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Associations of neighborhood socioeconomic, natural and built environmental characteristics with a 13-year trajectory of non-work physical activity among civil servants in Rio de Janeiro, Brazil: The Pro-Saude Study

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ABSTRACT

Positive influences of natural and built environment characteristics on human physical activity have been observed mainly in high-income countries, but mixed results exist. We explored these relationships in Rio de Janeiro, Brazil, where exuberant nature coexists with high levels of social inequality and urban violence. Data originated from questionnaires self-administered by 1731 civil servants at university campuses who participated in 4 waves (1999, 2001, 2007, 2012) of a longitudinal study, and had their residential addresses geocoded. In multinomial regression models, adjusted for individual sociodemographic characteristics, mutually adjusted associations were estimated between 13-year trajectories of non-work physical activity and 8 contextual variables: distances from waterfronts, cycle paths, outdoor gym equipment, and squares; 2 indicators of exposure to greenness (a vegetation index - NDVI - derived from satellite images, and trees close to home); an indicator of walkability (street density), and neighborhood average income. Compared to participants living in the upper quartile of distance to waterfronts, those living in its lowest quartile had 2.6-fold higher odds (aOR: 2.62, 95% CI: 1.37–5.01) of reporting non-work PA in all 4 study waves. Similar results were observed in relation to distance to cycle paths; no independent associations were observed with other natural and built environment variables.

1. Introduction

Physical inactivity, increasingly recognized as a global pandemic, is a leading risk factor for noncommunicable diseases. The World Health Organization member states have agreed to reduce it by 10% by 2025 (WHO, 2013); despite existing efforts, however, evidence of improvements in prevalence is still scarce, and national physical activity policies are operational in only 56% of countries. In low- and middle-income countries (LMIC) physical inactivity is higher in urban settings (Sallis et al., 2016a, 2016b), which is of concern since the projected world population growth is expected to be concentrated in LMIC cities (UN, 2018).

Physical inactivity is not the consequence of individual attributes and choices alone; rather, it is also associated with characteristics of the built environment (e.g. Popkin et al., 2005; Foster et al., 2008; Sallis and Glanz, 2009; Renalds et al., 2010; McCormack et al., 2011; Bancroft et al., 2015; Sallis et al., 2016a, 2016b). Evidence is still mixed, but in general, studies conducted in high-income countries, such as the USA, Canada, Australia, and countries in Western Europe, tend to revealed that characteristics of urban space influence physical activity participation. Higher levels are observed in regions that have interconnected streets, which facilitate access to services, parks and recreational areas (Bauman, 2012; Heath, 2006; Sallis et al., 2016a, 2016b). Perceived safety and better traffic conditions, besides the presence of sidewalks, adequate urban street lighting, cycle paths, trails, green space and aesthetic landscapes have been also associated with physical activity (Bedimo-Rung, 2005; Pereira et al., 2012; McMorris et al., 2015). More specifically, with regard to green spaces and parks, several studies showed that physical activity is associated with access and ease for undertaking physical activity, low or zero cost, contact with nature, low

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air pollution, and sharing space with other physically active individuals (Bedimo-Rung, 2005; Nieuwenhuijsen et al., 2017).

Sallis et al. (2016a, 2016b) observed similar results in associations between the urban environment and leisure-time physical activity in 14 cities of middle-to-high income countries. Despite advances in knowledge, however, the vast majority of studies focused on high-income countries and fail to encompass a broader variety of urban environments. In addition, a large proportion of studies are based on measures of residents´ perceptions of the urban spaces in which they live, and do not consider the objective characteristics of those spaces (Sallis et al., 2016a, 2016b). Much inconsistency of results remain: Lachowycz and Jones (2011) observed that among studies examining the relationships between access-related measures of local green spaces and physical activity, only 40% found direct associations. In contrast, in a systematic review, Fong et al. (2018) found strong evidence about the positive role of exposure to greenness on levels of physical activity

In Brazil, classified by the World Bank as an upper middle-income country, (https://data.worldbank.org/country), there was an annual increase of 1.9% between 2006 and 2012 in self-reported leisure-time physical activity in capital cities; nonetheless, 48% of Brazilians living in those cities reported physical inactivity, more frequent among women (52%) than men (42%), and among older and less educated individuals (Mielke et al., 2014). A review by Bauman (2012) indicated the growth of related research in Brazil, mostly limited on subjective perceptions; moreover, results were inconsistent among those incorporating objective measures. (Hino et al., 2011; Reis et al., 2013).

To our knowledge, no such investigation has been conducted in Rio de Janeiro, Brazil´s second-largest city (1204 km^2), with a population of 6,5 million inhabitants (IBGE, 2010). Rio's exuberant nature includes a world-famous coastline, and plenty of other public open spaces, in principle favouring the adoption of healthy lifestyles, particularly physical activity. However, access and utilization of such spaces have been hindered by deeply rooted social and racial inequalities, as well as by pervasive urban violence.

