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original article

Validity and reliability of an instrument to measure barriers to bike use in adults

Validade e fidedignidade de um instrumento para avaliar as barreiras para o uso de bicicleta em adultos

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Abstract – The purpose of this study was to analyze the validity and reliability of an instrument to assess the perception of barriers related to bicycling for leisure and transportation in adults. The items composing the instrument were selected from the literature review on the subject. Content validity was analyzed by consulting experts in physical activity field. The reliability was assessed through internal consistency (Cronbach's alpha) and agreement (intraclass correlation coefficient (ICC), kappa coefficient and relative agreement in a sample of 66 adults (18-79 years old) selected from three census tracts in Curitiba-PR. Data were analyzed using SPSS 17.0, with a significance level of 5%. Most of the sample consisted of women (60%), aged ≥40 years old (47%) and intermediate socioeconomic level (68%). The frequency of bicycling in leisure time was higher than for transportation means (15.2 vs 7.6%). The internal consistency (Cronbach's alpha) was significant, both in leisure time (α=0.77) and transportation (α=0.82). The agreement was higher for leisure (80.3 to 93.9%) than compared to commuting (76.9 to 90.8%). Kappa values were moderate to high (leisure: 0.41 to 0.82: commuting: 0.53 to 0.82). The ICC sub-scores were 0.93 ($CI_{95\%}$: 0.88 to 0.96) and 0.89 ($CI_{95\%}$: 0.82 to 0.94) for leisure and transport, respectively. It follows that the instrument has psychometric quality suitable for measuring the barriers to bicycle use in adults.

Key words: Bicycling; Commuting; Facilities access; Leisure activity.

Resumo –*O objetivo deste estudo foi analisar a validade e fidedignidade de um instrumento para avaliar a percepção de barreiras para o uso da bicicleta no lazer e no transporte em adultos. Os itens que compuseram o instrumento foram selecionados a partir da revisão da literatura sobre o tema. A validade de conteúdo foi analisada pelo parecer consensual de especialistas da área de atividade física. A fidedignidade foi verificada por meio da consistência interna (alfa de Cronbach) e concordância (correlação intraclasse-CCI, coeficiente de Kappa e concordância relativa), em uma amostra de 66 adultos (18-79 anos), selecionados em três setores censitários de Curitiba-PR. Os dados foram analisados pelo programa SPSS versão 17.0, com nível de significância de 5%. A maior parte da amostra foi composta por mulheres (59%), com idade ≥40 anos (47%) e nível socioeconômico médio (68%). A frequência de utilização de bicicleta no lazer foi maior do que no transporte (15,2 vs 7,6%). A consistência interna dos itens apresentou valor de alpha Cronbach (α) significativo, tanto no lazer (α=0,77) quanto no transporte (α=0,82) e os itens da escala apresentaram concordância elevada no lazer (80,3 a 93,9%) e no transporte (76,9 a 90,8%). Os valores de Kappa foram moderados a elevados para os dois domínios (lazer: 0,41-0,82 e transporte: 0,53-0,82). O CCI dos subescores foi de 0,93 ($IC_{95\%}$: 0,88-0,96) e 0,89 ($IC_{95\%}$: 0,82-0,94) para o lazer e transporte, respectivamente. Conclui-se que o instrumento apresenta qualidade psicométrica adequada para avaliar barreiras para o uso de bicicleta em adultos.*

Palavras-chave: *Atividades de lazer; Ciclismo; Deslocamento; Estruturas de acesso.*

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INTRODUCTION

Brazil is estimated to have the sixth largest fleet of bicycles in the world, with nearly 75 million units, behind countries like China, India, the United States, Japan and Germany[1]. Evidence points out that bicycling is associated with a lower risk of mortality due to cardiovascular disease and with a reduction in overall morbidity[2].

Despite this evidence, few studies investigated leisure and transportation bicycling in Brazil[3,4]. Population-based studies conducted in Pelotas-RS, Brazil, observed that 17% of workers use the bicycle to commute to work[5] and 13% of adults use it in their leisure time[4]. By contrast, bicycling is substantially higher in high-income countries, between 22 and 32% to commute to work[6,7], 41% to commute to college[8], and 26% in leisure time. This visible difference in comparison with Brazil takes on a special meaning when one considers the potential of active commuting, such as bicycling, to increase overall physical activity (PA) levels[3].

