Journal of Transport & Health 3 (2016) 315–320

Contents lists available at ScienceDirect

Journal of Transport & Health

journal homepage: www.elsevier.com/locate/jth

What distance do university students walk and bike daily to class in Spain

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ARTICLE INFO

Article history:
Received 23 January 2016
Received in revised form
1 June 2016
Accepted 1 June 2016
Available online 7 July 2016

Keywords:
Walking
Cycling
Distance
College
Active transport
Neighborhood

ABSTRACT

Introduction: Physical activity levels are low in the general population and these levels decrease from childhood to adolescence, as well as from adolescence to adulthood. Active commuting (AC) is an opportunity to increase the physical activity levels. The distance between home and destinations is a main correlate of AC; however, the distance that university students walk or cycle to university is unknown.
Methods: Participants self-reported their modes and time of commuting to and from university in a questionnaire, and the main mode of commuting was identified. Moreover, they reported their home address, and the Spanish version of Mapquest software was used to measure street-network distance (kilometers) from home to university. The 'threshold' distance for walking and cycling was calculated through the Receiver Operating Characteristic (ROC) curve analyses.
Results: AC rates decreased with longer distances from home to university for walk ($p < 0.001$) and bike ($p = 0.002$). The threshold distance that university students walked was 2.6 km and the threshold distance that they cycled was 5.1 km.
Conclusion: Public health decisions at university should consider the distance that students actually walk and cycle. Locating university accommodation facilities within a walkable or cyclable distance from university might increase the AC rates among the university population.

1. Introduction

There is a clear evidence of the effectiveness of regular physical activity in the prevention of health risks including obesity-related diseases in adolescents (Rauner et al., 2013) and adults (Sodlerlund et al., 2009). In spite of these benefits, the levels of physical activity are low in the general population and these levels decrease from childhood to adolescence, as well as from adolescence to adulthood (Kwan et al., 2012; Ortega et al., 2013). The transition out of high school is often accompanied by unhealthy behavior changes such as decreasing physical activity and increasing sedentary behaviors (Vella-Zarb and Elgar, 2009). Recent longitudinal studies have shown that this decrease in physical activity during this transition is associated to a decline on active commuting (AC) (i.e., walking and cycling for transportation) and, moreover, the most important factor explaining this trend is the increase in the distance from home to university compared to the distance from home to high school (Molina-Garcia et al., 2015b; Van Dyck et al., 2015).

According to Irwin's review (Irwin, 2004), approximately half or more university students from the United States, Canada and China, 40% from Australia and 67% from Europe, were insufficiently active. It is a serious health concern among university students and appropriate strategies to increase physical activity levels must be implemented. In this regard, the behavior of AC to and from university might be a source for increasing the physical activity levels. Actually, there is evidence that U.S. and Spanish students who cycled or walked to university had higher levels of physical activity than those students who used passive modes of commuting (Molina-Garcia

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http://dx.doi.org/10.1016/j.jth.2016.06.001
2214-1405/

et al., 2014; Sisson and Tudor-Locke, 2008). Active modes of commuting have been associated with several health benefits, such as healthy weight and improvements in risk factors for chronic diseases in youths and adults (Hendriksen et al., 2010; Oja et al., 2011). However, rates of AC to university in the Spanish population are quite low (35%) (Molina-Garcia et al., 2014) and further explorations of the determinants of AC among university students are required.

Travel distance to school has been shown as the main determinant of AC among young people, with shorter distances associated with higher rates of AC (Chillon et al., 2014; Pont et al., 2009). Moreover, the distance that young people are willing to walk to school have been previously studied: children (10–11 years old) walked around 1.5 km and adolescents (14 years old) around 3 km (Chillon et al., 2015). However, evidences of the association of the distance with the mode of commuting among university students and the distance that they are willing to travel using both active and passive modes of commuting are lacking.

For this reason, the aims of the current study are: (a) to study the association between distance from home to university and mode of commuting, and (b) to identify specific threshold distances below which university students are more likely to walk and bike as opposed to using passive modes of commuting.

