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Validation of the Walking Behavior Questionnaire (WBQ): A tool for measuring risky and safe walking under a behavioral perspective

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ABSTRACT

Introduction: Although daily walking implies several potential benefits for the health and well-being of people, and, besides the raise of more "walkable" cities, it is currently being promoted as an active transportation means that is rich in benefits for its users, road risks affecting pedestrians, together with their high vulnerability to suffer severe injuries as a consequence of traffic crashes, have turned into a relevant concern for both policymakers and public health practitioners. In this regard, risky and positive (proactively safe) behaviors have acquired a substantial relevance for the study and prevention of traffic causalities involving different road users, including pedestrians.
Objective: The objective of this study was to thoroughly describe the validation of an instrument for measuring the walking risky and positive behavior on the road, using the Walking Behavior Questionnaire (WBQ).
Methods: This cross-sectional study analyzed the data from 1070 Spanish pedestrians answering a questionnaire on road behaviors. The data were analyzed using the competitive Confirmatory Factor Analysis (CFA), thus obtaining basic psychometric properties, testing convergent validity and predictive value, and presenting an optimized structure for the scale.
Results: The obtained findings suggest that the WBQ has a clear dimensional structure, items with high factorial weight, good internal consistency and reliability and an adequate convergent validity with variables theoretically associated with road behaviors.
Conclusion: The results of this study endorse the psychometric value of the WBQ for measuring errors, violations and positive behaviors of pedestrians. This questionnaire might have relevant applications in the practical field, since, apart from having good psychometric properties, it introduces items related to social and technological trends (e.g., the use of cellphones) that may compromise pedestrians' safety. This can be particularly useful for designing behavioral-based interventions and educational programs, focused on road risk reduction and on the promotion of safe walking behavior.

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1. Introduction

During the last few years urban walking has become more and more "fashionable", also as a consequence of different strategies aimed at promoting public health. This is happening in modern city planning, as well as in measures and countermeasures to prevent the strain suffered by the lifestyle and health of current societies. Mainly in the case of urban contexts, for which "walkability" (how walking-friendly is an area?) has been acquiring a special relevance (Litman, 2003), considerably contributing to the transformation of the environment in many cities, walking is -despite being a means of transport as old as transport as a concept itself-one of the few active ways for daily commuting in a highly motorized society. It allows people to combine both traveling and non-intensive physical activity with everyday tasks and other ways of transportations. Therefore, the promotion of active means of transportation, such as cycling and walking, has systematically acquired a higher relevance for public policy, considering that it is a task easily accessible for almost the entire population, it is free, and entails a series of key benefits for both transport and health of road users.

1.1. Benefits and constraints of walking in urban areas

Encouraging daily walking, apart from enhancing environmental sustainability and saving money, has valuable effects for both physical and mental health: in other words, a more "walkable" environment has a higher potential to improve community health in all spheres (Al Shammas and Escobar, 2019; Siqueira Reis et al., 2013). Regarding physical health, walking enhances a multitude of corporal processes that are essential for musculoskeletal motion, and therefore constitutes the most common weight-bearing activity, which is an advisable exercise for people of all ages for the increase of bone strength (Morris and Hardman, 1997). Furthermore, its role in the prevention of cardiovascular diseases and other several non-communicable chronic illnesses has been proven through numerous studies, some of which see daily walking as a way to improve public health (Kelly et al., 2018; Wojtys, 2015; Lee and Buchner, 2008). As for mental health, the benefits of walking for people's psychological health have been recently remarked by studies assessing its effect on (e.g.) psychological distress (Teut et al., 2013), anxiety and depression (Yuenyongchaiwat, 2016; Biddle, 2016), subjective well-being (Kelly et al., 2018) and various lifestyle improvements (Sharma et al., 2006; Diehr and Hirsch, 2010).

However, the "healthy" and "sustainable" vision of everyday walking can be considered *relative*, or at least highly dependent on the context: in fact, although it has multiple demonstrable benefits on the health and well-being of regular *walkers*, the large number of road hazards and traffic accidents makes pedestrians a highly vulnerable type of road user. For instance, every year around 80,000 pedestrians are injured and 6000 killed in the United States, principally as a consequence of traffic crashes suffered with motor vehicles (Wells et al., 2018). In the European Union, out of the 9500 people who died in traffic crashes on urban roads during 2018, 40% were pedestrians, a figure that does not come as a surprise if we consider their high bodily vulnerability and the absence of passive safety devices (ETSC, 2019). In the case of Spain, in the year 2017 a total number of 351 pedestrians involved in traffic crashes were killed; 1940 suffered severe injuries (requiring hospitalization) and 12,382 suffered minor injuries (DGT, 2017a).

Also, different gaps commonly observed in "low walkable" urban environments, such as inadequate infrastructure, lack of signaling and high traffic density, negatively impact walking patterns, road behaviors of pedestrians and their safety (Tribby et al., 2016; Hajna et al., 2015). Recent studies have highlighted how the environment is significantly linked to walking behavior and safe decision making, and it especially affects highly vulnerable groups of pedestrians such as young and elderly people (Zito et al., 2015; Granié et al., 2014; Van Cauwenderg et al., 2011). Furthermore, it is worth considering that, although an increased *walkability* enhances the safe behavior of pedestrians (Liao et al., 2020), more constraints related to key issues such as people's attitudes towards road safety, their risk perception and road-rule knowledge should be borne in mind as potential contributors to the road risks of pedestrians. Recent studies have suggested that, considering the widespread shortcomings of many countries in road safety education, the road risks of non-motorized road users are enhanced by the lack of a comprehensive road safety culture supported by different sectors (Alonso et al., 2018). In fact, pedestrian safety has been described in different studies not only as an important issue for road safety, but also as a growing problem for public health around the whole world, considering the high burden that pedestrian injuries and fatalities represent for the social settings and healthcare systems of countries (Deb et al., 2017; Sarikhani et al., 2017).

