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The Perceived Neighborhood, Street Network Connectivity, and PA Correlates of the Fitness of the Elderly of over 60 Years in Six European Countries

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Abstract

Background
Although fitness is a stronger determinant of health compared to PA, a large body of literature focuses on the correlations of health with PA, while less studies have been allocated to the correlates of fitness. This is true, especially the built environment correlates of fitness among the elderly.
Methods
The objective of this study is to clarify the correlations between the subjective neighborhood and objective and street network as well as personal and socioeconomic factors with the fitness of the elderly of over 60 years. The following questions were answered in this study: (1) What subjective and objective variables related to the neighborhood, living place, and PA determine the fitness of the elderly in European cities? (2) Are there differences in personal, land use, and PA attributes across fitness classes among the European elderly? And finally, (3) what personal, street network, and PA variables determine fitness among older European men and women? The primary data used in this was collected in 2022 in Six European countries, namely, Portugal, Italy, Greece, Poland, Croatia, and Turkey (N=1018). Multivariate Ordinary Least Squares, Kruskal-Wallis test, and Multinomial Logistic Regression modeling were applied to answer the questions.
Results
The results show that subjective and objective variables related to the living place and neighborhood as well as PA can significantly determine the fitness of the elderly of more than 60 years. Moreover, the values of personal, land use, and PA attributes, street connectivity near home place, the PA levels, and sitting times are different among older adults with different fitness classes.
Conclusion
Finally, change in variables like age, objectively measured street connectivity near home place, and PA can lead to a change in the fitness levels including below average, average, and above average.

Keywords: Fitness, elderly, street network, land use, perceptions, urban travel behaviour.

1. Introduction

PA plays an important role in maintaining energy balance and bone strength in childhood, thereby reducing the risk of chronic diseases later in life. The benefits of PA are important for social interaction, well-being, and establishing good lifestyle habits. Consequently, the impacts of PA on fitness and psychological health are evident. PA reduces the risk of type 2 diabetes, cardiovascular disease, cancers, and clinical depression (Miles 2007). The impacts and correlates of PA may vary among different socioeconomic groups. Factors associated with PA or those that determine it (having a causal relationship) have been well studied in high-income countries. Socioeconomic factors, including age, sex, and health status, as well as social and physical environmental features such as urban planning, transportation systems, and accessibility to parks and green spaces, contribute to the activity level among different groups in different contexts (Bauman et al. 2012).
To provide relevant policies and effective strategies for increasing PA and improving mental and physical health, it is necessary to identify factors that can be changed to influence PA habits. Research into the correlates of the built environment on health has significantly increased in recent years. The results of several studies show correlations between PA and environmental features, such as the presence of sidewalks, street network configuration, and accessibility to parks (Durand et al. 2011). While there is a substantial body of research on the environmental and psychological correlates of PA, the impacts of environmental features and perceptual correlates of PA among different age and sex groups are still not clear. Additionally, the association between PA, environmental features, and fitness remains unclear among various socioeconomic groups. There is a need to study the perceptual and environmental correlates of PA for different socioeconomic

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groups. Determining influential features of fitness related to urban planning, transportation systems, and PA levels for different age and sex groups can help policymakers and strategists gain a better and clearer understanding and develop efficient policies and interventions.

The associations of fitness with subjective and objective neighborhood structure among elderly people are a less-studied topic. However, the association of PA and health status has been well investigated for older people (Aoyagi and Shephard 2010; Benedict et al. 2013; Kerr et al. 2012; Lautenschlager et al. 2004; Nelson et al. 2007; Taylor 2014). There is still a shortcoming in understanding the socioeconomic and environmental correlates of fitness for the elderly. Although some studies have assessed the relationship between environmental features and PA among older people (Mowen et al. 2007; Carlson et al. 2012), there is a need for more research to provide a comprehensive and consistent literature on the correlates of PA.

This paper aims to fill the knowledge gap regarding the associations of fitness among the elderly, related to subjective and objective urban forms, socioeconomic features, and PA levels. In other words, the main objective of this paper is to determine the relationship between street network configuration, such as intersection density, street-length density, and link-node ratio, and the level of PA among people over 60 years old in six European countries. Another objective of this paper is to assess the associations between PA among the elderly and the perceptions and attitudes of older people regarding built environment characteristics in Portugal, Italy, Greece, Croatia, Poland, and Turkey.

To achieve the objectives of this paper and address the research questions, the remaining sections of the paper are structured as follows: Section 2 provides a brief review of the current literature on the correlates of PA. Section 3 describes the methodology, including the data collection and analysis methods, along with the research question. The results of this study are presented in the fourth section (Findings). Section 5 consists of a concise discussion about the findings of this paper, followed by a comparison of the outcomes with the results of other studies. Finally, the conclusion of this study is presented in the final section.

2. Literature review

Although several studies have investigated the associations between urban forms and PA or active transportation, there are few studies that assess the correlations between urban form and fitness. McMillan (2007) examined the impacts of objectively measured urban forms on the travel mode of schoolchildren, which demonstrated that urban form is an important factor in utilizing active mobility for school travel, but it is not the sole factor. The relationship between active transportation and land use structures has been discussed by urban and transportation planners (Handy et al. 2002; Cervero 2002). However, our knowledge regarding the relationship between urban form and fitness still has some shortcomings. Nevertheless, there are several studies that have investigated the impacts of PA on fitness and general health. There is a lack of research assessing the socioeconomic, land use, street network, and PA correlates of fitness. Land use mix and street connectivity are core components of walkable neighborhoods (Lee and Moudon 2006). A study on the relationship between urban form and walking among women over the age of 70 in Portland, Oregon, showed that a traditional urban form with mixed land use and good pedestrian ways is associated with increased walking among older women (Patterson and Chapman 2004). The associations between access to parks in residential neighborhoods and PA were supported by Kaczynski and Henderson (2008). The impact of green space on fitness was confirmed by another study (Lu et al. 2022). According to the findings of this study, university students' physical fitness was linked to the availability of green space per capita and street connectivity.

