



## Effectiveness of a scaled up physical activity intervention in Brazil: A natural experiment



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### ARTICLE INFO

#### Article history:

Received 18 March 2016

Received in revised form 6 September 2016

Accepted 23 September 2016

Available online 28 September 2016

#### Keywords:

Leisure-time physical activity

Physical activity classes in community settings

Impact

Effect

Odds ratio

### ABSTRACT

Physical inactivity causes 5.3 million deaths annually worldwide. We evaluated the impact on population leisure-time physical activity (LTPA) of scaling up an intervention in Brazil, Academia das Cidades program (AC-P). AC-P is a health promotion program classified as physical activity classes in community settings which started in the state of Pernambuco state in 2008.

We surveyed households from 80 cities of Pernambuco state in 2011, 2012 and 2013, using monitoring data to classify city-level exposure to AC-P. We targeted 2370 individuals in 2011; 3824 individuals in 2012; and 3835 individuals in 2013. We measured participation in AC-P and whether respondents had seen an AC-P activity or heard about AC-P. We measured LTPA using the International Physical Activity Questionnaire. We estimated the odds of reaching recommended LTPA by levels of exposure to the three AC-P measures.

For women, the odds of reaching recommended LTPA were 1.10 for those living in cities with AC-P activity for less than three years, and 1.46 for those living in cities with AC-P activity for more than three years compared to those living in cities that had not adopted AC-P. The odds of reaching recommended LTPA increased with AC-P participation and knowledge about AC-P.

AC-P exposure is associated with increased population LTPA. Extending AC-P to all cities could potentially impact non-communicable diseases in Brazil.

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### 1. Introduction

The pandemic of physical inactivity is a major public health threat worldwide (Kohl et al., 2012). Globally, one out of three adults and four out of five adolescents fail to reach the levels of physical activity

recommended for health benefits (Hallal et al., 2012; [WHO] World Health Organization, 2010). Annually, 5.3 million deaths are attributable to physical inactivity (Lee et al., 2012). Recent reviews show interventions that could potentially increase population physical activity, but few have been evaluated in low and middle-income countries where >80% of the world's population live and >80% of all non-communicable disease deaths occur (Heath et al., 2012; Pratt et al., 2012). In addition, few interventions have been extended to a national scale.

Since 2002, physical activity classes in community settings have emerged in Latin America (Hoehner et al., 2008) as a promising means of increasing population levels of physical activity and decreasing health inequalities by reaching a population at higher risk for inactivity (Reis et al., 2014).

Between 2006 and 2010, researchers evaluated the Academia da Cidade (AC-R) program of the city of Recife (AC-R), a supervised classes

*Abbreviations:* AC-P, Academia das Cidades – Pernambuco State; AC-R, Academia da Cidade – City of Recife; AS, Academia da Saude – Brazil; LTPA, leisure-time physical activity.

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in community settings (Simoes et al., 2009; Parra et al., 2010; Hallal et al., 2010a; Hallal et al., 2009). The city of Recife, capital of the state of Pernambuco in Northeast Brazil, with 1.7 million people, started AC-R in 2002. The program reaches much of the city's population through 19 sites across the city (Simoes et al., 2009). A cross-sectional study showed that different measures of self-reported exposure to AC-R were associated with increased LTPA (Simoes et al., 2009). A study showed that individuals using public open spaces at an AC-R site were more active than those visiting similar locations without AC-R (Parra et al., 2010). In qualitative studies, users and instructors indicated a high level of satisfaction with the program (Hallal et al., 2010a; Hallal et al., 2009). Following dissemination of these evaluations for Recife, the government of Pernambuco created in 2008 the Academia das Cidades (AC-P) modeled after AC-R. The government aimed for ACP to reach all 184 cities other than City of Recife and 7 million people of Pernambuco over five years. An alliance between the two dominant political parties of Recife mayor's and Pernambuco governor's offices contributed to the adoption of similar policies by the Secretariat of Health of Recife (AC-R in 2002) and the Secretariat of Cities of Pernambuco (AC-P in 2008).

AC-P is a multicomponent program characterized by: (a) free physical activity classes offered to the population by trained physical educators every weekday morning and late afternoon; (b) classes offered in AC-P sites consisting of re-engineered and beautified public spaces (e.g., small parks and plazas) or creation of new space, including equipment for group exercise provided; (c) referral of program participants screened for hypertension and obesity to the public primary health care system; (d) participants' assessment and guidance on body weight and diet. The Pernambuco government provides infrastructure for program operation by financing construction and/or rehabilitation of spaces for classes in parks and squares. Training and development is achieved through continuing education for managers and physical activity professionals with financial support of the Ministry of Health.

