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The Sitting Time of the Elderly of More than 60 Years in European Cities: The Neighborhood, Street Network, Vehicle Ownership, and Socioeconomic Determinants

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Abstract

There are inadequate studies on the correlations between the sitting times of the elderly and the subjective and objective land use and neighborhood around their homes, especially the street network. Thus, the objective of this paper is to clarify these connections in six European countries of Grandola, Portugal; Sassari, Italy; Thessaloniki, Greece; Krakow, Poland; Zagreb, Croatia; and Malatya, Turkey. The present paper answers the following questions: (1) how correlated are perceived land use and vehicle ownership with the sitting times of the elderly in European countries? (2) are the sitting times of the elderly in European countries significantly different? And (3) are the sitting times of the elderly significantly different across personal and health classes? The primary data used in this study include 1018 subjects (394 males and 624 females with ages between 60 and 96 years), collected by a survey instrument including the "International Physical Activity Questionnaire" and the "Assessing Levels of Physical Activity and Fitness at Population Level" project questionnaire, as well as some variables about personal, household, and socioeconomic factors. Statistical methods like multivariate Ordinary Least Squares modeling, Kruskal-Wallis test of independence, T-test, and Multinomial Logit Regression were applied to answer the questions. The results show that the perceptions of the elderly of more than 60 years about the neighborhood surrounding their home place, as well as their accessibility, perceived walking and biking facilities, and availability of car and bike are among the significant correlates of sitting times. Moreover, the sitting times of the respondents in Italy and Greece are significantly more than the counterparts in other countries. Finally, there are significant differences among the sitting times of the elderly across the levels of hampering in daily activities, work status, education level, and marital status, but there is no significant difference between the sitting times of elderly men and women. These results particularly emphasize on the effectiveness of urban design and a human-oriented built environment on the sitting behavior of the elderly in the European context.

Keywords: Sitting time; urban transportation; travel behavior; physical activity; street network; land use.

1. Introduction

Several studies show an association between total daily sitting time and the risk of all-cause mortality (Chau et al. 2013). According to Benatti and Ried-Larsen (2015), the significant impact of sedentary behavior on the increased risk of all-cause mortality among adults is evident. The relationship between SB, mortality, and cardiovascular disease is not always clear (Stamatakis et al. 2019). Although the association between total daily sitting time and the risk of all-cause mortality is unclear, higher levels of total daily sitting time are correlated with an increased risk of cardiovascular disease and diabetes (Bailey et al. 2019).

Several studies have assessed the associations between sociodemographic factors and sitting time (Staiano et al. 2014; Engberg et al. 2017). Engberg et al. (2017) indicated that age, education level, and sex are correlated with sedentary behavior. Older, highly educated men are more physically active than others. Another study on the socioeconomic correlates of physical activity and prolonged sitting time among Latin American countries showed that age and sex are two significant correlates of sitting time in Latin America. However, the current pattern of sitting time in Latin America is closely connected to urban development characterized by social inequalities (Luis de Moraes Ferrari et al. 2019). Gender was reported as a significant correlate of sitting time in South American cities, with girls being less physically active than boys in South American adolescents (Araujo et al. 2022). (Burton et al. 2012) argued that women, smokers, and those not working full-time spent more time sitting during leisure time.

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Wallmann-Sperlich et al. (2013) assessed the socioeconomic and environmental correlates of sitting time in Germany. According to that research, men spent more time sitting than women in Germany. Additionally, educational level and higher neighborhood safety were positively associated with sitting time in Germany. At the same time income was not a significantly correlated with prolonged sitting time in both genders. In another study conducted by Wallmann-Sperlich et al. (2014) in Germany, correlates of sitting time in the workplace were studied. Highly educated men and women, as well as young women, were identified as the most at-risk groups regarding prolonged sitting time in the workplace in Germany. The hierarchy of sociodemographic correlates of sitting time in 28 European countries was studied by (Lakerveld et al. 2017). The results of that study showed that European adults with higher socioeconomic status are more likely to spend more time in sedentary behavior. Additionally, living in large cities is one of the positively significant correlates of prolonged sitting time in Europe. However, while gender is an important correlate for sitting time, the findings of that study do not confirm a clear pattern in all European countries.

Although several studies confirm age as an important factor in prolonged sitting time (Peeters et al. 2013; Park et al. 2018; Pavey et al. 2015), the evidence in older adults is limited. The impacts of sedentary behavior on the physical and mental health of children and adolescents have been studied extensively (Hoare et al. 2016; Saunders et al. 2013), but there is a shortage of research on the correlates of sitting time in elderly people.

A growing body of research indicates that sedentary behavior increases the risk of obesity, cardiovascular diseases, and diabetes (Thorp et al. 2011; Peeters et al. 2013). Mummery et al. (2005) studied the relationship between occupational sitting time and obesity among Australian workers. According to that study, occupational sitting time was correlated with obesity in men who worked full-time. Another investigation examined the correlation between occupational sitting time and mental health in Tasmania, Australia. The findings of that study confirmed the association between occupational sitting time and intermediate levels of physiological problems. In particular, women reported high physiological distress associated with longer work sitting (Kilpatrick et al. 2013). Moreover, the impact of workplace design on prolonged occupational sitting time was examined and confirmed in Japan (Koohsari et al. 2022).

In addition to the socioeconomic correlates of sitting time, the built environment characteristics of residential areas impact people's motivation to engage in active mobility or reduce sedentary lifestyles. However, social and environmental characteristics' impacts can vary among age and gender groups or contexts. Andrade Neto et al. (2014) analyzed the association between sedentary lifestyle and living in rural or urban areas among schoolchildren in Brazil. According to the findings of that study, schoolchildren who lived in rural areas were more active and spent less time on sedentary behaviors than children in urban areas in Brazil. Environmental characteristics are important variables when analyzing PA and sedentary behavior because the practice of PA depends on suitable environmental conditions (Loucaides et al. 2004). Changes in environmental conditions may lead to changes in people's behavior towards more or less active lifestyles (Bauman et al. 2012). The expansion of urban areas is related to a decreased level of PA (Andrade Neto et al., 2014). Sprawled urban forms with less street connectivity and longer streets are associated with low levels of active mobility and increased sedentary behavior, such as driving cars (Mehriar et al. 2021; Mehriar et al. 2020). Machado-Rodrigues et al. (2014) examined physical inactivity and sedentary behavior among adolescents aged 13 to 16 years in urban and rural areas in Portugal. Urban adolescents of both sexes were more active than rural adolescents. This finding is contrary to the findings of (Andrade Neto et al., 2014). However, urban females were significantly less active than rural areas in Portugal. The findings of a study confirmed that lower walkability (PA) was significantly associated with a higher rate of spending time in cars. Additionally, prolonged sitting time in cars during leisure time was correlated with lower residential area, lower intersection density, and lower net retail ratio in Adelaide, Australia (Koohsari et al. 2014). Urbanization and the characteristics of urban form are highlighted as factors that influence PA, sedentary behavior, weight status, and

