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ENVIRONMENTAL FACTORS INFLUENCING THE ELDERLY'S USE OF PUBLIC SPACES IN MADRID

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I. INTRODUCTION

The aging of the population, understood as a heterogenous process with the accumulation of molecular and cellular damage that leads to the gradual reduction of physical and mental capacities (World Health Organization, 2015) is a challenge for XXI century cities. It depends on a serious of factors, be these social, economic, lifestyle, genetic predisposition or the environment (World Health Organization, 2001).

The concept of active aging is "the process of optimizing opportunities for health, participation and security in order to enhance the quality of life as people age" (United Nations, 2002) emerged from the "Madrid International Action Plan on Aging". One of its determining factors is the physical environment, since spaces which are adapted to meet the needs of the elderly can affect their level of dependence, social isolation, mobility issues and sedentarism (Noncommunicable Diseases and Mental Health Cluster - NMH, 2002). In this context, the "Global Network for Age-Friendly Communities and Cities" appeared in 2010, whose main goal is the creation of integrating, safe and accessible urban environments (IMSERSO, 2017).

The main causes of morbidity among the elderly are related with cardiovascular diseases with sedentarism and stress included among the risk factors. Some authors have proven that infrastructure in neighborhoods to do physical activities is associated to a 38% reduction of type two diabetes (Auchincloss, 2009), while the lack of security in the neighborhood affects stress, leading to the elderly restricting their movements and isolating themselves (Beard et al., 2009). For many elderly people, public spaces play an important role in overcoming loneliness and isolation (Arup et al., 2015).

The goal of this research, while seeking to contribute towards active and healthy aging, is identifying environmental and design factors that affect the elderly's use of the public space, using a quantitative-qualitative method which combines environmental and design variables along with the perception of the elderly.

This work is part of the "Thermal and Acoustic Comfort Perception of the Elderly in the Public Space of Madrid" study, from which some preliminary results were published during the 14th National Environment Congress (Baquero Larriva & Higueras García, 2018).

II. THEORETICAL FRAMEWORK

In 1960, Lynch (1998) stated that no element of the city is experienced by itself, but rather this occurs with regard to its surroundings, while in 1971, Gehl (2001) emphasized the need of understanding human physiology to create urban environments that matched their needs. The first environmental gerontology studies appeared around 1970, analyzing the influence of interactions between the elderly and their surroundings (Lawton & Powell Nahemow, 1973; Lawton, 1985).

Whyte (1980) used direct observation through photographs, videos and notes to describe the use and behavior of New York's urban squares. Other authors have used this methodology adding measurements of environmental parameters and surveys to analyze the use of public spaces. Nikolopoulou & Lykoudis (2007), for instance, studied two public spaces in Athens, where 15% of the users were elderly people, and a strong relationship between the microclimate and the use of these spaces was proven. Likewise, Urrutia del Campo (2001) analyzed the physical, functional and climatic characteristics of three Madrid squares, finding a relationship between physical and environmental conditions and the way the public space is used. In this case, the elderly represented 11%. Meanwhile, Lai et al. (2014) analyzed a square and a park in Wuhan, China, where the elderly represented the highest percentage of users, emphasizing the need of designing these spaces considering their needs. In this case, they found that thermal comfort was the most influential factor in the use of these.

On the other hand, Sánchez-González et al (2018) establish that proximity and the frequency of visits to natural settings and public spaces build social relationships among the elderly, keeping them more active and capable, as these generate a sense of connectivity, belonging and environmental identity, determined by the interaction, exposure and perception of the environment, favoring active and healthy aging in the place (Vidal & Pol, 2005; Maas et al., 2009; Sugihara & Evans, 2000). In this context, it is important to identify which factors affect the use of public spaces by the elderly and how a good bioclimatic urban design can foster active aging using spaces that meet their needs.

III. METHODOLOGY

A mixed methodology has been used that includes measurements of environmental parameters, observations and interviews. Fieldwork was done once a month, from May to December 2018 at three different points within each public space. It was carried out for fifteen minutes for each one, twice a day between 10am and 6pm since these are the busiest times. A PCE-322 A sound-level meter has been used to measure noise levels. It had a frequency of 31.5-8 Hz, measurement of 30-130 dB and a precision of ±1.4 dB. A HOBO UX100 datalogger thermo-hygrometer was used for temperature and humidity,

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with a precision of ±0.21°C for temperature and of ±2.5% for relative humidity. A Proster MS625A digital anemometer has been used to measure the wind speed, while the Sky View Factor (SVF) has been calculated using fisheye (180°) photography and Rayman 1.2 software.