The rapid scaling up of AC-P provided an opportunity to evaluate its impact on population levels of LTPA in Pernambuco with an improved study design. The previous studies used self-reported measures of "participation in the AC-R" and "knowledge of the AC-R" that were subject to major selection and recall bias (Simoes et al., 2009; Parra et al., 2010; Hallal et al., 2010a; Hallal et al., 2009). Also, the longer AC-P is present, the more cues there are that would help people remember LTPA. The current study adds a direct measure of community exposure to AC-P which is unaffected by recall bias. Our primary a priori hypothesis was that individuals in communities with an active AC-P site would experience an increase in LTPA, and this increase would be greater for both women and individuals living closer to an AC-P site (i.e., individuals with greater access to AC-P). Secondly, we tested the associations of LTPA with self-reported participation in AC-P and knowledge of AC-P.

## 2. Methods

### 2.1. Study design and sampling

We implemented a natural experiment with characteristics of wedge and nested cross-sectional designs to evaluate AC-P's impact on population level of LTPA (Brown and Lilford, 2006; Murray, 1998). Between the AC-P funding announcement in early 2011 and 2013, 134 of the 184 cities in Pernambuco enrolled in AC-P. Cities adopted AC-P by responding to program announcements for funding approximately 50 new sites yearly. In the application for funds, cities have to demonstrate choice of a site location, commitment to program objectives and certificate of financial responsibility. Though 134 new AC-P sites is within expectation for the observed study period, the timing and sequencing of cities' enrollment was unpredictable and similar to wedge-designs. This created 184 naturally observable population groups exposed to different stages of AC-P implementation that could be compared over time: not enrolled, enrolled but for short duration, enrolled and for

longer duration. We obtained study approval by the Institutional Review Board of the Federal University of Pelotas.

The nested cross-sectional characteristics of the study consisted of one baseline and two follow-up random sample surveys of households and participants within households of the non-institutionalized populations of the same 80 cities at one-year intervals during September in 2011, 2012 and 2013. Cities in the study are representative of most municipalities in Pernambuco and Brazil regarding population size, income and education (data available upon request). We used systematic random samples in four stages with the following sampling units per stage: 1) cities stratified by seven regions of the state but excluding capital city of Recife; 2) census tracts (areas with approximately 300 households each); 3) streets; and 4) households. In the first stage, at baseline only, we randomly selected the first city from all possible 184 cities in the sampling frame, and then systematically sampled 79 additional cities. These same 80 cities were used in the two follow-up surveys. At the baseline and both follow-up surveys, we then randomly selected census tracts per city by year (10 in 2011 survey, 16 in both 2012 and 2013 surveys), then randomly selected a street and 2 additional streets systematically. Finally, we randomly sampled one household per street then randomly asked one person per household (age 16 or older) to offer an in-person interview. We were able to increase the sample size in surveys 2 and 3 thus increasing the precision of our estimates. We aimed to generate sample sizes with power to estimate an AC-P on LTPA effect size (odds ratio) of 1.25 or greater with 95% confidence.

Due to the number of non-interviews (refusal and break-off plus non-contacts plus others) plus all cases of unknown eligibility (unknown if housing unit, plus unknown, other) the response rates for the survey years 2011–2013 ranged between 90.3% and 92.8% (The American Association for Public Opinion Research, 2016). In the 2011 survey, we interviewed 2370 individuals (49.8% women). In the 2012 and 2013 surveys, we interviewed 3824 (49.9% women) and 3835 (50.7% women) respectively.

### 2.2. Exposure variables

We used self-report responses to questions to classify participation in AC-P: (1) never participated in AC-P; (2) participated in AC-P for less than six months; (3) participated in AC-P for at least six months; (4) currently participates in AC-P for less than six months; and (5) currently participates in AC-P for at least six months.

We used AC-P implementation monitoring data to create a city-level exposure to AC-P that expresses level and duration of exposure in which survey year is implicit. This variable was defined as follows: (1) no construction initiated or ongoing construction as of the year the respondent took the survey; (2) construction concluded in the survey year, but no officially-organized activity at the AC-P site begun; (3) construction completed by the year prior to the survey, but still no officially-organized activity; (4) construction concluded, with activity in the survey year but not for all three survey years; and (5) construction concluded with ongoing activities for all survey years. Due to model instability during regression analysis, we re-classified city-level AC-P as: (1) no AC-P site construction (or in construction); (2) AC-P site construction completed and either no activity present or activity present by survey year, but for less than three years; and (3) AC-P site construction completed and activity present for all three survey years.

We dichotomized self-reported knowledge of AC-P based on whether respondents "have heard about or have seen activity of AC-P".