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physical and mental health in youth (Springer et al. 2006; Ismailov and Leatherdale 2010; Albarwani et al. 2009). However, there are fewer or no studies among elderly people.
A study examined the impacts of objective urban form characteristics on sitting time and non-motorized transportation modes among the elderly in Hong Kong. The results of that study illustrated that neighborhood attributes such as street lighting, public toilets, benches, and public transportation stations could potentially encourage older people to walk and stroll around residential areas, reducing sitting time and associated negative health outcomes in the elderly (Barnett et al. 2015). Another study on the relationship between objectively assessed neighborhood environmental attributes, socioeconomic features, and sedentary time among older people in Hong Kong indicated that socioeconomic factors, including age, gender, education level, and car ownership, have significant correlations with PA and sedentary time among the elderly in Hong Kong. Therefore, socioeconomic factors, rather than physical capacity and health status, should be considered when designing or planning activity-friendly environments for Chinese elderly in cities (Cerin et al. 2016). Additionally, (Cerin et al. 2013) discussed that accessibility to parks, low pollution neighborhoods, and recreational facilities was positively associated with walking and reducing sitting time among elderly residents.
Although socioeconomic and environmental correlates of sedentary behavior have been well studied, there is no clear understanding of the perceived environmental correlates of sitting time among elderly residents. There is a strong body of research and evidence regarding correlates of sitting time among children and adolescents, while elderly adults with different physical capabilities and attitudes follow different lifestyles. Considering the strong association between sitting time and mortality (Lee et al. 2012; Dunstan et al. 2011; Warren et al. 2010), there is a real need to assess land use structure and environmental features that encourage PA and reduce sedentary behavior for different socioeconomic groups, particularly older people. The evidence from land use structures and built environment characteristics on PA and sitting time could provide a clearer picture of the impacts of indoor environments on sedentary behavior for medical, public health, sports, and exercise policymakers and scientists.
The current paper contributes to the literature by assessing the association between perceived built environment characteristics and older people in six European countries, including Greece, Italy, Croatia, Poland, Turkey, and Portugal. In addition to socioeconomic factors such as age group, cultural differences in different contexts are an important factor regarding behavior studies. Most of the evidence on sedentary behavior and active lifestyle comes from Western and high-income countries, while sedentary behavior among adults in Southern and Eastern European countries has been less studied. This paper aims to fill the knowledge gap in sitting time and sedentary behavior between high-income and low-income countries in Europe. Therefore, the main aim of this paper is to determine the environmental and socioeconomic correlates of sitting time among the elderly in six European countries. Another objective of the current paper is to compare sitting time among countries and between different health classes.
For reaching the objectives, this paper consists of five main parts. 1. Introduction: The introduction provides an overview of the paper and reviews the existing literature on sedentary behavior, identifying knowledge gaps and highlighting the contributions of the current study; 2. Methodology: The methodology section describes the research analysis approach used to answer the research questions. It includes details on the data sources, variables, and research questions; 3. Findings: This section presents the key findings of the study, summarizing the results related to the environmental and socioeconomic correlates of sitting time among elderly residents in the six European countries; 4. Discussion: The discussion section provides a comprehensive analysis and interpretation of the findings. It compares the results of this study with other relevant studies to gain a better understanding of the environmental and socioeconomic factors influencing sitting time among elderly residents, and finally 5. Conclusion: The conclusion section summarizes the main

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findings. It highlights the significance of the study and suggests potential directions for future research in this area.

2. Methodology

2.1. Research questions and hypothesis

The present paper attempts to answer the following research questions: (1) how correlated are perceived land use and vehicle ownership with the sitting times of the elderly in European countries? (2) are the sitting times of the elderly in European countries significantly different? And finally, (3) are the sitting times of the elderly significantly different across personal and health classes? The hypotheses of this study are as follows: (1) perceived neighborhood attributes, objective street network factors, i.e. street connectivity, and finally vehicle ownership significantly determine the sitting times of the elderly in European cities, (2) the sitting times of the elderly in European countries are significantly different, and (3) the sitting times vary among different levels of household and socioeconomic variables including hampering in daily activity, work status, education level, and marital status, and gender.

2.2. Data and variables

The data used in this study were gathered in the fall of 2021 as part of the "Interventions in the Elderly's Mobility Modes for Promotion of their PA and Fitness" (Fit-Old) project, which was funded by the European Commission. The data collection focused on individuals aged over 60 years in six European countries: Portugal (Grandola), Italy (Sassari), Greece (Thessaloniki), Poland (Krakow), Croatia (Zagreb), and Turkey (Malatya). The data collection consisted of two main phases: baseline and follow-up. The data utilized in this paper specifically pertains to the baseline data collection conducted before the intervention.

The overall sample for this study included 1018 respondents from the six countries. The dataset was compiled by gathering information from questionnaires, calculating street network variables using ArcMap 10.4, and measuring fitness status through accelerometer data. The questionnaire covered various aspects, including socioeconomic features, travel habits, PA, and neighborhood environment. Data on PA and neighborhood environment were collected using questions from the "International Physical Activity Questionnaire" (IPAQ) and the "Assessing Levels of Physical Activity and Fitness at Population Level" (ALPHA) questionnaire.