1.2. Using behavioral approaches to enhance safe walking

As we have mentioned before, several factors influence traffic crashes involving pedestrians. Nonetheless, the most relevant contributor highlighted by the literature on traffic causalities is human behavior (Gicquel et al., 2017; Montoro et al., 2000); in fact, some studies state that human factors are responsible for about 90% of overall road crashes (Alavi et al., 2017). However, there a substantial gap in the amount of empirical knowledge on pedestrians, if compared, for example, with motor-vehicle drivers, field in which most of behavioral studies have been conducted. In fact, the Driver Behavior Questionnaire (DBQ; Reason et al., 1990) has been the "raw material" of road behavioral analysis based on self-reports for a long time, but -although dealing with a similar theoretical paradigm-its application to further group users (and even to specific groups of drivers) requires adaptation and more specificity (Hezaveh et al., 2018; Deb et al., 2017; Af Wåhlberg et al., 2015). Thus, the development of tools with consideration for the specific needs of the context and for the task features of users seems to be a good alternative for generating more accurate and reliable knowledge on the particular risk and protective factors of pedestrians. Precisely, this has been the core motivation for developing and empirically testing the Walking Behavior Questionnaire (WBQ).

In this regard, the structure of this behavioral questionnaire follows the behavioral questionnaire (BQ) paradigm, based on two dimensions of the pedestrian behavior largely supported by the previous research on the topic, and one that -although relatively emergent-has demonstrated good potential in studies performed with other groups of road users; however, it should also be assessed for what concerns the case of pedestrians.

Firstly, behavioral-based questionnaires agree on the need of considering *traffic violations* (deliberate risky behaviors) a problematic issue for road users' safety. This is true even though, across different studies dealing with self-reported behaviors of (e.g.) drivers and cyclists, the significance of the relationship between violations-crashes has been found to be both significant and non-significant (Af Wåhlberg et al., 2015; O'Hern et al., 2019); in the case of pedestrian crashes -especially those involving vehicles as third parties-, intended risky behaviors have predominantly shown to be a significant predictor of pedestrians' injuries and fatalities (Cinnamon et al., 2011). Particularly, deliberate unsafe walking behaviors performed in high-risk urban locations (e.g., intersections) have shown to be preceded by several psychosocial factors, such as the knowledge and valuation of traffic norms, risk perception, the intention of bypassing the law, and the influence of others' road behavior (Hashemiparast et al., 2017). Furthermore, a recent study of the Spanish Directorate-General of Traffic has shown that, in the case of serious accidents caused by pedestrians, the most common misbehaviors were: disrespecting red lights, not using crosswalks and walking on mixed lanes (DGT, 2017b).

However, not all risky road behaviors can be considered deliberate. There are many unintended hazardous actions (i.e., *errors*) affecting walking performance (Wells et al., 2018; Deb et al., 2017; Zito et al., 2015). In the same way in which it has been suggested that traffic crashes caused by (e.g.) cyclists and motor-vehicle drivers are often preceded by errors (Reason et al., 1990; Hezaveh et al., 2018; Useche et al., 2019), it is frequent that other studies on pedestrian behaviors also point out errors as an undisputable contributor to pedestrian's crash likelihood, and even to the severity of the injuries suffered as a consequence of these crashes (Deb et al., 2017; Stefanova et al., 2015; Granié et al., 2013; Barrero et al., 2013).

Furthermore, in recent years the role of positive (or *protective*) behaviors has acquired relevance as a way to improve the safe circulation of different types of road users, but it's application in the field of pedestrian behavior is still scarce, and needs to be evaluated in order to determine if, indeed, safe habits and "precautions" proactively performed by pedestrians actually improve their safety. This concept, that was introduced in behavioral questionnaires for drivers by Özkan and Lajunen (2005), cannot be understood as the absence of risky behaviors -that are often accidental or unplanned, such as in the case of errors-, but should rather be defined as intended habits and actions that contribute to reducing the risk of suffering a traffic crash. Up to the date, some self-report-based instruments that aimed at measuring road behaviors of, for instance, drivers (Özkan and Lajunen, 2005) and cyclists (Useche et al., 2018), have introduced this concept in applied researches, finding interesting and coherent associations between risky-protective behaviors, to the point of even determining their influence on traffic crash avoidance. Also, and although few studies have examined the particular environment-walking relationships (Owen et al., 2004), especially in relation to risky/safe behavior of pedestrians, there is an indisputable need to mention the effect of the built environment on the walking behavior of pedestrians (Tribby et al., 2016), explained by the constant interaction between human and infrastructural factors. In this regard, recent studies have suggested that higher walkability measures, apart from influencing sedentary/active lifestyle behaviors (Hajna et al., 2015; Ferdinand et al., 2012), might be relevant contributors of protective behaviors performed by users in other spheres, not only by reducing the potentially problematic pedestrian-vehicle interactions, but also enhancing protective factors such as a greater norm-compliance, as well as recognition of signals and potentially risky traffic situations (Marisamynathan and Vedagiri, 2013,Marisamynathan and Vedagiri, 2014).