### 2.3. Outcome variable

The survey used a modified form of the long version of the International Physical Activity Questionnaire (IPAQ), but with only two of the IPAQ's original four domains of physical activity: leisure-time and transport (Hallal et al., 2012; Hallal et al., 2003). For these analyses, we focused only on LTPA lasting 10 or more consecutive minutes. We

calculated minutes per week of walking and moderate-intensity LTPA. Because the number of minutes spent doing vigorous-intensity physical activities are weighted to contribute twice the time of moderate-intensity activities for adults in the physical activity guidelines, we multiplied minutes spent in vigorous-intensity LTPA by two (Hallal et al., 2012; Hallal et al., 2003). Finally, we calculated a weekly score by adding up minutes per week of walking, moderate- and vigorous-intensity activities. We compared those reaching the World Health Organization's (WHO) combined recommended levels of moderate and vigorous physical activity (i.e., Adults: at least 75 min/week of vigorous, or 150 min/week of moderate, or an equivalent mix of vigorous & moderate; Children (for the 36 participants ages 16–17 in study): 60 min/day of combined moderate & vigorous activity at least 3 days/week) against the others (Hallal et al., 2012; [WHO] World Health Organization, 2010; Hallal et al., 2003).

#### 2.4. Covariates

We assessed age (16–34, 35–54 and 55+), gender (men and women), education (less than high school graduation, high school graduation, college or more) and marital status (single or separated; married or cohabiting). Because survey data did not include income or job status, but socioeconomic status is known to be associated with LTPA, we used available information on household item ownership to create a socioeconomic measure (SES) (Oakes and Rossi, 2003; Cerin and Leslie, 2008) People who owned at least one of the household items typical of middle and upper-middle class (e.g., vacuum cleaner, car, DVD player, washing machine, freezer, motorcycle) were categorized into the higher SES category; otherwise, they were classified as lower SES. We created a “mean time to LTPA locations” score by calculating the mean duration in minutes of walking from home to the following places: parks; squares; walking and bicycling paths; fitness centers; sports courts and fields; and AC-P site. We then dichotomized the score as below or above the median of 12 min. We used reported weight and height to calculate BMI, then divided those calculations into: <25.0 kg/m<sup>2</sup> – normal/underweight; 25.0–29.9 kg/m<sup>2</sup> – overweight; and ≥30.0–34.9 kg/m<sup>2</sup> – obese. Tobacco smoking was categorized into never smoked versus former or current smoker.

#### 2.5. Data analysis

We used the procedure Freq in SAS to generate overall and gender-specific percentages of sociodemographics (i.e., age, gender, education, marital status, SES), chronic disease primary risk factors (i.e., BMI, smoking), environmental variables (access to LTPA), LTPA and exposure to AC-P (city-level AC-P, participation in AC-P and knowledge of AC-P).

We used the procedure Logistic and Glimmix from SAS to compute crude and adjusted odds ratios and corresponding 95% confidence intervals of reaching LTPA guidelines across levels of sociodemographics, primary chronic disease risk factors, environmental factors and three measures of exposure to AC-P: (a) city-level AC-P; (b) participation in AC-P; and (c) knowledge of AC-P. We included the design variables survey year, city, and census tract as random effects in the regression models along with socioeconomic and demographic measurements. Because weight and height measures were missing from 35% of respondents, we excluded BMI from final analytical models after running sensitivity analysis showing its odds ratios were similar to models with BMI imputed (data not shown). We evaluated interactions of the measures of AC-P exposure with gender and access to an AC-P site. We employed regression diagnostic methods to assess model adequacy (Hosmer et al., 1991)

### 3. Results

The ~10,000 participants were equally distributed by gender. Around 40% of both men and women were aged 16–34 years (Table 1). Only 3.5% of the men and 6.6% of the women had college educations and about half of the participants were married or lived with a partner.

