlations were calculated for the four key variables, weekly walking duration, neighborhood safety, neighborhood satisfaction and social capital for the two groups. For participants without PSG, weekly walking duration was significantly correlated with life quality satisfaction only (r=-.358; p<.001), while social capital and life quality satisfaction were significantly correlated to each other (r= -.328; p < .001). There were no significant associations between neighborhood safety and other variables.

For participants with PSG, weekly walking duration was significantly associated with life satisfaction (r= .202, p < .001) and social capital only (r=.192, p<.005). Neighborhood safety, Life satisfaction and social capital were all positively associated with each other (p < .001).

### **3.3 Multivariate Analysis**

Table 2 shows the results of the WLS predicting weekly walking duration, stratified by PSG ownership. In model 1 we compared the two groups of participants with and without PSG, in model 2 we verified PSG ownership moderating effects on the association between our main variables and in model 3 we tried to identify PSG characteristics that were significantly associated with walking duration controlling for covariates.

Table 2. WLS explaining WEEKLY WALKING DURATION in minutes (N=388)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Model 1** | | **Model 2** | | | **Model 3** |
|  | **no PSG** | **with PSG** | **Step 1** | **Step 2** | **Step 3** |  |
|  | **B (CI)** | **B (CI)** | **B (CI)** | **B (CI)** | **B (CI)** | **B (CI)** |
| PSG ownership |  |  | 1.10  -23.25/25.44 | .65  -23.53/24.84 | -.11  -25.97/25.74 |  |
| life quality satisfaction | 7.25  (-4.28/18.79) | **33.45\*\***  **(12.77/54.12)** | **14.713\*\*\***  **(6.50/22.92)** | **12.74\*\***  **(4.43/21.05)** | **13.36\***  **(2.28/24.44)** | 1.33  -8.70/11.36 |
| Social capital | 6.00  (-2.28/14.30) | **19.08\*\***  **(4.76/33.40)** | **8.016\***  **(1.01/15.02)** | **13.48\*\***  **(5.17/21.79)** | **13.21\*\***  **(4.29/22.12)** | 1.63  (-5.75/9.02) |
| Safety  perception | -7.17  (-24.92/10.57 | 14.32  (-31.48/60.14) | 1.359  (-13.74/16.46) | 5.13  (-10.19/20.46) | 5.59  (-10.66/21.84) | 3.64  (-7.6/15.18) |
| social capital x  PSG ownership |  |  |  | **16.637\***  **(2.83/30.43)** | **16.320\***  **(2.01/30.63)** |  |
| life quality satisfaction x  PSG ownership |  |  |  | - | 1.50  (-16.16/19.16) |  |
| PSG  publicness |  |  |  |  |  | 9.76  (-1.94/21.48) |
| PSG size |  |  |  |  |  | -1.38  (-2.82/.058) |
| PSG age |  |  |  |  |  | **-.54\*\***  **(-.90/-.18)** |
| Weekly  care duration |  |  |  |  |  | **.40\***  **(.038/.75** |
| Activity  diversity |  |  |  |  |  | **16.91\***  **(1.08/32.75)** |
| Activity  frequency |  |  |  |  |  | 3.66  (-5.87/13.20) |
| Gender  Female | -4.13  -29.45/21.19 | **77.50\*\***  **17.92/137.06** | -2.547  -25.24/20.14 | .489  -22.19/23.17 | .852  -22.26/23.96 | -12.66  -34.91/9.58 |
| Age category  (range 1-5) | **21.37 \***  **4.40/38.35** | 27.04  -19.11/73.20 | **26.242\*\***  **11.49/40.989** | **23.884\*\***  **9.11/38.66** | **23.970\*\***  **9.13/38.80** | 4.44  (-11.03/19.92) |
| Marital status  Married  Widowed  Divorced  Single | 19.91  -11.52/51.36  91.58  -36.25/219.43  -  7.73  (-34.46/49.92 | 58.53  -7.72/124.80  -107.54  361.67/146.6  **-149.77\*\***  **-245.75/-53.8**  - | **49.81\*\*\***  **25.43/74.2**  49.334  60.30/159.0  -  **66.130\*\***  **30.64/101.61** | **46.060\*\*\***  **21.64/70.47**  36.909  -72.46/146.28  -  **57.798\*\***  **21.88/93.71** | **45.786\*\*\***  **21.12/70.45**  36.626  -72.96/146.21  -  **58.208\*\***  **21.91/94.50** | -  123.53  -23.55/270.63  29.32  (-4.62/63.27)  10.60  -16.73/37.93 |
| Education | **20.47\*\*\***  **11.11/29.83** | -3.31  (-22.23/15.60) | 7.706  (-.1/15.51) | **8.717\***  **.92/16.51** | **8.77\***  **.94/16.61** | **20.83\*\*\***  **14.60/27.06** |
| Household  size | 7.91  (-.55/16.37) | -10.22  (-23.40/2.94) | **-5.757\***  **(-10.98/-.53)** | -4.336  (-9.66/.99 | -4.18  (-9.81/1.45) | **16.63\*\*\***  **11.31/21.96** |
| Years in neighborhood | -.34  (-1.65/.97) | 2.843  (-.63/5.50) | .639  (-.17/1.45) | .17  (-.72/1.07) | .15  (-.78/1.08) | .12  (-.91/.1.16) |
| House  ownership | .036  (-30.16/30.23) | 37.95  -32.17/108.07 | 16.424  (-10.53/43.38) | 17.403  (-9.38/44.19) | 17.50  (-9.35/44.35) | **27.24\*\***  **(7.88/46.61)** |
| Car ownership | **31.00\***  **(6.71/55.30)** | -41.55  (-89.68/6.57) | 10.951  (-8.71/30.61 | 4.072  (-16.27/24.42) | 4.02  (-16.36/24.41) | **26.02\*\***  **10.88/41.15** |
| Constant | -527.335 | -5318.62 | -1306.013 | -377.967 | -340.48 | -392.11 |
| F test | **14.437\*\*\*** | **6.514\*\*\*** | 25.269 | 24.285 | 22.702 | **18.347\*\*\*** |

