Addictive Behaviors 77 (2018) 38–46

Contents lists available at ScienceDirect

Addictive Behaviors

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

Item Response Theory analysis of Fagerström Test for Cigarette Dependence

Andrea Svicher[a], Fiammetta Cosci[a,*], Marco Giannini[a], Francesco Pistelli[b], Karl Fagerström[c]

[a] Department of Health Sciences, University of Florence, Florence, Italy
[b] Cardio-thoracic and Vascular Department, University Hospital of Pisa, Italy
[c] Fagerström Consulting, Vaxholm, Sweden

HIGHLIGHTS

- FTCD has acceptable homogeneity, discriminative power, and reliability.
- HSI has high homogeneity, discriminative power, and reliability.
- HSI is highly recommended to assess heavy smokers.
- FTCD would be better used to subtype cigarette dependence.
- Item 1 is the most informative.

ARTICLE INFO

Keywords:
Cigarette
Smoking
Dependence
Fagerström Test for Cigarette Dependence,
Item Response Theory
Fagerström Test for Nicotine Dependence

ABSTRACT

Introduction: The Fagerström Test for Cigarette Dependence (FTCD) and the Heaviness of Smoking Index (HSI) are the gold standard measures to assess cigarette dependence. However, FTCD reliability and factor structure have been questioned and HSI psychometric properties are in need of further investigations. The present study examined the psychometrics properties of the FTCD and the HSI via the Item Response Theory.
Methods: The study was a secondary analysis of data collected in 862 Italian daily smokers. Confirmatory factor analysis was run to evaluate the dimensionality of FTCD. A Grade Response Model was applied to FTCD and HSI to verify the fit to the data. Both item and test functioning were analyzed and item statistics, Test Information Function, and scale reliabilities were calculated. Mokken Scale Analysis was applied to estimate homogeneity and Loevinger's coefficients were calculated.
Results: The FTCD showed unidimensionality and homogeneity for most of the items and for the total score. It also showed high sensitivity and good reliability from medium to high levels of cigarette dependence, although problems related to some items (i.e., items 3 and 5) were evident. HSI had good homogeneity, adequate item functioning, and high reliability from medium to high levels of cigarette dependence. Significant Differential Item Functioning was found for items 1, 4, 5 of the FTCD and for both items of HSI.
Conclusions: HSI seems highly recommended in clinical settings addressed to heavy smokers while FTCD would be better used in smokers with a level of cigarette dependence ranging between low and high.

1. Introduction

The Fagerström Test for Cigarette Dependence (FTCD) (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) is the most used instrument assessing the level of cigarette dependence. It was developed to assist clinicians to better diagnose the smoker willing to quit (Fagerström, 1978). The test can be both self- or interviewer administered. Its validity has been studied since its first version, named Tolerance Questionnaire (Fagerström, 1978). It was found to predict outcome in smoking cessation (Fagerström, Russ, Yu, Yunis, & Foulds, 2012). It correlates positively with several indices of smoke intake, such as cotinine, exhaled carbon monoxide (Muhammad-Kah, Hayden, Liang, Frost-Pineda, & Sarkar, 2011), dopamine release after a nicotine administration (Takahashi et al., 2007), compensatory smoking (Fagerström & Bates, 1981), upregulation of nicotinic receptors (Chen et al., 2013), risk for lung cancer (Muscat, Ahn, Richie, & Stellman, 2011) as well as chronic obstructive pulmonary disease (Jiménez-Ruiz et al., 2004) and negatively with dopamine synthesis (Rademacher et al., 2016). FTCD scores can be also used for selecting the dose (Shiffman et al., 2002) and type of nicotine replacement treatment to

* Corresponding author at: Department of Health Sciences, University of Florence, via di San Salvi, 12, 50135 Florence, Italy.
E-mail addresses: andrea.svicher@unifi.it (A. Svicher), fiammetta.cosci@unifi.it (F. Cosci), marco.giannini@unifi.it (M. Giannini), f.pistelli@ao-pisa.toscana.it (F. Pistelli), karl.fagerstrom@swipnet.se (K. Fagerström).

