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EDITED BY
Bojan Masanovic,
University of Montenegro, Montenegro

REVIEWED BY
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Universidad de León, Spain
Nebojša Čokorilo,
University of Novi Sad, Serbia

*CORRESPONDENCE
Houshmand Masoumi
✉ Masoumi@ztg.tu-berlin.de

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Built environment effects on the physical activity and mental well-being of young women in the Balkans

Houshmand Masoumi[1,2]*, Melika Mehriar[1], Georgios Laskaris[3], Ioanna Spyropoulou[3], Biljana Popeska[4], Snezana Jovanova Mitkovska[4], Mishko Djidrov[5] and Maryam Mirafshar[6]

[1]Center for Technology and Society, Technische Universität Berlin, Berlin, Germany, [2]Department of Transport and Supply Chain Management, College of Business and Economics, University of Johannesburg, Johannesburg, South Africa, [3]School of Rural, Surveying, and Geoinformatics Engineering, National Technical University of Athens, Athens, Greece, [4]Faculty of Educational Sciences, Goce Delcev University, Štip, North Macedonia, [5]Faculty of Mechanical Engineering, Goce Delcev University, Štip, North Macedonia, [6]Urban Research and Education UG, Berlin, Germany

Introduction: While physical activity is widely recognized as a key factor in physical and mental health, the impact of subjective and objective built environment characteristics on well-being across different population groups remains understudied. This gap is particularly evident among specific ethnic groups and genders, as most such studies focus on populations from Western and high-income countries. The primary objective of this paper is to assess the associations between various built environment characteristics, including both objective and subjective features, with the levels of physical activity and the well-being of young women in the Balkans.

Methods: To achieve this, a questionnaire survey was designed and implemented in five cities in the Balkans: Niš (Serbia), Plovdiv (Bulgaria), Athens (Greece), Bucharest (Romania), and Štip (North Macedonia), targeting the sub-population of young women. Multiple Linear Regression (MLR) modelling was employed to identify the subjective and objective built environment characteristics that affect engagement in moderate and vigorous physical activity and well-being.

Results: Findings of this paper show that a high level of street connectivity is associated with a higher level of moderate and vigorous physical activity. Additionally, there is a significant association between exciting green spaces in the neighborhood, proximity to shops, mixed land-use neighborhoods, cycling infrastructure, and higher levels of physical activity and well-being.

Discussion: These results suggest that inclusive urban planning strategies could play a key role in improving public health outcomes for this underrepresented demographic.

KEYWORDS

built environment, physical activity, mental well-being, young women, Balkan countries

1 Introduction

Physical activity (PA) comprises a key factor in promoting well-being, regardless of age, gender, or nationality, with well-being being strongly correlated with physical, mental and psychological health conditions (Marco et al., 2005; Haskell et al., 2007; Mahindru et al., 2023). Numerous studies exploring the association between women's PA and mental well-being can be found in international literature, with their results indicating a positive correlation of PA and well-being (Brehm and Iannotta, 1998; Molina-García et al., 2011; Staurowsky et al., 2015). At the same time, diverse populations may experience disparities in access to or engagement with physical activities (Saffer et al., 2013). Women, in particular, tend to engage in less PA than men, due to various exogenous but also gender-based factors. This issue is particularly significant for young women, as it not only shapes their present well-being, but it may also have long-term implications. Mayo et al. (2020) noted that establishing healthy routines at a young age increases the likelihood that they will be maintained throughout life.

While various age groups are considered in the relevant studies, the most explored ones are students, middle-aged and older women, while studies on young women (e.g., 26–40 years) are less frequent. The present study focuses on young women aged between 17 and 40 years of age. The reason for selecting this particular age group is that it is closely linked to many gender-specific factors that can significantly influence PA and mental well-being. These factors include major transitions in daily routines (such as daily commuting routines from school to university, from university to work, or directly from school to work), stress from relationships, childbirth, domestic violence, low socioeconomic status, poverty, concerns about weight and body image, and the challenge of balancing parental and work responsibilities (O'Leary and Helgeson, 1997).

One of the key contributing factors of physical activity levels, and hence well-being is an individual's surroundings, often referred to as the built environment (McCormack and Shiell, 2011). The influence of the built environment affects several types of physical activity: home-based PA, occupational or work-related PA, travel PA, and leisure time PA (Elshahat et al., 2020). Built environment elements affecting active travel, i.e., walking or cycling for utilitarian or recreational purposes, include the design characteristics of pedestrian or cyclist infrastructure (availability, quality, connectivity, safety), the surrounding environment (open spaces, landscape aesthetics, security, lighting, buildings' height, cleanliness) and the neighborhood design (distance to several destinations, land use mix, interaction of the different transportation mode networks) (Pearce and Maddison, 2011). In particular, factors that contribute to improved PA and well-being, specifically regarding walking and cycling infrastructure, include access to sidewalks, walking or cycling paths, walkways or cycleways, biking facilities such as parking stations and shared bike systems, as well as high-quality surfaces, increased connectivity, and safe crossing sections (such as enhanced traffic signage, bridges, and underpasses). These elements make walking and cycling more appealing, thus promoting travel-related PA. An additional element affecting the level of PA is landscape characteristics. Walking or cycling is more appealing in aesthetically pleasing environments, water-related features (such as lakes, rivers, seas, and fountains), landmarks, and in areas with clean infrastructure, good air quality, attractive buildings, green and open spaces, and low noise levels. Safety and security are particularly significant elements, the deterioration of which may hinder PA, especially for young women. Conversely, well-lit areas, areas with low crime rates and enhanced road safety increase the propensity for PA. Last, additional elements such as land use diversity, short distances to reach different destinations, proximity to public transport stations, proximity to parks with gym facilities, and neighborhoods with strong social bonds that foster social interaction usually affect positively PA levels. The relationship between built environment characteristics and physical activity and mental health is understudied, particularly among residents of Eastern Europe and Balkan countries, as well as among specific population groups such as women. Although several studies have assessed the associations between urban design, neighborhood characteristics, and PA or active mobility (such as cycling and walking), most of this research has focused on high-income and Western European countries. Social, economic, and cultural differences may significantly influence the relationship between built environment features and physical activity or mental health in different regions. Sallis et al. (2016) examined the associations between physical activity and urban environment features in 14 cities worldwide; however, only two cities from Eastern Europe; Olomouc and Hradec Králové in the Czech Republic were included in the study. Another study assessed the relationship between the physical environment and the domains of PA among European adults using a systematic literature review. According to that study, there is an imbalance in the findings between Western and Eastern Europe, as most of the existing knowledge in this area comes from Western European countries (Holle et al., 2012). Most studies exploring the effect of the built environment on PA are based on cases from Western and Northern Europe, the US, Australia, as well as some middle and low-income countries (Bassett et al., 2008; Oyeyemi et al., 2011; Elshahat et al., 2020). Few studies, however, focus on Balkan countries, where the populations exhibit different characteristics, socioeconomic status and mentalities compared to those of the aforementioned regions, while also being highly car-dependent. The Balkans suffer from inadequate infrastructure for pedestrians and cyclists, while at the same time, various additional elements of the built environment may discourage PA, particularly among women (Pojani et al., 2017). To address this gap, the present study focuses on five cities in Balkan countries. The contribution of this study is to assess the correlation between built environment characteristics and PA, mental health among a less-study group: women in Balkan countries.