A questionnaire prepared based on a revision of the bibliography (Table N°1) was used for the interviews and a test period (November 2017 to April 2018), focused on the physical environment as one of the determining factors of active aging. In addition, the people present at each point during each measurement have been recorded, both those who stay there and those passing through. This was done by direct observation and using photographic records (Whyte, 1980; Urrutia del Campo, 2001; Katzschner, Bosch & Röttgen, 2006; Nikolopoulou & Lykoudis, 2007).

Finally, the statistical analysis with a 5% degree of significance has been made using (*Kolmogoroy-Smirnov*) data normality tests, choosing the corresponding tests as the Pearson correlation to measure the degree of relation between those who stay (number of people) and the environmental variables (Ta, HR, dB, wind speed, SVF); meanwhile, the Spearman correlation coefficient was used to establish the relation between those staying and the environmental perception (thermal sensation, thermal preference, humidity perception, wind, noise level and noise discomfort); the *Mann Whitney U* non-parametric test was used to identify relations between those who stay and the time of day (morning/afternoon), the gender and the design elements; the *Kruskal Wallis H* non-parametric test was used to identify the relation between those staying and the site, point of measurement and season of the year; the chi-squared parametric test was used to define the association between the gender of the interviewee and the activity, frequency, time and preference. Finally, a multivariate statistical analysis was made via multiple regression to determine the degree in which the environmental factors condition the use of public space by the elderly.

Table N°1. Survey form. Source: (Baquero Larriva & Higueras García, 2018)

IV. CASE STUDY: ARAPILE NEIGHBORBOOD (MADRID)

Madrid is located at 667 masl, and its Mediterranean climate is characterized by dry hot summers, with mean temperatures between 6°C in winter and 24°C in summer, reaching peaks of over 30°C (AEMET, 2011). The Arapiles neighborhood in the Chamberi district was chosen because of its aging (24.19%), over-aging (37.89%) and density (418 inhab/Ha), which are the highest in the city. Finally, three public spaces with different characteristics were identified in the neighborhood (Figure 1), a park, a square and a street, bearing in mind their proximity to old-people's homes, schools and health centers (Table N°2).

Figure 1. Location of Madrid and the studied sites: a) Madrid; b) Chamberi district, Arapiles neighborhood and the chosen public spaces. Source**:** (Baquero Larriva & Higueras García, 2018).
Table N°2. Characteristics of the analyzed public spaces. Source: Own preparation.

V. RESULTS AND DISCUSSION

200 old people were interviewed, 54% of which were women. A summary of the environmental parameters measured can been seen in Table N°3, while Figure 2 presents the spatial location of each one of the three measuring points within each site, the zoning, as well as an example of their sky view factor (SVF).

Table N°3. Summary of the environmental variables measured in the different seasons of 2018 in the Arapiles neighborhood, Madrid. Source: Own preparation using onsite measurements.
Figure 2. Measuring and zoning points of each public space and sky view factor (SVF). a) Conde del Valle de Súchill Square (PCVS); b) José Luis Sampedro Park (PTG); *c) Vallehermoso Street (CVH).* Source: (Baquero Larriva & Higueras García, 2018).

The presence of elderly people has been analyzed, counting both those who stayed onsite (stays) and those passing through. From all the users recorded in these spaces, 21% were elderly and they represented 18.66% of the stays (Figure 3), while the rest were adults, children and adolescents.

Environmental factors

No significant differences have been found considering the stays and the time of day (morning/afternoon), although the afternoons in both summer and winter had the lowest percentage of elderly people (Figure 3), coinciding with the times with the highest and lowest temperatures, respectively; however, there were no significant differences ($p>0.05$) related to the seasons. While, in a first analysis between the stays and the environmental variables (Table N°4), a weak positive correlation was found with the mean, minimum and maximum temperature; a weak negative with the mean and minimum relative humidity, as well as a weak positive with the wind speed ($p<0.01$), which would explain the former. The highest number of stays is seen within a temperature range of between 19.31°C and 29.98°C (Figure 4a), where a mean temperature of 28.94°C had the highest presence while the lowest presence was seen when the minimum temperatures were below 16.94°C. Stays meanwhile, are more frequent with a relative humidity of 51.35% upwards (Figure 4b) and drop when the wind exceeds a maximum speed of 1.86 m/s (Figure 4c).