http://dx.doi.org/10.1016/j.addbeh.2017.09.005
Received 18 March 2017; Received in revised form 13 September 2017; Accepted 14 September 2017
Available online 18 September 2017

improve the cessation outcome (Stapleton & Sutherland, 2011), and are related with genes for nicotinic receptors (Feng et al., 2004). Despite its wide use in clinical practice and research, the psychometrics properties of the FTCD are still debated. Problems with the factor structure and the internal consistency have been raised (Etter, 2005; Richardson & Ratner, 2005). Some authors found two factors correlated (Haddock, Lando, Klesges, Talcott, & Renaud, 1999; Radzius et al., 2003; Richardson & Ratner, 2005) while others suggested a one-factor solution (Chabrol, Niezborala, Chastan, Montastruc, & Mullet, 2003; Etter, Duc, & Perneger, 1999; John et al., 2004; Robinson, Schroeder, & Moolchan, 2006). Sex-related differences in scoring the FTCD have been reported in adult smokers (Johnson, Morgan-Lopez, Breslau, Hatsukami, & Bierut, 2008) with males usually having higher scores. Young adult smokers seem to have higher FTCD scores than adults (Haberstick et al., 2007; Jayakrishnan et al., 2012; Olfson et al., 2016; Yang, Shiffman, Rockett, Cui, & Cao, 2011). The Italian version of the FTCD is consistent with other versions and has shown positive and significant relationships with expired carbon monoxide (Ferketich, Fossati, & Apolone, 2008).

A short version of the FTCD, named Heaviness of Smoking Index (HSI), has been proposed. It includes only the items 1 and 4 of the FTCD, and has been shown having good validity in predicting smoking cessation outcome (Borland, Yong, O'Connor, Hyland, & Thompson, 2010; Fagerström et al., 2012). Its psychometric properties have been investigated in some studies (Chabrol, Niezborala, Chastan, & de Leon, 2005; de Leon et al., 2003; John et al., 2004) but to date, differences in sex or age in terms of response to the items have not been tested.

A growing literature suggests that the validity for clinical rating scales is based on a balance between reliability and sensitivity (Feinstein, 1999; Kellner, 1992; Fava, Ruini, & Rafanelli, 2004; Fava & Belaise, 2005; Bech, 2012). The latter indicating the ability of a scale to detect differences between different clinical groups or changes between pre- and post-treatment (Feinstein, 1987; Kellner, 1992). In addition, modern psychometric methods and psychiatric taxonomy (i.e., DSM-5 and ICD-10) have recommended to use a limited number of items to preserve the sensitivity of clinical rating scales (Bech, 2012; Hanson, Woods, Martimianakis, Rasasingham, & Kulasegaram, 2016), which might be biased by a redundant nature of items (Feinstein, 1987; Wright & Feinsten, 1992). The Item Response Theory (IRT) approach has had an increasing application in clinical research (e.g., Cappelleri, Lundy, & Hays, 2014; Nguyen, Han, Kim, & Chan, 2014; Petrillo, Cano, McLeod, & Coon, 2015) since it identifies the items of a scale which effectively discriminate the different degrees of severity of the same disease (Embretson & Reise, 2000; Thomas, 2011). Unfortunately, only a minority of studies applied the IRT to the FTCD. Yamada, Acton, & Tsoh (2009) provided support for a two-dimensional structure using Rasch models, even though Rasch models requires items having equivalent factor loadings (Thomas, 2011), which is not the case for the FTCD items (e.g., Haddock et al., 1999; Radzius et al., 2003). Breteler, Hilberink, Zeeman, and Lammers (2004) applied a simple Rasch model, recoding the items 1 and 4 into binary variables, although such a re-coding led to a loss of information (Cohen, 1983). Finally, Courvoisier and Etter (2008) applied the graded response model as a two-parameter model for dichotomous observed variables. However, this mathematical model deals with ordered polytomous categories (Samejima, 2016) while 4 out of 6 FTCD items are dichotomously scored. The HSI, to our knowledge, has never been studied by using the Item Response Theory.