From the mid-18th century until 1960, Rio was Brazil's capital city. After Brasilia was inaugurated, its participation in the national economy gradually declined, but still remained a highly influential political and cultural hub. Following the 1964 civil-military coup d'état, repression of leaderships and institutions opposing the regime was particularly fierce in Rio, opening political spaces for clientelistic groups to hold local power (Osorio and Versiani, 2016). Among other consequences of those historical, socioeconomic and political processes, in combination with unique geographical features, 22% of the city population ended up living in informal settlements (compared to 6% nationwide), mostly slums. During the last decade, population in those settlements grew 19%, in contrast with a 5% growth elsewhere in the city (IBGE, 2011). Slum dwellers have less access to adequate water and sanitation, average income is less than one third of other areas, and their life expectancy is much lower (Szwarcwald et al., 2011). Differently from the territorial distribution of poorer neighborhoods in other regions, in Rio those areas are dispersed (Snyder et al., 2014), including multinucleated "heat islands" (Peres, 2018).

In recent years, Rio has been under additional and complex territorial transformations, causing changes in its natural and built environment associated with multi-billion investments in infrastructures for several mega sporting events (2007 Pan American Games, 2014 World Cup, 2016 Olympics). Critics argue (e.g. Gaffney, 2010; Sanchez and Broudehoux, 2013) that a coalition of politicians and private entrepreneurs imposed temporary regimes of extra-legal governance that transformed Rio social space. Finally, escalating drug-related gang violence (Perlman, 2006) strongly contributes to the deterioration of Rio's population quality of life, thus negatively affecting health and health-related behaviours such as physical activity.

Investigating the experiences of a population exposed to such complex environment may contribute to the improve the understanding of the role of contextual determinants of physical activity. The objective of this study was to estimate associations of neighborhood socioeconomic, natural and built environmental characteristics with a 13-year trajectory of non-work physical activity among civil servants living in the city of Rio de Janeiro, Brazil.

2. Materials and methods

2.1. Study design and population

The longitudinal Pro-Saude study focuses primarily on social and psychosocial determinants of health and health-related behaviours of civil servants at several campuses of a university in the State of Rio de Janeiro, Brazil. All non-faculty administrative and technical employees except those relocated to another institution or who were on a non-health leave were eligible and invited to participate.

Data were collected using self-administered multidimensional questionnaires applied close to participants' workplaces by trained personnel. Methods were employed that ensured the quality of the information and data collection and processing (e.g., Chor et al., 2003; Faerstein et al., 2005).

The current analyses drew on data collected from 1731 individuals living in the Municipality of Rio de Janeiro (80% of total), who participated in all four waves of data collection (1999, 2001, 2007, 2012), and who had address information that could be geocoded, provided information on non-work physical activity (PA) and were not prevented from performing usual activities for health reasons.

2.1.1. Outcome variable

A variable was created to jointly represent the study participants' longitudinal trajectory of self-reported non-work physical activity (PA), assessed across the 4 study waves by dichotomous responses (yes vs. no) to the same question:*"In the past two weeks, have you done any physical activity to improve your health, physical condition or for aesthetic or leisure purposes?"*. In a pilot study involving 89 temporary civil servants at the same university campuses, the estimated bias-adjusted kappa coefficient (Byrt et al., 1993) was 0.95 (95% CI 0.98–1.00) for the test-retest dichotomous responses to the question. For analytic purposes, the PA longitudinal trajectory was classified into three outcome categories: No PA in all 4 study waves; PA in 1, 2 or 3 study waves, and PA in all 4 study waves.

Participants' sociodemographic characteristics (individual independent variables) were assessed in the first study wave: sex (male, female); age in years (categorized into < 40, 40–49, 50–59,60 + years); skin color/race (white, mixed race, black, other); education (elementary or less, high school, college or more); family income *per capita* in monthly minimum wages (MW, categorized into < 3 MW, 3–6 MW, > 6 MW); marital status (never married, married, separated/divorced, widowed).

Characteristics of the natural and built environment surrounding participants' homes, as well as their neighborhood average income were included in the study as contextual independent variables: First, participants´ residential addresses were geocoded using the georeferencing function of the Application Programming Interface – API of Google Maps. The API yielded the latitude and longitude of reported addresses using the Google Maps database. Subsequently, contextual variables were obtained from 3 different sources, as follows:

a) *Digital maps databases provided by Instituto Pereira Passos (IPP, Rio de Janeiro Municipality)*:

- Proximity to waterfronts, cycle paths, outdoor gym equipment, and squares: Euclidean distances (in meters) from residences;
- Street density: an estimate of walkability, this indicator considered a circular buffer of 800 m centred at participants´ homes, equivalent to a 10-min walk, suggested as maximum walking distance for a pedestrian-friendly environment (Gori et al., 2014), being the sum