Table 1 presents all the variables used in this paper, their quantification and coding methods in SPSS, and the variable types. Street network variables such as street length density, link density, intersection density, and link-node ratio were calculated using ArcMap 10.4. In the data collection process, respondents were asked about the nearest intersection to their home during face-to-face interviews, ensuring the privacy of participants by considering the nearest intersection instead of exact addresses. A 600-meter catchment area was then developed around each point in the GIS based on the street network. Street length density, link density, intersection density, and link-node ratio were computed for each catchment area to obtain disaggregated street network variables with higher accuracy compared to aggregated data.

Variables related to the perceived neighborhood were extracted from the questionnaire based on ALPHA questions, while sitting time was obtained from the IPAQ section of the questionnaire. Table 1 provides a comprehensive overview of these variables and their respective quantification methods. Table 2 shows the descriptive statistics of the continuous variables used in the study. The categorical and binary variables used in this study as well as their frequencies have been summarized in the appendix.

Table1. Variables in paper including quantification methods and recoding approach.

Variable	Original Variabl	Quantification Method	Recoding

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	e Type (in the Dataset)		
Work status	Categorical	Questionnaire. Categories: 1: In paid work; 2: Unemployed and actively looking for a job; 3: Permanently sick or disabled; 4: Retired; 5: Doing housework, looking after children or other persons; 6: Others	N/A
Education status	Categorical	Questionnaire. Categories:1: Up to 9 years; 2: 10-12 years; 3: More than 12 years.	N/A
Marital status	Categorical	Questionnaire. Categories: 1: Single; 2: Divorced; 3: Married/living with my partner; 4: Widow.	N/A
Hampered in daily activity	Categorical	Questionnaire. Categories: 1: Yes, a lot; 2: Yes, to some extent; 3: No.	N/A
Health status	Categorical	Questionnaire. Categories: 1: Very good; 2: Good; 3: Fair; 4: Bad; 5: Very bad.	N/A
Age	Continuous	Questionnaire. More than 60 years old.	N/A
Household size	Continuous	Questionnaire.	N/A
The numbers of years of staying in the current home	Continuous	Questionnaire.	N/A
Possession of Garden	Dummy	Questionnaire. Categories: 0: No; 1: Yes.	N/A
Possession of small sport equipment	Dummy	Questionnaire. Categories: 0: No; 1:Yes.	N/A
Possession of exercise equipment such as weights, treadmill, & stationary cycle	Dummy	Questionnaire. Categories: 0: No; 1: Yes.	N/A
Access to car	Dummy	Questionnaire. Categories: 0: No; 1: Yes.	N/A
Possession of bicycle	Dummy	Questionnaire. Categories: 0: No; 1: Yes.	N/A
Possession of dog	Dummy	Questionnaire. Categories: 0: No; 1: Yes.	N/A
Detached houses in the neighborhood	Categorical	Questionnaire. Categories: 1: None; 2: A few; 3: Some; 4: Most; 5: All.	0: None/A few/Some; 1: Most/All
Semi-detached houses or terraced houses in the neighborhood	Categorical	Questionnaire. Categories: 1: None; 2: A few; 3: Some; 4: Most; 5: All.	0: None/A few/Some; 1: Most/All
Apartment buildings or blocks of flats in the neighborhood	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20	0: 1-20 minutes; 1: More than 20 minutes

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		minutes; 4: 21-30 minutes, 5: More than 30 minutes.	
The nearest local shop: grocery shop, bakery, butcher etc.	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest supermarket	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest local services such as a bank, post office or library, …	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest restaurant, café, pub or bar	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest fast-food restaurant or takeaway	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest bus stop, tram, metro or train station	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest sport and leisure facility such as a swimming pool, sports field or fitness center	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
The nearest open recreation area such as a park or other open space	Categorical	Questionnaire. Categories: 1: 1-5 minutes; 2: 6-10 minutes; 3: 11-20 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 minutes
There are sidewalks in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
There are pedestrian zones or pedestrian trails in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
There are special lanes, routes or paths for cycling in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.

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There are cycle routes in my neighborhood that are separated from traffic	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
It is dangerous to leave a bicycle locked in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
There are not enough safe places to cross busy streets in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
Walking is dangerous because of the traffic in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
Cycling is dangerous because of the traffic in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
It is dangerous in my neighborhood during the day because of the level of crime	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
It is dangerous in my neighborhood during the night because of the level of crime	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
My local neighborhood is a pleasant environment for walking or cycling	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
There is litter or graffiti in the streets of my neighborhood	Categorical	Questionnaire. Categories: 1: None; 2: A few; 3: Some; 4: Plenty.	0: None/a few; 1: Some/plenty.
There are trees along the streets in my neighborhood	Categorical	Questionnaire. Categories: 1: None; 2: A few; 3: Some; 4: Plenty.	0: None/a few; 1: Some/plenty.
In my neighborhood there are badly maintained, unoccupied or ugly buildings	Categorical	Questionnaire. Categories: 1: None; 2: A few; 3: Some; 4: Plenty.	0: None/a few; 1: Some/plenty.
There are many shortcuts for walking in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3:	0: Strongly disagree/somewhat disagree/not applicable;

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		Somewhat agree; 4: Strongly agree; 5: not applicable.	1: Strongly agree/somewhat agree.
Cycling is quicker than driving in my neighborhood during the day	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
There are many road junctions in my neighborhood	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
There are many different routes for walking or cycling from place to place	Categorical	Questionnaire. Categories: 1: Strongly disagree; 2: Somewhat disagree; 3: Somewhat agree; 4: Strongly agree; 5: not applicable.	0: Strongly disagree/somewhat disagree/not applicable; 1: Strongly agree/somewhat agree.
Street length density around home place	Continuous	Questionnaire. The sum of street-lengths in the catchment area divided into the area.	N/A
Link density around home place	Continuous	Questionnaire. the number of links in the catchment area divided into the area.	N/A
Intersection density around home place	Continuous	Questionnaire. The number of intersections in the catchment area divided into area.	N/A
Link-node ratio around home place	Continuous	Questionnaire. The number of links in the catchment area divided into the number of intersections in the catchment area.	N/A

Table 2: The continuous variables used in the study.