There are several aspects, both personal and environmental, associated with leisure and transportation bicycling, such as higher bicycle lane connectivity, personal satisfaction, safety perception, and social support[6-9]. Identifying the factors associated with bicycling may contribute to the promotion of more effective interventions aimed at utilitarian bicycling[10]. However, identifying the aspects that are perceived as obstacles for bicycling is an important issue, since they are capable of being changed. Studies point out that lack of time and interest, distance to destination, physical discomfort, and low practicality as a mode of transportation are among the most reported barriers to bicycling in adults[7-9]. Brazilian studies demonstrated that individual aspects (male sex, lower education and socioeconomic status - SES) are associated with bicycling to commute to work[4,5]. In leisure time, living with a partner was associated with bicycling[4].

Despite this evidence, there were no studies investigating the perception of barriers to bicycling in Brazil. Although instruments that can identify barriers to PA in adults[11] and adolescents have been developed, this was not observed with regard to bicycling[12]. The absence of studies on barriers to bicycling in Brazil can be partially explained by the lack of instruments adapted to the Brazilian context. Therefore, the aim of the present study was to analyze the validity and reliability of an instrument to assess the perception of barriers related to bicycling in adults.

METHODOLOGY

For the development and subsequent validity and reliability analysis of the instrument, two stages implemented in a similar study[13] were performed, comprising: a) construction of the instrument (identification of the items); b) content validity (clarity and objectiveness of the items, assessed by experts); c) reliability by internal consistency (contribution of the items for the composition of the instrument) and reproducibility analysis (test-retest agreement).

Construction of the instrument

In the PA field, the term "barrier" is conceptually defined as the reasons that may reduce the possibility or hamper the engagement of an individual in a specific activity[14]. Concerning bicycling, these barriers can be related to intrinsic (individual's characteristics, motivation, etc.) and extrinsic aspects (lack of time, family support, street facilities, etc.), which can change individuals' perception on their motivation or willingness to use the bicycle[15].

To develop the instrument, a literature review on the barriers to bicycling among adults was performed in health databases (PubMed, SciElo and Lilacs). Combinations of the following Health Science Descriptors (Descritores em Ciências da Saúde - DeCS) were used: "barriers", "bicycling", "commuting", "active transport", "transportation", "motor activity", "PA", "exercise" and "recreation", and their corresponding terms in Portuguese. The selected studies should meet the following inclusion criteria: a) being empirical, b) quantitative, c) with outcomes for barriers to bicycling, d) with individuals between 18 and 65 years old, e) indexed in periodicals published in Portuguese or English.

Eleven studies met search criteria. Next, the authors categorized the barriers reported in the studies into three sets of barriers: individual (demographic-biological and psychological, cognitive and emotional), social, and environmental (physical and natural environment), as seen in box 1. Physical environmental factors were categorized into three subsets: a) functionality - representing items related to access to bicycling, and conditions to commute around the city; b) safety – representing traffic safety conditions for bicycling; c) esthetics – or those attractive elements for bicycling. As for natural environment, rain and cold were also included because they represent potential barriers to bicycling[20].

Box 1. Individual, social and environmental factors associated with bicycling among adults[6-9,16-22]

Leisure and transportation factors associated with bicycling					
Physical environment			Social environment	Natural environment	Psychological, cognitive and emotional
Functionality	Safety	Esthetics			
Lack of cycling paths	Intense traffic	Dirty and abandoned place	Lack of social support	Unfavorable climate	Physical discomfort
Lack of dressing rooms	Unsafe places	Few green areas	Ownership of a vehicle		Lack of interest
Lack of parking safely	Unsafe parking spaces	Lack of maintenance	Low fuel cost		Lack of time
Low walkability	Busy crossroads	Little to see	Lack of social cohesion		Low self-efficacy
Low demographic density	High car speed	Pollution			Low satisfaction
Sloped streets (uphill)	Lack of lighting				
Low connectivity (cycling paths)	Lack of public safety				
Distance to destination	Thefts/crimes				

Based on the items listed, and on the assumptions of the ecological approach[23], the items of the instrument were developed considering a conceptual framework. The framework was used to organize the conceptual basis so as to ensure the visualization of the concerned construct (barriers to bicycling), as well as ensuring that the instrument items were appropriately represented[24].