The boldface indicates statistically significant results. \*P < .05; \*\*P < .01; \*\*\*P < .001.

Model 1 shows the results of the hierarchical regression; step 1 with the main effect variables only, and step 2 with the interaction terms.

Model 2, shows the results of the weighted least square regression for PSG owners only, adding PSG-related daily routines and PSG perception variables.

Model 1 and 2 are adjusted for gender, age group, marital status, education level, household size, and homeownership.

As can be seen in model 1, among PSG owners, neighborhood life quality satisfaction (b=7.25, CI=-4.28/18.79. p>.05), Social Capital (b=.055, CI=-2.28/14.30. p>.05) and neighborhood safety (b=-7.17, CI=-24.92/10.57. p>.05) were not significantly associated with weekly walking duration.

However, for participants without PSG there was a significant association between life satisfaction and social capital, and weekly walking duration, where 1 point increase in life quality satisfaction index was associated with a 33 minutes increase in weekly walking duration (b=33.45, CI= 5.48/21.72 p<.005), and 1 point increase in social capital index was associated with an increase of 19 minutes in weekly walking duration (b=19.08, CI= 4.76/33.40. p<.05).

Model 2 shows the results of the hierarchical regression; step 1 with the main effect variables only (PSG ownership, perceived safety, social capital and neighborhood safety), and step 2 and step 3 with the introduction of the interaction terms one by one.

In step 1, only life satisfaction and social capital were significantly associated with walking duration. One point increase in life quality satisfaction was associated with 14 minutes increase in weekly walking duration, (b=14.713, CI=6.50/22.92; p<.001) and 1 point increase in social capital was associated with 8 minutes in weekly walking duration (b=8.016, CI=1.01/15.02. p<.05).This result supports hypothesis 1, that life satisfaction and social capital are positively associated with weekly walking duration.

In step 2 and step 3 we verified if PSG ownership moderation effect on the association between weekly walking duration, and life satisfaction, and social capital. Only the interaction term between PSG ownership and social capital was significant in step 2 and 3, the additional variation explained between step 1 and step 2 was 1% (F(1,334)=5.624, p<.05. R² change=.008). Meaning, as can be seen in figure 1, that for PSGs owners, an increase in social capital score was associated with a decrease in weekly walking duration, while for nonowners an increase in social capital score was associated with an increase in weekly walking duration.

These results support hypothesis 2, PSG ownership has an antagonizing moderation effect on weekly walking duration – social capital association.

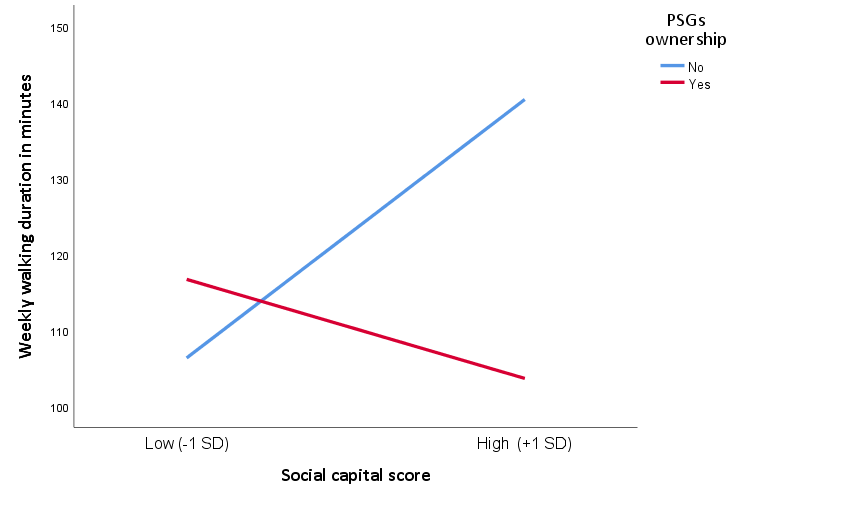


Figure 1: Simple slope for PSG ownership moderation of the weekly walking duration – social capital relationship. The low value for social capital is plotted at 1 SD below the mean, and the high value is plotted at 1 SD above the mean.