2. Methods

Participants were 518 undergraduate students (22.4 years, SD 5.3; 59.7% female) from two urban universities in Valencia (Spain) recruited via convenience sampling in classes. The entire city is nearly flat terrain and there were 130 km of bicycle lanes at the time of study (Molina-Garcia et al., 2015b). Because university schools are integrated into the city urban area, the surrounding neighborhoods have high levels of residential density, street connectivity and land mixed-use. Participants lived in the city of Valencia and its metropolitan area, as well as in rural areas of the Valencian region. A paper survey was self-completed, requiring about 20 min during class (April and May 2009). An institutional approval of the study protocol was obtained from participating university schools and central university administrations. Informed consent was obtained from all participants before study enrollment.

2.1. Measures

2.1.1. Mode of commuting

Modes of commuting to university were measured by "How often do you use each of the following ways to go to and from the university?" Response options were bike, bus, car, train/metro/tram, motorbike, and walking. Participants indicated the number of trips per week (to or from university) and usual minutes per trip in each mode of transport. The main mode of transport to university among students who used mixed mode trips (e.g., bike to train) was assigned based on the longest (in minutes) portion of their trip. Test–retest reliability for each item (modes of transport) was good in previous studies and ICCs were above 0.90 (Molina-Garcia et al., 2014).

2.1.2. Distance to university

Participants reported their home and university addresses. The Spanish version of Mapquest software was used to measure street-network distance (kilometers) from home to university (www.mapquest.es), as in a previous study (Molina-Garcia et al., 2010). Mapquest uses Dijkstra's shortest path algorithm to road maps to plot the shortest route between the two locations (Bliss et al., 2012).

Table 1
Descriptive characteristics of the sample regarding one and mixed-mode commuting.

	All (n=518) N (%)	One-mode (n=196) N (%)	Mixed-mode (n=322) N (%)	p
Gender				0.451
Male	209 (49.3)	75 (38.3)	134 (41.6)	
Female	309 (59.7)	121 (61.7)	188 (58.4)	
Age (years)	22.4 (5.3)	22.9 (5.3)	22.1 (5.2)	0.077
BMI (kg/m^2)	22.2 (2.9)	22.2 (2.7)	22.2 (3.0)	0.820
Mode of commuting				< **0.001**
Walk	126 (24.3)	83 (42.3)	43 (13.4)	
Bicycle	55 (10.6)	32 (16.3)	23 (7.1)	
Car	80 (15.4)	56 (28.6)	24 (7.5)	
Train	161 (31.1)	0 (0.0)	161 (50.0)	
Bus	71 (13.7)	1 (0.5)	70 (21.7)	
Motorcycle	25 (4.8)	24 (12.2)	1 (0.3)	
Distance to university (m)[a]	4.2 (2.2,5.8)	2.6 (1.4,5.5)	6.8 (3.1,19.5)	< **0.001**
Access to car/motorbike				< **0.001**
Never	172 (33.2)	55 (28.1)	117 (36.3)	
Sometimes	320 (61.8)	124 (63.3)	206 (60.8)	
Always	26 (5.0)	17 (8.7)	9 (2.8)	
Socioeconomic status				0.061
Low	13 (2.5)	1 (0.5)	12 (3.7)	
Middle	497 (95.9)	191 (38.4)	306 (61.6)	
High	8 (1.5)	4 (2.0)	4 (1.2)	
Type of residence				< **0.001**
Family	382 (73.7)	115 (58.7)	267 (82.9)	
University	136 (26.3)	81 (41.3)	55 (17.1)	
Type of university				0.619
Public	318 (61.4)	123 (62.8)	195 (60.6)	
Private	200 (38.6)	73 (37.2)	127 (39.4)	

[a] Expressed as Median (25th, 75th) percentile.

2.1.3. Access to car/motorbike

Access to car and motorbike was assessed using two items: “Do you have a car for personal use?”; “Do you have a motorbike for personal use?” Items were rated 1 (“never”), 2 (“sometimes”), or 3 (“always”). A composite variable was calculated using the average of these two questions based on previous research (Molina-Garcia et al., 2010).

2.1.4. Socioeconomic status

Socio-economic status (SES) was measured using one item: “In general, how do you define your socio-economic status? (”low”=1, “medium”=2, “high”=3). Test–retest ICC for this question was 0.89 (Molina-Garcia et al., 2015a; Molina-Garcia et al., 2014).

2.1.5. Type of residence

Type of residence was assessed by “Where do you live during the academic year?” Response options were divided into two categories: family residence (parents’ home or own house) and university residence (shared flat with other students or hall of residence).

2.1.6. Type of university

Participants reported whether they attended the University of Valencia (i.e. public university) or Catholic University of Valencia (i.e. private university).

