Psychometric evaluation of Persian Nomophobia Questionnaire: Differential item functioning and measurement invariance across gender

CHUNG-YING LIN[1], MARK D. GRIFFITHS[2] and AMIR H PAKPOUR[3,4]*

[1]Department of Rehabilitation Sciences, The Hong Kong Polytechnic University, Hung Hom, Hong Kong
[2]International Gaming Research Unit, Psychology Department, Nottingham Trent University, Nottingham, UK
[3]Social Determinants of Health Research Center, Qazvin University of Medical Sciences, Qazvin, Iran
[4]Department of Nursing, School of Health and Welfare, Jönköping University, Jönköping, Sweden

Background and aims: Research examining problematic mobile phone use has increased markedly over the past 5 years and has been related to "no mobile phone phobia" (so-called nomophobia). The 20-item Nomophobia Questionnaire (NMP-Q) is the only instrument that assesses nomophobia with an underlying theoretical structure and robust psychometric testing. This study aimed to confirm the construct validity of the Persian NMP-Q using Rasch and confirmatory factor analysis (CFA) models. *Methods:* After ensuring the linguistic validity, Rasch models were used to examine the unidimensionality of each Persian NMP-Q factor among 3,216 Iranian adolescents and CFAs were used to confirm its four-factor structure. Differential item functioning (DIF) and multigroup CFA were used to examine whether males and females interpreted the NMP-Q similarly, including item content and NMP-Q structure. *Results:* Each factor was unidimensional according to the Rach findings, and the four-factor structure was supported by CFA. Two items did not quite fit the Rasch models (Item 14: "*I would be nervous because I could not know if someone had tried to get a hold of me;*" Item 9: "*If I could not check my smartphone for a while, I would feel a desire to check it*"). No DIF items were found across gender and measurement invariance was supported in multigroup CFA across gender. *Conclusions:* Due to the satisfactory psychometric properties, it is concluded that the Persian NMP-Q can be used to assess nomophobia among adolescents. Moreover, NMP-Q users may compare its scores between genders in the knowledge that there are no score differences contributed by different understandings of NMP-Q items.

Keywords: mobile phone addiction, mobile phone dependence, nomophobia, Rasch, smartphone addiction, smartphone dependence

INTRODUCTION

Due to increasing technological advance, mobile phones (now referred to more commonly as "smartphones") have become an indispensable tool, because they offer a variety of convenient functions such as Internet surfing and access to a wide variety of applications ("apps") that can be used within specific platforms (Yang, Chen, Huang, Lin, & Chang, 2017). Consequently, the ownership of smartphones is relatively prevalent, especially among youth population, across different countries (Nathan & Zeitzer, 2013; Ikeda & Nakamura, 2014; Zheng et al., 2014). Although there are many benefits in using a mobile phone such as fulfilling learning needs and the potential to develop meaningful human relationships (Kang & Jung, 2014), some extreme and/or problematic patterns of using smartphones have been reported, such as checking smartphones immediately after waking up or before going to bed (González-Cabrera, León-Mejía, Pérez-Sancho, & Calvete, 2017) and suffering from lower sleep quality (Sahin, Ozdemir, Unsal, & Temiz, 2013).

Another psychological problem highly related to the smartphone use is a subtype of anxiety that has been termed as "nomophobia" ("no mobile phone phobia") in the literature. Nomophobia has been defined into different types by King, Valença, and Nardi (2010) and King et al. (2013, 2014). King et al. (2010) first used the behaviors in both mobile phone and computer use to describe nomophobia, and in a more recent study (King et al., 2014), they focused on mobile phone use only: "*Nomophobia is the modern fear of being unable to communicate through a mobile phone (MP) or the Internet . . . Nomophobia is a term that refers to a collection of behaviors or symptoms related to MP use. Nomophobia is a situational phobia related to agoraphobia and includes the fear of becoming ill and not receiving immediate assistance*" (p. 28). In essence, nomophobia can be viewed as "*the fear of being unable to communicate through the mobile phone*" (González-Cabrera et al., 2017, p. 138). Therefore, nomophobia can be viewed as a specific

* Corresponding author: Amir H. Pakpour; Social Determinants of Health Research Center (SDH), Qazvin University of Medical Sciences, Shahid Bahonar Blvd, Qazvin 3419759811, Iran; Phone/Fax: +98 28 33239259; E-mails: pakpour_amir@yahoo.com; apakpour@qums.ac.ir

phobia defined by the fifth edition of *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; American Psychiatric Association, 2013). That is, individuals suffer from intense fear or anxiety when they are exposed to specific situations regarding mobile phones that are out of reach or have no access to their mobile phone.