Model 3 shows that, one month increase in PSG age was associated with ½ minute decrease in weekly walking duration (b=-.54, CI=-.90/-.18; p<.01), one minute increase in weekly care time (cleaning, watering PSG) was associated with a ½ minute increase in weekly walking duration (b=.40, CI=.038/.75; p<.05), while one additional kind of activities done next to PSG (eating, siting, chatting with neighbors, etc.) was associated with 17 minutes increase in weekly walking duration (b=16.91, CI=1.08/32.75; p<.05). This result supports hypothesis 3, suggesting that more interaction with PSG is associated with more physical activity.

## Discussion

### **4.1 Principal findings**

Understanding the impact of PSG on PA levels is of great importance in order to generalize green space benefits at a lesser cost to all urban populations, especially in densely populated residential neighborhoods. This research is the first study of the association between informal green spaces such as PSG and PA.

We analyzed the groups with and without PSG separately before collapsing the whole sample into one model. We then introduced the variables measuring the daily routines related to PSG ownership to identify the most significant ones.

The study showed that an increase in PSG-related activities, including recreational and gardening activities, owners had next to their gardens had a significant association with an increase in walking duration, these initial results suggest that PSG owners would display longer walking durations than nonowners. However, the results showed no significant difference in PA levels between owners and nonowners.

We suggest three possible explanatory hypotheses to these findings:

* PSG ownership related activities are associated with a preexisting walking behavior.
* PSG impact on increasing greenery perception in the neighborhood increased weekly walking duration for both groups, urban green space at street level was associated with increased physical activity (Lu et al., 2018).
* PSG ownership increased PA first for owners due to recreational and gardening activities happening outdoor, and then for nonowners practicing walking with PSG owners as a social activity, specially that PSG owners had a significantly higher social capital than nonowners, and walking was associated with higher social capital (Kim & Yang, 2017).

For PSG owners, an increase in social capital was associated with a decrease in weekly walking duration, while for nonowners it was associated with an increase in weekly walking duration. The results suggest that PSG provide a venue to sedentary social activities to owners with higher social capital in the neighborhood, or that higher social capital makes owners care for the PSG for the public good, social capital was linked to altruistic prosocial behaviors in previous studies (Helliwell et al., 2017).

The results of this study suggest that PSG ownership and presence in the studied neighborhood has a significant impact on weekly walking duration, however the mechanisms of this association need more research to be fully understood.

### **4.2 Limitations**

To the authors knowledge this research is the first investigation of the relationships between PSG and PA. Therefore, it is not possible to compare our findings with similar studies.

Another limitation is that the observed associations could be caused by selection bias given that our sample is 70% male (for cultural reasons), we tried to avoid this possibility by controlling for demographic characteristics, but social effects of selection cannot be ruled out completely. In  
addition, the study did not control for household income because none of the pilot study participants agreed to share this information.

Another limitation is the possible inaccuracy of self-reported PA duration.

### **4.3 Conclusion**

The results of this study suggest that encouraging PSG ownership and PSG-related gardening and social activities may be a low-cost and practical way to significantly increase PA levels in densely populated neighborhoods for both PSG owners and nonowners. However, the mechanisms of this association are still unclear.

We recommend more cross-sectional and longitudinal studies to be conducted with bigger sample sizes, controlling for UGS availability rate and proximity to nonowners.

We also recommend future efforts focus on multiplying and diversifying PSG-related recreational and maintenance activities by encouraging the creation of gardening clubs, and the design of new ways to integrate similar forms of green space adapted to the scarcity of vacant land in dense neighborhoods.

### **4.4 Acknowledgement**

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**4.5 Authors’ statements**

**Ethical approval:** The study received ethical approval from the ethics committee of the University of Tokyo.

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**Competing interests**: The authors declare no competing interests.

**Abbreviations**

b, Unstandardized regression coefficient;

Cl, confidence interval;

PSG, potted street garden.

PI physical inactivity

PA physical activity

UGS, Urban green space

RGPH, Recensement Général de la Population et de l'Habitat

NGO, non-governmental organization

CI, confidence interval

WLS, weighted least square regression or weighted least squares

SD, standard deviation

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