Physical activity (PA) can be measured using several indices, including intensity (light, moderate, or vigorous), duration, frequency, type (e.g., aerobic, strength training), and volume, which combines intensity, frequency, and duration, and other, less commonly used indices. Well-being on the other hand is a more abstract term, which can be measured by several different standardized questionnaires including the General Health Questionnaire, GHQ (Goldberg, 1978), the Affectometer (Kammann and Flett, 1983), the Beck Depression Inventory (BDI) (Beck et al., 1987), the Health Questionnaire for Adults (HQA) the Medical Outcomes Study (MOS), the MOS Short-Form General Health Survey, the Gothenburg Quality of Life Instrument (GQL) (Tibblin et al., 1990), the Rosenberg Self-Esteem Scale (Rosenberg, 2015), and the Subjective Vitality Scale (Ryan and Frederick, 1997). In this study, PA will be measured through intensity, frequency and duration, and mental well-being will be computed using the Warwick-Edinburgh scale (WEMWBS) which represents the perceived mental well-being (Stewart-Brown et al., 2011).

The objective of this study is to determine the impact of various built environment characteristics on PA levels and perceived mental well-being in Balkan countries, with a focus on young women. This

objective will be addressed by answering the following research questions (RQ):

> *RQ1*: Does the built environmental affect moderate and vigorous PA of young women in the Balkan countries, and how?
>
> *RQ2*: Does the built environmental affect young women's mental well-being in the Balkans countries, and how?

2 Methodology

2.1 Case cities

For the needs of this study, five cities from different Balkan countries were selected for the questionnaire survey. These are Niš (Serbia), Plovdiv (Bulgaria), Athens (Greece), Bucharest (Romania) and Štip (North Macedonia). The selected cities vary in size, built environment characteristics and dedicated pedestrian and cyclist infrastructure.

Niš is the largest city and industrial center in the south-east of Serbia, with a population of around 250,000 citizens which also makes it the third largest city in the country. The private car still comprises the dominant transport mode. The public transport network primarily relies on buses. Dedicated infrastructure for walking and cycling has not been a priority for the city so far.

Plovdiv is the second largest city in Bulgaria with a population of 348,000 inhabitants, 52% of which are women. Plovdiv boasts the most extensive cycling network, which is continuously expanded to further promote the use of active transport modes. The total length of the cycle lanes is 60 km, covering 58.8% of the city's area. Additional factors including the wrongly positioned bus stops and the ongoing infrastructure reconstruction activities, also hinder cycling continuity.

Athens, the capital of Greece, has an urban population of 3,059,764 and a metropolitan population of 3,638,281 inhabitants, making it the largest city of the country. Athens is a major transportation hub and has an extended public transport network that serves the city and its metropolitan area. The Athenian metro is the most reliable public transport mode. In addition, trips are served by a tram and an extensive bus network, but their performance is affected by traffic congestion. Although sustainable transport options are offered, Athenians comprise a car-dependent population, with the proportion of more than 50% of the total trips made by private car. In general, the quality of pedestrian infrastructure is poor with narrow or even non-existent sidewalks, obstacles on them (ranging from kiosks and restaurant seats to parked vehicles) and bad surface conditions. Considering the cycling network, its quality is even worse.

Bucharest, the capital of Romania, is a vibrant metropolis with a population of approximately 2 million residents, making it the largest city in the country. Public transportation is widely used, with an extensive network of buses, trams, and the metro system facilitating daily commutes for over 1.2 million people. Active mobility is also on the rise, with increased investments in cycling infrastructure and pedestrian zones, including over 25 km of dedicated cycle lanes. Despite these improvements, walking and cycling rates remain lower than the EU average, with only about 5% of trips made by bicycle and 10% by walking, compared to the EU averages of 8 and 12%, respectively.

Štip is the smallest participating city with 44,866 inhabitants. The city is located in the eastern part of the Republic of North Macedonia and is the 7th largest city in the country. The city is connected to its suburbs and neighboring municipalities through a bus network, and its pedestrian and cycling infrastructure spans approximately 7 km. The terrain in Štip is diverse, with flat areas along the Bregalnica and Otinja rivers, and hilly regions in other parts of the city. On the other hand, hilly terrains in some city areas reduce the uptake of active transport modes. For example, cycling, as a recreational activity, is popular around the fortress Isar or the Štip Kale. However, reaching the city's most famous landmark requires climbing more than 400 stairs.

2.2 Questionnaire design

A questionnaire survey was designed to identify knowledge gaps regarding physical activity, mental well-being, and the built environment in the Balkans region. The tool used was a revealed preference questionnaire, which was designed following a mixed-methods approach, incorporating both quantitative and qualitative questions. The questionnaire was divided into five sections: "Neighborhood and Mobility Attributes," "Physical Activity," "Nutrition," "Well-being," and "Socioeconomic Factors."

Data on mobility attributes was collected through questions revealing participants' modal choice preferences. Data on neighborhood attributes is classified into two categories: perceived attributes and objective characteristics of the built environment. The perceived attributes were collected utilizing the ALPHA environmental questionnaire (Spittaels et al., 2009). This involves a standardized set of questions addressing various elements of the neighborhood environment such as land uses, walking and cycling infrastructure, prevailing conditions including safety and security and so on. To explore the objective built-environment elements, participants were asked to indicate the nearest intersection or landmark to their home [their exact home address inquired, in accordance with the General Data Protection Regulation (GDPR)]. Objective built environment variables, such as link density, street-length density, intersection density, and link-node ratio, were calculated within a 600-meter catchment area utilizing GIS software. The physical activity level of the participants was estimated using the short form of the International Physical Activity Questionnaires (IPAQ) (Lee et al., 2011). Through IPAQ self–reported physical levels and attributes of engagement in moderate and vigorous PA, including the number of days and time (minutes) spent for walking, sitting, and screen time are recorded. Furthermore, three questions on eating habits provided data on participants' nutrition. Participant well-being was measured using the Warwick-Edinburg Mental Well-Being Scale (WEMWBS). This scale is aimed at identifying the perceived mental well-being, through a set of 14 different statements referring to personal feelings and different aspects of well-being. Last, data regarding socioeconomic variables was collected in the last section of the questionnaire and included information on age, marital status, household size, number of children, work status, gross household income, financial status, and private transport mode ownership and accessibility.

The questionnaire was initially designed in English, while prior to being distributed in the five cities it was translated to the respective languages. A set of guidelines was also created for clarification reasons.

In total the questionnaire consisted of 49 questions, and participants required approximately 10–15 min to complete it.