Figure 3. Stays of elderly people at the different sites: a) Conde del Valle de Súchil Square (PCVS; b) José Luis Sampedro Park (PTG); c) Vallehermoso Street (CVH). Source: Own preparation using fieldwork and Google Earth.
Table N°4. Statistical tests, relation between variables and differences. Source: own preparation

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Figure 4. Stays of elderly people depending on: a) mean air temperature, b) mean relative humidity, c) maximum wind speed. Source: Own preparation using onsite measurements.

These results coincide with the study of Nikolopoulou & Lykoudis (2007) who demonstrated a strong relation between the microclimate and the use of open spaces; they also emphasized the difference of the thermal sensitivity of the elderly as their presence fell significantly in summer. Other studies have also found that the perception of general comfort is related with the activity in public spaces (Sallis et al. 2007; Lai et al. 2014; Vidal & Pol 2005; Maas et al. 2009; Sugihara & Evans 2000).
A multiple linear regression analysis has been conducted to establish the degree in which these factors could predict the stays of the elderly onsite. It was found that the only significant factor is the maximum wind speed, with a low determinant coefficient of R^2=7%, using the following model: **Stays**=0.175+1.64 (Vv m/s).
As for the frequency of the visits, 46% go daily, while 24.5% do so several times a week. Only 39% pass through to head to another destination, while 25.5% stay for around 15 minutes, 21% for 30 minutes and 14.5% for more than an hour. The most common activity of the elderly in these spaces is walking (40%) and resting (28%). To provide a better analysis, this has been divided into three activities (Figure 5), where 50% corresponds to physical activity, 48.5% to passive activities and 1.5% to social activities. However, it must be considered that most of the people interviewed were accompanied, thus, although their main activity was not social, this would be combined with others, which highlights what has been said by several authors about the importance of suitable friendly urban environments to increase the opportunities for physical and social activity, managing to promote the participation and integration in old age (Sánchez-González, 2013; Schaie & Pietrucha, 2000; Lawton, 2001).

Figure 5. Type of activities performed by the elderly in public spaces. Source: Own preparation from interviews.

With regard to the thermal preference and sensation, 74.5% of those interviewed were within what is known as the comfort zone (ASHRAE, 1992), which could be improved by microclimatic control, using urban passive conditioning techniques (Higueras, 2006). Many studies agree that thermal sensitivity reduces with age, with this being one of the factors that makes the elderly vulnerable to thermal extremes (Guergova & Dufour 2011; Blatteis 2012; Baquero Larriva & Higueras García 2019,Schneider et al. 2017).
In terms of the perception of the noise landscape, 77.6% of those interviewed considered it was pleasant, 16% found the birdsong pleasurable and 10% felt the same for the water fountain. The latter was the location where the highest number of elderly people was recorded (Table N°5). Meanwhile, 36% highlighted the sound of the traffic as unpleasant, with the street recording the lowest presence. On the other hand, it is interesting to point out that, despite mean noise levels of up to 77 dB (A) and maximum levels of up to 108 dB (A) being recorded, over the limit of 65 dB allowed for residential areas and levels which are considered harmful for the health (Head of State, 2003), 70.5% were not bothered by the noise. The limited discomfort caused by the noise, in some studies is attributed to the loss of hearing sensitivity which makes the elderly more tolerant to it (Miedema & Vos, 1999; Yu & Kang, 2008). Others explain this through the psychological factor of expectation, which reduces the discomfort caused by noise that is expected to be present in a given place, like is the case of the street in a city like Madrid (Ge & Hokao, 2005; Bruce & Davies, 2014).

Design elements of the public space

Outdoor spaces are difficult contexts to analyze, as it is impossible to completely separate one of the diverse variables they are comprised by (Lynch, 1998), to establish a cause and effect of the use of these spaces by the elderly. For this reason, these spaces have also been analyzed regarding design criteria (Table N°5) which fit the needs of the elderly (Ayuntamiento de Madrid, 2015; Pozo Menéndez, 2019; Fariña, Higueras & Román, 2018; World Health Organization, 2007), both statistically (Table N°7) and as a perception of the quality of these spaces (Figure 6).