Content validity

The items were discussed by a group of experts comprising two PhD professors from the physical activity and health field and six Physical Education graduate students, all of them researchers from the environmental and PA field. This stage was developed with the purpose of adapting the aspects reported in international studies to the Brazilian context and helped in the agreement on and definition of the items selected to compose the instrument[24]. Finally, the experts identified 13 barriers to bicycling, 11 of which were common to leisure and transportation bicycling (figure 1) (appendix).

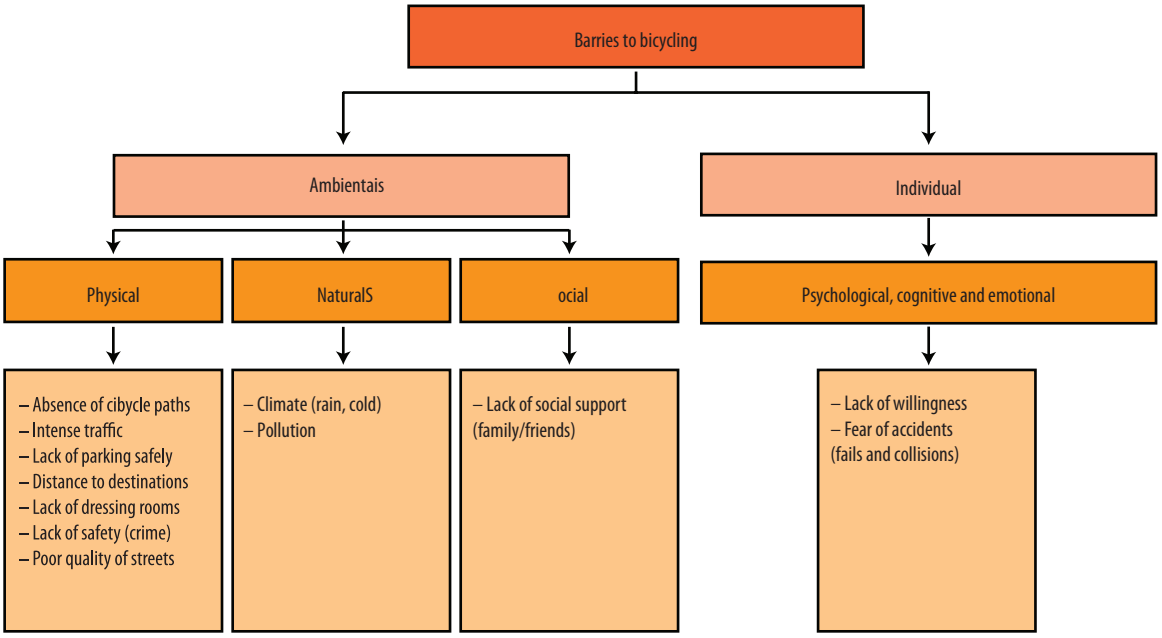

Figure 1. Items included in the instrument of perceived barriers to bicycling.

To assess clarity, adequacy of items, and way of implementing the instrument, a preliminary version was applied to eight undergraduate students (20-32 years). Subsequently, researchers gathered to make corrections and adapt the items for a better understanding by the study subjects. We chose to apply the instrument using a scale with dichotomous answers indicating the presence ("*yes*") or the absence ("*no*") of the barrier, based on previous studies[25,26]. The total instrument score was obtained by the sum of the items of each scale, yielding two scores (leisure and transportation), which could range from zero (lower) to 11 (higher), indicating the number of perceived barriers to bicycling.

Reliability analysis

Reliability was assessed through internal consistency analysis (Cronbach's alpha) and temporal stability (agreement between two tests). In order to test the discriminatory power of the instrument to evaluate different individuals and ensuring different SES characteristics (considering the mean income of heads of household in each census tract according to the Brazilian Institute of Geography and Statistics - IBGE) and environmental conditions for PA (using the classification of walkability, obtained by the presence of attributes of the built environment: street intersections, diversified land use, and commercial and population density), three census tracts of the city of Curitiba, state of Paraná, Brazil, were intentionally selected.