The aim of the present study was to evaluate the reliability and homogeneity of the FTCD and of the HSI via an IRT model. Reliability was used to explore the extent to which FTCD and HSI items are reliable for smokers with different levels of cigarette dependence. Homogeneity was assessed to evaluate whether the total summed item score was a sufficient statistic for FTCD and HSI. Item-level measurement bias due to sex- and age-related differences were investigated to verify if they can influence the response to FTCD or HIS items. Finally, FTCD and HSI were studied to verify if they discriminate between heavy and non-heavy smokers as well as between light and non-light smokers.

2. Methods

2.1. Study design

This is a secondary analysis of data collected in previous studies (Cosci et al., 2009; Bertoli, Amendola, & Cosci, 2013; Cosci, Bertoli, & Abrams, 2013; Cosci, Aldi, & Nardi, 2015; Cosci, Ibrahim, Nannini, & Schruers, 2015; Svicher, Zvolensky, & Cosci, 2017), where FTCD was used to verify subjects' eligibility.

2.2. Participants

The data were collected in 869 Italian smokers (i.e., subjects smoking at least 5 tobacco cigarettes/day in the last year) aged at least 18 years. Of them, 354 were out-patients attending the smoking cessation clinic of the University-Hospital of Pisa (± 100.000 inhabitants, Tuscany, North Italy), with no history of dermatological, cardiac, or psychiatric diseases (Cosci et al., 2009), and 515 subjects were recruited from the general population of the metropolitan urban area of Florence (± 1.000.000 inhabitants, Tuscany, North Italy), with no history of medical or psychiatric disorders (Bertoli et al., 2013; Cosci et al., 2013, 2015; Svicher et al., 2017).

2.3. Procedure

Participants were recruited through advertisements posted on social networks (i.e., Facebook, Inc.) and/or flyers posted in local businesses, academic places, and community bulletin boards, or were recruited among out-patients attending a clinical smoking cessation intervention. Subjects filled in the survey either online (195 of the 515 coming from the general population), by using a secure link hosted by the researchers or a paper-pencil format. Participants were asked to give written (n = 674) or digital (n = 195) informed consent including a privacy protection disclaimer. Thereafter they were invited to fill in a self-report questionnaire collecting demographic information (i.e., age, sex, level of education) and smoking habits (i.e., cigarettes smoked daily, age of onset of smoking) as well as the FTCD.

Approval to run the present research among out-patients of the smoking cessation clinic was granted by the Medical Ethics Review Board of the University Hospital of Pisa. Approval to run the present research among smokers from the general population was granted by the University of Florence Review Board.

2.4. Instruments

The FTCD (Heatherton et al., 1991) is a questionnaire providing an ordinal measure of cigarette dependence which consists of six items: item 1 “How soon after you wake do you smoke your first cigarette?” (scoring: 31 + min = 0; 6–30 min = 2; 0–5 min = 3); item 2 “Do you find it difficult to refrain from smoking in places where it is forbidden, e.g., library, cinema, workplace, etc.?” (scoring: No = 0; Yes = 1); item 3 “Which cigarette would you hate most to give up?” (scoring: first of the morning = 1, others = 0); item 4 “How many cigarettes per day do you smoke?” (scoring: 10 or less = 0; 11–20 = 1; 21–30 = 2; 31 or more = 3); item 5 “Do you smoke more frequently during the first hours after waking than during the rest of the day?” (scoring: No = 0; Yes = 1); item 6 “Do you smoke even if you are so ill that you are in bed most of the day?” (scoring: No = 0; Yes = 1). The total score ranges between 0 and 10; FTCD scores from 0 to 2 indicate very low cigarette dependence, from 3 to 4 low cigarette dependence, 5 medium, 6–7 high, and 8–10 very high cigarette dependence (Fagerstrom, Heatherton, & Kozlowski, 1990).

Items 1 and 4 of the FTCD constitute the HSI (Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989), having a total score