Therefore, the WBQ was developed for studying not only risky, but also positive walking behaviors, answering the following research question: *what are the psychometric properties, and what is the convergent validity, of a questionnaire aimed at assessing the risky and positive behavior of pedestrians?* Also, recent studies have remarked that it is important to bear in mind the need of exploring new behavioral trends potentially threatening the safety of road users (Young, Stephens, O'Hern and Koppel, 2020; Oviedo-Trespalacios et al., 2019), reason why the WBQ introduces four items specifically related to the use of cellphones and handheld devices that, same as other sets of items and behaviors, may serve as additional indicators to the three root factors; this can be considered a contextual and technical advantage over other similar self-reported behavioral questionnaires.

1.3. Study objective and hypotheses

In order to respond to the aforementioned research question, the objective of this study was to thoroughly describe the validation of an instrument for measuring walking risky and positive behavior on the road, using the Walking Behavior Questionnaire (WBQ).

It was hypothesized that: (a) the WBQ is adequately adjusted to a three-factor structure, presenting good fit indices and psychometric properties within a representative sample of Spanish pedestrians; and (b) that the three dimensions of the WBQ (traffic violations, errors and positive behaviors) have a coherent and significant associations with other variables used to contrast their construct validity and predictive value. For testing these hypotheses, this paper will address and discuss, first, the psychometric analysis of the scale (see Sections 3.1, 3.2 and 4); second, the relationships found between each factor and other constructs theoretically related to pedestrian behavior (see Sections 3.3 and 4); and third, the predictive value of the instrument in the self-reported crashes of pedestrians (see Sections 3.4 and 4).

2. Materials and methods

2.1. Sample

Prior to the data collection phase, we performed an initial calculation of the sample size, in order to achieve representativeness of the overall Spanish population. As there is no specialized information available and/or consensus on how many Spaniards regularly perform walking trips, we considered the full Spanish census (almost 47 million individuals) as population size; this entails the need of collecting a higher amount of information (number of individuals) but decreases the margin of error. The minimum sample size calculated was 670 individuals, assuming a confidence level of 99% and a maximum margin of error/confidence interval [CI] of 5%. Nonetheless, the relatively elevated response rate allowed the research team to collect more respondents for the final sample, reaching a bigger sample size for the study.

Thus, the data used for this cross-sectional research were retrieved from a sample of $n = 1070$ Spanish pedestrians aged between 16 and 79 years old, with an average age of $M = 30.83$ ($SD = 12.92$) years. It is worth mentioning that, in Spain, up to 47% of pedestrians injured in traffic crashes are aged between 25 and 64 years (Statista, 2019). For this study, 44% of the sample corresponded to this age range. Moreover, 642 participants were females and 428 males. Further relevant data on demographic features and walking patterns of the sample are described in detail in Table 1.

2.2. Study design and procedure

For this (cross-sectional) empirical research, participants completed an online-based self-report questionnaire, and they were selected through a convenience (and non-probabilistic) sampling method. For this purpose, they were directly asked to take part in the study by means of an e-mail invitation, using an inter-institutional mailing list, shared by different universities and research groups from different regions of Spain. Also, partakers were encouraged to share the survey with other people, such as friends or relatives. Regarding the application of the e-survey, all participants were informed about the aims of the study and the protection of their personal data by means of an informed consent form, which highlighted that the data would be exclusively used for research purposes. The general response of the study rate was around 67%, keeping in mind that approximately 1600 invitations were initially delivered.

2.3. Description of the questionnaire

The questionnaire used to gather the data for this study was composed of three main sections:

The first part of the instrument asked about individual and demographic variables, such as age, gender, educational level and main occupation. It also contained a brief set of questions on walking habits and patterns, including the approximate number of hours the participants used to walk per week and the average length of their most common walking journeys; walking intensity was calculated by means of logarithmically computing the last two factors.

In the second part, we used the Walking Behavior Questionnaire (WBQ), a self-report instrument that measures both risky (errors and violations) and protective (or positive) walking behaviors. The WBQ follows the original error/violation factorial structure typical of the BQ (Behavioral Questionnaire) perspective, based on widely used and validated questionnaires such as the Driving Behavior Questionnaire (DBQ; Reason et al., 1990) in the case of motor-vehicle drivers, and the Cycling Behavior Questionnaire (CBQ; Useche

Table 1
Descriptive data of the study sample.

Feature	Category	Frequency	Percentage
Gender	Female	642	60.0
	Male	428	40.0
Educational level	Primary studies or lower	71	6.6
	Secondary-high school	230	21.5
	Technical studies	188	17.6
	University degree	477	44.6
	Postgraduate degree	104	9.7
Main reason for walking	Daily commuting	414	38.7
	Doing exercise or fitness	106	9.9
	Doing some daily task or housework (e.g., shopping, picking up children …)	154	14.4
	Making a short trip to a specific point in the city	227	21.2
	Recreational ("go for a walk")	132	12.3
	As a part of their job	37	3.5
Hours spent walking per week	<1 h	49	4.6
	1–5 h	403	37.7
	6–10 h	380	35.5
	11–15 h	104	9.7
	16–20 h	45	4.2
	21–25 h	31	2.9
	>25 h	58	5.4
Length of most common walking trip	0–15 min	305	28.5
	16–30 min	486	45.4
	31–45 min	134	12.5
	46–60 min	91	8.5
	61–90 min	35	3.3
	91–120 min	19	1.8

et al., 2018) and Bicycle Rider Behavior Questionnaire (BRBQ; Hezaveh et al., 2018) used for bicyclists. Nevertheless, and although the questionnaire follows the BQ paradigm applicable to different types of road users, all the behaviors measured and analyzed by the WBQ correspond to features rigorously related to pedestrian behavior, considering the key qualitative task differences existing between them and any other group of users. Furthermore, the WBQ introduces the concept of "Positive Behaviors" as a study factor for pedestrian behavior, as done by Özkan and Lajunen (2005) for the study of driving behavior and by Useche et al. (2018a,b) in the case of bicycle riders' behavior; however, this is done considering the specific features of walking (intended habits and actions of pedestrians that may contribute to reducing their road risk) applicable to different geographical contexts.