Hoehner et al. (2013) examined the correlations between built environment characteristics around home and workplace and cardiorespiratory fitness (CRF). The results showed that higher intersection density, a greater number of exercise facilities in the neighborhood, green space around home and workplace, and shorter distance to the city center are associated with higher CRF among adults aged 20–80 years in Texas counties. Physical fitness was found to be associated with the natural

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environment in suburban areas and artificial environment factors such as trip distance in urban areas (Yang et al. 2023). The negative relationship between communication distance and cardiorespiratory fitness was confirmed by Hoehner et al. (2012). Marshall et al. (2014) investigated the influence of street network configuration on public health. The results of that study suggested that a compact urban form with high street connectivity is associated with reduced rates of obesity, diabetes, high blood pressure, and heart disease among people. Another study examined the associations between objectively-determined and self-reported neighborhood walkability and specific components of perceived fitness in Calgary, Canada (McCormack et al. 2020). The findings of this study showed a positive connection between access to parks and health fitness.
The physical fitness of school children in urban areas and rural points in Oaxaca, southern Mexico, was compared by Peña Reyes et al. (2003). According to that study, there is no clear difference in the fitness of schoolchildren based on whether they live in urban neighborhoods or rural areas. Milanović et al. (2013) assessed the impact of age on the physical fitness of elderly men and women. The results of that study confirmed that age is a significant factor in the reduction of functional fitness for both genders. In other words, the differences between young and old elderly people are due to reductions in muscle strength in both the upper and lower limbs, as well as changes in body fat, flexibility, and agility. Elderly people often experience age-related health problems that may affect their overall well-being.
Ayenigbara (2020) discussed the correlation between PA and the fitness and health status of elderly people by reviewing literature on PA and health. PA can be effective in reducing the risk of various diseases such as heart disease, hypertension, type 2 diabetes, colon, post-menopausal breast and endometrial cancers, depression, falls, and disability in the elderly population (Ayenigbara 2020).
Physical fitness and cardiorespiratory fitness (CRF) are dimensions of physical health and are partially influenced by the level of PA (Gossard et al. 1986; King et al. 1995; O'Donovan et al. 2005). Several studies have assessed the links between various factors and cardiorespiratory fitness, even after adjusting for PA (Perumal et al. 2017). Examples of these factors include age (Serrano-Sánchez et al. 2010; Schneider 2013) and the residential built environment. Ombrellaro et al. (2018) studied the correlation between socioeconomic features and cardiorespiratory fitness. The results of that study showed a positive association between high levels of education and CRF. Al-Mallah et al. (2016) studied the influence of gender on fitness and mortality. Based on the results of that study, fitness is inversely correlated with mortality in both men and women.
Although there is a strong body of literature that assesses correlates of PA, the socioeconomics and built environment correlates of fitness are not yet clear. In particular, both subjective and objective built environment characteristics that are related to the fitness of different age groups are understudied topics. While fitness and PA are related, fitness is assumed to be a more proximate and stronger correlate for health. Therefore, this paper contributes to the current literature by assessing the associations of subjective and objective built environment characteristics with fitness among elderly individuals over 60 years old in European cities.

3. Methodology

3.1. Research questions and hypothesis

This study seeks to answer the following questions: (1) What subjective and objective variables related to the neighborhood, living place, and PA determine the fitness of the elderly in European cities? (2) Are there differences in personal, land use, and PA attributes across fitness classes among the European elderly? And finally, (3) what personal, street network, and PA variables determine fitness among older European men and women?
The hypothesis to prove by this study is that subjective and objective variables related to the living place and neighborhood such as household size, availability of walking and cycling routes, availability of leisure facilities, perceived dangers during night, bicycle ownership, possession of Garden, street

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connectivity near home place, Work and transportation-related PA can significantly determine the fitness of the elderly of more than 60 years in European cities. Moreover, the values of personal, land use, and PA attributes such as variables like age, household size, years of staying in the current home, connectivity measures around the home, the PA levels related to work, transportation use, domestic activities, leisure, and sitting times are different among older adults with different fitness classes. And finally, change in variables like age, objectively measured street connectivity near home place, and PA can lead to a change in the fitness levels including below average, average, and above average.

3.2. Data and variable

This research paper was designed based on a dataset that was developed under the project 'Interventions in the Elderly's Mobility Modes for Promotion of their PA and Fitness' (Fit-Old), funded by the European Commission. The target group consisted of elderly adults aged over 60 years old in six European cities, including Grandola (Portugal), Sassari (Italy), Thessaloniki (Greece), Krakow (Poland), Zagreb (Croatia), and Malatya (Turkey). The Fit-Old project had two phases of data collection: baseline (before the intervention) and follow-up (after the intervention). This paper utilized data from the baseline data collection. The total sample size was 1018 respondents from the six countries. Data collection was conducted through face-to-face interviews with elderly individuals (over 60 years old) using the Fit-Old questionnaire. The questionnaire was designed to collect socioeconomic, neighborhood structure, and PA features. To gather data regarding perceived neighborhood structure and PA behaviors, two standard questionnaires, 'Assessing Levels of PA and Fitness at Population Level' (ALPHA) and 'International PA Questionnaire' (IPAQ), were included in the main questionnaire. Table 1 presents all the variables used in this paper. The PA variables from the IPAQ include PA in the work domain, PA in the transportation domain, PA in the domestic domain, PA in the leisure time domain, and total sitting time. All PA variables are measured in metabolic equivalent-minutes per week (MET-min/week), and total sitting time is presented in minutes per week. The street network variables include link density, intersection density, street-length density, and link-node ratio. These street network variables were calculated within a 600-meter catchment area based on the street network for each participant in the survey, who provided the nearest intersection to their home. Asking for the nearest intersection instead of the exact home location was done to respect the privacy of the participants. All street network variables were computed using Arc Map 10.4 and employing network and spatial analyses. Table 1 presents all the variables, including socioeconomic variables and perceived neighborhood structure from the ALPHA questionnaire. Fitness (2-minute step) was measured for each participant in the survey. To calculate fitness, the number of steps was measured during a 2-minute step test. For the test, participants were asked to stand near a marked wall and lift their knees to the top of the mark for 2 minutes. Table 2 shows the descriptive statistics of the continuous variables in this paper, while the frequencies of categorical variables are provided in the Appendix.