**Table 1**  
Characteristics of the study population.

| Variables                                    | Men<br>N (%)   | Women<br>N (%) | All sample<br>N (%) |
|--|----------------|----------------|---------------------|
| <i>Socio-demographics</i>                    |                |                |                     |
| Age (years)                                  |                |                |                     |
| 16–34  | 1803<br>(38.9) | 1882<br>(39.9) | 3685<br>(39.4)      |
| 35–54  | 1125<br>(24.3) | 1124<br>(23.8) | 2249<br>(24.1)      |
| 55+  | 1706<br>(36.8) | 1710<br>(36.3) | 3416<br>(36.5)      |
| Education                                    |                |                |                     |
| <High school                                 | 3547<br>(72.7) | 3282<br>(67.2) | 6829<br>(70.0)      |
| High school grad                             | 1161<br>(23.8) | 1283<br>(26.3) | 2443<br>(25.0)      |
| College or more                              | 168 (3.5)      | 320 (6.6)      | 488 (5.0)           |
| Socioeconomic status                         |                |                |                     |
| Lower  | 837 (17.1)     | 872 (17.7)     | 1709<br>(17.4)      |
| Higher                                       | 4046<br>(82.9) | 4051<br>(82.3) | 8097<br>(82.6)      |
| Marital status                               |                |                |                     |
| Single, separated                            | 2146<br>(43.7) | 2466<br>(49.9) | 4612<br>(46.8)      |
| Married or cohabiting                        | 2761<br>(56.3) | 2475<br>(50.1) | 5236<br>(53.2)      |
| <i>Primary behavioral factors</i>            |                |                |                     |
| Smoking                                      |                |                |                     |
| Never  | 2467<br>(50.2) | 3198<br>(64.7) | 5665<br>(57.5)      |
| Former                                       | 1490<br>(30.3) | 1133<br>(22.9) | 2623<br>(26.6)      |
| Current                                      | 955 (19.4)     | 615 (12.4)     | 1570<br>(15.9)      |
| Leisure-time physical activity               |                |                |                     |
| <150 min/wk                                  | 3428<br>(69.6) | 3905<br>(78.8) | 7333<br>(74.2)      |
| 150+ min/wk                                  | 1498<br>(30.4) | 1048<br>(21.2) | 2546<br>(25.8)      |
| <i>Environmental factors</i>                 |                |                |                     |
| Mean time to LTPA locations                  |                |                |                     |
| Less than 12 min                             | 2577<br>(54.3) | 2262<br>(47.6) | 4839<br>(50.9)      |
| At least 12 min                              | 2167<br>(45.7) | 2492<br>(52.4) | 4659<br>(49.1)      |
| <i>Exposure to AC-P</i>                      |                |                |                     |
| Participation in AC-P                        |                |                |                     |
| Never  | 4603<br>(95.8) | 4472<br>(92.4) | 9075<br>(94.1)      |
| Former ≤6 months                             | 72 (1.5)       | 130 (2.7)      | 202 (2.1)           |
| Former >6 months                             | 33 (0.7)       | 66 (1.4)       | 99 (1.0)            |
| Current ≤6 months                            | 36 (0.8)       | 74 (1.5)       | 110 (1.1)           |
| Current >6 months                            | 61 (1.3)       | 96 (2.0)       | 157 (1.7)           |
| Knowledge of AC-P                            |                |                |                     |
| Never heard/seen AC-P                        | 1699<br>(35.5) | 1487<br>(30.8) | 3186<br>(33.1)      |
| Have heard/seen AC-P                         | 3091<br>(64.5) | 3345<br>(69.2) | 6436<br>(66.9)      |
| City-level exposure to AC-P                  |                |                |                     |
| No (or ongoing) construction                 | 1852<br>(37.6) | 1867<br>(37.7) | 3719<br>(37.6)      |
| Construction completed & activity (<3 years) | 2621<br>(53.1) | 2620<br>(52.9) | 5241<br>(53.0)      |
| Construction completed & activity (≥3 years) | 458 (9.3)      | 470 (9.5)      | 928 (9.4)           |

Only 17.4% of study participants had a lower SES and 52.0% were either overweight or obese. The prevalence of smoking was 19.4% among men and 12.4% among women. The proportion of individuals reaching LTPA guidelines was 25.8% in the whole sample, 30.4% among men and 21.2% among women. In terms of participation in AC-P, 93.8% of the individuals never participated in AC-P activities, 3.3% were former participants and 2.9% were current members of the program. About two-thirds of the study population had heard about AC-P or seen AC-P activities.

For the combined three survey years, nearly 38% of the study population lived in a city without an AC-P site or with incomplete construction of an AC-P site. In 2011, 59.5% of respondents lived in municipalities which had not completed construction (Fig. 1). This proportion decreased to 33.9% in 2012 and 27.5% in 2013. At the same time, the proportion of respondents in cities with completed construction and AC-P activity rose from 24.1% in 2011, to 42.3% in 2012, and to 53.7% in 2013.

Across the three random effects logistics regression models for exposure to AC-P (i.e., participation in AC-P, knowledge of AC-P and city-level AC-P), reaching LTPA guidelines was more likely for men, unmarried individuals, non-smokers, and those with higher education, high SES, and more access to physical activity facilities (Tables 2–4).

The statistically significant interaction of exposure to city-level AC-P with gender on their effect on reaching LTPA guidelines ( $p$ -value = 0.0244) is presented as contrasts among levels of the interactive variables (Table 2). For women, the adjusted odds ratio of reaching LTPA guidelines were 1.09 (95% CI 0.92–1.30,  $p$ -value = 0.3195) for those in a city with AC-P site and activity for less than three years and 1.46 (95% CI 1.11–1.92,  $p$ -value = 0.0063) for those living in a city with AC-P site and activity for three or more years compared to those living in cities that had not adopted AC-P. This trend in the odds ratio of reaching LTPA guidelines across levels of AC-P among women was statistically significant ( $p$ -value  $\leq$  0.05). Men's exposure to city-level AC-P did not significantly change the odds ratio of reaching LTPA guidelines ( $p$ -values 0.0755 and 0.6745 for the two levels of AC-P exposure contrasted to no exposure).