Table N°5. Design characteristics, stay and comfort results in each point of measurement. Source: own preparation

The statistical analysis shows significant differences ($p<0.05$) regarding the stays between the analyzed public spaces, especially between the square which has the highest affluence and the other two spaces (Table N°4). Likewise, there are significant differences ($p<0.05$) both in the PTG park and at the PCVS square between the points and these are physically shown considering the elements these comprise (Table N°5), while, in the street there are no significant differences in any of its points ($p>0.05$). It was found that the most determining physical elements (Table N°6) are benches, water features, exercise areas for the elderly and the children's playground, some matching the results of evaluations of friendly cities (Arup et al., 2015; Ayuntamiento de Madrid, 2015). It must also be highlighted that there is vegetation in all the studied spaces.
As a result, the areas with more elements and a greater diversity in use are the points with the highest number of people staying, with point 2 of the PCVS square, which has all these elements (Table N°5) and which coincides with the preference areas, having the highest affluence. 74% of the elderly preferred areas where there were benches to sit on, 6.8% where there were playgrounds and 4.9% with exercise areas for them, also reflected in the distribution of these users (Table N°5, Figure 3), as the playgrounds are areas with a higher presence of elderly just as seen in the study of Lai et al. (2014), and Urrutia del Campo (2001), where the areas with a greater range of activities had the highest presence.

Figure 7. General perception of the space: a) factors considered as unpleasant for the elderly; b) factors considered as pleasant for the elderly. Source: Own preparation from interviews.

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On the other hand, the lack of cleanliness (29.5%) is considered as the most unpleasant aspect (Figure 6a). Meanwhile, 9.5% have a sense of insecurity, above all in point 2 of the PTG park (people drinking), while 12% feel that there is a lack of green areas. With regard to pleasing aspects (Figure 6b), the perception of a pleasant and clean environment (Beard et al., 2009) stands out. Vegetation with 27.5% falls within this. This is backed by the results of some studies which identify green areas (Vidal & Pol, 2005; Maas et al., 2009; Sugihara & Evans, 2000; Sánchez-González, Rivera Adame & Rodríguez-Rodríguez, 2018; Takano, Nakamura & Watanabe, 2002), aesthetics, access to areas to walk in, parks, playgrounds, safety, upkeep as factors which affect physical activity in the public spaces (Hekler et al., 2012; Buman et al., 2013; Choi et al., 2017; Kerr, Rosenberg & Frank, 2012). Finally, in terms of gender, a significant correlation was only found with the perception of the site's humidity (Table N°4). However, in this study, women stayed longer in each public space, walked more and the men rested more (Figure 6). Likewise, women liked having more vegetation, while men valued the tranquility of the neighborhood more (Figure 6).

VI. CONCLUSIONS

This study has analyzed the factors of the physical environment that affect the use by the elderly of three public spaces in Madrid. It was found that the elderly represents 21% of the users, 18.66% of the stays, that most visit the site daily and 50% do physical activities like walking. In terms of gender, no significant differences were found in any of the variables; however, women stayed longer and walked more in these spaces.

The environmental factors like temperature, relative humidity and wind speed, as well as the discomfort caused by noise, are factors which affect the stays of the elderly in public spaces; however, only the wind speed is significant within a regression model. A temperature preference range of between 19.31°C and 29.98°C can be considered. This provided the highest percentage of the stays, where 74.5% of the interviewees felt comfortable.

The stays of the elderly have significant differences between the spaces. It was found that the most determining design elements are benches, water features, water fountains, exercise areas for the elderly and playgrounds, with the latter one of the areas having the highest presence of the elderly both in the square and in the park, which contributes to the intergenerational social exchange and matches what has been recommended by several prior studies.

Analyzing outdoor spaces is a complex task due to the great number of variables involved; however, this study shows that public spaces foster vitality in old age as locations for physical and social development, which are essential for improving their quality of life, promoting an active and healthy aging. The importance of the environmental variables and their control by means of a suitable design stands out, having to bear in mind the physiological changes related to aging that can affect thermal and hearing sensitivity, making the elderly more or less tolerant to certain environmental parameters and increase their vulnerability to the effects these have on their health. Finally, important lines of work are opened to face the challenges of cities in the XXI century to adapt their spaces to the demographic change.

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