Table 1. All variables in the paper.

Variable	Original Variable Type (in the Dataset)	Quantification Method	Recoding
Gender	Categorical	Questionnaire. Categories: 1: Male; 2: Female; 3: Prefer not to say.	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

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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 minutes; 4: 21-30 minutes, 5: More than 30 minutes.	0: 1-20 minutes; 1: More than 20 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 neighbourhood	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 special lanes, routes or paths for cycling in my neighbourhood	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 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 neighbourhood	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.

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There are many shortcuts for walking 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 quicker than driving in my neighbourhood 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
PA related to work (MET-min/week)	Continuous	Questionnaire. The total time that was spent per week for PA at the work.	N/A
PA related to transportation (MET-min/week)	Continuous	Questionnaire. The total time was spent per week for using walking and cycling in commuting and non-commuting trips.	N/A
PA related to domestic activities (MET-min/week)	Continuous	Questionnaire. The total time was spent per week for PA regarding domestic activity such as gardening.	N/A
PA in leisure time (MET-min/week)	Continuous	Questionnaire. The total time was spent per week for PA in leisure time.	N/A
Total setting time	Continuous	Questionnaire. The total time was spent per week for setting.	N/A
Fitness (2-min step test)	Continuous	The participants marched in place for two minutes, lifted the knees to top pdf the mark on the wall. The numbers of steps in two minutes were measured.	N/A

Table 2. Descriptive statistics of continues variables.

variables	N	Minimum	Maximum	Mean	Std. Deviation
Age	1018	60,00	96.00	71.15	5.44
Household size	1017	1.00	11.00	2.30	1.23

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The numbers of years for living in the current home	1015	1.00	92.00	24.86	17.09
PA related to domestic activities (MET-min/week)	1018	0.00	26460.	1748.13	2655.77
PA related to transportation (MET-min/week)	1018	0.00	9144.00	977.99	1188.94
PA in leisure time (MET-min/week)	1018	0.00	17760.00	1065.16	1473.56
PA related to work (MET-min/week)	1018	0.00	21252.00	402.52	1539.80
Total setting time	954	30.00	420.00	1709.40	714.97
Link-node ratio	542	0.00	6.40	1.85	0.70
Intersection density	542	0.00	9.80	2.39	2.20
Link density	542	0,00	9.41	2.86	1.99
Street-length density	547	0.00	9.83	2.49	2.18
Fitness (2-mins step test)	438	20,00	139.00	80.94	17.41

3.3. Analysis Methods

To answer the first research question regarding the determinants of fitness in the sample, multivariate Ordinary Least Square (OLS) models were generated separately for the overall sample, males, and females. Previous literature suggests that the determinants of fitness may differ between males and females, hence the models were repeated for each gender to capture these differences. The dependent variable in the OLS models was the result of the 2-minute step test, treated as a continuous variable. All continuous, dummy, and categorical variables from Table 1 were used as predictors in the models. Continuous and binary variables were used as they appear in the table, while categorical variables were recoded into binary variables as indicated in the last column of the table. To refine the OLS models for the three target samples, most of the non-significant variables were eliminated. P-values less than 0.001 were considered highly significant, P-values between 0.001 and 0.05 were treated as significant, P-values between 0.05 and 0.1 are considered to be marginally significant, and P-values greater than 0.05 represented insignificant variables. The R^2 values indicate the proportion of variability in the fitness results that can be predicted by the models. The validity of the models was assessed separately using ANOVA - F tests, where p-values less than 0.05 were considered significant, indicating that the respective model was valid.

To address research question 2 in this study, the subjects in each fitness category were determined as follows: "below average" (N=39), "average" (N=227), and "above average" (N=167) participants, with the total sample size being N=585. The number, frequency, mean, and standard deviation were calculated for each age group based on the criteria defined by Bohannon and Crouch (2019). It should be noted that the age groups are the same for both male and female elderly individuals, but the thresholds for the three fitness levels differ between the genders. The age classes and thresholds for both genders can be found in Table 3. Furthermore, two normality tests, the Kolmogorov-Smirnov and Shapiro-Wilk tests, were conducted to assess the distribution of the independent variables, including age, household size, years of staying in the current home, connectivity measures around the home (length-density, link-density, intersection-density, and link-node ratio), work-related PA (MET-min/week), transport-related PA (MET-min/week), domestic PA (MET-min/week), leisure-related PA (MET-min/week), and sitting time (min/week). The results of these tests indicated that

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these variables did not follow a normal distribution. Consequently, the t-test was not appropriate for identifying significant differences among the means of the personal, land use, and PA variables. Instead, non-parametric comparison methods were deemed more suitable.

Since there were more than two categories, the Kruskal-Wallis test was applied to all the explanatory variables. A p-value less than 0.05 indicated a significant difference in the mean rank of the aforementioned variables across different fitness groups.

Finally, to address the third research question, Multinomial Logistic Regression (MNL) was applied to the overall sample, as well as the all-male and all-female subsamples. The dependent variable in the analysis was the fitness categories. All continuous variables listed in Table 2 were included as explanatory variables in the overall model. The model was iteratively refined by removing insignificant variables until the best result was obtained. The same structure of the best overall model was then applied to the male and female models, and significant variables were identified. In this analysis, p-values less than 0.001 were considered highly significant, p-values between 0.001 and 0.05 were considered marginally significant, and p-values greater than 0.05 indicated insignificant variables. To assess the validity of the models, Likelihood Ratio tests and Goodness-of-Fit tests were conducted. A p-value less than 0.05 for the Likelihood Ratio test indicated a valid model, while a p-value greater than 0.05 for the Goodness-of-Fit test indicated model validity. To evaluate the predictive power of the models, Nagelkerke Pseudo R^2 was calculated for all three models. This indicator quantifies the proportion of variability in the fitness levels that can be predicted by the MNL models. The value ranges from 0 to 1, with higher values indicating greater prediction power.