Participation in AC-P and knowledge of AC-P did not interact with either gender or access to an AC-P site on the odds of reaching LTPA guidelines. Compared to those who never participated in AC-P, the adjusted odds ratio of reaching LTPA guidelines significantly increased with participation in AC-P in the past (OR = 1.61; 95% CI 1.18; 2.20,  $p$ -value = 0.0029 for less than or equal to six months; OR = 1.83; 95% CI 1.17; 2.86,  $p$ -value = 0.0078 for more than six months) and present (OR = 5.06; 95% CI 3.34; 7.67,  $p$ -value < 0.0001 for less than or equal to six months' exposure; OR = 10.35; 95% CI 6.93; 15.47,  $p$ -value < 0.0001 for more than six months' exposure) (Table 3).

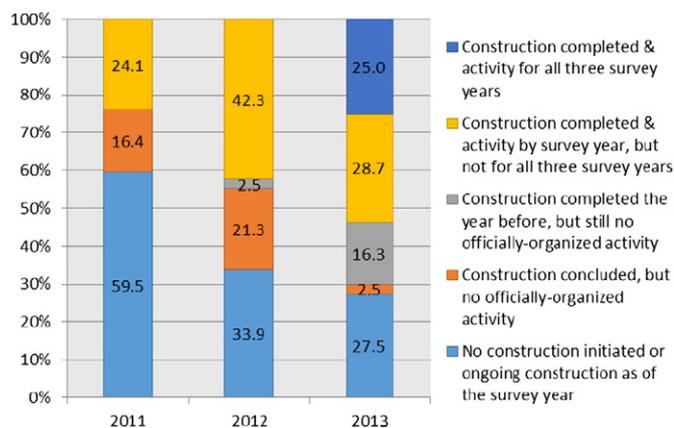


Fig. 1. Percent of respondents in cities with each implementation level of the intervention (ACP) by year of the survey. Pernambuco, Brazil. Stages of Academia dos Cidades Program Implementation.

Table 2

Adjusted odds ratio of reaching leisure-time physical activity guidelines according to city-level exposure to Academia das Cidades (AC-P) and covariates.<sup>a</sup>

|   | Reaching LTPA guidelines (%) | Odds ratio          | 95% confidence interval |       |
|---|------------------------------|---------------------|-------------------------|-------|
|   |                              |                     | Lower                   | Upper |
| Age (years)   |                              |                     |                         |       |
| 16–34   | 30.1%                        | 1.04                | 0.91                    | 1.19  |
| 35–54   | 24.9%                        | 0.97                | 0.84                    | 1.11  |
| 55+   | 22.1%                        | 1.00                |                         |       |
| Education   |                              |                     |                         |       |
| <High school  | 22.0%                        | 1.00                |                         |       |
| High school grad                                    | 34.2%                        | 1.66 <sup>b</sup>   | 1.47                    | 1.88  |
| College or more                                     | 40.8%                        | 2.33 <sup>b,c</sup> | 1.90                    | 2.87  |
| Socioeconomic status                                |                              |                     |                         |       |
| Lower   | 18.9%                        | 1.00                |                         |       |
| Higher  | 27.3%                        | 1.35 <sup>b</sup>   | 1.16                    | 1.58  |
| Marital status                                      |                              |                     |                         |       |
| Single, separated                                   | 27.4%                        | 1.16 <sup>b</sup>   | 1.05                    | 1.29  |
| Married or cohabiting                               | 24.5%                        | 1.00                |                         |       |
| Smoking   |                              |                     |                         |       |
| Former/current                                      | 22.6%                        | 1.00                |                         |       |
| Never   | 28.3%                        | 1.17 <sup>b</sup>   | 1.05                    | 1.31  |
| Mean time to LTPA locations                         |                              |                     |                         |       |
| <12 min   | 27.9%                        | 1.11 <sup>b</sup>   | 1.01                    | 1.23  |
| 12+ min   | 23.8%                        | 1.00                |                         |       |
| City-level exposure to AC-P by gender <sup>d</sup>  |                              |                     |                         |       |
| Men   |                              |                     |                         |       |
| No (or ongoing) construction                        | 32.4%                        | 1.00                |                         |       |
| Construction completed & activity (<3 years)        | 30.1%                        | 0.87                | 0.74                    | 1.02  |
| Construction completed & activity ( $\geq$ 3 years) | 31.5%                        | 0.95                | 0.73                    | 1.23  |
| Women   |                              |                     |                         |       |
| No (or ongoing) construction                        | 19.6%                        | 1.00                |                         |       |
| Construction completed & activity (<3 years)        | 21.8%                        | 1.09                | 0.92                    | 1.30  |
| Construction completed & activity ( $\geq$ 3 years) | 26.6%                        | 1.46 <sup>b,c</sup> | 1.11                    | 1.92  |

Pernambuco, Brazil 2011–2013.