Therefore, this Likert scale is composed of 30 items distributed along three factors or short sub-scales: *Violations* (V), consisting of 16 items; *Errors* (E), 10 items; and *Positive Behaviors* (PB), 4 items. Using behaviors) for different safe (*protective*) and unsafe (*risky*) walking behaviors commonly observable on the road. Item composition and key scores/coefficients of the scale are presented in Table 3.

Finally, and based on the same theoretical considerations and relationships that exist between road behaviors, risk perception, distractions and traffic crashes (which have been highlighted in the introduction of this manuscript) we included three additional indicators for testing the convergent validity of the instrument. Road risk perception was assessed using the Risk Perception Scale (RPS) (Useche et al., 2019), a Likert scale composed of 7 items ($\alpha = 0.851$) ranging from 0 (no risk perceived) to 4 (highest risk perceived), whose scoring consists of the average of the seven statements. Road distractions were assessed by means of the Road Distractions Inventory (RDI) (Useche et al., 2019), an 8-item ($\alpha = 0.652$) dichotomous (1 = Yes; 0 = No) scale aimed at presenting different potential distractors commonly existing within the road environment that may enhance the occurrence of risky behaviors (mainly errors) among pedestrians. Apart from the individual prevalence of each potential distractor, this scale allows for the calculation of a continuous score that ranges between 0 and 8 by summing the positives scores in the list of distractors presented. Finally, walking crashes were measured through a single item asking for "*the amount of traffic accidents or crashes suffered while walking during the last 5 years*", that was also dichotomized for the SEM model, presented in Section 3.4.

2.4. Ethics

To perform this study, the Ethics Committee of Research in Social Science in Health of the University of Valencia was consulted, granting that it responded to the general ethical principles and certifying its accordance with the Declaration of Helsinki (IRB approval number H1535548125595).

2.5. Data processing (statistical analysis)

Initially, a basic data curation was carried out, allowing us to perform descriptive analytic procedures on the sample features and the scoring for the supplementary scales that were used. Then, the factorial structure of the Walking Behavior Questionnaire (WBQ) was tested by means of a rigorous confirmatory procedure, through competitive Confirmatory Factor Analyses (CFA) with successive fit steps (forward), after an initial assessment via Exploratory Factor Analysis with maximum likelihood (EFA; a statistical method used to uncover the underlying structure of a relatively large set of variables). Given than the EFA showed good results, endorsing the basic assumptions of the questionnaire, and that theoretical and empirical approaches to road behaviors for different types of road users following similar measuring models were already available, this study used confirmatory models. This constituted the "a priori" or baseline model to be contrasted (please see Section 3.1 for more information about model specifications). It is worth saying that Confirmatory Factor Analysis (CFA) also entails several advantages for what concerns the management of missing data, categorical and non-normally distributed variables (Finney and DiStefano, 2013). Furthermore, one key advantage of competitive confirmatory factor analysis is that it allows for the testing of several models under different theoretical assumptions and hypothesized structures, thus indicating what solution has a more adequate and parsimonious fit. In this case, SPSS AMOS software (version 24.0) was used for specifying and estimating these models. Weighted Least Square Mean and Variance adjusted (WLSMV) estimations were applied, keeping in mind that the data was ordinal and did not meet the assumption of multivariate normality.

As suggested in expert literature, the model fit was weighed by means of several estimators and indexes from different logics and families (for further information, see Marsh et al., 2004). More specifically, all the accessible indexes suggested for the method of

Table 2
Competitive analysis-based fit indices of the structural models.

Model	X^2	df[1]	p	CMIN/df[2]	RMSEA[3]	90% CI for RMSEA		CFI[4]	NFI[5]
						Lower	Upper		
Unifactorial solution	4105.954	389	<0.001	10.555	0.095	0.092	0.097	0.710	0.691
Three-factor baseline model	2078.188	388	<0.001	5.356	0.064	0.061	0.067	0.868	0.853
Three-factor final (retained) model	1244.058	370	<0.001	3.362	0.047	0.044	0.050	0.932	0.906

[1]df = Degrees of freedom.
[2]CMIN/df = Minimum discrepancy between X^2 and df.
[3]RMSEA = Root Mean Square Error of Approximation.
[4]CFI = Confirmatory Fit Index.
[5]NFI = Normed Fit Index.

Table 3
Item content, factor that the item belongs to, standardized factor loading (λ), standard error (S.E.) and p-values in the retained model.