Table 3. Thresholds of fitness class based on gender.

	Men's Results			Women's Results		
Age	below average	average	above average	below average	average	above average
60-64	< 87	87 to 115	> 115	< 75	75 to 107	> 107
65-69	< 87	86 to 116	> 116	< 73	73 to 107	> 107
70-74	< 80	80 to 110	> 110	< 68	68 to 101	> 101
75-79	< 73	73 to 109	> 109	< 68	68 to 100	> 100
80-84	< 71	71 to 103	> 103	< 60	60 to 91	> 91
85-89	< 59	59 to 91	> 91	< 55	55 to 85	> 85
90-94	< 52	52 to 86	> 86	< 44	44 to 72	> 72

4. Findings

4.1. The correlates of fitness

As explained in the methodology section, three OLS models were developed for the overall sample, the male sub- (Bohannon and Crouch 2019) sample, and the female subsample. The results of these models are presented in Table 4. The variables of age and household size were included in all three models. Three variables were used to explain perceptions of the neighborhood: availability of multiple routes for walking and biking, availability of leisure facilities near home, and perception of danger at night. All three variables showed high significance levels (P<0.001) or (0.001<P<0.05) for the overall sample. The variable measuring the perception of availability of many routes for walking and biking had different effects for men and women. While it was insignificant for men, it was highly significant for women. Women who believed that there were many walking or biking routes near their home, indicating awareness of such facilities, exhibited 31% better fitness results. The perception of availability of leisure facilities in the neighborhood was marginally significant for men (P=0.071), while it was insignificant for elderly women. Men who reported the presence of such facilities near their home experienced 19% better fitness. The perception of danger near the home at night showed a significant negative correlation with fitness for both males (P=0.046) and females

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(P=0.042) in the sample. Interestingly, the negative effect was stronger for men. This variable was associated with a 23.5% lower fitness in men and a 16% lower fitness in women.

There are two variables related to personal and household factors included in the models, both of which are significant in the overall model. Surprisingly, bicycle ownership is correlated with 20% lower fitness results, while possession of a garden is associated with 18% better fitness results, as expected. The unexpected result for bike ownership in the overall sample is likely connected to the fact that this variable is insignificant for men. However, owning a bicycle is significantly correlated with 20% lower fitness in women (P=0.007). This result may be related to the assumption that females in the sample may own a bike but not use it. Similarly, possession of a garden is insignificant for men but significant for women (P=0.001), and owning a garden is associated with 25% better fitness in women.

There is one variable related to objective neighborhood measures: the link-node ratio within the 600-meter catchment area of the respondents' home. This variable represents the connectivity of the street network and is significant in the overall model (P=0.45). However, it is not significant for men but is positively and significantly correlated with fitness for women.

Finally, there are two variables in the PA variable group: PA related to work and PA related to transportation. Both variables are significantly and positively correlated with fitness, with a P-value of 0.034 for the former and 0.022 for the latter. However, both variables are insignificant for women, while PA related to work is significant for men (P=0.006) and has the strongest positive correlation with their fitness compared to all other variables (ß=32%). The effects of PA related to transportation also show a positive correlation with men's fitness, but its effects are marginally significant (P=0.098).

The R^2 of the overall model is equal to 0.369, which is comparable to that of the model for males (R^2=0.347). This indicates that the two models can predict 36.9% and 34.7% of the variability in the dependent variable (fitness based on the 2-minute step test). The prediction power of the women's model is slightly higher (R^2=42.7%). The validity of all three models was tested using an ANOVA – F test, the results of which can be observed in Table 4. The P-values for the three models are less than 0.001, indicating that the models are valid.

Table 4. Three OLS models for the fitness of the overall sample, as well as males and females.

Variable Group	Variable	OLS model for the fitness of the overall sample including males and females (R^2=0.369)				OLS model for the fitness of males (R^2=0.347)				OLS model for the fitness of females (R^2=0.427)			
		B	β	t	P	B	β	t	P	B	β	t	P
N/A	Constant	62.415		4.685	<0.001	49.488		2.308	0.024	60.544		3.556	0.001
Fixed Variables	Age	0.108	0.034	0.616	0.539	0.371	0.127	1.263	0.210	0.019	0.006	0.086	0.932
	Household size	1.413	0.094	1.686	0.093	1.072	0.088	0.850	0.398	1.338	0.080	1.131	0.260
Perceptions of Neighborhood	There are many routes for walking and cycling	8.802	0.234	3.675	<0.001	3.286	0.096	0.847	0.400	12.183	0.309	3.974	<0.001
	Lesiure facilities	6.130	0.156	2.807	0.005	6.365	0.189	1.833	0.071	3.988	0.094	1.379	0.170
	My neighborhood is dangerous during night	-6.436	-0.169	-2.665	0.008	-8.057	-0.235	-2.029	0.046	-6.335	-0.160	-2.054	0.042
Personal/ Household Factors	Bicycle ownership	-8.085	-0.202	-3.475	0.001	-5.021	-0.132	-1.222	0.225	-8.046	-0.197	-2.743	0.007
	Possession of Garden	7.332	0.186	3.202	0.002	2.735	0.079	0.751	0.455	10.274	0.247	3.443	0.001
Objective Neighborhood	Link-node ratio in the catchment area of the home place	3.416	0.115	2.018	0.045	0.072	0.002	0.021	0.984	4.184	0.149	2.088	0.039
PA	Work (MET-min/week)	0.001	0.121	2.133	0.034	0.003	0.318	2.813	0.006	0.001	0.056	0.830	0.408
	Trans (MET-min/week)	0.002	0.128	2.311	0.022	0.002	0.174	1.677	0.098	0.001	0.058	0.877	0.382