Because of growing interests in nomophobia, psychometric instruments are needed for healthcare providers and researchers to identify and assess such a phobia. However, to date, only the Nomophobia Questionnaire (NMP-Q) has been developed and undergone any type of psychometric testing (González-Cabrera et al., 2017; Yildirim & Correia, 2015). To the best of the present authors' knowledge, only two studies have examined the psychometric properties of the NMP-Q (i.e., González-Cabrera et al., 2017; Yildirim & Correia, 2015). Therefore, the psychometric robustness of the NMP-Q is somewhat insufficient. Given that the tested populations are critical factors to the psychometric properties of an instrument, the reliability and validity may not be the same across different populations (Crocker & Algina, 1986; Gronlund & Linn, 1990; Thompson, 1994). Thus, cross-validating an instrument in different populations is essential. In addition to using different populations, a psychometrically robust instrument should be tested using different statistical methods, because accumulated empirical evidence using different methods is the nature of scientific inquiry. To date, only the NMP-Q has been examined using exploratory factor analysis, along with assessment of its internal consistency and concurrent validity (i.e., González-Cabrera et al., 2017; Yildirim & Correia, 2015). Consequently, this study utilized more advanced psychometric statistics [including confirmatory factor analysis (CFA) and Rasch models] to assess the psychometric properties of the NMP-Q.

Previous studies have found that the NMP-Q was highly correlated with instruments assessing mobile phone use (González-Cabrera et al., 2017; Yildirim & Correia, 2015). However, no previous studies have examined the correlation between NMP-Q and other instruments. Because the NMP-Q was developed to assess nomophobia (Yildirim & Correia, 2015), it was hypothesized that it would be correlated with anxiety. In addition, it was expected that the NMP-Q would correlate with other psychological distress (e.g., stress and depression), because anxiety is correlated with other types of psychological distress (Lin & Pakpour, 2017) and problematic smartphone use is correlated with depression (Ikeda & Nakamura, 2014). In addition, it was expected that the correlations with stress and depression would be lower than the correlation with anxiety. It was additionally hypothesized that the NMP-Q would be associated with some behavioral problems (e.g., inattention and hyperactivity), because applications excessively accessed through mobile phones (e.g., social media sites) are related to behavioral problems (Lin, Broström, Nilsen, Griffiths, & Pakpour, 2017) and decreased attention has been found among those who use mobile phones more than 1 hr daily (Zheng et al., 2014).

Given that more than 110 million people speak Persian as their first language across Iran, Pakistan, Tajikistan, and Afghanistan (Encyclopaedia Britannica, 2011), many studies have adapted and validated a variety of sound instruments into Persian versions (e.g., Mohammadsalehi et al., 2015;

Ostovar, Nor, Griffiths, & Chermahini, 2017), including instruments assessing Internet-related addictions (e.g., the Internet Gaming Disorder Scale – short form; Wu et al., 2017). Translating these instruments is a timely and necessary step to facilitate research in a Persian context. Consequently, the main purposes of this study were to (a) develop a Persian version of the NMP-Q using standard translation procedure and (b) assess various psychometric properties of the Persian NMP-Q. In addition, it was hypothesized that the NMP-Q would be (a) highly associated with mobile phone use and anxiety and (b) moderately associated with stress, depression, inattention, and hyperactivity.

METHODS

Participants and procedure

The study participants comprised schoolchildren aged 13–19 years attending high schools in Qazvin (a city located in 150 km northwest of Tehran) in Iran. The schoolchildren were selected using a two-stage random sampling from 58 high schools. After obtaining a list of all high schools from the Ministry of Education in the Qazvin region, 20 high schools were randomly selected and approached in the first stage of the sampling design. Following this, all students in each selected school were approached and informed about the research project in the second stage. A letter containing study aims and procedure was sent to participants' parents. Participants were recruited only when both parents and students had given written informed consent. Of 3,960 students approached, 3,216 students agreed to participate in the study (81.2% response rate). Only adolescents in possession of a smartphone were included in the study.