Variable	N	Min.	Max.	Mean	Std. Deviation
Age	1018	60	96	71.154	5.44
Household size	1017	1	11	2.304	1.23
The numbers of years of staying in the current home	1015	1	92	24.863	17.09
Street length density around home place	547	≈0	9.83	2.489	2.18
Link density around home place	542	≈0	9.41	2.856	1.99
Intersection density around home place	542	≈0	9.80	2.394	2.20
Link-node ratio around home place	542	≈0	6.40	1.849	0.70

2.3. Analysis methods

For answering the first research question of this study, multivariate Ordinary Least Squares (OLS) modeling was applied. The dependent variable was the sitting time of the respondents and the explanatory variables were indicators of personal and household characteristics (for being controlled for), perceived and objective land use and accessibility variables, and vehicle ownership variables. In the first round of running the model, the independent variables were all the continuous and binary

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variables in Table 1 were applied. In the next rounds, the non-significant variables were taken out of the model. After several iterations, the best-quality model was generated, whereas most of the explanatory variables were significant. The levels of significance were $P<0.001$ representing highly significantly coefficients, $0.001<P<0.05$ indicating significant, $0.05<P<0.1$ representing marginally significant, and finally $P>0.05$ showing non-significance. The model validity was tested by ANOVA - F test, where $P<0.05$ indicated a valid model. The multicollinearity among the independent variables was tested by Variance Inflation Factor (VIF). Absence of multicollinearity among the variables was decided when the VIF value was between 1 and 3, so in this case multicollinearity was detected in the model. The prediction power of the model was measured by R^2, where higher values (limited to 0 and 1 or a percentage) represented a better prediction power of the model.

For answering research question 2 (finding the significant differences in the sitting times of different European countries), Analysis of Variance (ANOVA) was applied. For facilitating the comparisons among the sub-samples of all the countries with one another, Tukey HSD was applied, whereas P-values of less than 0.05 indicated significant difference between the mean value of the sitting time in one country compared to another one. Again, like the OLS modeling, the significance levels were as follows: $P < 0.001$: highly significant; $0.001<P<0.05$: significant, $0.05<P<0.1$: marginally significant, and $P>0.05$: non-significance.

Finally, the third research question was answered by applying Kruskal-Wallis test and T-test. The results of Kolmogorov-Smirnov and Shapiro-Wilk test of normality shows that the household and personal variables of hampering in daily activity, work status, education level, and marital status are non-normal, so using T-tests for findings the significant differences between the sitting times among the categories of these variables was not conducted. Instead, the non-parametric test of Kruskal-Wallis test was applied, where P-values of less than 0.001 showed highly significant difference between the mean rank of the sitting times among the categories of the household and socioeconomic variables, and values of between 0.01 and 0.05 indicate significant difference. The significance of the differences between the sitting times of the two gender classes was tested by applying T-test. The same significance levels mentioned for the Kruskal-Wallis test were applied to the T-test.

3. Findings

3.1. The perceived land use and vehicle ownership correlates of sitting time

The results of the OLS model are summarized in Table 3. According to the table, ten independent variables significantly ($0.001 < P < 0.05$) or highly significantly ($P < 0.001$) determine the sitting times of the elderly in the overall sample across different countries. These variables include household size, bicycle ownership, accessibility to a car, accessibility to restaurants, cafés, pubs, or bars, accessibility to public transportation stations, availability of pedestrian zones near the living place, availability of a pleasant environment for walking and cycling, availability of trees near the home place, respondents' perception that cycling is quicker than driving, and the availability of many routes for walking and cycling near the home place.

The analysis shows that household size is negatively correlated with sitting times, with each additional member in the household associated with an 11% decrease in sitting times. Bicycle ownership and accessibility to a car also have significant correlations with sitting time. Owning a bicycle is linked to a 15% decrease in sitting times, while accessibility to a car is associated with a 16% increase in sitting times. Accessibility to local facilities such as cafés, pubs, and bars, as well as public transportation, are also significant determinants of sitting time. Local facilities are associated with a 9% increase in sitting times, while accessing public transportation in the vicinity of the living place is correlated with an 11% decrease in sitting times. Other neighborhood-related

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variables, such as the availability of pedestrian zones, a pleasant environment for walking and cycling, and the presence of trees near the home place, also show significant correlations. The availability of pedestrian zones and a pleasant environment is linked to a 12% increase in sitting times, while the availability of trees is associated with a 9% decrease in sitting times. Respondents' perception that cycling is quicker than driving (especially for short trips) is correlated with an 11% decrease in sitting times. Finally, if respondents believe there are many walking or biking routes in their neighborhood, their sitting times may be 8% shorter.

The results of the ANOVA - F test indicate that the model is valid ($P < 0.001$). The R^2 value of the model is 16%, meaning that the model predicts 16% of the variability in the dependent variable (sedentary time). Furthermore, the VIF values demonstrate that there is no multicollinearity between the independent variables, as all values are between 1 and 2.

Table 3: OLS model for sitting times (DV) (R^2=0.16).

	Unstandardized Coefficients		**β**	**t**	**P**	**Collinearity Statistics**	
	B	**Std. Error**				**Tolerance**	**VIF**
(Constant)	2204.77	79.390		27.771	<0.001		
Household size	-70.08	19.853	-0.114	-3.530	<0.001	0.896	1.116
Bicycle ownership	-255.03	51.140	-0.154	-4.987	<0.001	0.973	1.028
Access to car	252.80	48.585	0.161	5.203	<0.001	0.975	1.026
Access to restaurant, café, pub, or bar	155.18	56.220	0.088	2.760	0.006	0.907	1.103
Access to PT stations	-245.84	71.888	-0.112	-3.420	0.001	0.863	1.159
Pedestrian zone	-172.80	48.220	-0.117	-3.584	<0.001	0.863	1.158
Pleasant environment for walking and cycling	-174.25	52.132	-0.118	-3.343	0.001	0.740	1.351
Availability of trees	-141.77	49.549	-0.094	-2.861	0.004	0.860	1.163
Cycling is quicker than driving	-161.08	45.175	-0.111	-3.566	<0.001	0.950	1.053
There are many routes for walking and cycling	-119.67	49.309	-0.083	-2.427	0.015	0.795	1.258
ANOVA - F Test							
Sum of Squares	**df**	**Mean Square**	**F**	**P**			
75577877.6	10	7557787.8	17.245	<0.001			

3.2. Sitting times in different European countries

As shown in Fig. 1, the mean sitting times of the respondents in the sub-samples vary from 1362 minutes per week to 2171 minutes in the Italian sub-sample. However, to determine the significance of these differences, a statistical test is required. As described in the methodology section, an Analysis of Variance (ANOVA) using Tukey HSD was conducted for cross-country comparison of

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sitting times, enabling a comparison of results across all countries. The test results are summarized in Table 4, where a P-value is calculated for the mean difference between the sitting times of each country (I) and those of all other countries in the sample (J).