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ANOVA F-Test				ANOVA F-Test				ANOVA F-Test			
df	Mean Square	F	P	df	Mean Squar e	F	P	df	Mean Square	F	P
10	3083.348	13.220	<0.001	10	819.8 55	3.981	<0.001	10	2501.7 26	10.443	<0.001

4.2. Differences of personal, land use, and PA attributes across fitness classes

In order to understand the differences between personal, PA, and neighborhood-related variables across the fitness classes of males and females, the fitness of subjects was classified into three classes. The results can be seen in Tables 5 and 6. Table 5 shows how the fitness of the subjects was classified as below average, average, and above average separately for males and females. Table 6 presents the means and standard deviations of the personal and neighborhood variables for each fitness class in an overall sample of 585 individuals who took the 2-minute-step-in-place test (below average: N=39, average: N=227, and above average: N=167). Finally, the mean ranks of the personal, land use, and PA variables were compared among the fitness classes.

Table 8 displays only the significant results of the cross-fitness-class comparisons conducted by the Kruskal-Wallis test, broken down by men and women (the mean values can be found in Table 7). According to these findings, the age and household size of males do not show statistically significant differences across the three fitness classes, while significant differences are observed for females. The mean rank of females with average fitness is significantly higher than those with above average fitness (P=0.033). Females with average and above average fitness come from larger families compared to those who have below average fitness (P<0.001 and P=0.03, respectively). The number of years respondents have lived in their current home is significant for both genders. For males, the mean rank of this variable is significantly higher for respondents with above average fitness compared to those with average or below average fitness (P=0.03 and P=0.007). For females, respondents in the average and above average classes have lived in their current home significantly longer than those with below average fitness (P<0.001). The findings regarding the length of time respondents have lived in their current home reflect an important neighborhood effect related to the fitness of both men and women.

In the male subsample, three street connectivity variables (length-density, link-density, and intersection density) show different values among fitness classes, whereas for females, the only significant street connectivity variable is link-node ratio. In both sexes, higher street network connectivity is associated with better fitness classes.

Regarding PA attributes, the mean ranks of two variables, work-related PA and domestic PA, differ among the fitness classes for men. For women, only work-related PA shows a significant difference among the three fitness classes. For men, the mean rank of work-related PA (minutes per week) in the average and above average fitness classes is significantly higher than in the below average class (P=0.018 and P=0.005). The same pattern is observed for domestic PA in men, where the mean rank for above average is significantly higher than the mean ranks of below average and average (P=0.038 and P=0.041). For women, the mean rank of work-related PA in the above average category is significantly higher than in the average (P=0.001) and below average (P=0.007) categories.

Table 5. Distribution of fitness classes (below average, average, and above average) among the males and females of the sample.

Age Class	Sampl e	N	Mea n	Mi n.	Ma x.	Samp le	N	Me an	Min .	Ma x.	Sampl e	N	Mea n	Min.	Max.
60-64		34	81	59	120		22	79	59	120	Male	12	85	67	120

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65-69	Overall	419	83	20	127	Female	241	81	20	126		178	84	58	127
70-74		317	82	43	139		195	81	43	130		122	83	52	139
75-79		161	77	42	135		108	76	42	135		53	79	57	95
80-84		66	75	48	104		43	75	48	104		23	75	56	94
85-89		16	85	58	120		10	80	59	120		6	90	58	104
90-94		4	71	62	87		4	71	62	87		0			

Table 6. The frequency of the subject in age group based on gender.

Fitness Measure (2-min. step in place test result) vs. Age class	Fitness Classification	N	%	Fitness Measure (2-min. step in place test result) vs. Age class	Fitness Classification	N	%
Male				Female			
60-64 years	Above average	1	0.1	60-64 years	Above average	2	0.2
	Average	1	0.1		Average	7	0.7
	Below average	7	0.7	65-69 years	Above average	5	0.5
65-69 years	Above average	4	0.4		Average	55	5.4
	Average	32	3.1		Below average	24	2.4
	Below average	52	5.1	70-74 years	Above average	11	1.1
70-74 years	Above average	1	0.1		Average	45	4.4
	Average	32	3.1		Below average	23	2.3
	Below average	27	2.7	75-79 years	Above average	4	0.4
75-79 years	Average	6	0.6		Average	25	2.5
	Below average	6	0.6		Below average	17	1.7
80-84 years	Average	6	0.6	80-84 years	Above average	6	0.6
	Below average	7	0.7		Average	13	1.3
85-89 years	Above average	3	0.3		Below average	3	0.3
	Average	1	0.1	85-89 years	Above average	1	0.1
	Below average	1	0.1		Average	3	0.3
				90-94 years	Above average	1	0.1
					Average	2	0.2

Table 7. The mean values of personal, and use, and PA variables broken down on the fitness levels of the overall sample.

Personal / land use / PA variable	Total (N=585)		Above average (N=39)		Average (N=227)		Below average (N=167)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age	71.11	5.81	74.12	7.13	71.12	6.12	70.34	5.14
Household size	2.57	1.22	3.14	2.22	2	1	2	1.10
The numbers of years of staying in the current home	26.35	17.20	28.04	21.43	24.22	17.23	21	18.14
length-density	2.60	2.23	2.19	1.69	2.34	2.04	2.39	2.31

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link-density	2.85	1.88	2.74	1.83	F	1.95	3.19	2.41
Intersection-density	2.58	2.37	2.43	2.42	2.17	2.08	2.04	1.53
link-node ratio	1.93	0.74	1.97	1.10	1.77	0.61	1.62	0.42
Work (MET-min/week)	464	1595	1267	3725	295	1122	133	638
Trans (MET-min/week)	1046	1322	1162	1017	941	1069	748	799
Domestic (MET-min/week)	1457	2351	2478	4490	1866	2284	2435	3337
Leisure (MET-min/week)	1163	1645	835	1101	1068	1341	771	959
Sitting time (min/week)	1751	746	1449	604	1624	638	1727	702

Table 8. Kruskal-Wallis test results for the differences in personal, land use, and PA variables among fitness classes.