After this selection, the households in the tracts were listed (n=1,043). From the list of households, with the aid of Epi Info software, a table of random numbers was generated to draw the households to be visited. The number of households (n=120) was determined based on a similar study[25].

In each drawn household, based on the number of eligible dwellers, an individual was randomly selected[27]. Adult individuals (≥18 years) of both sexes who were living for at least one year at that home were considered eligible. Individuals who did not live at the household (e.g.: house servants and visitors), those with some physical limitation that prevented PA or those with cognitive limitations that prevented them from understanding the questions were excluded from the study. If the drawn individual was not at home at the moment of the visit or could not answer the survey at that moment, the interviewers were instructed to schedule a second meeting with the dweller. In case of refusal, the next household on the right was automatically selected. Before it was considered a refusal, researchers should have made three unsuccessful attempts of contacting the drawn individual.

Data were collected through a face-to-face interview including questions on barriers to leisure and commuter bicycling. Besides these questions, socio-demographic information (sex, age, SES) and data on leisure and transportation bicycling were obtained. SES was evaluated based on the Brazilian Economic Classification Criteria and categorized into three strata: high (A1+A2), intermediate (B1+B2) and low (C1+C2+D+E)[28]. The frequency of bicycling was assessed by a dichotomous answer ("yes", "no") to the following questions: a) Do you use a bicycle in your free time? b) Do you use a bicycle to commute from some place to another, as a mode of transportation?

Data collection was performed in two stages: a) face-to-face interviews (n=84) to assess internal consistency; and b) re-interviews (n=66), after an interval between seven and 10 days, to assess reproducibility. In the re-interview, 18 subjects refused to participate. Therefore, we chose to analyze only the cases with complete data (n=66). The final sample had a power ≥0.80 for the performed analyses.

Data analysis

Data were analyzed using absolute and relative frequency distribution. Internal consistency was analyzed by Cronbach's α scores. Temporal stability was assessed by the test-retest method (interval between seven and 10 days), and tested by intraclass correlation coefficient (ICC), relative agreement, and kappa index. Values for α and ICC ≥0.70, relative agreement ≥70.0% and kappa index with $p<0.05$ were considered as appropriate reliability values[13]. Analyses were performed with SPSS 17.0 software and the significance level was set at 5%.

Ethical aspects

The study was approved by the Research Ethics Committee of Pontifícia Universidade Católica do Paraná (protocol no. 3034/2009) and subjects voluntarily participated signing a free and informed consent.

RESULTS

A total of 120 households were visited; however, 30% (n=36) of them did not have eligible individuals or refused to participate in the study. The number of participants in the first interview was 84 individuals in the three census tracts (test). In the second interview (retest), 18 individuals (21.4%) refused to participate. Therefore, the number of participants in the second stage was 66 individuals (78% of the eligible subjects from the first phase).

Most participants were female (59.1%), were aged ≥40 years (47%) and belonged to the intermediate SES (67.7%), as seen in table 1. Nearly 15% of participants ($CI_{95\%}$: 6.5-24.0) used the bicycle in leisure time and 7% ($CI_{95\%}$: 1.2-14.0) for transportation means. Commuting bicycling was more frequent among men (11.1 *vs.* 5.1%; $p<0.05$).

Table 1. Socio-demographic characteristics and data on bicycling among adults from Curitiba-PR, Brazil, 2010 (n=66).

Variable	n	%
Sex		
Male	27	40.9
Female	39	59.1
Age group		
18 - 29 years	16	24.2
30 - 39 years	19	28.8
≥ 40 years	31	47.0
Socioeconomic status		
High	6	9.2
Intermediate	44	67.7
Low	15	23.1
Bicycling		
Leisure	10	15.2
Transportation	5	7.6

Internal consistency analysis (Cronbach's α) showed significant val-

ues (≥0.70) for all items of the instrument, both for leisure (α=0.77) and transportation (α=0.82). The items had equal importance in the calculation of the total value of the scale and were maintained in the final structure (table 2).