Item	Content	Factor	Mean	S.D.	λ	S.E.	*p*
WBQ1	Crossing in the middle of the road, not on the crosswalk, in a city street	*F1: Violations*	1.99	0.96	0.573	0.048	<0.001
WBQ2	Crossing on the crosswalk when the traffic light is red		1.88	1.01	0.608	0.052	<0.001
WBQ3	Walking on the driveway because the sidewalk is very narrow or there are many pedestrians already walking on it		1.20	0.95	0.461	0.046	<0.001
WBQ4	Despite being relatively close to the crosswalk, crossing the road among cars		1.37	1.07	0.558	0.053	<0.001
WBQ5	Crossing at a run when the pedestrian traffic light is flashing, even if you make cars wait		1.85	1.16	0.703	0.062	<0.001
WBQ6	Making your place in order to overtake someone who is ahead of you, but is walking very slowly		1.94	1.21	0.578	0.051	<0.001
WBQ7	Walking on the bike lane, even for a short time		1.09	1.02	0.463	0.050	<0.001
WBQ8	Jumping a wall or a fence in order to shorten the way		0.68	0.93	0.485	0.046	<0.001
WBQ9	Running at the last moment, so you won't lose the public transportation		1.93	1.27	0.623	0.065	<0.001
WBQ10	Walking while under the effects of alcohol or drugs		1.09	1.17	0.548	0.059	<0.001
WBQ11	Walking while listening to music with your headphones		1.76	1.48	0.549	0.075	<0.001
WBQ12	Walking while watching a video or checking your social media on your phone		1.59	1.20	0.541	0.060	<0.001
WBQ13	Walking while you send a text message or talk in a chat		1.96	1.19	0.613	0.061	<0.001
WBQ14	Walking while talking on the phone, with or without a "hands-free" device		2.15	1.04	0.495	0.052	<0.001
WBQ15	Walking so fast that people have to sidestep		1.06	0.99	0.540	0.042	<0.001
WBQ16	Zig-zagging among people to reach your destination faster		1.74	1.18	0.617	0.060	<0.001
WBQ17	Walking while being distracted, so that a car has to stop or honk at you	*F2: Errors*	0.46	0.69	0.761	0.060	<0.001
WBQ18	Bumping into someone because you were distracted		0.54	0.72	0.672	0.058	<0.001
WBQ19	Bumping into an object because you were distracted		0.48	0.68	0.670	0.054	<0.001
WBQ20	Forgetting, for a moment, the place you were going to		0.57	0.79	0.475	0.059	<0.001
WBQ21	Stumbling upon an obstacle, a bump or a gap that you hadn't seen		1.18	0.84	0.600	0.068	<0.001
WBQ22	Suddenly stopping or changing direction, almost making someone bump into you (for instance, looking at a store window)		0.73	0.79	0.654	0.065	<0.001
WBQ23	Realizing that you have just crossed the road without looking in both directions		0.77	0.88	0.639	0.067	<0.001
WBQ24	Realizing that you have just crossed at a traffic light that was not green for pedestrians		0.79	0.87	0.613	00.068	<0.001
WBQ25	Almost bumping into someone while turning a corner, because you were not looking		1.10	0.87	0.655	0.071	<0.001
WBQ26	Looking at some billboard instead of focusing on traffic		0.64	0.81	0.592	0.050	<0.001
WBQ27	Looking at both sides of the road before crossing, even if you take precedence	*F3: Positive behaviors*	2.69	1.20	0.446	0.050	<0.001
WBQ28	Waiting for the pedestrian traffic light to turn green before crossing, even when there are no vehicles approaching		1.83	1.15	0.804	0.056	<0.001
WBQ29	Trying to walk on the right side, to avoid bumping into another pedestrian who may come from the opposite direction		1.94	1.22	0.536	0.052	<0.001
WBQ30	Walking till the crosswalk to cross the road, even if it requires some more time		1.85	1.10	0.745	0.082	<0.001

estimation were used: Chi-square (χ^2), minimum discrepancy ratio (χ^2/df); Confirmatory Fit Index (CFI), Normed Fit Index (NFI) and Root Mean Square Error of Approximation (RMSEA). Goodness-of-fit cut-off points were established as proposed by Marsh et al. (2004): CFI/NFI indexes > 0.90, a RMSEA < 0.08, and a χ^2/df ratio < 5.0 suggest a satisfactory model fit (see Table 2 for the questionnaire's fit and Section 3.4 for the predictive SEM model's fit).

Furthermore, the suitability of the model was also evaluated using the strength and coherence of the estimates, plus the absence of large or unnecessary indices of modification. Also, the convergent validity of WBQ was tested by means of three selected Criterion Variables (CVs) supported by the literature (see Section 2.3 for further information). Finally, the reliability (or internal consistency) of the scale and its items was gauged through: (1) Cronbach's alpha coefficients (α), and (2) the Composite Reliability Index (CRI), an additional consistency index that ranges between 0 (no consistency) and 1 (total consistency), statistically founded on the factor loadings and residuals observed in the confirmatory results. The use of this second index also helps overcome some of the traditional gaps of Cronbach's alpha as a single way for assessing scale reliability (Raykov, 2001; Raykov and Marcoulides, 2011).

3. Results

3.1. Structural models

With the aim of understanding the factorial structure of the Spanish version of the Walking Behavior Questionnaire (WBQ) scale, and after testing the raw fit of the model through EFA, two competitive theoretical-based CFAs were performed. First, we tested the original structure composed of three factors and, second, an unifactorial structure, in order to perform fit comparisons and thus determine the best possible theoretical structure for the scale. The model fit for the unifactorial solution was considerably inadequate, while the baseline three-factor model showed better fit indexes (see Table 2). A close inspection of this unconstrained three-factor model allowed us to identify a reduced set of very large modification indexes that pointed out a relevant relationship between some items. The new simplified model fitted the data reasonably well, presenting the key indices reported in Table 2.

It is relevant to remark that when this model fit is compared to an unifactorial solution with the same set of items, the final three-factor structure presents a much better fit without the need of deleting questions, bearing in mind both the considerably adequate factor loadings (all over $\lambda = 0.45$) and the reliability scores obtained in the following analysis (see Section 3.2). Table 3 shows the content, descriptive data (average scores and standard deviations), standardized factor loadings and significance levels of each one of the items composing the WBQ. It is noticeable how all factor loadings are large, positive, and statistically significant at their correspondent factors, as also shown in Fig. 1.