Male				Female			
Variable	**Fitness categories compared**	**Test Statistic**	**P**	**Variable**	**Fitness categories compared**	**Test Statistic**	**P**
The numbers of years of staying in the current home	Above average-Average	-86.620	0.030	Age	Average-Above average	76.680	0.033
	Above average-Below average	-105.618	0.007	Household size	Average-Below average	-95.350	<0.001
length-density	Above average-Average	-50.271	0.042		Above average-Below average	-80.620	0.030
	Below average-Average	35.452	0.009	The numbers of years of staying in the current home	Below average-Average	154.096	0.000
Link-density	Above average-Below average	-61.248	0.011		Below average-Above average	218.362	<0.001
	Average-Below average	-34.533	0.010	Link-node ratio	Below average-Above average	69.082	0.007
Intersection density	Average-Below average	-33.197	0.014	Work (MET-min/week)	Average-Above average	55.297	0.001
	Above average-Average	-43.821	0.074		Below average-Above average	50.358	0.007
Work (MET-min/week)	Below average-Average	27.998	0.018				
	Below average-Above average	76.032	0.005				
Domestic (MET-min/week)	Below average-Above average	81.944	0.038				
	Average-Above average	81.428	0.041				

4.3. MNL model of the fitness class

The results of the three MNL models for the fitness classes of the overall sample, males, and females are presented in Table 9. According to the overall model, age, the length of time since relocating to the current home, and work-related PA are significant determinants of the fitness class. In other words, changes in these explanatory variables can affect the fitness class of the respondents.

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For the overall sample, each additional year in age increases the probability of having an average fitness class rather than above average by 10% (P=0.003). Adding each hour of work-related PA corresponds to a 1.17% probability increase in changing the fitness class from average to above average (for each minute per week: β=-0.99972; P=0.005). With each added year in age, it is 10% less likely for the fitness class to change from below average to above average (β=-0.898; P=0.004). Additionally, for every year that has passed since relocating to the current home, there is a 4% decrease in the probability of changing the fitness class from below average to above average (β=-0.96; P=0.005). A more connected street network in the neighborhood surrounding the respondents' homes also increases the likelihood of changing the fitness class from below average to above average (β=-0.341; P=0.002).

Finally, adding each hour of weekly work-related PA has a 1.17% likelihood of increasing the fitness class from below average to above average (for each minute per week: β=-0.999; P=0.001). Intersection density, as a representative indicator of the street network, is marginally significant in the all-male subsample. Increasing the intersection density of the area surrounding men's homes is likely to weaken the fitness class from above average to average (P=0.077). Age is another significant explanatory variable for the male model. Adding one year to the age of men marginally significantly increases the probability of dropping the fitness class from above average to average by 14.1% (P=0.072). Moreover, increasing the age by one year is 15.6% likely to decrease the fitness class from above average to below average (β=-0.844; P=0.043). The link-density of the street network around men's homes is positively and marginally significantly likely to change their fitness class from below average to above average (β=2.223; P=0.072). Although this explanatory variable is marginally significant, it has a strong effect on men. Finally, similar to the overall sample, adding each hour of work-related PA is 1.17% likely to increase the fitness class of men from below average to above average (for each minute per week: β=-0.999; P=0.001).

In the females' model, age is marginally significant (P=0.052). One more year of age is 7.9% likely to decrease the fitness from above average to average. Street connectivity is also important for women's fitness. Increasing the link-node ratio (decreasing the street connectivity) can increase the probability of changing the fitness from average to above average (P=0.027). Work-related PA marginally significantly increases the likelihood of changing from average to above average fitness in women. Each hour of work-related PA per week increases this probability by 2.2% (β=-0.99964; P=0.052). Like the overall sample, the number of years passing from relocation to the current home is correlated with the change in fitness class for women. One more year passing from the relocation time of elderly women to their current home significantly decreases the probability of changing the fitness from below average to above average by 7.4% (β=-0.926; P=<0.001). An increase in the link-node ratio of the nearby areas of women's homes can increase the probability of changing the fitness from below average to above average (P=0.002).

The validity of the models was checked using the log-likelihood test, and all three models were found to be valid (P<0.001). The goodness-of-fit tests also confirmed the validity of the models (P=0.597, 0.997, and 0.496, respectively, for the overall sample, males, and females). The Nagelkerke pseudo R^2 of the general model is equal to 0.203, while that of the male model and female models are slightly better (0.338 and 0.295, respectively). In other words, 33.8% and 29.5% of the variability in the fitness classes can be predicted by the male and female models.

Table 9. MNL model for the fitness class of older men and women.

Categories of fitness classification	Explanatory variables	Overall Sample				Male				Female			
		B	Wald	P	β	B	Wald	P	β	B	Wald	P	β
	Constant	8.298	11.118	0.001		5.000	0.703	0.402		7.904	6.708	0.010	