The items of the scale showed high agreement both for leisure (80.3 to 93.9%) and transportation (76.9 to 90.8%) (table 2). Similarly, kappa agreement values were moderate to high for both domains (leisure: 0.41-0.82; transportation: 0.53-0.82). ICC values of the sub-scores were 0.93 ($CI_{95\%}$: 0.88-0.96) and 0.89 ($CI_{95\%}$: 0.82-0.94) for leisure and transportation, respectively.

Table 2. Cronbach's alpha values for (α), agreement percentage and kappa index for the barriers to leisure and transportation bicycling in adults, Curitiba-PR, Brazil, 2010.

Barriers to bicycling	Internal consistency (Cronbach's α)		Reproducibility (test-retest)			
	Leisure	Transportation	Leisure		Transportation	
	α deleted item	α deleted item	%A	Kappa	%A	Kappa
Not owning a bicycle	0.79	0.83	90.9*	0.82	86.9*	0.73
Poor quality of streets	0.73	0.79	89.4*	0.73	89.2*	0.73
Intense traffic	0.72	0.78	92.4*	0.84	86.2*	0.72
Fear of accidents (falls/collisions)	0.73	0.78	87.9*	0.76	89.2*	0.78
Lack of safety	0.73	0.79	80.3*	0.59	76.9*	0.53
Lack of safe parking spaces	0.77	0.80	92.4*	0.80	81.5*	0.54
Lack of willingness (motivation)	0.82	0.79	84.8*	0.70	80.0*	0.60
Climatic factors (rain, sun, cold)	0.77	0.80	86.4*	0.73	90.8*	0.81
Pollution	0.75	0.80	93.9*	0.78	90.8*	0.65
Lack of support from family/friends†	0.77	-	89.4*	0.41	-	-
Absence of cycling paths†	0.76	-	86.4*	0.64	-	-
Distance to destinations††	-	0.82	-	-	87.7*	0.69
Lack of dressing rooms (for having a shower/changing clothes)††	-	0.81	-	-	86.2*	0.58
Total α	0.77	0.82				

†specific barriers for leisure; †† specific barriers for transportation; %A: relative agreement. *p<0.05. Sub-scores: ICC for leisure: 0.93 ($CI_{95\%}$: 0.88-0.96); ICC for transportation: 0.89 ($CI_{95\%}$: 0.82-0.94).

DISCUSSION

The present study aimed to analyze the validity and reliability of an instrument to assess barriers to leisure and transportation bicycling in adults, including items related to individual, social and environmental factors. This reinforces the assumption that the study on the barriers to bicycling needs to include a broader contextual approach, such as, for example, a socio-ecological approach[23]. The literature review also pointed out that individual and environmental aspects are associated with bicycling in different regions of the world[6,16-18,20]; therefore, the instrument included items that took this diversity into consideration.

As to content validity, there was a consensus among experts that the barriers should be analyzed specifically regarding the type of bicycling (leisure vs. transportation). Thus, we chose to use two sub-scales, each of them comprising 11 items. Internal consistency results showed adequate values. All items contributed significantly to explain overall variance in the instrument. In general, α values ≥0.70 are good for internal consistency analysis[13]. A study conducted with focus groups to analyze the barriers to PA in adolescents reported similar internal consistency values (>0.85)[12]. However, the lack of similar measures in adults hampers the comparison with the findings from the present study.

The items included as barriers to bicycling are supported by studies indicating that these factors are also associated with bicycling. Studies conducted in three European countries[6,7,9], where bicycling is more frequent, point out that socio-cultural aspects are related to this behavior, which directly influences public policies to stimulate its use[29]. On the other hand, items that indicate convenience (such as access to dressing rooms) are also reported as important facilitators of bicycling, especially for transportation means[17]. Climatic factors are also reported as barriers to bicycling, since in countries with severe winters a decrease in bicycling was observed during rainy days[20]. The distance to destination has been associated with bicycling in Brazil[21] and in Europe[6]. Therefore, to some extent it is possible that the associated aspects may be common in different countries and thus compose instruments applying to the Brazilian context.