3.2. Internal consistencies

Alpha estimates were all above the usual 0.7 criteria, suggested by methodological sources (Morera and Stokes, 2016), which indicates adequate internal reliability: 0.888 for Traffic Violations; 0.870 for Errors; and 0.727 for Positive Behaviors. Furthermore, the composite reliability indices (CRI) had very satisfying reliabilities for all the latent constructs. CRI for F1 (Violations) was 0.989. The CRI for F2 (Errors) was 0.984. Finally, CRI for F3 (Positive Behaviors) was 0.963.

3.3. Factor correlations and convergent validity

Overall, bivariate correlations between factors were statistically significant and considerably large, as it was hypothesized. Association measures were gathered as follows: regarding factor correlations, F1 (violations), and F2 (errors), were positively and significantly correlated between them and, on the other hand, F1 (violations) and F3 (positive behaviors) presented a negative association. As it was initially hypothesized, considering the theoretical background, F2 (errors) and F3 (positive behaviors) were tendentially negative but not significantly correlated, as shown in Table 4, in which association (Pearson) coefficients (σ) are also available.

Furthermore, the convergent validity between WBQ factors and other related variables was evaluated by means of the correlation coefficients found between each one of the scores of the three resulting dimensions and three Criterion Variables (CVs): (a) risk perception, (b) road distractions, and (c) the number of traffic accidents suffered as a pedestrian during the last 5 years. In this regard,

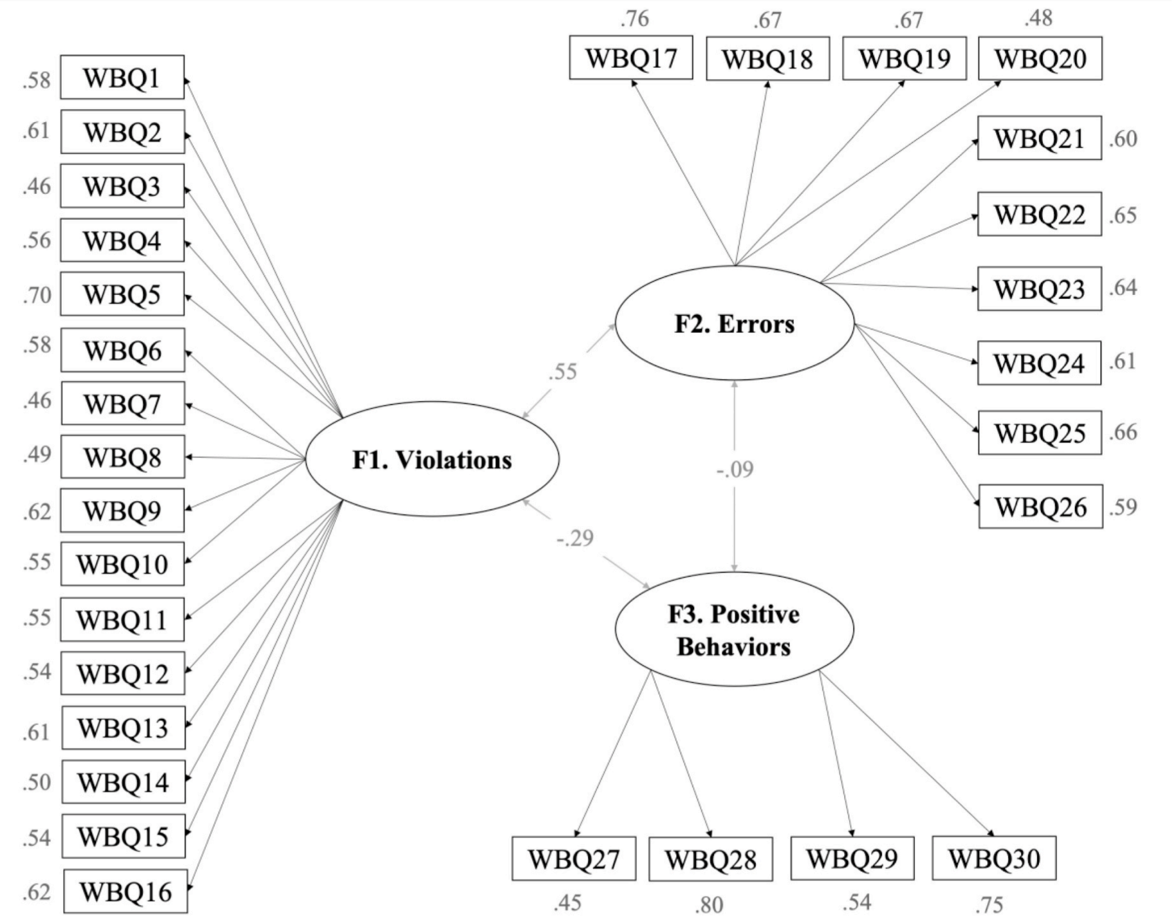

Fig. 1. Standardized parameter estimates and factor correlations. *Note:* All standardized estimates were $p < 0.001$; the numbers within squares represent the original numbers of the items in the WBQ (as shown in Table 3).

Pearson' association coefficients showed positive and significant correlations between: risk perception (CV^a) and F3 (positive behaviors; $\sigma = 0.273$); road distractions (CV^b) and F1 (violations; $\sigma = 0.084$) and F2 (errors; $\sigma = 0.279$). Finally, traffic crashes suffered as a pedestrian (CV^c) were positively associated with F2 (errors; $\sigma = 0.110$), and negatively correlated with F3 (positive behaviors; $\sigma = -0.061$).