The results indicate that sitting times in Croatia are significantly lower than those in Greece and Italy ($P < 0.001$). The sitting times in Greece are significantly or highly significantly higher than those in Croatia, Poland, Portugal, and Turkey ($0.001 < P < 0.05$), and significantly lower than those in Italy ($P < 0.001$). The Italian sub-sample has significantly higher sitting times compared to all other countries. Portugal's sitting times are significantly lower than those in Greece and Italy, but similar to those in Croatia, Poland, and Turkey. The sitting times in Poland are significantly lower than those in Greece and highly significantly lower than those in Italy. Finally, in Turkey, the respondents have significantly shorter sitting times than Greece and Italy, still their sitting times are statistically similar to those in Croatia, Portugal, and Poland.

Based on the test results, the countries in the sample can be divided into two categories. The highest sitting times are observed among Italian and Greek participants, while the participants from Croatia, Poland, Turkey, and Portugal exhibit similar levels of sitting times.

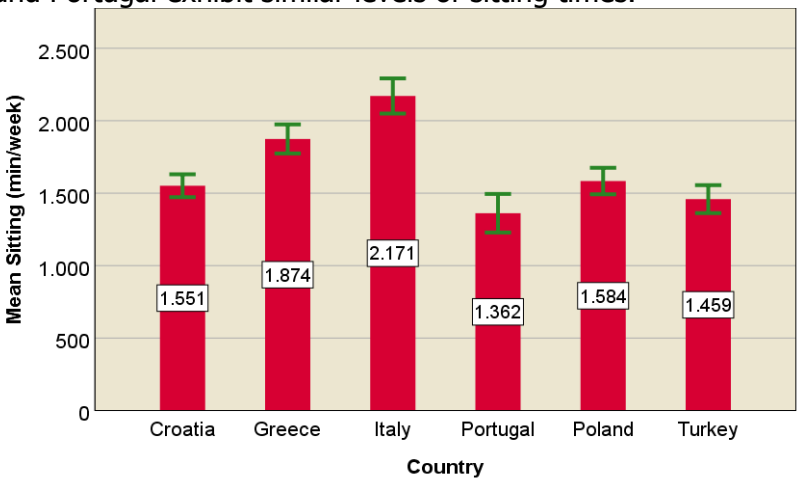

Fig. 1: Mean sitting time for the respondents in the six countries of the study.

Table 4: The results of ANOVA Tukey HSD for comparison of sitting times in six countries.

Country	Compared with	Mean Difference (I-J)	Std. Error	P
Croatia	Greece	-322,771	68.1	<0.001
	Italy	-619,275	67.0	<0.001
	Portugal	189.6	83.9	0.212
	Poland	-32.3	69.5	0.997
	Turkey	92.5	74.4	0.816
Greece	Croatia	322,771	68.1	<0.001
	Italy	-296,504	69.1	<0.001
	Portugal	512,380	85.6	<0.001
	Poland	290,472	71.5	0.001
	Turkey	415,234	76.4	<0.001
Italy	Croatia	619,275	67.0	<0.001
	Greece	296,504	69.1	<0.001
	Portugal	808,884	84.8	<0.001

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	Poland	586,977	70.5	<0.001
	Turkey	711,738	75.4	<0.001
Portugal	Croatia	-189.6	83.9	0.212
	Greece	-512,380	85.6	<0.001
	Italy	-808,884	84.8	<0.001
	Poland	-221.9	86.7	0.109
	Turkey	-97.1	90.8	0.893
Poland	Croatia	32.3	69.5	0.997
	Greece	-290,472	71.5	0.001
	Italy	-586,977	70.5	<0.001
	Portugal	221.9	86.7	0.109
	Turkey	124.8	77.6	0.594
Turkey	Croatia	-92.5	74.4	0.816
	Greece	-415,234	76.4	<0.001
	Italy	-711,738	75.4	<0.001
	Portugal	97.1	90.8	0.893
	Poland	-124.8	77.6	0.594

ANOVA

Sum of Squares	**df**	**F**	**P**
71726893.8	5	32.736	<0.001

3.3. Sitting times across personal and health classes

This subsection examines the differences in sitting times among various categories related to hampering in daily activities, health status, education status, work status, and marital status. The frequencies and standard deviations of sitting times for each category within these personal and health classes are depicted in Fig. 2. As stated in the methodology section, the Kruskal-Wallis test was employed to test the significance of the differences in sitting times among the categories of all personal and health classes, except for gender. The results of these tests are presented in Table 5. The distribution of sitting times does not significantly differ among the categories of health status, including "very good," "good," and "fair" (P = 0.636). However, a significant difference is observed among the categories of hampering in daily activities (P = 0.016), where respondents selected options regarding their perception of hampering: "yes, a lot," "yes, to some extent," and "no." Another significant difference is found in work status, with a significant variation in sitting times among the categories (P = 0.001). Highly significant differences are observed among the different education classes (P < 0.001), with the highest sitting times reported by respondents with "10-12 years" of education, followed by "more than 12 years" and "less than 9 years." Finally, there is a significant difference in the distribution of sitting times among the categories of marital status (P = 0.005), where single respondents have shorter sitting times compared to other groups, including divorced individuals, widows, and those who are married or living with a partner.

The results of the t-test, conducted to investigate the significant difference in sitting times between male and female elderly participants in the overall sample of 954 respondents (369 males and 585 females), are summarized in Table 6. The results indicate that there is no significant difference in sitting times between males and females in the overall sample (P = 0.594).