Development of the Persian NMP-Q

The translation procedure in developing the Persian NMP-Q was conducted according to international guidelines (Beaton, Bombardier, Guillemin, & Ferraz, 2000; Khoshnevisan et al., 2012; Saffari, Zeidi, Pakpour, & Koenig, 2013). Several steps were taken to translate the NMP-Q into Persian version. First, two bilingual translators, whose mother tongue were Persian, independently translated the NMP-Q into Persian (forward translation). Second, the two translators and a recording observer compared and synthesized the translations into an interim Persian version. Third, the interim Persian version was then translated back into English by another two translators. The translators were not aware of the original English version and had no specific medical or psychological background. Fourth, an expert panel was conducted to achieve cross-cultural equivalency. The panel comprised psychiatrists, psychologists, Persian language professionals, and the translators. All translations were compared to resolve any discrepancies. Fifth, the interim Persian version was then piloted on 43 schoolchildren (22 boys and 21 girls) to assess whether the target sample was able to understand item content. The final Persian NMP-Q was then administered to the 3,216 schoolchildren who participated in this study.

Instruments

Nomophobia Questionnaire (NMP-Q). The NMP-Q is a 20-item scale developed by Yildirim and Correia (2015) through a thorough procedure including qualitative and quantitative phases. The NMP-Q comprises four factors (*Factor 1*: not being able to communicate; *Factor 2:* losing connectedness; *Factor 3:* not being able to access information; and *Factor 4:* giving up convenience). These factors emerged from semi-structure interviews during the qualitative phase. Twenty items were then generated based on the qualitative phase and performed satisfactorily in the following quantitative phase. More specifically, the four-factor structure among the 20-item instrument was supported in an exploratory factor analysis. The Cronbach's α was excellent across the entire NMP-Q (α = .945) and in each factor (α = .814–.939). Concurrent validity was achieved through its high correlation with Mobile Phone Involvement Questionnaire (MPIQ; r = .71; Yildirim & Correia, 2015). More recently, the NMP-Q was translated into Spanish, again showing acceptable psychometric properties (González-Cabrera et al., 2017).

A 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) is applied to each NMP-Q item leading to a summated total score. The higher the score, the greater the severity of nomophobia. In addition, the interpretation of the NMP-Q score into the level of nomophobia (out of a total score between 20 and 140) is 20 corresponding to the absence; 21–59 corresponding to a mild level; 60–99 corresponding to a moderate level; and ≥100 corresponding to severe level (Yildirim & Correia, 2015).

Mobile Phone Involvement Questionnaire (MPIQ). The MPIQ is an 8-item addiction scale developed by Walsh, White, and Young (2010) assessing how much an individual is involved in using a mobile phone (e.g., assessing behaviors such as withdrawal, loss of control, and relapse and reinstatement). The internal consistency of the MPIQ was acceptable (α = 0.78; Argumosa-Villar, Boada-Grau, & Vigil-Colet, 2017). A 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*) is applied to the MPIQ leading to a summated total score. The higher the score, the higher the level of mobile phone involvement is. Because nomophobia occurs with the interaction to mobile phone or smartphone, it was hypothesized that the NMP-Q score would have strong correlational relationship with the MPIQ score.

Depression, Anxiety, and Stress Scale-21 (DASS-21). The DASS-21 is a 21-item scale that assesses depression, anxiety, and stress. The psychometric properties of the DASS-21 were acceptable as shown by its internal consistency (α = 0.86 for depression; 0.88 for anxiety; and 0.89 for stress; Pontes & Griffiths, 2016) and its confirmed factorial structure (Asghari, Saed, & Dibajnia, 2008). A 4-point Likert scale ranging from 0 (*did not apply to me at all*) to 3 (*applied to me very much, or most of the time*) is applied to the DASS-21. The higher the scores, the higher the levels of depression, anxiety, or stress are. Because nomophobia is one type of anxiety, it was hypothesized that the NMP-Q score would have strong correlational relationship with the anxiety score, followed by the stress and depression scores.