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	Age	-0.074	5.415	0.020	0.928	-0.077	1.017	0.313	0.926	-0.064	2.677	0.102	0.938
	The numbers of years of staying in the current home	0.000385	0.001	0.975	1.00039	0.036	0.834	0.361	1.036	0.003	0.050	0.823	1.003
	link-density	-0.024	0.049	0.825	0.976	0.413	0.980	0.322	1.512	-0.090	0.590	0.443	0.914
	Intersection-density	0.030	0.113	0.737	1.031	-0.078	0.196	0.658	0.925	0.003	0.001	0.977	1.003
	link-node ratio	-0.129	0.243	0.622	0.879	1.684	4.034	0.045	5.386	-0.445	2.497	0.114	0.641
	Work (MET-min/week)	-0.00014	4.327	0.038	0.99986	0.000097	0.342	0.559	1.0001	-0.0003	4.558	0.033	0.9997
	Trans (MET-min/week)	0.00001	0.004	0.951	1.00001	-0.000157	0.323	0.570	0.99984	0.00018	0.477	0.490	1.00018
	Domestic (MET-min/week)	-0.00007	1.365	0.243	0.99993	-0.00012	1.746	0.186	0.99988	0.00001	0.012	0.915	1.00001
Average	Constant	10.649	15.129	<0.001		9.999	2.394	0.122		9.804	8.807	0.003	
	Age	-0.104	8.629	0.003	0.901	-0.152	3.238	0.072	0.859	-0.083	3.783	0.052	0.921
	The numbers of years of staying in the current home	-0.014	1.040	0.308	0.987	0.043	1.130	0.288	1.044	-0.020	1.624	0.203	0.981
	link-density	-0.053	0.200	0.655	0.948	0.527	1.289	0.256	1.694	-0.105	0.687	0.407	0.901
	Intersection-density	-0.022	0.046	0.830	0.979	-0.622	3.134	0.077	0.537	0.033	0.080	0.777	1.034
	link-node ratio	-0.436	2.177	0.140	0.647	1.247	2.068	0.150	3.478	-0.719	4.877	0.027	0.487
	Work (MET-min/week)	-0.00028	7.991	0.005	0.99972	-0.000042	0.052	0.820	0.99996	-0.00036	3.782	0.052	0.99964
	Trans (MET-min/week)	-0.00008	0.178	0.673	0.99992	-0.000112	0.163	0.686	0.9999	-0.00008	0.085	0.770	0.99992
	Domestic (MET-min/week)	-0.00004	0.494	0.482	0.99996	0.000023	0.063	0.802	1.00002	-0.00004	0.097	0.756	0.99997
Below average	Constant	12.001	17.185	<0.001		12.186	3.596	0.058		9.280	6.289	0.012	
	Age	-0.108	8.391	0.004	0.898	-0.169	4.106	0.043	0.844	-0.056	1.439	0.230	0.945
	The numbers of years of staying in the current home	-0.041	7.830	0.005	0.960	0.026	0.418	0.518	1.026	-0.077	13.906	<0.001	0.926
	link-density	0.224	2.633	0.105	1.251	0.799	3.227	0.072	2.223	0.120	0.368	0.544	1.127
	Intersection-density	-0.234	2.273	0.132	0.791	-0.473	2.563	0.109	0.623	-0.309	1.402	0.236	0.734
	link-node ratio	-1.077	9.342	0.002	0.341	0.811	0.863	0.353	2.251	-1.492	9.813	0.002	0.225
	Work (MET-min/week)	-0.001	10.475	0.001	0.999	-0.001	5.193	0.023	0.999	-0.004	2.713	0.100	0.996
	Trans (MET-min/week)	-0.0003	1.977	0.160	0.99972	-0.0003	1.173	0.279	0.99968	-0.0002	0.544	0.461	0.99977
	Domestic (MET-min/week)	0.00005	0.715	0.398	1.00005	0.00002	0.058	0.809	1.00002	0.0002	2.193	0.139	1.00018
						Model Fitting Information				Model Fitting Information			

Model Fitting Information				Model Fitting Information				Model Fitting Information			
-2 Log Likelihood	**Likelihood Ratio Tests**			**-2 Log Likelihood**	**Likelihood Ratio Tests**			**-2 Log Likelihood**	**Likelihood Ratio Tests**		
	X²	**df**	**P**		**X²**	**df**	**P**		**X²**	**df**	**P**
1081.424	107.386	24	<0.001	358.881	71.787	24	<0.001	642.665	102.898	24	<0.001

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Goodness-of-Fit			Goodness-of-Fit			Goodness-of-Fit		
Chi-Square	df	P	Chi-Square	df	P	Chi-Square	df	P
1572.483	1587	0.597	490.359	579	0.997	980.739	981	0.496

5. Discussion

The findings of this study confirm that built environment characteristics are correlated with fitness for both genders. The neighborhood built environment plays an important role in supporting PA, improving fitness, and enhancing health status. Factors such as social and recreational facilities in the neighborhoods, street network configuration, facility quality, availability of biking and walking paths, presence of parks and green spaces, and feelings of safety during both day and night are influential factors in the fitness of the elderly in European cities. However, the impact and correlation of these features may differ based on gender. According to the results, the availability of multiple routes for walking and biking in the neighborhood, access to recreational facilities in the living area, and perceptions of danger during nighttime are highly significant variables related to fitness.

Hoehner et al. (2011) discussed the correlation between neighborhood walkability factors and cardiorespiratory fitness (CRF), which aligns with the findings of the current paper. Additionally, the results of this study support the correlation between link-node ratio, which represents street connectivity, and fitness for women. Furthermore, the findings regarding the correlation between recreational facilities and fitness align with another study conducted by Hoehner et al. (2013), emphasizing the importance of parks and diverse land use in the neighborhood to improve fitness among adults. Moreover, the current paper confirms the results of another investigation on the correlation between the built urban environment and fitness (Frehlich et al. 2021). Zewdie et al. (2023) also confirmed the relationship between built environment characteristics and fitness; however, their study focused on youth in New York City. Therefore, our result regarding the relationship between the built environment and fitness is novel. While the availability of recreational facilities is associated with fitness, the availability of parks is not correlated with fitness, contrary to a study that showed an association between parks and perceived fitness (McCormack et al. 2020).

Several studies have confirmed the positive associations between physical activity and fitness. This study also confirms the positive correlations between PA related to work and transportation and fitness (2-minute step test). Additionally, the findings of this study show a positive association between link-node ratio (street connectivity) and fitness. This finding aligns with the results of several studies on the positive relationship between active mobility (walking and cycling) and street network configuration.