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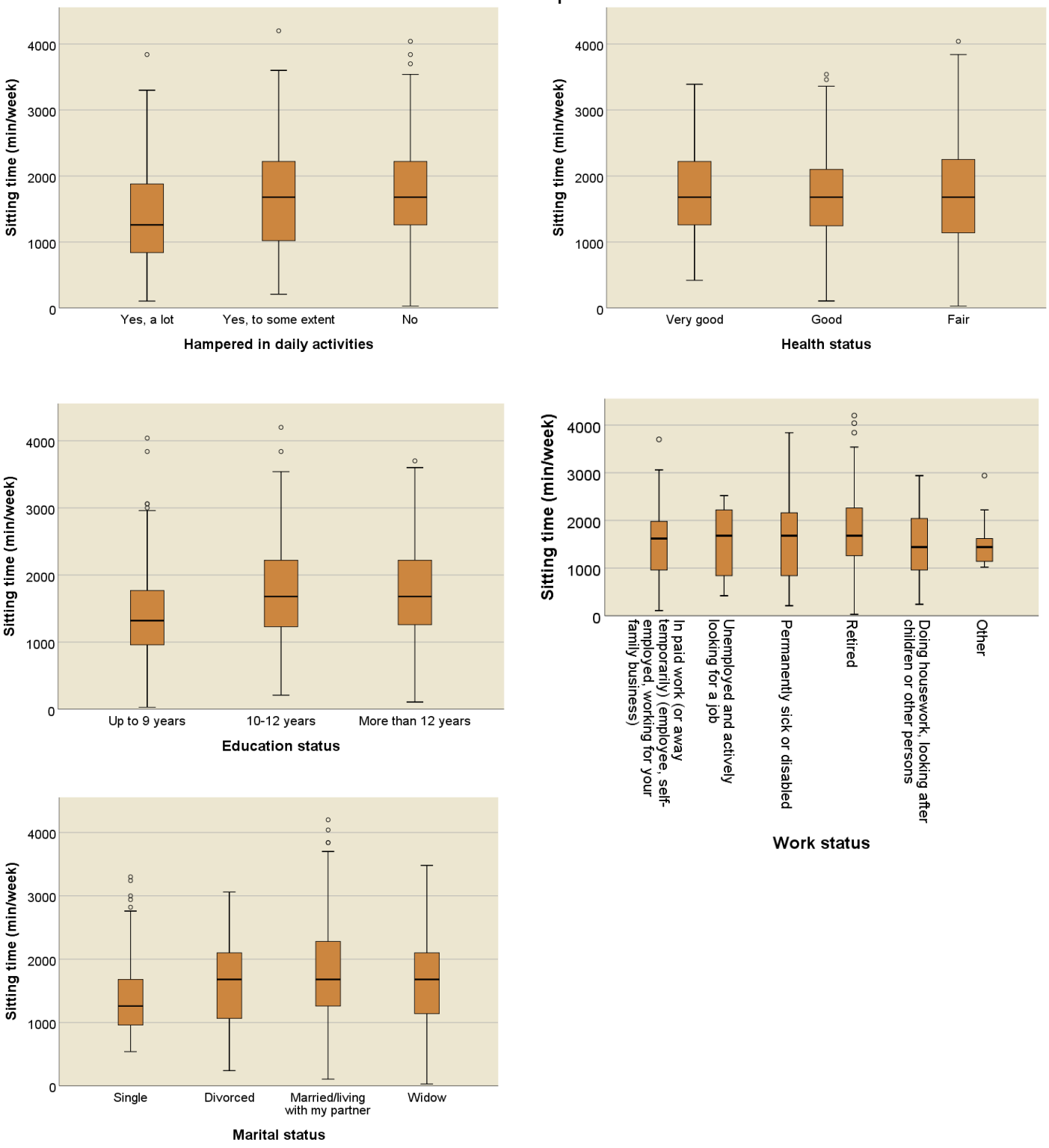

Fig. 2: The mean and distribution of sitting times among the personal and health categories.

Table 5. Pairwise Kruskal-Wallis tests investigating the significant differences between the sitting times of respondents across the categories of their personal and health variables.

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Variable	Category	Compared category	Test Statistic	Std. Error	P
Hampering in daily activities	Yes, a lot	Yes, to some extent	-114.095	47.708	0.017
	Yes, a lot	No	-128.874	45.314	0.004
Work status	Doing housework, looking after children or other persons	Retired	105.684	33.270	0.001
	In paid work (or away temporarily) (employee, self-employed, working for your family business)	Retired	-82.831	25.265	0.001
Education level	Up to 9 years	10-12 years	-110.112	26.635	<0.001
	Up to 9 years	More than 12 years	-116.268	24.811	<0.001
Marital status	Single	Married/living with partner	-114.253	46.478	0.014
	Divorced	Married/living with partner	-76,077	30,124	0.012

Table 6. The results of T- test for sitting times across genders (N=954).

Gender	N	Mean Sitting Time	Std. Deviation	Std. Error Mean
Male	369	1724.95	693.35	36.09
Female	585	1699.59	728.70	30.13
T-Test				
F	**P**	**t**	**df**	**2-tailed P**
1.229	0.268	0.533	952	0.594

4. Discussion

The current paper confirms the relationship between land use structure, socioeconomic features, and sitting habits among the elderly in six European countries: Portugal, Italy, Greece, Croatia, Poland, and Turkey. The study reveals several correlations with sitting time, including the number of people in the household, bicycle ownership, access to a car, access to recreational facilities (such as restaurants, cafés, pubs, or bars) in the neighborhood, access to public transportation stations, availability of pedestrian areas in the neighborhood, availability of a pleasant and green environment in the neighborhood for active transportation, participants' perceptions about cycling, and the availability of different routes for walking and cycling in the residential area.

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Several studies have assessed the socioeconomic correlates of sedentary behavior, including income, educational status, age, gender, and car ownership (Wallmann-Sperlich et al. 2013; Wallmann-Sperlich et al. 2014; Lakerveld et al. 2017; Hoare et al. 2016; Saunders et al. 2013; Peeters et al. 2013). However, the current paper focuses specifically on investigating sedentary behavior among elderly people, and therefore, does not consider the impacts of age on sitting time. Work status, education level, and marital status are not significant variables for sitting time among the elderly in this study. As a result, the findings of this study neither accept nor reject the results of the studies conducted by Wallmann-Sperlich et al. (2013) and (2014), possibly due to the specific focus on elderly individuals. Since elderly people aged over 60 years are typically in the retirement stage and tend to have similar socioeconomic statuses, these factors may not play a significant role in determining sitting time.