2.3 Data collection

Data was collected over a three-month period, through on-line distribution. Online distribution included posts at various social media channels and groups, as well as to participants known to the interviewers or interviewees. Efforts were made to ensure a heterogeneous sample, including participants with diverse sociodemographic characteristics, to capture a wide range of perspectives. Participants who had difficulty understanding the questions were invited to an online meeting to receive additional information and guidance on how to answer them. As such, the sampling method comprised a combination of convenience, snowball and quota sampling methods. For the needs of the study, participant gender and age were predefined, i.e., participants had to be young women, aged between 17 and 40. The final sample consisted of 1,222 women, with their distribution across the different cities being 49% (597) from Bucharest, 17% (205) from Niš, 15% (135) from Athens, 11% (191) from Štip, and 8% (94) from Plovdiv.

The sample composition in total and per city is illustrated in Table 1.

As anticipated, the sociodemographic characteristics of the survey participants differ across the five cities/countries. In particular, the predominant age group varies across the pilot cities, with the sample concentrated in the 17–30 age range. Considering employment, the prevalent groups are students and women who work. Marital status is fairly evenly distributed across the different groups, while only a small proportion of women have children. Most women in the sample own a private car, and the majority report a middle-income financial status category.

2.4 Data processing

Following data collection, the responses provided in text format were first translated from the local languages into English. Two rounds of data cleaning and validation were then conducted to create a valid dataset. The next step involved variable coding, which was primarily required for categorical variables. The dependent variables were MPA, VPA and mental well-being, while the independent were the built environment and neighborhood subjective variables, the built environment objective variables and the different socioeconomic characteristics.

The index utilized to represent moderate and vigorous PA was calculated according to the guidelines of the short version of IPAQ, with the coefficients for moderate and vigorous PA being 4 and 8, respectively. The total Metabolic Equivalent of Task (MET) was calculated as the sum of MET-minutes per week from walking, moderate, and vigorous activities. The MET coefficients used were 3.3 for walking, 4.0 for moderate physical activity (MPA), and 8.0 for vigorous physical activity (VPA) based on IPAQ protocol. To estimate mental well-being index, the methodology reported in Stewart-Brown et al. (2011) was adopted. Participants rated different elements of their well-being utilizing a 5-point Likert scale for each question. The mental well-being index was then computed by summing the scores of all 14 questions for each participant. Figure 1 shows the different levels of MPA, VPA, and well-being among various countries included in this study. To compute the objective built environment parameters, GIS software (ArcMap 10.4) was used. Shapefiles from the pilot cities, i.e., Athens, Štip, Plovdiv, Bucharest, and Niš were downloaded from OpenStreetMap, and participants' "home" locations (indicated by the nearest intersection or landmark) were transferred from Google Maps to ArcMap. The disaggregated built environment variables, which were link, intersection, and street-length density, within a pre-defined catchment area were calculated in GIS using network and spatial analysis tools. The catchment area was defined as a 600-meter radius, measured along the street network, in accordance with urban transportation literature (Masoumi et al., 2019; Li et al., 2019).

2.5 Analysis methods

Kolmogorov–Smirnov and Sharipo-Wilk tests were applied for the assessment of the variable distributions, which would determine the statistical analysis that would be adopted. A p-value smaller than 0.05 suggests that the null hypothesis, which is that the variable follows a normal distribution, should be rejected. The computed p-values (Table 2) were below 0.05, hence the three dependent variables – namely, moderate and vigorous PA, and mental well-being among young women in the Balkans are not normally distributed.

Multiple linear regression (MLR) modelling was performed to identify the subjective and objective built environment and neighborhood factors that affect the engagement in moderate and vigorous PA, and the mental well-being of the sample, and provide answers to the study's research questions. The subjective built environment and neighborhood variables were derived from the questionnaire based on the perceptions and attitudes of participants reported in the relevant questionnaire section. These variables include the availability of different routes for cycling, the pleasantness of these routes, land use diversity, the pleasantness of the walking environment, the availability of green spaces and trees near pedestrian areas, shops in the neighborhood, and segregated cycling routes in the neighborhood. The objective built environment variables are the link-node ratio, link density, and street-length density, as specified in the previous section. However, only those exhibiting significant associations in the MLRs were kept in the final models.

To obtain better results, socioeconomic variables were treated as control variables in the MLR models. The control variables for MPA, as indicated from the statistical analysis, were age, household size, number of children, income, and employment status. Additionally, age, household size, number of children, and income were the control variables in the VPA model. Finally, the only controlled variable in the MLR for mental well-being was income. Different socioeconomic variables were fixed in the multiple linear regression (MLR) models to achieve the best results, characterized by the highest R-squared value, more significant independent variables, and statistically significant control variables.

3 Results

3.1 Descriptive statistical analysis

The five pilot cities exhibited variations in the objective built environment characteristics, which also represent street connectivity. Higher values of link density, link-node ratio, and intersection density

TABLE 1 Distribution of socioeconomic characteristics.

Variable	Category	Measure	Country					Total
			Greece	Bulgaria	Romania	Serbia	North Macedonia	
Participants	Country	N/%	135 (11%)	94 (8%)	597 (49%)	205 (17%)	191 (15%)	1,222
Participants per age	17–20y	N/%	11 (8%)	15 (16%)	484 (81%)	0 (0%)	92 (48%)	602 (49%)
	21–25 y	N/%	68 (50%)	45 (48%)	48 (8%)	58 (28%)	66 (35%)	285 (23%)
	26–30 y	N/%	55 (41%)	33 (35%)	63 (11%)	147 (72%)	33 (17%)	331 (27%)
	31–38 y	N/%	1 (1%)	1 (1%)	2 (0.3%)	0 (0%)	0 (0%)	4 (0.3%)
	Total	N/%	135 (11%)	94 (7.7%)	597 (48.9%)	205 (16.8%)	191 (15.6%)	1,222
Employment and work status	In paid work (or away temporarily) (employee, self-employed, working for your family business)	N/%	71 (52.6%)	55 (58.5%)	96 (16.1%)	205 (100.0%)	44 (23.0%)	471 (38.5%)
	Unemployed and actively looking for a job	N/%	8 (5.9%)	5 (5.3%)	6 (1%)	0 (0%)	12 (6.3%)	31 (2.5%)
	Permanently sick or disabled	N/%	1 (0.7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (0.1%)
	Doing housework, looking after children or other persons	N/%	2 (1.5%)	0 (0%)	5 (0.8%)	0 (0%)	6 (3.1%)	13 (1.1%)
	Student	N/%	53 (39.3%)	34 (36.2%)	490 (82.1%)	0 (0%)	129 (67.5%)	706 (57.8%)
	Total	N/%	135 (11%)	94 (7.7%)	597 (48.9%)	205 (16.8%)	191 (15.6%)	1,222
Marital status	Single/divorced/ widow	N/%	57 (42.2%)	46 (48.9%)	282 (47.2%)	89 (43.4%)	87 (45.5%)	561 (45.9%)
	Married/living with my partner	N/%	19 (14.1%)	25 (26.6%)	86 (14.4%)	116 (56.6%)	34 (17.8%)	280 (22.9%)
	In a relationship but living separately	N/%	59 (43.7%)	23 (24.5%)	229 (38.4%)	0 (0%)	70 (36.6%)	381 (31.2%)
	Total	N/%	135 (11%)	94 (7.7%)	597 (48.9%)	205 (16.8%)	191 (15.6%)	1,222
Number of children in the household	0	N/%	133 (99%)	89 (95%)	550 (92%)	48 (23%)	159 (84%)	979 (80%)
	1	N/%	2 (1%)	4 (4%)	27 (5%)	66 (32%)	14 (7%)	113 (9%)
	2	N/%	0 (0%)	1 (0.01%)	15 (3%)	91 (44%)	14 (7%)	121 (10%)
	3	N/%	0 (0%)	0 (0%)	5 (1%)	0 (0%)	2 (1%)	7 (1%)
	4	N/%	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)	1 (1%)
	Total	N/%	135 (11%)	94 (7.7%)	597 (48.9%)	205 (16.8%)	191 (15.6%)	1,221
Car ownership	No	N/%	53 (39.3%)	39 (41.5%)	189 (31.7%)	0 (0%)	68 (35.6%)	349 (28.6%)
	Yes	N/%	82 (60.7%)	55 (58.5%)	408 (68.3%)	203 (100%)	123 (64.4%)	871 (71.4%)
	Total	N/%	135 (11%)	94 (7.7%)	597 (49%)	203 (16.7%)	191 (15.6%)	1,220