In addition to neighborhood structure, socioeconomic variables including bicycle ownership and possession of a garden are correlated with fitness among elderly women. However, there is a negative association between bike ownership and women's fitness, which contradicts the results of several studies that have reported a positive association between bike use and fitness (Kaplan et al. 2019; Dudas and Crocetti 2008). One reason for this opposing result could be behavioral differences between different age groups. The two studies above consider children, while the participants in the current study are older adults. Another reason behind this result could be the absence of a relationship between owning a bicycle and using it. Boone-Heinonen et al. (2010) argued that link-node ratio is related to moderate and vigorous PA in adolescents. However, the results of this study contradict another study on Canadian youth, which found positive associations between street connectivity and PA (Mecredy et al. 2011). The differences in age groups could be one of the reasons for this reverse result.

The results of this study also demonstrate an association between PA related to work and transportation and fitness. The positive correlation between active transportation (walking and cycling) and improvements in fitness status aligns with the results of another study in the USA

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(Schauder and Foley 2015). Mueller et al. (2015) assessed the impact of active transportation on health status using health impact assessment, and the results of that study confirm the positive impact of active transportation on health status. The findings of a study on the positive association between PA (aerobic exercise) and improved physical fitness in the elderly are consistent with the results of the current study (Rismayanthi et al. 2022). Furthermore, the positive association between fitness (2-minute step test) and PA related to transportation (walking and cycling) was confirmed among elderly adults aged 65-75 years in Bremen, Germany (Albrecht et al. 2023), which supports the findings of the current paper.
The findings of the current paper regarding fitness class show that age, the number of years living in the current home, and PA related to work are determinants of fitness class. According to the results, increases in age are likely related to changes in fitness class from above and average to average and below. This result is consistent with another research study that showed a negative association between physical fitness and age for both genders (Milanović et al. 2013). Hillman et al. (2002) demonstrated that physical fitness is associated with the attenuation of cognitive decline in older individuals.
The results of this paper indicate that an increase of one hour of work-related PA is associated with an increase in fitness class. This finding contradicts the results of a 2017 study that suggested there is no significant relationship between physical fitness and work-related PA in adults (Schmidt et al. 2017).
The findings of this paper confirm that land use structure and built environment characteristics play an important role in improving the fitness of older people. Therefore, policymakers and urban planners need to consider mixed land use structures, connected street networks, and high-quality recreational facilities in the neighborhood to enhance the residents' fitness.

6. Conclusion

This paper explores the correlates of fitness status and fitness class among the elderly in six Southern and Eastern European countries, including Portugal, Greece, Italy, Poland, Croatia, and Turkey. The findings of this paper reveal a meaningful relationship between subjective and objective neighborhood structure and the physical fitness of elderly people in these six European countries.
The availability of multiple routes for walking and biking, the presence of leisure facilities in residential areas, and the perception of danger at night are all correlated with the fitness status of the elderly. Additionally, the street configuration network is a significant determinant of fitness class. Specifically, a higher link density of the street network around the home (indicating a connected structure) is positively and significantly associated with a change in fitness class from below average to above average. Furthermore, a high link-node ratio (indicating decreasing connectivity) is related to a potential change in fitness class from average to above average among women. One of the novel findings of this paper is the association between the number of years living in the current home and fitness class, indicating a negative correlation between relocating to a new home and fitness class. The findings also highlight the importance of neighborhood impacts on the fitness of both genders based on the length of time respondents have lived in their current homes. Additionally, the paper shows a positive correlation between PA related to work and transportation and fitness.
According to the results, age and household size show significant differences regarding fitness class only among elderly women. The findings further confirm the differences in fitness class with respect to street network configuration and PA.
Although this paper assesses the land use and neighborhood correlates of fitness in elderly people, further research is needed to study the associations of neighborhood characteristics and street network configuration with physical fitness. Particularly, there is a need to investigate different age and social groups in Southern and Eastern European countries, which have been less studied compared to high-income countries. To gain a clear and in-depth understanding of the determinants

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of fitness, future studies should consider different socioeconomic contexts and examine the impacts of cultural, social, and economic features on PA behavior and subsequent fitness status.

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Appendix. The frequency of categorical variables.

Var.	Cat.	N	%	Var.	Cat.	N	%	Var.	Cat.	N	%	Var.	Cat.	N	%
Gender	Male	394	38,7	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	Some what Disagree	171	16.8	Pleasant environment for walking or cycling	Strongly disagree	160	15.7
	Female	624	61,3		6-10 min	291	28.6								
	Prefer not to say	0	0		11-20 min	261	25.6		Some what Agree	234	23				
Bicycle ownership	Yes	252	24.8		21-30 min	113	11.1		Strongly Agree	162	15.9				
	No	766	75.2		More than 30 min	132	13		Not applicable	151	14.8				
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		Some what Disagree	196	19.3		Somewhat Agree	315	30.9
Possession of small sport equipment	No	660	64.8		11-20 min	226	22.2		Some what 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 stationary	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		Some what Disagree	269	26.4		Some	241	23.7
	Yes	707	69.4		11-20 min	225	22.1		Some what 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 neighborhood	None	131	12.9
Detached houses in the neighborhood	None	358	35.2	The nearest bus stop, tram, metro or train station	1-5 min	423	41.6	There are not enough safe places to cross busy streets in my neighborhood	Strongly disagree	335	32.9		A few	213	20.9
	A few	254	25		6-10 min	310	30.5		Some what Disagree	279	27.4		Some	299	29.4
	Some	184	18.1		11-20 min	154	15.1		Some what Agree	258	25.3		Plenty	343	33.7

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	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 quicker than driving in my neighbourhood during the day	Strongly disagree	172	16.9
	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 zone	Strongly	152	14.9	It is dangerou	Strongly	321	31.5		Somewhat Agree	320	31.4

FIT-OLD

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					disagree				disagree						
	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										Somewhat Agree	352	34.6
	More than 30 min	72	7.1										Strongly Agree	202	19.8
													Not applicable	31	3

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