The results of this paper indicate a negative association between household size and sitting time among the elderly. In other words, individuals in smaller families or households tend to spend more time in sedentary behavior than those in larger families. These findings align with another study conducted on older adults over 60 years old (Loprinzi and Crush 2018), which also observed a correlation between household size and reduced sedentary behavior. While previous literature has shown a significant positive association between car ownership and sedentary behavior (Koornneef et al. 2017; Shoham et al. 2015), this paper did not find a correlation between car ownership and sitting time among the elderly. However, the results do confirm positive associations between car accessibility and bicycle ownership. Contrary to these findings, a study by Gerber et al. (2021) indicated that children with car accessibility were more physically active, but the current paper's results contradict that study's findings regarding the positive correlation between car accessibility and PA. Similarly, this result opposes a study on Japanese older adults, which showed that drivers engaged in more light and moderate physical activities and spent less time sitting compared to non-drivers (Amagasa et al. 2018).

Lu et al. (2022) conducted a study to determine the environmental correlates of sedentary behavior and PA in Chinese school children. While their results did not show a significant relationship between environmental factors and sedentary behavior, they did find positive associations between walking and cycling facilities in neighborhoods and light PA among Chinese children. This result is inconsistent with the findings of the current paper. On the other hand, the findings of the current paper align with a study that demonstrated an association between the presence of public transportation stations near residential areas and shorter sitting time in Hong Kong (Barnett et al. 2015). Additionally, the results of the current paper are consistent with an investigation that highlighted the positive impacts of recreational facilities and green spaces in residential areas on reducing sedentary behavior (Cerin et al. 2013). The findings of the current study indicate that the accessibility of recreational facilities such as restaurants, cafés, pubs, or bars, as well as green spaces, is correlated with shorter sitting time among the elderly in the six European countries examined.

These findings emphasize the importance of built environment characteristics in influencing sedentary behavior. They shed light on the field of urban transportation planning, suggesting the need to redesign neighborhoods with a mix of land uses, incorporating parks, and creating green pedestrian areas to reduce sedentary behavior and promote active mobility among different socioeconomic groups, particularly the elderly. By designing neighborhoods with accessible recreational facilities, residents may be encouraged to spend their leisure time within the neighborhood, indirectly reducing sedentary behavior among the elderly. Furthermore, the combination of green spaces with well-designed walking and cycling paths, and the availability of parks, has been shown to increase active transportation. Urban planners should take these factors into consideration when designing new residential areas or implementing neighborhood rehabilitation plans.

FIT-OLD

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The findings of this paper confirm that Italian and Greek older adults have longer sitting times compared to Polish, Portuguese, Croatian, and Turkish elderly. The lowest sitting time was reported in Portugal. This result aligns with another study that found Portugal to have the lowest sitting time compared to the rest of Europe (Bennie et al. 2013). However, that study also showed that the longest sitting time was observed in Northern European countries.

Furthermore, the findings of this paper highlight the role of socioeconomic factors in determining sedentary behavior. Work status, education level, and marital status are identified as socioeconomic correlates of sitting time among the elderly. It is worth noting that higher educational level was associated with longer sitting time in Germany (Wallmann-Sperlich et al. 2013), which contradicts the results of the current study where the highest sitting time was reported among individuals with "10-12 years" of education. Another study on the socioeconomic correlates of sitting time supports the findings of this paper, particularly regarding the impacts of educational level and marital status on sitting time. According to that study, single men reported longer sitting times compared to married men (Morgan et al. 2018). Additionally, the results of this study align with the findings of another study regarding the correlation between work status and sitting time (Brown et al. 2003).

Overall, the findings of this paper highlight the significant impacts of socioeconomic factors and environmental factors on sitting time among the elderly in six European countries. The results suggest the importance of reducing sedentary behavior by considering environmental features such as incorporating green spaces and recreational facilities in neighborhoods and promoting a mix of land use structures.

5. Conclusion

The current study assesses the socioeconomic, environmental, and perceptual correlates of sitting time among individuals over 60 in six European countries: Portugal, Greece, Croatia, Italy, Poland, and Turkey. The results of this paper indicate that sitting time is associated with household size, bicycle ownership, car accessibility, accessibility to restaurants, cafés, pubs, or bars, accessibility to public transportation stations, presence of pedestrian zones near residential areas, pleasant environment for walking and cycling in the neighborhood, availability of trees near home, respondents' perception that cycling is quicker than driving, and the availability of multiple routes for walking and cycling near home. These findings confirm that environmental characteristics play a significant role in reducing sedentary behavior.

Based on the study results, the six European countries in the sample are divided into two categories. Italian and Greek elderly participants reported the highest sitting times, while Portuguese participants reported the lowest sitting time. Additionally, this study demonstrates that sedentary behavior significantly differs among categories such as hampering in daily activities, work status, education level, and marital status. This suggests a relationship between sitting time and factors such as work status, education level, marital status, and self-reported limitations in daily activities.

While the findings of this paper shed light on the environmental correlates of sitting time, further research is needed to consider the built characteristics of the environment and street network configuration for different socioeconomic groups. Cultural background and attitude systems may also have significant impacts on sedentary behavior. Future studies could explore the influence of attitudes, value systems, and perceptual behavior on sedentary behavior among different age and gender groups.

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Appendix: The categorical variables used in this study.