Indeed, this possibility was reinforced by the results of the temporal consistency analysis (reproducibility). For example, a high agreement was found, both for leisure (80%-94%) and transportation (77%-91%). Despite this high agreement, kappa index was moderate to high among items related to leisure (k=0.41 to k=0.82) and transportation (k=0.53 to k=0.81; $p<0.05$). In spite of being considered adequate, kappa values are similar to those reported in another study that tested instruments assessing barriers to PA (k=0.55 to k=0.88)[11].

This study presents an important contribution to investigations focused on leisure and transportation bicycling. So far there were no instruments allowing assessing the barriers to bicycling in the Brazilian context. In addition, the use of different strategies and analyses ensured that validity and reliability were appropriately assessed. Finally, the application of rigorous methods to obtain data allowed that response biases were minimized, which contributed to improve the quality of the instrument.

Despite that, some limitations should be considered when extrapolating the results. The analysis of instrument clarity in a highly-educated group may have facilitated the initial understanding of the instrument, a result that could be different if the procedure was conducted with less educated individuals. The number of participants was small, which hampers accurate estimates for bicycling. However, the sample was large enough to ensure adequate analytical power in reliability tests (≥0.80). The participants came from the same city, which presented different social characteristics

from those of other localities, not representing the Brazilian population. Moreover, the city has important urban characteristics that may affect the perception of barriers to bicycling (green areas, parks, cycling paths, and special lanes for public transportation). The limited evidence on factors associated with bicycling in the Brazilian population, especially perceived barriers, limits the comparison of our findings with those from the literature. Finally, the clarity of the instrument was assessed in a sample of undergraduate students; therefore, we suggest further tests in other population groups.

CONCLUSION

It follows that the instrument has adequate psychometric quality and can be used to investigate perceived barriers to bicycling in Brazilian adults. The application of this instrument in surveys to identify factors associated with bicycling in the population will help in increasing the amount of evidence on the subject. These data are important for the effective implementation of this form of PA in the country, which takes on great importance in promoting health and sustainable transportation. Further additional studies should test the psychometric attributes of the instrument in different population groups.

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APPENDIX
INSTRUMENT TO EVALUATE PERCEPTION OF BARRIERS TO BICYCLING

Bicycling in leisure time

Please indicate which one of the above listed items represent reasons why you do not use the bicycle in your leisure time. Consider as leisure the free time, it means, the moments when you are not at work, school/college or doing household tasks.

Which are the reasons for you to avoid using the bicycle in leisure time?

1. Lack of safety	0[ ] No 1[ ] Yes
2. Poor quality of streets	0[ ] No 1[ ] Yes
3. Fear of accidents (falls and collisions)	0[ ] No 1[ ] Yes
4. Lack of support from family and friends	0[ ] No 1[ ] Yes
5. Lack of a safe parking space for the bicycle	0[ ] No 1[ ] Yes
6. Intense traffic	0[ ] No 1[ ] Yes
7. Too much pollution	0[ ] No 1[ ] Yes
8. Lack of willingness (motivation)	0[ ] No 1[ ] Yes
9. Unfavorable climate (sun, rain, cold)	0[ ] No 1[ ] Yes
10. Not owning a bicycle	0[ ] No 1[ ] Yes
11. Absence of cycling paths	0[ ] No 1[ ] Yes
12. Other reasons: _____	

Bicycling for transportation (commuting)

Please indicate which ones of the above listed items represent reasons why you do not use the bicycle as a mode of transportation (commuting from some place to another).

Which are the reasons for you to avoid using the bicycle for transportation?

1. Lack of safety	0[ ] No 1[ ] Yes
2. Poor quality of streets	0[ ] No 1[ ] Yes
3. Lack of dressing rooms (changing clothes/having a shower)	0[ ] No 1[ ] Yes
4. Lack of a safe parking space for the bicycle	0[ ] No 1[ ] Yes
5. Intense traffic	0[ ] No 1[ ] Yes
6. Too much pollution	0[ ] No 1[ ] Yes
7. Lack of willingness (motivation)	0[ ] No 1[ ] Yes
8. Unfavorable climate (sun, rain, cold)	0[ ] No 1[ ] Yes
9. Not owning a bicycle	0[ ] No 1[ ] Yes
10. Distance to destinations	0[ ] No 1[ ] Yes
11. Fear of accidents (falls and collisions)	0[ ] No 1[ ] Yes
12. Other reasons: _____	