(Continued)

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TABLE 1 (Continued)

Variable	Category	Measure	Country					Total
			Greece	Bulgaria	Romania	Serbia	North Macedonia	
Gross household monthly income	0	N/%	8 (5.9%)	1 (1.1%)	45 (7.5%)		84 (44%)	138 (13.6%)
	0–499	N/%	9 (6.7%)	10 (10.8%)	59 (9.9%)		52 (27.2%%)	130 (12.8%)
	500–999	N/%	19 (14.1%)	27 (29%)	91 (15.2%)		35 (18.3%)	172 (16.9%)
	1,000–1,499	N/%	28 (20.7%)	22 (23.7%)	110 (18.4%)		5 (2.6%)	165 (16.2%)
	1,499–1999	N/%	20 (14.8%)	15 (16.1%)	80 (13.4%)		2 (1%)	117 (11.5%)
	2000–2,499	N/%	16 (11.9%)	13 (14%)	79 (13.2%)		2 (1%)	110 (10.8%)
	2,500–2,999	N/%	20 (14.8%)	4 (4.3%)	31 (5.2%)		1 (0.5%)	56 (5.5%)
	3,000–3,499	N/%	13 (9.6%)	1 (1.1%)	24 (4%)		2 (1%)	40 (3.9%)
	3,500 and more	N/%	2 (1.5%)	0 (0%)	78 (13.1%)		8 (4.2%)	88 (8.7%)
	Total		135 (13.3%)	93 (9.2%)	597 (58.7%)		191 (18.8%)	1,016
Financial status	Low	N/%	20 (14.8%)	3 (3.2%)	17 (2.8%)		27 (14.1%)	67 (6.6%)
	Low-mid	N/%	24 (17.8%)	27 (28.7%)	38 (6.4%)		31 (16.2%)	120 (11.8%)
	Mid	N/%	70 (51.9%)	52 (55.3%)	373 (62.5%)		104 (54.5%)	599 (58.9%)
	Mid-high	N/%	21 (15.6%)	12 (12.8%)	139 (23.3%)		24 (12.6%)	196 (19.3%)
	High	N/%	0 (0%)	0 (0%)	30 (5%)		5 (2.6%)	35 (3.4%)
	Total	N/%	135 (13.3%)	94 (9.2%)	597 (58.7%)		191 (18.8%)	1,017

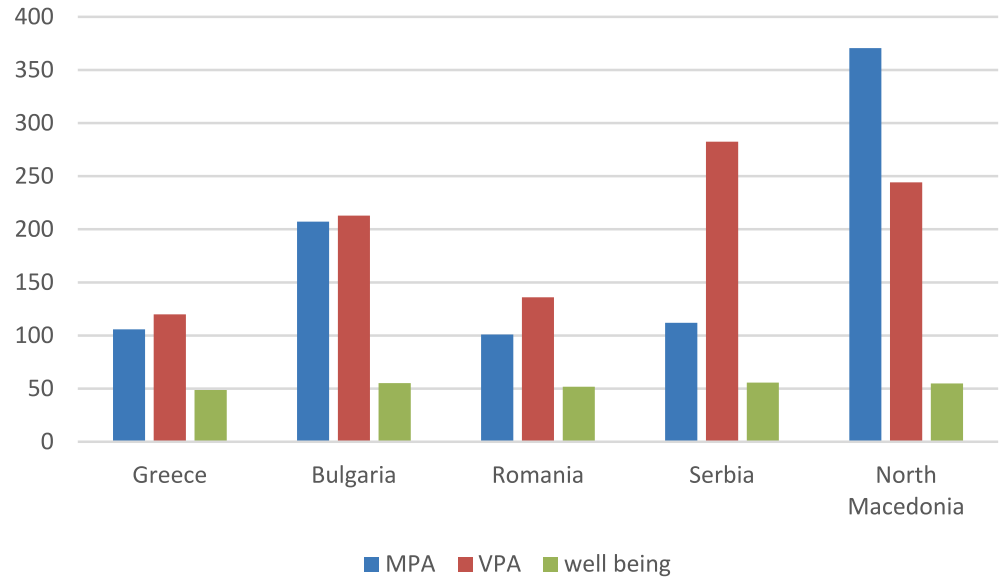

FIGURE 1
MPA, VPA and well-being scores.

are associated with greater street connectivity in the neighborhood. The average link-node ratios were found to be 2.859, 1.476, 1.741, 1.743, and 2.553 for Athens, Bucharest, Niš, Plodiv and Štip, respectively.

MPA and VPA present distinct patterns and mean values across the different countries. In particular, the distribution between MPA and VPA is rather similar in the explored cities in Greece, Bulgaria and Romania. In contrast, participants from Serbia engage in substantially more VPA than MPA, while women from North Macedonia engage in more MPA than VPA. Despite variations in MPA and VPA levels across countries, the average mental well-being score remains relatively consistent, ranging from approximately 49–56 (Table 3).

To explore the differences of MPA, VPA and mental well-being between countries, the Kruskal-Wallis test was performed. Tables 2, 4, 5, illustrate the results.

Results indicate that almost all pairwise comparisons show statistically significant differences considering MPA and VPA. These are reflected in Tables 2, 4, where *p*-values exhibit values equal or lower than 0.05. Moreover, although the differences of the mental well-being scores across the five cities were relatively small, the statistical analysis suggests that these differences are statistically significant for most pair-wise comparisons (Table 5).

3.2 MLR model for MPA and VPA

Two MLR models were developed separately for MPA and VPA. Table 6 summarizes the MPA model and the related ANOVA F-test. Most of the socioeconomic variables (age, household size, number of children, gross household monthly income, and employment status) affect MPA, however, as the aim of the study is to isolate the effect of the built environment on MPA, we treat them as control variables, and their effect is not elaborated in the present study. The only objective built environment variable in the model is street-length density, which is marginally significant ($p = 0.097$). It is positively correlated with MPA, suggesting that street connectivity increases the MPA levels of young women. Two subjective built environment variables were found to significantly affect MPA. The availability of shops near the living place presents an 8% reduction in MPA probably because shopping, i.e., walking around the shops is

TABLE 2 Kuskul-Wallis test for country-wide comparison of MPA levels.