3.4. Predictive value of the WBQ

Finally, in order to test the predictive value of the questionnaire, a Structural Equation Model (SEM) was built up for explaining the fact of having suffered walking crashes during the last 5 years (discrete value; success = 1). The model aimed at assessing the effect of demographic and walking-related variables, as well as the risky behavior (*errors* and *violations*) sub-scales of the Walking Behavior Questionnaire (WBQ) as potential predictors. Following the theoretical roots of this study (see Section 1) and some of the correlations explained in Table 4, it was hypothesized that violations and errors may exert a mediating effect between age, education and walking intensity of individuals, their proneness to road distractions and the fact of having suffered (or not) walking crashes during a period of 5 years.

In this regard, it was expected that both WBQ risk-related factors might contribute to explain self-reported crashes, although in different ways: violations were hypothesized to play a role in the involvement of pedestrians in a pre-crash scenario, thus enhancing the likelihood of getting experiencing a risky situation, while errors would precede the crash itself. As an example, running a traffic light at a crosswalk may result in a hazardous situation (high pedestrian-car proximity) demanding a rapid reaction, but a failure in the same situation (i.e., error) may enhance the occurrence of the crash.

The resulting Structural Equation Model ($x^2_{(5)} = 15.082$, $p = 0.010$; NFI = 0.986; CFI = 0.941; RMSEA = 0.043, IC90%: 0.019–0.069; CMIN/df = 3.016), controlling the covariances between age, education and weekly walking intensity, is presented in Table 5, and shows that (indeed) errors and violations fully mediate the relationship among sociodemographic and walking-related variables and pedestrian's crashes. In other words, sociodemographic variables, road distractions and violations have a significant effect on errors—but do not directly explain walking crashes; on the other hand, errors exert a significant effect on the occurrence of crashes.

4. Discussion and conclusion

The core aim of this empirical research was to thoroughly describe the validation of a measurement aimed at walking risky and positive behavior on the road, using the Walking Behavior Questionnaire on a large sample of Spanish pedestrians. In this regard, this study confirmed that the WBQ has a dimensional structure that guarantees psychometric value and reliability for measuring pedestrian risky and positive road behaviors. Apart from considerably high alpha (all above 0.7) and CRI (all above 0.9) indexes and items with high factorial weights ($\lambda > 0.45$), the questionnaire is satisfactorily adjusted to the latent variable model with a parsimonious structure of three dimensions: violations, errors and positive behaviors. These labels respond, in the first place, to the content of the items with greater factorial weight for each dimension and, secondly, to the shared theoretical background of the WBQ regarding other instruments based on the BQ (behavioral questionnaire) paradigm, which use the self-report approach for measuring road safety behaviors of different types of road user, that also differentiates deliberate and unintentional risky behaviors (Hezaveh et al., 2018; Useche et al., 2018; Deb et al., 2017; Reason et al., 1990).

As for the validity of the WBQ constructs, the fit of the three-dimensional model was significantly better than the one obtained with a single-dimensional approach. This finding acquires theoretical relevance, since it supports the ability of the instrument to differentiate between negative and positive behaviors of pedestrians and, also, between errors and traffic violations. This differentiation between intended (violations) and unintended (errors) risky behavior is crucial when considering that the evidence shows how interventions on voluntary risk assumption are primarily associated with (e.g.) the promotion of safe habits through traffic regulations, policymaking, education for road safety and other social-based matters (Martí-Belda et al., 2019).

Furthermore, the WBQ has shown an adequate convergent validity when crossing its three dimensions with variables that are theoretically related to both positive and risky road behaviors. In this sense, risk perception was significantly associated with protective road behaviors, as shown in other studies dealing with different road users, such as the one performed by Deb et al. (2017) with pedestrians, Harbeck & Glendon (2013) with young drivers and Useche et al. (2018) with bicycle riders from 20 countries, the last one also positively relating both types of risky road behaviors (errors and violations) with road distractions.

Table 4
Bivariate correlations (Pearson) between study factors and criterion variables.

Factor	F1	F2	F3	CV[a]	CV[a]	CV[a]
F1: Violations	1					
F2: Errors	0.523**	1				
F3: Positive behaviors	−0.154**	−0.054	1			
CV[a]: Risk perception	0.005	−0.044	0.273**	1		
CV[b]: Road distractions	0.084**	0.279**	0.008	0.058	1	
CV[c]: Traffic accidents as a pedestrian (5 years)	0.022	0.110**	−0.061*	−0.126**	0.005	1

**Correlation is significant at 0.01 level (2-tailed). *Correlation is significant at 0.05 level (2-tailed).
[a] Introduced as a criterion variable (CV).

Table 5
SEM model for assessing the effect of sociodemographic variables and walking behaviors on self-reported walking crashes.

Path			SPC[1]	S.E.[2]	C.R.[3]	p
Violations (WBQ)	←	Age	−0.525	0.001	−20.057	***
Violations (WBQ)	←	Education	0.097	0.016	3.693	***
Violations (WBQ)	←	Walking intensity	0.111	0.017	4.427	***
Errors (WBQ)	←	Age	0.150	0.001	4.975	***
Errors (WBQ)	←	Education	−0.056	0.013	−2.174	*
Errors (WBQ)	←	Walking intensity	0.103	0.013	4.043	***
Errors (WBQ)	←	Road distractions	0.205	0.007	8.131	***
Errors (WBQ)	←	Violations (WBQ)	0.596	0.024	19.806	***
Walking crashes	←	Age	0.042	0.001	1.116	0.264
Walking crashes	←	Education	−0.052	0.009	−1.642	0.100
Walking crashes	←	Walking intensity	0.034	0.009	1.071	0.284
Walking crashes	←	Road distractions	0.029	0.005	0.922	0.356
Walking crashes	←	Violations (WBQ)	−0.004	0.019	−0.100	0.920
Walking crashes	←	Errors (WBQ)	0.112	0.021	2.985	**

*significant at $p < 0.05$ level; **significant at $p < 0.01$ level; ***significant at $p < 0.001$ level.
[1]SPC = Standardized Path Coefficients (can be interpreted as linear regression weights); [2]S.E. = Standard Error; [3]CR = Critical Ratio.