<sup>a</sup> Odds ratio estimated from the random effects regression model with gender and city-level AC-P interaction and other six adjusting covariates.

<sup>b</sup> Odds ratio significant ( $p$ -value  $\leq$  0.05).

<sup>c</sup> Odds ratio trend is significant ( $p$ -value  $\leq$  0.05).

<sup>d</sup> Interaction statistically significant ( $p$ -value = 0.0244).

Compared to those who had never heard about nor seen AC-P, those who knew about AC-P had an odds ratio of reaching LTPA of 1.50 (95% CI 1.34; 1.69,  $p$ -value < 0.0001) (Table 4).

#### 4. Discussion

After three years of a planned five-year scaling up across 184 cities in Pernambuco (Brazil), we found a statistically significant effect of city-level AC-P on population level LTPA among women. The likelihood of reaching WHO-recommended levels of LTPA among women increased 9% for those living in a city with AC-P for less than three years and 46% for those living in a city with AC-P for three or more years. We found positive associations of reaching LTPA guidelines with self-reported participation in AC-P, knowledge of AC-P, age, gender and SES that have been previously reported (Simoes et al., 2009; Cerin and Leslie, 2008; Azevedo et al., 2007; Sallis, 2000).

Our finding of a city-level AC-P effect on LTPA among women is consistent with previous research indicating that the precursor of AC-P, AC-R, attracted more women than men (Reis et al., 2014). This gender-specific effect is relevant for the study population which has a lower LTPA prevalence in women than in men, a finding which has been reported before in Brazil and elsewhere (Azevedo et al., 2007; Martínez-González et al., 2001; Burton and Turrell, 2000). Three AC-P features may explain its effect on LTPA in women but not men: 1) sites are located for easy access

**Table 3**  
Adjusted odds ratio of reaching leisure-time physical activity guidelines according to participation in AC-P and covariates.<sup>a</sup>

|                             | Reaching LTPA guidelines (%) | Odds ratio           | 95% confidence interval |       |
|-----------------------------|------------------------------|----------------------|-------------------------|-------|
|                             |                              |                      | Lower                   | Upper |
| Age (years)                 |                              |                      |                         |       |
| 16–34                       | 30.0%                        | 1.07                 | 0.93                    | 1.22  |
| 35–54                       | 24.6%                        | 0.96                 | 0.84                    | 1.11  |
| 55+                         | 22.0%                        | 1.00                 |                         |       |
| Gender                      |                              |                      |                         |       |
| Men                         | 31.0%                        | 1.87                 | 1.68                    | 2.08  |
| Women                       | 21.0%                        | 1.00                 |                         |       |
| Education                   |                              |                      |                         |       |
| <High school                | 21.9%                        | 1.00                 |                         |       |
| High school grad            | 34.1%                        | 1.62 <sup>b</sup>    | 1.42                    | 1.83  |
| College or more             | 40.9%                        | 2.18 <sup>b,c</sup>  | 1.76                    | 2.70  |
| Socioeconomic status        |                              |                      |                         |       |
| Lower                       | 18.7%                        | 1.00                 |                         |       |
| Higher                      | 27.1%                        | 1.30 <sup>b</sup>    | 1.11                    | 1.51  |
| Marital status              |                              |                      |                         |       |
| Single, separated           | 27.2%                        | 1.17 <sup>b</sup>    | 1.05                    | 1.30  |
| Married or cohabiting       | 24.4%                        | 1.00                 |                         |       |
| Smoking                     |                              |                      |                         |       |
| Former/current              | 22.6%                        | 1.00                 |                         |       |
| Never                       | 28.0%                        | 1.13 <sup>b</sup>    | 1.01                    | 1.27  |
| Mean time to LTPA locations |                              |                      |                         |       |
| < 12 min                    | 27.6%                        | 1.08                 | 0.97                    | 1.19  |
| 12+ min                     | 23.7%                        | 1.00                 |                         |       |
| Participation in AC-P       |                              |                      |                         |       |
| Never                       | 24.1%                        | 1.00                 |                         |       |
| Former, ≤6 months           | 36.0%                        | 1.61 <sup>b</sup>    | 1.18                    | 2.20  |
| Former, >6 months           | 36.9%                        | 1.83 <sup>b</sup>    | 1.17                    | 2.86  |
| Current, ≤6 months          | 61.9%                        | 5.06 <sup>b</sup>    | 3.34                    | 7.67  |
| Current, >6 months          | 77.7%                        | 10.35 <sup>b,c</sup> | 6.93                    | 15.47 |

Pernambuco, Brazil 2011–2013.

<sup>a</sup> Odds ratio estimated from the random effects regression model with participation in AC-P as main exposure and other seven adjusting covariates.