Country 1 vs. Country 2	Test statistic	Std. error	Std. test statistic	*P*
Greece–Romania	−5.557	33.157	−0.168	0.867
Greece–Serbia	−99.565	38.563	−2.582	0.010
Greece–North Macedonia	−149.438	39.120	−3.820	<0.001
Greece–Bulgaria	−192.053	46.737	−4.109	<0.001
Romania–Serbia	−94.009	28.164	−3.338	0.001
Romania–North Macedonia	−143.882	28.922	−4.975	<0.001
Romania–Bulgaria	186.497	38.606	4.831	<0.001
Serbia–North Macedonia	−49.873	34.989	−1.425	0.154
Serbia–Bulgaria	92.488	43.338	2.134	0.033
North Macedonia–Bulgaria	42.615	43.834	0.972	0.331

TABLE 3 Descriptive statistics for MPA, VPA, and mental well-being.

Country	Variable	N	Min	Max	Mean	Std. deviation
Greece	MPA (min/week)	135	0	1,680	105.90	202.720
	VPA (min/week)	135	0	840	119.95	159.143
	Well-being	135	27	70	48.66	10.097
Bulgaria	MPA (min/week)	94	0	1,500	207.14	266.907
	VPA (min/week)	92	0	2,100	212.90	291.600
	Well-being	94	26	70	55.28	8.982
Romania	MPA (min/week)	597	0	1,440	100.91	160.436
	VPA (min/week)	597	0	2,520	136.03	220.545
	Well-being	597	14	70	51.78	10.188
Serbia	MPA (min/week)	205	0	420	112.05	91.515
	VPA (min/week)	205	120	800	282.54	133.554
	Well-being	205	52	62	55.71	3.037
North Macedonia	MPA (min/week)	191	0	3,360	370.58	621.042
	VPA (min/week)	191	0	1800	244.27	357.129
	Well-being	191	30	70	54.82	8.956

TABLE 4 Kuskul-Wallis test for country-wide comparison of VPA levels.

Country 1 vs. Country 2	Test statistic	Std. error	Std. test statistic	*P*
Greece–Romania	−5.449	33.216	−0.164	0.870
Greece–North Macedonia	−104.875	39.190	−2.676	0.007
Greece–Bulgaria	−141.250	47.119	−2.998	0.003
Greece–Serbia	−381.826	38.631	−9.884	<0.001
Romania–North Macedonia	−99.426	28.974	−3.432	0.001
Romania–Bulgaria	135.800	39.037	3.479	0.001
Romania–Serbia	−376.377	28.214	−13.340	<0.001
North Macedonia–Bulgaria	36.374	44.231	0.822	0.411
North Macedonia–Serbia	276.950	35.051	7.901	<0.001
Bulgaria–Serbia	−240.576	43.737	−5.500	<0.001

TABLE 5 Kuskul-Wallis test for country-wide comparison of mental well-being.

Country 1 vs. Country 2	Test statistic	Std. error	Std. test statistic	*P*
Greece–Romania	−111.870	33.605	−3.329	0.001
Greece–North Macedonia	−229.163	39.649	−5.780	<0.001
Greece–Bulgaria	−241.367	47.369	−5.096	<0.001
Greece–Serbia	−264.085	39.084	−6.757	<0.001
Romania–North Macedonia	−117.293	29.313	−4.001	<0.001
Romania–Bulgaria	129.497	39.128	3.310	0.001
Romania–Serbia	−152.215	28.545	−5.332	<0.001
North Macedonia–Bulgaria	12.205	44.427	0.275	0.784
North Macedonia–Serbia	34.922	35.462	0.985	0.325
Bulgaria–Serbia	−22.717	43.924	−0.517	0.605

TABLE 6 MLR model for MPA (R^2 = 0.054).

Variable group	Independent variable	B	Std. error	*β*	*t*	*P*	VIF
Constant		569.130	153.52		3.707	<0.001	
Control	Age	−4.914	3.19	−0.059	−1.543	0.123	1.264
	Household Size	28.028	7.25	0.135	3.866	<0.001	1.053
	Number of children	55.651	25.05	0.084	2.222	0.027	1.253
	Gross household monthly income	−51.913	23.89	−0.074	−2.173	0.030	1.017
	Employment and work status	−135.107	52.59	−0.089	−2.569	0.010	1.039
Objective built environment	Street-length density	163.927	98.74	0.057	1.660	0.097	1.014
Subjective built environment	Availability of shops in the neighborhood	−71.074	29.41	−0.084	−2.417	0.016	1.056
	Availability of many routes for cycling in the neighborhood	56.445	23.92	0.082	2.360	0.019	1.038

ANOVA *F*-test				
Sum of squares	df	Mean square	*F*	*P*
5,024,421	8	628,053	6.678	<0.001

TABLE 7 MLR model for VPA (R^2 = 0.062).

Variable group	Independent variable	B	Std. error	*Beta*	*t*	*P*	VIF
Control	Age	−2.892	2.666	−0.043	−1.085	0.278	1.278
	Household Size	18.181	6.070	0.107	2.995	0.003	1.048
	Number of children	−37.966	22.140	−0.068	−1.715	0.087	1.278
	Gross household monthly income	−24.941	19.668	−0.045	−1.268	0.205	1.013
Objective built environment	Link density	−25278.217	7762.613	−0.123	−3.256	0.001	1.160
	Link-node ratio	10.795	5.311	0.076	2.033	0.042	1.156
Subjective built environment	Availability of shops in the neighborhood	−41.562	24.399	−0.061	−1.703	0.089	1.055
	Availability of many routes for cycling in the neighborhood	56.273	17.843	0.111	3.154	0.002	1.016

ANOVA *F*-test				
Sum of squares	df	Mean square	*F*	*P*
2,674,066	8	334,258	5	<0.001

associated more with light PA rather than MPA ($p = 0.016$). Moreover, the presence of biking routes in the living neighborhood is, as expected, positively correlated with MPA, and is associated with 8% more MPA among the respondents of this study ($p = 0.019$). It should be noted that there is no multicollinearity among the model's independent variables, as the VIF values ranged between 1 and 1.3. The ANOVA F-test results indicate that the model is valid ($p < 0.001$).

Table 7 presents the MLR model for VPA. In the case of vigorous PA, there is a smaller number of socioeconomic factors that affect the variable levels. These are age, household size, number of children, and gross household monthly income, and were treated again as control variables. Two objective built environment variables, those of link density and link-node ratio were found to be significant in the model ($p = 0.001$ and $p = 0.042$, respectively). Both represent street network connectivity and both show that there is a positive relationship between connectivity and VPA. When link density, which is represented by ratio of intersections to the area, increases VPA also increases among the respondents. As the link-node ratio increases, represented by the ratio of the number of streets to the number of intersections, both connectivity and vigorous physical activity (VPA) decrease. Moreover, specific subjective built environment variables appear to affect VPA. These are the availability of shops in the neighborhood and the availability of biking routes. Availability of shops in the neighborhood is associated with 6% lower VPA among the respondents ($p = 0.089$). On the other hand, availability of cycling routes in the neighborhood is significantly correlated with 11% more VPA ($p = 0.002$). The model is valid as the *p*-value of the ANOVA F test is <0.001. The model has an R^2 of 6% and there is no collinearity between the independent variables, as the VIF values are between 1 and 1.3.