Nevertheless, and bearing in mind key features such as the frequency and severity of the crashes suffered by non-motorized users, such as cyclists and pedestrians, that seem to be considerably different from those reported by drivers (on which the majority of researches in this regard are focused), the stability of significant bivariate correlations and statistical effects between violations and traffic crashes remain inconsistent across different self-report studies. This is the reason why these data should be interpreted with caution. However, there is a major agreement on the fact that traffic-rule violations committed by these users are one of the most relevant human behavioral contributors to the risky scenarios in which both cyclist and pedestrian injuries commonly happen: e.g., crossing a red light, not yielding at intersections and deliberately omitting different traffic signals (Gitelman et al., 2019; O'Hern et al., 2019; Zhang et al., 2014; Cinnamon et al., 2011; Porter, 2011). In this regard, the structural model presented in Section 3.4 endorses two essential assumptions of this study: (1) first, that errors and violations are both related to (self-reported) walking crashes, even though the mechanism through which they influence them seems to be different (errors were the main and direct predictors, while violations influenced errors, that in turn mediate their relationship to crashes); and (2) that the WBQ allows for the measurement of these factors in consideration of specific features of the walking task, differently from what has been observed in studies performed with motor-vehicle drivers.

Based on these results, it is worth suggesting that interventions aimed at reducing walking errors and violations, in addition to being focused on (e.g.) strengthening psychomotor skills, awareness and law compliance (as respectively addressed in road training and road safety education paradigms—Twisk et al., 2014; Dragutinovic and Twisk, 2006), should be accompanied by infrastructural measures enhancing a proper interaction with the built environment; this way, they allow for the reduction of the impact of factors preceding risky behaviors, such as road distractions (Young, Stephens, O'Hern and Koppel, 2020; Staton et al., 2016; Violano et al., 2015). On the other hand, and although the concept of "positive behavior" is relatively new in the BQ paradigm, some interesting empirical experiences such as the one performed by Deb et al. (2017) have claimed for a better promotion of protective behaviors, as a strategy of enhancing better habits and awareness among pedestrians. This, together with infrastructural and societal interventions, might be subsequently translated into a lower road risk and crash involvement (Useche et al., 2018a,b; Özkan and Lajunen, 2005).

Also, it is important to mention that, qualitatively, the WBQ adds a total of four items (questions 11 to 14) related to the use of phones and other mobile devices and *connected* platforms that, during the last few years, have not only acquired a considerably high prevalence, but also constitute a major concern for road safety researchers and practitioners (Lin and Huang, 2017; Lim et al., 2016). In this regard, the current evidence predicts that the use of handheld device is likely to grow during the next few years, and that a deeper immersion of road users in this type of tasks while walking may compromise their safety (Oviedo-Trespalacios et al., 2019; Timmis et al., 2017; Peraman and Parasuraman, 2016). In fact, the present study already contributes to depicting the high prevalence and relevance of this issue: two out of the three most frequently observed traffic violations performed by Spanish pedestrians were directly related to the use of cellphones (i.e. talking and texting while walking, as shown in Table 3), and actions involving information and education are needed to raise awareness and enhance safe habits amongst pedestrians.

Therefore, the data provided in this study, performed by means of an instrument that considered different dimensions of walking behavior, may be useful for developing evidence-based strategies aimed at addressing, measuring and intervening risky walking behaviors; all of this while bearing in mind not only the "traditional" risks, but also those social and technological trends that are already impacting transportation dynamics, and their incidence on pedestrian behavior and safety. In this regard, past experiences have shown that evidence-based policymaking has been effective in improving the safety and behavior of motor-vehicle users; however, to the date, policymaking tailored to pedestrian, with a focus on their non-motorized safety and well-being, has been scarcely documented (Mader and Zick, 2014). Thus, the information retrieved by means of validated tools such as the Walking Behavior Questionnaire or WBQ (not only analyzing the factor structure of the scale but also allowing researchers to point on the most prevalent road risky and protective behaviors) can be particularly useful for designing evidence and behavioral-based interventions and educational programs, focused on the road risk reduction and the promotion of safe walking behavior.

5. Limitations of the study and further research

This study was carried out using a large and representative sample, following strict statistical procedures and parameters. However, some limitations should be acknowledged. First of all, this research is not exempted from the typical limitations of self-reported data-collection; in spite of the fact that during the gathering of data all participants were informed about the scientific value of the information they were providing, and reminded of the anonymity of the questionnaire, other studies dealing with road users' behaviors have shown that questions addressing topics such as traffic violations and unsafe behaviors may be prone to be affected by common method biases, potentially expressed in the form of social desirability and acquiescent responses. Furthermore, it is worth encouraging researchers to: (a) perform studies that analyze the relationship between walking behavior and physical characteristics of the built environment of pedestrians, and (b) carry out cross-cultural studies and further applications of the questionnaire, in order to test its external validity and the relationships between specific states-of-affairs in pedestrian road safety, descriptive and inferential outcomes of the instrument.

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Declaration of competing interest

All authors declare that there are no competing interests.

CRediT authorship contribution statement

Sergio A. Useche: Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Francisco Alonso:** Visualization, Supervision, Software. **Luis Montoro:** Investigation, Data curation, Writing - original draft.

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