Var.	Cat.	N	%	Var.	Cat.	N	%	Var.	Cat.	N	%	Var.	Cat.	N	%
Work status	In paid work (or away temporarily) (employee, self-employed, working for your family business)	132	13,0	Education status	Up to 9 years	184	18.1	Hampered in daily activity	Yes, a lot	38	3.7	Marital status	Single	41	4.0
	Unemployed and actively looking for a job	32	3,1		10-12 years	327	32.1		Yes, to some extent	235	23.1		Divorced	102	10.0
	Permanently sick or disabled	24	2,4		More than 12 years	503	49.4		No	709	69.6		Married /living with my partner	662	65.0
	Retired	663	65,1	The nearest local services such as a bank, post office or library	1-5 min	220	21.6	Special lanes, routes or paths for cycling in my neighbourhood	Strongly disagree	296	29.1		Widow	211	20.7
	Doing housework, looking after children or other persons	74	7,3		6-10 min	291	28.6		Somewhat Disagree	171	16.8	Health status	Very good	173	17

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	Other	19	1,9		11-20 min	261	25.6		Somewhat Agree	234	23		Good	454	44.6
Bicycle ownership	Yes	252	24.8		21-30 min	113	11.1		Strongly Agree	162	15.9		Fair	352	34.6
	No	766	75.2		More than 30 min	132	13		Not applicable	151	14.8	Pleasant environment for walking or cycling	Strongly disagree	160	15.7
Possession of Garden	No	626	61.5	The nearest restaurant, café, pub or bar	1-5 min	333	32.7	Cycle routes in my neighborhood that are separated from traffic	Strongly disagree	366	36		Somewhat Disagree	226	22.2
	Yes	392	38.5		6-10 min	238	23.4		Somewhat Disagree	196	19.3		Somewhat Agree	315	30.9
Possession of small sport equipment	No	660	64.8		11-20 min	226	22.2		Somewhat Agree	167	16.4		Strongly Agree	293	28.8
	Yes	358	35.2		21-30 min	114	11.2		Not applicable	99	9.7		Not applicable	23	2.3
Possession of exercise equipment	No	606	59.5		More than 30 min	102	10		5	188	18.5	Litter or graffiti in the streets of my neighborhood	None	237	23.3
	Yes	412	40.5	The nearest fast-food restaurant or takeaway	1-5 min	277	27.2	It is dangerous to leave a bicycle locked in my neighbourhood	Strongly disagree	292	28.7		A few	372	36.5
Access to car	No	311	30.6		6-10 min	272	26.7		Somewhat Disagree	269	26.4		Some	241	23.7
	Yes	707	69.4		11-20 min	225	22.1		Somewhat Agree	221	21.7		Plenty	134	13.2
Possession of dog	No	831	81.6		21-30 min	137	13.5		Strongly Agree	199	19.5		5	33	3.2
	Yes	187	18.4		More than 30 min	102	10		Not applicable	36	3.5	Trees along the streets in my	None	131	12.9
Detached houses	None	358	35.2	The nearest	1-5 min	423	41.6	There are not	Strongly disagree	335	32.9		A few	213	20.9

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	A few	254	25		6-10 min	310	30.5		Somewhat Disagree	279	27.4		Some	299	29.4
	Some	184	18.1		11-20 min	154	15.1		Somewhat Agree	258	25.3		Plenty	343	33.7
	Most	143	14		21-30 min	91	8.9		Strongly Agree	130	12.8		5	31	3
	All	75	7.4		More than 30 min	37	3.6		Not applicable	15	1.5	Badly maintained, unoccupied or ugly buildings	None	346	34
Semi-detached houses or terraced houses in the neighborhood	None	441	43.3	The nearest sport and leisure facility such as a swimming pool, sports field or fitness centre	1-5 min	142	13.9	Walking is dangerous because of the traffic in my neighborhood	Strongly disagree	366	36		A few	330	32.4
	A few	282	27.7		6-10 min	221	21.7		Somewhat Disagree	290	28.5		Some	178	17.5
	Some	167	16.4		11-20 min	234	23		Somewhat Agree	226	22.2		Plenty	96	9.4
	Most	80	7.9		21-30 min	185	18.2		Strongly Agree	99	9.7	Many shortcuts for walking in my neighborhood	Strongly disagree	137	13.5
	All	39	3.8		More than 30 min	232	22.8		Not applicable	35	3.4		Somewhat Disagree	230	22.6
	6	1	0.1	The nearest open recreation area such as a park or other open space	1-5 min	216	21.2	Cycling is dangerous because of the traffic in my neighborhood	Strongly disagree	276	27.1		Somewhat Agree	346	34
Apartment buildings or blocks of flats in the neighborhood	None	201	19.7		6-10 min	276	27.1		Somewhat Disagree	251	24.7		Strongly Agree	257	25.2
	A few	141	13.9		11-20 min	212	20.8		Somewhat Agree	297	29.2		Not applicable	47	4.6
	Some	115	11.3		21-30 min	175	17.2		Strongly Agree	153	15	Cycling is	Strongly disagree	172	16.9

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	Most	313	30.7		More than 30 min	138	13.6		Not applicable	40	3.9		Somewhat Disagree	258	25.3
	All	241	23.7	Sidewalks in my neighborhood	Strongly disagree	123	12.1	It is dangerous in my neighborhood during the day because of the level of crime	Strongly disagree	528	51.9		Somewhat Agree	269	26.4
	7	1	0.1		Somewhat Disagree	131	12.9		Somewhat Disagree	283	27.8		Strongly Agree	180	17.7
The nearest local shop: grocery shop, bakery, butcher etc.	1-5 min	525	51.6		Somewhat Agree	252	24.8		Somewhat Agree	117	11.5		Not applicable	137	13.5
	6-10 min	276	27.1		Strongly Agree	406	39.9		Strongly Agree	49	4.8	Many road junctions in my neighborhood	Strongly disagree	105	10.3
	11-20 min	133	13.1		Not applicable	104	10.2		Not applicable	38	3.7		Somewhat Disagree	196	19.3
	21-30 min	51	5	Pedestrian zones or pedestrian trails in my neighbourhood	Strongly disagree	152	14.9	It is dangerous in my neighborhood during the night because of the level of crime	Strongly disagree	321	31.5		Somewhat Agree	320	31.4
	More than 30 min	32	3.1		Somewhat Disagree	174	17.1		Somewhat Disagree	335	32.9		Strongly Agree	371	36.4
The nearest supermarket	1-5 min	274	26.9		Somewhat Agree	267	26.2		Somewhat Agree	200	19.6		Not applicable	23	2.3
	6-10 min	312	30.6		Strongly Agree	325	31.9		Strongly Agree	123	12.1	Many different routes for walking or cycling from place to place	Strongly disagree	133	13.1
	11-20 min	226	22.2		Not applicable	98	9.6		Not applicable	38	3.7		Somewhat Disagree	297	29.2
	21-30 min	131	12.9	Gender	Male	394	38.7						Somewhat Agree	352	34.6
	More than 30 min	72	7.1		Female	624	61.3						Strongly Agree	202	19.8

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