2.1.7. Demographic information

Data on gender, age and Body Mass Index (BMI) were obtained using a survey. BMI (kg/m^2) was calculated using self-reported weight and height.

2.2. Statistical analysis

Differences in characteristics between participants using one-mode ($n=196$) vs mixed-mode ($n=322$) commuting, were tested using chi-square for categorical variables, *t*-tests for normally distributed continuous variables (i.e., one-way Anova) and non-parametric tests for non-normally distributed continuous variables (i.e., the Median test). The following analyses were performed only for the one-mode commuting sample. The associations between travel mode and distance from home to university for those who walk or cycle were studied using two different binary logistic regressions. Travel mode was included as a binary dependent variable (walk vs passive commuting or bike vs passive commuting) and the distance from home to university (categorized in two groups -to guarantee the statistical sample power- using the median to split both categories, with the longest distance as reference for each analysis) as a categorical exposure variable, adjusting for gender, access to car/motorbike and socio-economic status. The 'threshold' distance for walking and cycling was calculated through the Receiver Operating Characteristic (ROC) curve analyses. ROC curve analysis has been widely used in situations where the evaluation of discrimination performance is of great concern for the researchers (Komori and Eguchi, 2010). The area under the ROC curve is the most popular metric because it has a simple probabilistic interpretation and the larger the area under the curve (ranging from 0 to 1), the more discriminatory

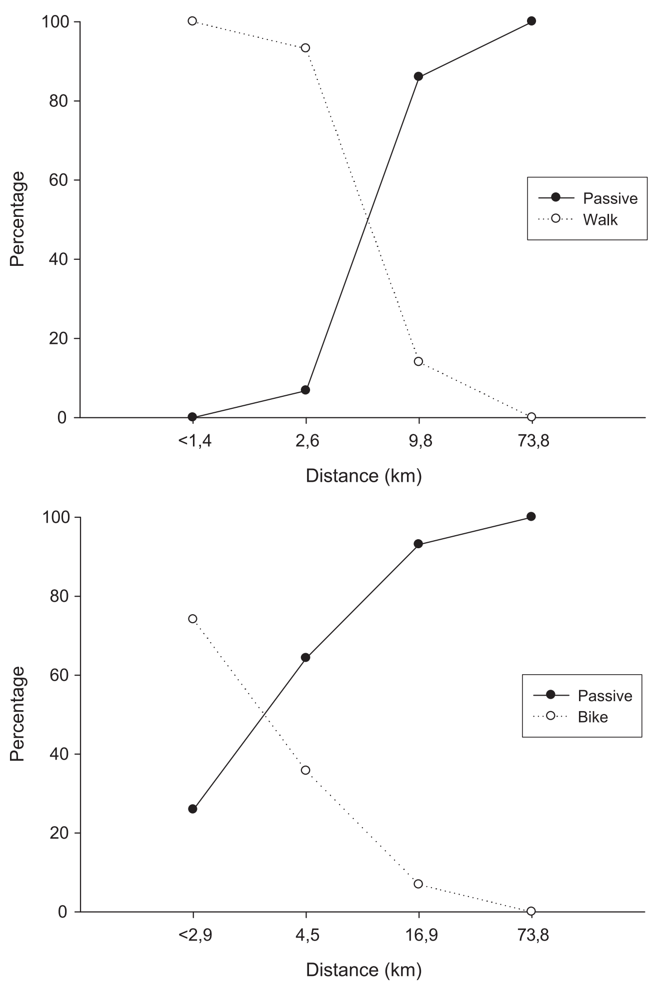

Fig. 1. Percentage of walkers vs passive commuters ($n=164$) and bikers vs passive commuters ($n=113$) with one-mode commuting, by distance from home to university (in quartiles). **Description**: This Fig. 1 includes two graphics using descriptive data. The first graph indicates the percentage of walkers and passive regarding the distance from home to university. The second graph indicates the percentage of bikers and passive regarding the distance from home to university.

the test. Using the sensitivity and specificity obtained through the ROC-curves, the Youden index, which corresponds to the maximum vertical distance between the ROC curve and the diagonal line (Schisterman et al., 2005) was calculated. The Youden index corresponded to the distance (i.e. threshold distance) that best discriminates walkers and bikers from passive travelers.