3.3 MLR model for mental well-being

MLR modelling was employed to analyse the associations between built environment variables and mental well-being. The respondents' well-being scores were treated as the dependent variable. The model achieved the best fit by treating gross household and monthly income as control variables. Five subjective built environment factors were identified as having an impact on mental well-being levels, while objective built environment variables related to street network were not found to be influential (Table 8).

The availability of cycling routes in the neighborhood is strongly correlated with perceived well-being ($p < 0.001$). The correlation is positive, and the model results show that the availability of biking routes in the neighborhood is associated with a 12% higher well-being score. The diversity of land use, reflecting the presence of different urban functions in the living neighborhood, is significantly and positively associated with perceived well-being ($p = 0.006$). This indicates that a diverse land-use environment results in an 8.5% higher well-being score, particularly among women. The attractiveness of cycling routes and their surrounding environment is marginally positively correlated with well-being ($p = 0.072$), with a 7% increase in mental well-being associated with more attractive cycling routes. Similarly, the attractiveness of the neighborhood for walking comprises yet another significant independent variable ($p = 0.009$). Its positive coefficient indicates that the attractiveness of the area for walking results to a 10% increase in mental well-being among the respondents. Finally, the presence of green areas and trees in the neighborhood shows a marginally significant association with mental well-being ($p = 0.077$), corresponding to a 6% increase in the reported well-being. The *p*-value of the ANOVA F-test is below 0.001, indicating model validity. R^2 is 7.8%, meaning that the independent variables in the model explain 7.8% of the variation in the mental well-being of young women. As seen in Table 8, there is no sign of multicollinearity among the independent variables, as the VIF values range from 1 to 1.5.

4 Discussion

The present study provides valuable insights into how built environment characteristics influence physical activity (PA) and

TABLE 8 MLR model for mental well-being (R^2 = 0.078).

Variable group	Independent variable	*B*	Std. error	*Beta*	*t*	*P*	VIF
Constant		39.434	1.941		20.312	<0.001	
Control	Gross household monthly income	−1.281	0.671	−0.058	−1.910	0.056	1.006
Subjective built environment	Availability of shops in the neighborhood	2.687	0.709	0.123	3.791	<0.001	1.156
	Presence of diverse land use in the area	1.776	0.649	0.085	2.736	0.006	1.052
	Pleasance and attractiveness of the cycling routes	1.328	0.737	0.066	1.802	0.072	1.470
	Pleasance of the local neighborhood for walking	2.119	0.807	0.096	2.628	0.009	1.464
	Availability of green or trees along the streets in the neighborhood	1.365	0.771	0.059	1.770	0.077	1.194

ANOVA *F*-test				
Sum of squares	df	Mean square	*F*	*P*
7,939	6	1323.2	14.183	<0.001

well-being in young women across five cities in the Balkans. International research suggests that the PA levels in females are lower than in males and presents a consistent decline throughout their lifespan (Guthold et al., 2018). The investigated age group of women (i.e., 17–40 year old) is unique in terms of their PA levels and well-being due to several age-specific events. As confirmed by study results, participants from different countries present different PA levels and different self-perceptions of their well-being. Statistical findings reveal significant cross-country differences in both moderate physical activity and vigorous physical activity. Women in North Macedonia report the highest MPA, followed by women from Bulgaria, while Romania reports lowest. Similar patterns are observed for VPA, with Serbia and North Macedonia leading in participation, while the lowest mean scores are reported for Romania and Greece. The low results for MPA and VPA for Romania and Greece are also confirmed in Sport and Physical Activity - Eurobarometer Survey (2022), WHO PA Fact Sheets for EU countries WHO (2021), and review studies from EU countries (Gerovasili et al., 2015). The lower PA levels in women are not only a result of biological factors, but are also influenced by societal expectations and cultural norms, which are more pronounced considering women in the target age group, thus exhibiting a higher effect (Peng et al., 2023). Changes in societal roles, for example enrolling in university, starting work, marriage, and motherhood are directly related to income, available free time, and setting life priorities. At the same time, these factors are closely associated with motivation for PA and the time available for it. As such, they can significantly impact the PA levels and movement habits of women. Several studies report that work (Winpenny et al., 2020), marriage, and childbirth (Brown et al., 2009; Gropper et al., 2020) as leading reasons for the decrease in the PA levels among young women. The participants in our study were quite diverse in terms of socioeconomic status, especially regarding employment and marital status. In particular, the majority of participants from Romania and North Macedonia were students, while participants from Greece, Bulgaria, and Serbia were employed. The variation in employment rates and student status across countries (e.g., 100% employment in Serbia vs. 16.1% in Romania) presents significant socioeconomic disparities. Previous research has shown that employment status and economic security are crucial determinants of PA levels, particularly in women (Bauman et al., 2012). Lower employment rates among participants from Romania may correlate with lower PA engagement due to financial constraints, limited access to recreational facilities, or psychological stress. As confirmed by Beenackers et al. (2012), in their review regarding different EU countries, higher socioeconomic status is associated with higher PA levels, particularly VPA during leisure time. At the same time, having a job, especially for married women with children, may result in a lack of free time, reducing the potential or the time spent for PA.

While finding time to engage in PAs is the key to being active, the way - HOW to do it or WHAT to do - and the location - WHERE to do it - can vary, affecting its feasibility, and hence its frequency and duration. Regarding the "HOW" dimension of PA, a wide range of activities are available including low and high-intensity activities, strength-oriented or cardio-oriented activities. The list of activities is long, and it can include walking, running, cycling, tennis, table tennis, swimming, ball sports, pilates, aerobics, HIIT, fitness, skying, yoga, tai–chi, martial arts, and so on. The preferences regarding the "HOW" and "WHAT" are highly subjective, and are based on personal abilities, interests, preferences, and available options. The "WHERE" dimension is also important, as different location options may also affect PA engagement. Examples include home-based activities, club-based activities, outdoor activities, and community-based activities. The "WHERE" location involves first the availability of PA in different locations and second the preferences of potential participants considering these activities. While selecting among the different

available options depends usually on participant-related characteristics, the existence of the different options is usually affected by technical resources and space allocation. In this regard, and in line with our study objectives and research questions, the built environment characteristics, may also affect the design of dedicated measures promoting PA. Active travel increases PA, and is particularly appealing to employed young women, who do not own or have access to a private car, as car ownership can reduce utilitarian walking and cycling, regardless of gender, hence affecting moderate PA levels (Dyck et al., 2010).