<sup>b</sup> Odds ratio significant (p-value ≤ 0.05).

<sup>c</sup> Odds ratio trend is significant (p-value ≤ 0.05).

to the community; 2) professionally supervised LTPA activities, dietary counseling, hypertension screening and automatic linkage with health services for those identified as hypertensive are free of cost to participants; and 3) offer of a variety of LTPA, with majority classified as light or recreational exercise.

The associations of LTPA with AC-P is strengthened by replication of findings previously reported for AC-R: former and current participants of the program were more likely to reach LTPA guidelines than 'never' participants, and individuals who had seen or heard about the program were more likely than their peers to be active (Simoes et al., 2009).

However, previous findings of the effect of AC-R on LTPA have relied on small observational studies without comparison groups, thus subject to selection and recall biases, and uncertainty whether intervention preceded outcomes (Simoes et al., 2009; Mendonca et al., 2010; Fadnes et al., 2008). Our study design adds to this research field in several ways: a) it measured community exposure to AC-P and its duration directly from program monitoring data as opposed to self-reported information; b) this city-level AC-P measure created naturally forming intervention comparison groups (i.e., cities with/without AC-P); c) three random surveys of the same population over time provided a longitudinal perspective of AC-P's effect on LTPA and clarity on exposure preceding outcome.

Some limitations of our study need to be discussed. Despite the unpredictability of enrollment of cities into the program which mimicked random selection of study participants into intervention groups, biases are still possible. The effect of city-level AC-P on LTPA among women may be biased towards the null hypothesis of no association for two reasons. First, AC-P implementation was incomplete for most cities

**Table 4**  
Adjusted odds ratio of reaching leisure-time physical activity guidelines according to knowledge of AC-P and covariates.<sup>a</sup>

|                                      | Reaching LTPA guidelines (%) | Odds ratio          | 95% confidence interval |       |
|--------------------------------------|------------------------------|---------------------|-------------------------|-------|
|                                      |                              |                     | Lower                   | Upper |
| Age (years)                          |                              |                     |                         |       |
| 16–34                                | 30.3%                        | 1.05                | 0.92                    | 1.21  |
| 35–54                                | 24.9%                        | 0.96                | 0.83                    | 1.10  |
| 55+                                  | 22.2%                        | 1.00                |                         |       |
| Gender                               |                              |                     |                         |       |
| Men                                  | 31.1%                        | 1.78 <sup>b</sup>   | 1.61                    | 1.98  |
| Women                                | 21.4%                        | 1.00                |                         |       |
| Education                            |                              |                     |                         |       |
| <High school                         | 22.1%                        | 1.00                |                         |       |
| High school grad                     | 34.3%                        | 1.57 <sup>b</sup>   | 1.39                    | 1.78  |
| College or more                      | 40.9%                        | 2.16 <sup>b,c</sup> | 1.75                    | 2.66  |
| Socioeconomic status                 |                              |                     |                         |       |
| Lower                                | 18.8%                        | 1.00                |                         |       |
| Higher                               | 27.5%                        | 1.29 <sup>b</sup>   | 1.10                    | 1.50  |
| Marital status                       |                              |                     |                         |       |
| Single, separated                    | 27.5%                        | 1.16 <sup>b</sup>   | 1.05                    | 1.29  |
| Married or cohabiting                | 24.7%                        | 1.00                |                         |       |
| Smoking                              |                              |                     |                         |       |
| Former/current                       | 22.9%                        | 1.00                |                         |       |
| Never                                | 28.3%                        | 1.15 <sup>b</sup>   | 1.02                    | 1.28  |
| Mean time to LTPA locations          |                              |                     |                         |       |
| < 12 min                             | 28.0%                        | 1.10                | 0.99                    | 1.22  |
| 12+ min                              | 23.9%                        | 1.00                |                         |       |
| Knowledge of AC-P                    |                              |                     |                         |       |
| Haven't seen nor heard about AC-P    | 19.8%                        | 1.00                |                         |       |
| Seen or heard about an AC-P activity | 29.1%                        | 1.50 <sup>b</sup>   | 1.34                    | 1.69  |

Pernambuco, Brazil 2011–2013.

<sup>a</sup> Odds ratio estimated from the random effects regression model with knowledge of AC-P as main exposure and other seven adjusting covariates.

<sup>b</sup> Odds ratio significant (p-value ≤ 0.05).

<sup>c</sup> Odds ratio trend is significant (p-value ≤ 0.05).

exposed to AC-P during the study follow-up time (i.e., less than three years). Only 24.1% and 53.7% of the respondents were in cities with "fully" implemented AC-P (i.e., construction and organized activities) by end of 2011 and 2013, respectively. We hypothesize that the AC-P impact on LTPA will be stronger in the future, as more cities enroll in the program and cities enrolling earlier experience longer duration of exposure. Second, in the measurement of city-level AC-P, we assume that all residents in a city with an AC-P site are exposed to the intervention, but program capacity is limited and people living far from the AC-P facility are unlikely to be exposed to the program. Though inclusion of "mean time to LTPA locations" adjusted for bias in analysis due to accessibility to an AC-P site, only 60% of survey respondents knew their travel time to an AC-P site.