3. Results

Table 1 presents the descriptive characteristics of the whole sample and also regarding both one-mode and mixed-mode of commuting separately. There were significant differences between one-mode and mixed-mode commuting for the mode of commuting, distance from home to university, access to car/motorbike and type of residence (all $p<0.001$).

As expected, the percentage of students walking and cycling to university decreased with increasing distance (Fig. 1). In adjusted logistic regression analyses, the association between travel distance and mode was statistically significant for walk ($p<0.001$) and bike ($p=0.002$) (Table 2).

The ROC curves for walkers and bikers vs passive commuters respectively, are shown in the Fig. 2. The areas under the curve (standard error) were 0.985 (0.008) and 0.900 (0.028) (all $p<0.001$), respectively. The Youden indices points (sensitivity, 1-specificity) were 0.891 (0.963, 0.072) and 0.654 (0.654, 0.000), respectively. The corresponding threshold distances were 2.6 km and 5.1 km, respectively.

4. Discussion

The main findings in the current study confirmed that university students living closer to university were more likely to active commute and the threshold distances that students walk and cycle to university are 2.6 km and 5.1 km, respectively.

Although there is consistent evidence that distance from home to school is a key predictor of AC to school in young people (Davison et al., 2008), this evidence is not so clear in university students and further research is required. There is one study conducted in Australia (Shannon et al., 2006) where they reported that travel time (which is related with the distance from home to university) was the most important barrier for staff and students. In the current study, there was an association between distance and the mode of commuting using binary logistic regression. Based on our findings, distance from home to university should be consider as a non-normally distributed variable when performing statistical analysis or designing future interventions to promote AC.

This study confirmed that students living closer to university showed higher rates of AC, either walking or cycling. This association has been previously and broadly observed among young people when commuting to school (Chillon et al., 2015; Davison et al., 2008), but it has been scarce among university students. Again, further research is needed to confirm the present results regarding the association between distance and mode of commuting in university students.

A further step in the current study was to determine the optimum distance for walking and cycling in university students. We used ROC curves to address these analyses. The distance best discriminating walkers from passive commuters was identified as 2.6 km; and the distance best discriminating bikers from passive commuters was identified as 5.1 km. To our knowledge, there are no previous studies addressing this issue among university students. However, there is previous evidence among younger people only when walking to school. Two studies determined the walking threshold distance among children (Chillon et al., 2015; D'Haese et al., 2011) and three studies among adolescents (Chillon et al., 2015; Nelson et al., 2008; Van Dyck et al., 2010). The walking threshold distances varied between 1.5 km in Belgium and British children and 2, 2.4, and 3 km in Belgium, Irish, and British adolescents, respectively. The distance that university students are willing to walk to university is similar to the average distance that adolescents are willing to walk to school. Consequently, we are in a position to confirm that the distance that adolescents and university students walk to school or university is similar, and it is longer than the distance that children walk to school. We might speculate that the independent mobility (i.e., ability of young people to walk or cycle without adult company) reached by adolescents seems to remain in young adulthood. To our knowledge, regarding the threshold distance for cycling, there are no previous studies addressing this issue neither in young or adult populations. Our data confirmed that the cycling distance might be double than the walking distance among the university students.

These results may provide practical implications for implementing public health policies in university settings to increase the rate of active commuters. The threshold distance that university students are willing to commute indicate that university accommodations should be located within a 2.5 km buffer area from university to allow walking to university. If students live further than 2.5 km to university, cycling should be promoted building bike-lanes within at least a 5 km buffer area from university and implementing parking

Table 2
Odds ratio for walking (vs passive commuting) and for biking (vs passive commuting), according to distance from home to university in the participants with one-mode commuting ($n=196$).

Distance[a] (km)	N	OR	95% CI	*P*
Walk[b]				
2.7–100	80	1	Reference	
≤ 2.6	84	906.22	57.26–14341.10	< 0.001
Bike[c]				
4.6–100	56	1	Reference	
≤ 4.5	57	42.49	3.83–470.82	0.002

[a] Based on two groups (i.e., walking and biking) and the median value for each model.
[b] Analysis were adjusted for gender ($p=0.441$), access to car/motorbike ($p<0.001$) and socioeconomic-status ($p=0.080$).
[c] Analysis were adjusted for gender ($p=0.244$), access to car/motorbike ($p<0.001$) and socioeconomic-status ($p=0.799$).