4.1 Effects of the built environment on physical activity

One of the objective built environment variables affecting MPA levels of women in the Balkan countries was found to be street-length density, which is marginally significant and positively correlated with MPA, indicating that areas with densely connected networks promote more MPA. This finding aligns with previous research, which has shown that community design with higher street connectivity promotes walking and cycling and encourages active travel by offering more direct and safer routes (Saelens and Handy, 2008; Frank et al., 2005). Similarly, Sallis et al. (2012) demonstrated that urban areas with high intersection density and accessible infrastructure encourage greater PA participation. However, the relationship between street connectivity and MPA in our study appears inconsistent, as some countries with higher street connectivity (e.g., Greece) report lower MPA and VPA levels and vice-versa (e.g., Serbia). This suggests that not only street connectivity, but additional factors also affect the PA levels (e.g., weather conditions, pedestrian areas, sidewalks, lighting, overall safety etc.). For example, in our study, in Athens, pedestrian infrastructure is identified as low quality with narrow or non-existent sidewalks and bad surface conditions, making the streets unattractive for walking, running, and cycling. Sallis et al. (2012) reported that the availability of high-quality infrastructure for walking and cycling (e.g., sidewalks, bike paths, crosswalks) promotes active travel PA among the population, hence the lack of such infrastructure discourages PA. Additionally, high temperatures during summer months can be an additional burden and further discourage PA. A similar situation is observed in Bucharest, where, despite the relatively good infrastructure and street connectivity, and the increased investments in cycling infrastructure and pedestrian zones (including over 25 kilometers of dedicated cycling lanes), participants from Romania exhibited the lowest reported minutes for MPA and the second lowest for VPA. On the contrary, Niš (Serbia) is reported to have the second lowest values for street connectivity, but still exhibits the highest reported minutes for VPA, and a higher level of MPA compared to Greece and Romania. Although the dedicated infrastructure for walking and cycling is not recognized as a priority for the city of Niš, it is described as a relatively pedestrian-friendly city, that offers a network of sidewalks and pedestrianized areas, especially in its central part. Cycling also gained popularity among residents, as a result of the design of dedicated cycling lanes and the adoption of a bike-sharing scheme. These examples suggest that additional objective factors (infrastructure, climate, air pollution etc.), as well as habits, cultural, and social factors also play a role when considering PA behaviors (Sallis et al., 2012). Societal barriers are especially present in Balkan countries. Pojani et al. (2017), based on results from a study conducted in the Netherlands, Albania and Kosovo, reported that Balkan cities face societal barriers such as the high status associated with car ownership and the perceived incompatibility between cycling and the female gender. This discourages people from cycling, particularly limiting PA engagement resulting from utilitarian walking or cycling trips. The location of places for walking and cycling is also important. Zhang et al. (2019) identified significant positive associations between park-based leisure PA, park lighting, and walking and cycling trails. Among the contributing subjective built environment variables, the availability of shops in the neighborhood was found to be significantly associated with an 8% decrease in MPA. Although proximity to shops encourages walking, which is a light-intensity physical activity, participants may not include shopping time when reporting MPA. Previous studies have noted similar trends, where accessibility to retail destinations is linked to increased walking, but not necessarily with higher-intensity physical activities (Giles-Corti et al., 2005).

On the other hand, the presence of cycling routes near the living area is positively correlated with MPA, supporting the notion that dedicated cycling infrastructure promotes active travel and physical activity (Winters et al., 2010; Pojani et al., 2017). Living close to a natural outdoor environment suitable for different forms of PA was found positively correlated with the PA levels of adults in a study performed in different European cities (Triguero-Mas et al., 2017). The observed 8% increase in MPA due to the presence of cycling routes is consistent with prior findings, highlighting the importance of cycling infrastructure in active commuting (Buehler and Pucher, 2012; Pojani et al., 2017).

Two objective built environment variables, link density and link-node ratio, were found to significantly affect vigorous physical activity. The positive relationship between link density and VPA suggests that areas with a higher number of intersections per unit area facilitate more vigorous activity, likely by promoting walkability and access to various destinations (Ewing and Cervero, 2010). However, the positive association between the link-node ratio and VPA suggests that as the number of streets divided by intersections increases, connectivity weakens, potentially reducing accessibility and engagement in vigorous activity. This finding is somewhat counterintuitive and warrants further investigation.

Similarly to the MPA model, the subjective built environment variables function in the same manner. The availability of shops is negatively correlated with VPA, reinforcing the idea that shopping-related movement is generally of lower intensity. The availability of cycling routes shows a significant positive relationship with VPA, with an 11% increase in vigorous PA, further confirming the role of cycling infrastructure in promoting active travel (Buehler and Pucher, 2012).

Overall, these findings highlight the importance of both objective and subjective built environment factors in shaping physical activity behaviors. Higher street connectivity and cycling infrastructure appear to facilitate moderate and vigorous physical activity, whereas proximity to shops may promote lighter activity such as walking rather than MPA or VPA. These results suggest that urban planning and transportation policies should prioritize the development of connected street networks, with available sidewalks, safe pedestrian areas, and dedicated cycling infrastructure to encourage higher levels of physical activity among young women. In this regard, it should not be forgotten to consider issues that arise from unplanned urban expansions leading to environmental and health hazards, including air

pollution, diminished safe spaces for walking and cycling, and so on (Agarwal et al., 2007).

Positive practices, such as bike-sharing schemes, community support in creating green spaces and urban zones that encourage PA, subsidies for bicycles and other micro-mobility transport modes purchase, and other activities like forming walking and cycling groups can serve as effective strategies. In this regard, in PA Factsheets from 2021, WHO included urban planning in one of the policy responses aimed at improving PA levels among EU member countries. Within these recommendations, it is suggested that "all population groups should have access to infrastructure conducive to active leisure time." Guidelines have been prepared within the European Commission-funded project Improving Infrastructures for Leisure-time Physical Activity in the Local Arena (IMPALA), including sports facilities, infrastructure, and urban "green" and "blue" spaces" (WHO, 2021 PA factsheet, pp. 11). This has initiated the design and implementation of specific actions and policies in the EU countries. For example, in Greece a national bicycle strategy and a national accessibility plan have been designed. Within this framework, a "bicycle observatory" was developed to monitor the implementation of the strategy, assess cycling infrastructure and record the number of daily bicycle trips (WHO, 2021, pp. 108).

4.2 Effects of the built environment on mental well-being

The relationship between built environment variables and the mental well-being of young women in the participating countries comprised the second research question of the present study. The respective MLR model for mental well-being highlights significant associations between subjective built environment variables and perceived well-being. Notably, no objective built environment variable related to the street network was found to be significant. Instead, five subjective built environment variables contribute significantly to perceived well-being, explaining 7.8% of the variance. They are the availability of cycling routes, the extent of land use diversity, the attractiveness of cycling routes, the overall attractiveness of the neighborhood and the presence of green areas and trees.