Conversely, the estimated AC-P effect on LTPA among women could have been lower due to selection bias. Cities that enrolled in AC-P sooner may have been more likely to be physically active than cities that did not enroll or enrolled later because of their pre-intervention difference in LTPA related factors (e.g., recreational public space, community engagement around physical activity). Larger cities that tend to have better administration and more funds to implement public programs may have enrolled more in AC-P than smaller ones. However, including in regression models city population size as a variable with equal number of participants in each of three groups did not change magnitude or statistical significance of study findings (data not shown in tables). Furthermore, if the program per se offers around 100 min per week of activity for the participants, we should expect that participants are more active than non-participants. However, the median time spent on LTPA was 240 min per week greater in AC-P participants than 'never' participants. One could also argue that AC-P participants were already more prone to

be active and that their higher activity level are due to self-selection bias.

Recall bias and social desirability in the measurement of LTPA, participation in AC-P and knowledge of AC-P may bias the associations of the latter two variables with LTPA (Hallal et al., 2010b). These biases may only be minimized by adjusting effect measures for all predictors of LTPA.

The rapid expansion of AC-P to all cities in the state precluded the random assignment of subjects into comparison groups. Although randomized experiments are considered gold standards, researchers have recently questioned its use to evaluate complex community interventions, policies (laws) and system changes (Concato et al., 2000; Habicht et al., 1999; Craig et al., 2008; Santos and Victora, 2004). Our study combines design elements other than randomization into groups that may render a non-randomized experiment as valid and useful (Craig et al., 2008): (a) evaluate the impact of a “real world” intervention on population-level of LTPA while scaling it up; (b) incorporate objectively measured comparison groups with different levels of intervention; (c) assure that exposure to intervention precedes outcome; (d) measure individual and city-level effects of the intervention on the outcome; and (e) use a validated measure of physical activity (Hallal et al., 2003) with well-established measurement properties (Craig et al., 2003).

A key strength of AC-P is the reduction of inequalities in physical activity. Worldwide and in Brazil, multiple surveys show that men are more active than women, education is directly related to LTPA, and individuals of low socioeconomic status are less likely to engage in LTPA (Hallal et al., 2012). AC-P tends to attract more women than men, mostly low-income individuals, and middle-aged and older adults (Reis et al., 2014). In the long-term, with the consolidation of AC-P across the entire state, inequities in LTPA may be reduced.

Physical activity has been identified in Brazil and Latin America as one of five priority risk factors for preventing chronic non-communicable diseases and promoting health (Malta et al., 2011). Based on the evaluations of AC-R, Brazil's Ministry of Health created Academia da Saude (AS) (Malta and Barbosa da Silva, 2012). AS is similar but more comprehensive than AC-R. Over five years, AS will fund construction of program sites in 4000 municipalities to offer physical activity classes and promotion of healthy eating. The unprecedented scaling up in Brazil of this community-based strategy relies on coordination and shared decision-making among federal, state, and municipal spheres, as well as active community participation characteristic of Brazil's Unified Health System (SUS) (Elias and Cohn, 2003) AS could potentially help Brazil reduce two-thirds of all deaths due to non-communicable diseases (Malta et al., 2011).

## 5. Conclusions

In summary, AC-P, a community-based, professionally supervised physical activity intervention, reaching 134 out of 184 cities of Pernambuco in Brazil positively impacted on population levels of LTPA among women. Evaluation of complex programs like AC-P is feasible, with creative study design and the flexibility, to quickly fund and operationalize the study. A modified version of AC-P has been adopted in California, suggesting the prevention potential for this model in the United States (Institute for Behavioral and Community Health, 2010, 2012). In order to evaluate AC-P's full population impact, we recommend extending the follow-up period for LTPA and measuring improvement in health status. The AC-P experience in Brazil may be a model for scaling up interventions around the world to tackle the pandemic of physical inactivity.

### Conflict of interest statement

The authors declare that there are no conflicts of interest.

## Transparency document

The Transparency Document associated with this article can be found, in the online version.

## Acknowledgments

We thank Emmanuely Correia de Lemos, José Cazuza de Farias Júnior and the staff of UFPEL, MS, IMIP/PE, UFPR and the AC-P for their contribution and assistance with monitoring of intervention. The authors would like to thank Prof. Cesar Victora for commenting on drafts of this article and Allison Miller for her editorial work. This study was funded through the CNPq (grant number: 552752/2011-8). The Institutional Review Board of the UFPEL approved this study.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.ypmed.2016.09.032>.

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