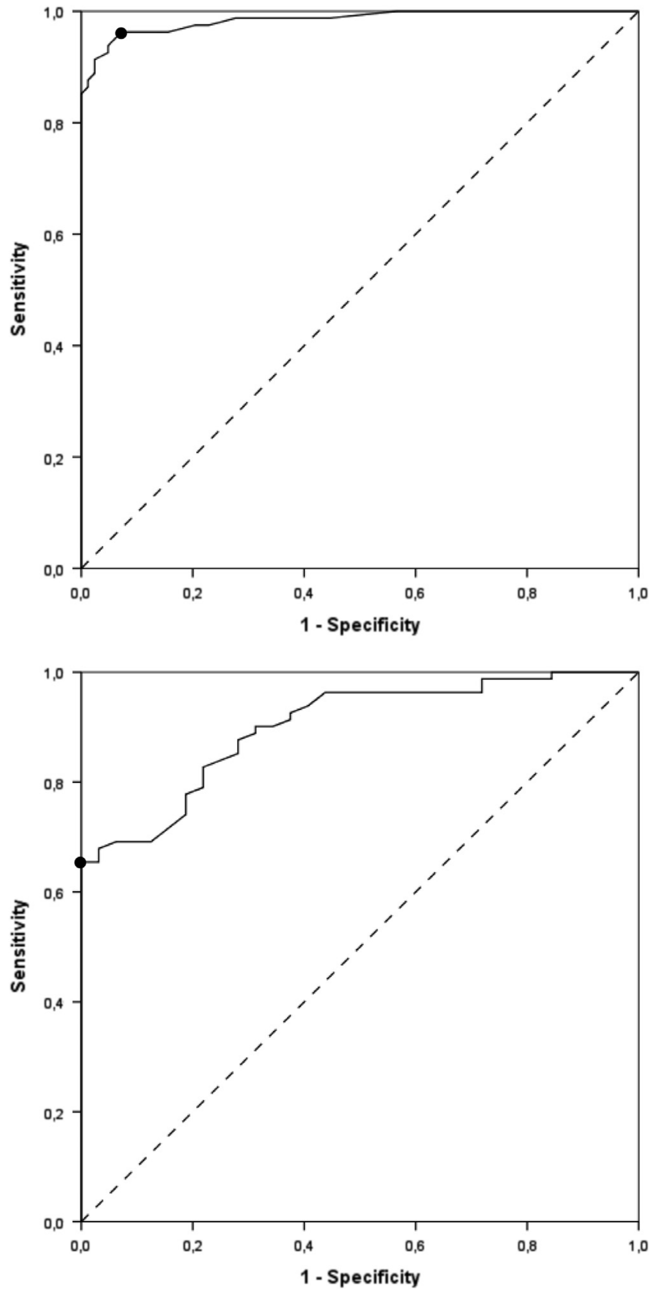

Fig. 2. ROC curve analysis for walkers (negative) vs passive commuters (positive) and for bikers (negative) vs passive commuters (positive) with one-mode commuting, according to distance from home to university. Youden index points are shown **Description**: This Fig. 2 includes two graphics using the data obtained from the ROC curve analysis. The first graph indicates the sensitivity and specificity of the tests for walkers and passive regarding the distance from home to university. The second graph indicates the sensitivity and specificity of the tests for bikers and passive regarding the distance from home to university.

spaces for bicycles. As the literature indicates (Molina-Garcia et al., 2014; Shannon et al., 2006), setting accommodation facilities (e.g., residence halls) on or near campus might be a strategy for increasing AC to university. Moreover, the current study has added new information regarding the distance from the university where these accommodation facilities should be placed to promote active travels within the university campus and neighborhood areas. Future research should study the threshold distances for walking and cycling among the university staff to provide a better understanding of the whole university population.

The main strength of this work is the unique data from the university population. Low sample size in the binary logistic regression and ROC curve analysis, including only those with one-mode of commuting, is the main limitation of the present study. However, it is notable that university students usually use mixed mode trips to university in contrast to young people who commonly use single modes of commuting to school (Chillon et al., 2015). One possible explanation would be that children and adolescents often have to travel to schools that are in the neighborhoods where they live and, consequently, they often travel shorter distances than university students. The second main limitation of this study is its reliance on self-report measures and the subjective nature of SES indicator.

In conclusion, our results show that the threshold distance that university students walk is 2.6 km and cycle is 5.1 km. Future interventions for increasing active modes of commuting to university should take into account these findings.

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