The availability and attractiveness of cycling routes in the neighborhood were identified as relevant and important for mental well-being. These factors were also found to be associated with PA, highlighting the link between well-being and PA. This finding is in line with previous studies noting that access to active transport infrastructure enhances physical activity levels (Mueller et al., 2015) and mental health by reducing stress and promoting outdoor engagement (Ma and Dill, 2015). To comprehend outdoor engagement and its impact on well-being, it is worth emphasizing the links between outdoor activities and spending time outdoors with well-being. Engagement in outdoor activities encourages positive emotions and enthusiasm providing pleasure, enjoyment, and personal satisfaction, comfort and intense emotions, satisfaction from personal achievements, vital strength and experience from nature (Clough et al., 2016; Tsaur et al., 2015; Crust et al., 2013). Spending time outdoors enhances awareness of personal health and its importance for overall well-being. It fosters a commitment to develop healthy habits and cultivates a healthy and active lifestyle as a personal goal, offering numerous benefits for both mental and physical well-being (Deenihan and Caulfield, 2014). Evidence on the positive correlations of outdoor activities on different dimensions of health and well-being can be found in several studies. Examples include revitalization, and reduction in tension, confusion, anger, and depression (Eigenschenk et al., 2019), greater enjoyment (Crust et al., 2013), improvement of individual well-being and increased perception of personal health and stronger nature-relatedness (Puhakka et al., 2018). This is also confirmed by the results of the present study, which showed that the presence of green areas and trees is associated with a 6% increase in mental well-being. This finding supports the growing body of evidence indicating that exposure to green spaces and tree-lined streets enhances psychological well-being by reducing stress and promoting relaxation (Gascon et al., 2015), and by increasing enjoyment (Crust et al., 2013).

The attractiveness of cycling routes and the overall attractiveness of the neighborhood for walking and cycling were also found to be positively associated with well-being, as they increased the well-being scores by 7 and 10%, respectively. These results reinforce the notion that aesthetically pleasing and accessible pedestrian and cycling environments contribute to mental health benefits (Mitchell et al., 2015), emphasizing the links between aesthetics and well-being.

The presence of diverse land uses in the neighborhood comprises yet another significant predictor associated with an 8.5% increase in well-being. Land use diversity facilitates access to commercial, recreational, and institutional establishments that are located within close proximity, thereby increasing the likelihood of utilitarian active travel, and hence PA levels and well-being. As indicated in our study, the different cities offer a variety of available facilities and spaces that meet PA needs and support mental well-being. This aligns with research emphasizing the psychological benefits of mixed land use, which provides greater opportunities for social interaction, active travel, and access to essential services (Sugiyama et al., 2008). Areas with a diverse mix of land uses encourage walking and cycling by providing essential services close to residential areas (Frank et al., 2005), affecting positively PA levels as people are more likely to walk or bike to nearby destinations (Saelens and Handy, 2008). It also supports community engagement and improves mental well-being by offering various public spaces and social opportunities (Sugiyama et al., 2008).

Overall, these findings highlight the importance of land use planning and urban design in shaping physical activity behaviors and mental well-being. Well-connected street networks and dedicated cycling infrastructure appear to facilitate both moderate and vigorous physical activity. Additionally, aesthetically pleasing and diverse land uses, including green spaces and pedestrian-friendly environments, contribute to improved mental well-being. These results underscore the need for policymakers and urban planners to prioritize active transport networks and mixed land-use designs to support both physical and mental health outcomes among young women.

By assessing the differences in the effects and coefficients of subjective and objective built environment features on levels of physical activity and mental well-being, the results showed that perceived environment variables had stronger associations than objective ones. This finding suggests that mobility behavior and well-being among young women in Balkan countries may be more closely linked to their perceptions of urban design, such as perceived neighborhood safety, mixed land use, attractiveness, and aesthetic quality than to the actual physical characteristics of the environment.

It is also important to note that the objective built environment features used in this study primarily reflected street-network

characteristics, rather than detailed measures of land use or urban design elements. Therefore, to better understand the differences between subjective and objective impacts of the built environment, it is necessary to conduct direct, one-to-one comparisons between corresponding variables in future research.

4.3 Limitations of the study

This study presents interesting findings on the effects of built environment on the PA levels and mental well-being of young women from Balkan countries. However, it has specific limitations that may reduce its representativeness and generability potential.

The structure of the utilized sample is identified as one of the study limitations. This study was conducted in five different cities, with a sample that is diverse in terms of socio-economic structure, comprising mainly students in Romania and North Macedonia, employed women in Serbia, and mixed groups in Greece and Bulgaria. Therefore, the generalization of the findings should be made with care.

Using self-reported tools for physical activity and mental well-being, as well as subjective reports of some variables of the built environment, can be another limitation. Supplementing self-reported tools with objective measures (e.g., accelerometers, GPS tracking, or psychological assessments) could enhance data accuracy.

The cross-sectional design is another identified limitation. The study is based on a cross-sectional dataset, meaning it captures a single point in time. As a result, causality cannot be established between land use diversity, physical activity and mental well-being. Longitudinal or experimental studies would provide stronger causal inferences. Longitudinal data can provide a more accurate and comprehensive understanding of how built environment features influence PA and well-being in Balkan countries. So, the current study suggests that future studies should examine the correlates and determinants of physical activity and mental well-being using longitudinal designs. Such an approach would allow researchers to better capture causal relationships over time and account for seasonal, social, or environmental changes that may influence behavior and health outcomes.

While control variables were included, other factors; such as personal motivation, weather conditions, safety concerns, air pollution, and cultural norms may also influence PA levels and well-being, particularly among women. These factors were not directly accounted for in the model, presenting an additional limitation. Although the aim of this paper was to examine the relationship between subjective and objective built environment features and physical activity and well-being, it is important to acknowledge that contextual factors and cultural variation can significantly shape perceptions of the built environment. This paper suggests that incorporating some of these variables in future studies would provide a deeper and more comprehensive understanding of the research problem.

5 Conclusion

This study highlights the critical role of both objective and subjective built environment factors in shaping physical activity behaviors and mental well-being among young women in the Balkans. Findings indicate that higher street connectivity and cycling infrastructure promote moderate and vigorous physical activity, while proximity to shops may encourage lighter activities such as walking. Additionally, aesthetically pleasing and diverse land use, including green spaces and pedestrian-friendly environments, is associated with enhanced well-being.

From a policy perspective, urban planning and transport strategies should prioritize the development of connected street networks, safe pedestrian areas, and dedicated cycling infrastructure to encourage active lifestyles. Best practices, such as bike-sharing programs, subsidies for active transportation, and community initiatives supporting physical activity, can further increase PA engagement. Policymakers and urban planners should integrate these findings into future development strategies to create healthier and more livable cities for young women and the broader population.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the studies involving humans because this study does not have intervention on Human. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

HM: Conceptualization, Writing – review & editing, Funding acquisition, Software, Writing – original draft, Project administration, Methodology, Supervision, Visualization. MeM: Writing – original draft, Writing – review & editing, Conceptualization, Project administration, Validation, Methodology, Data curation. GL: Writing – original draft, Supervision, Investigation, Validation, Writing – review & editing. IS: Writing – original draft, Investigation, Supervision, Writing – review & editing. BP: Writing – review & editing, Writing – original draft, Investigation. SM: Writing – original draft, Writing – review & editing. MD: Writing – review & editing, Writing – original draft. MaM: Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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