Attention Deficit Hyperactivity Disorder Rating Scale (ADHDRS). The ADHDRS is an 18-item checklist that is completed by parents. The ADHDRS is based on two sets of DSM-IV criteria assessing two symptoms (inattention and hyperactivity) related to attention deficit hyperactivity disorder (ADHD; Pappas, 2006). The psychometric properties of ADHDRS are adequate as shown by its confirmed two-factor structure (Ghanizadeh & Jafari, 2010; Mercier et al., 2016) and other satisfactory reliability and validity tests (Ghanizadeh & Jafari, 2010). A 4-point Likert scale ranging from 0 (*never or not observed*) to 3 (*often or always*) is applied to the ADHDRS, with a higher score indicating more inattention or hyperactivity problems. The two ADHD-related behaviors have been found to be associated with social media addiction (Andreassen et al., 2016) and decreased attention has been found to be associated with long-time smartphone use (Zheng et al., 2014). Therefore, it was hypothesized that the NMP-Q score would be correlated with the ADHDRS score, although it might not be as strong as other relationships being examined in this study.

Data analysis

Descriptive statistics were used to present the characteristics of the participants and their families. Following this, Rasch analyses were conducted using a partial credit model to examine the psychometric properties of each NMP-Q factor. Differential item functioning (DIF) was carried out during the Rasch analyses. Other psychometric testing was performed including CFA on construct validity and measurement invariance. Also, concurrent validity was tested using zero-order Pearson's correlations, and partial correlations were adjusted for age because age was associated with the NMP-Q scores (r = .16–.39, p < .001). In addition to the aforementioned analyses, ceiling and floor effects with a percentage of <20% suggesting acceptable (Jette, Warren, & Wirtalla, 2005) were checked for each NMP-Q factor; internal consistency with a Cronbach's α >.7 indicating satisfactory (Cheng, Luh, Yang, Su, & Lin, 2016) was examined for each NMP-Q factor and the entire NMP-Q; corrected item-total correlation with a value of >0.4 representing acceptable (Wang, Wang, & Shee, 2007) was tested for each NMP-Q item. The standard error of measurement was also adopted to assess how much measurement error was involved in the observed scores of the NMP-Q total score with a value <SD/2 suggesting acceptability (Monacis, De Palo, Griffiths, & Sinatra, 2017).

In the details of the Rasch partial credit models, they were applied to report item difficulty and to examine the following properties: unidimensionality, item validity, item and person separation reliabilities, and item and person separation indices. Based on the mathematical equation in probability, all the item difficulties were converted into a continuous scale with the unit of *logit*, and a higher logit represents a more difficult item (Chang, Wang, Tang, Cheng, & Lin, 2014). The unidimensionality of each factor was determined using principal component analysis (PCA) on the standardized residuals retrieved from Rasch models: the first component's eigenvalue of <2 supports unidimensionality (Chang et al., 2015). In the item validity, an information-weighted fit statistic (infit) mean square (MnSq)

and outlier-sensitive fit statistic (outfit) MnSq were used to ensure each item fitted in its embedded factor within the recommended range of 0.5–1.5 (Jafari, Bagheri, & Safe, 2012). The interpretation of the MnSq is that a value <0.5 indicates redundancy; a value >1.5 indicates a misfit (Khan, Chien, & Brauer, 2013). Separation reliability, including item and person reliabilities, is recommended to be >0.7 (Chang et al., 2014). Separation index, including item and person indices, is recommended to be >2 (Kook & Varni, 2008). Meanwhile, DIF in the Rasch models was used to test whether males and females interpreted the NMP-Q item descriptions differently (Lin, Yang, Lai, Su, & Wang, 2017). The difference between the item difficulty for males and females (i.e., the DIF contrast) was used to determine whether the DIF is substantial, and the DIF contrast is suggested to be <0.5 (Shih & Wang, 2009).

In the CFA, the estimator of diagonally weighted least squares (DWLS) was used, because such estimator is suitable for Likert-type scale used in the NMP-Q (Lin, Burri, Fridlund, & Pakpour, 2017; Lin, Oveisi, Burri, & Pakpour, 2017). A number of fit indices were then used to examine the construct validity of NMP-Q, including the comparative fit index (CFI), Tucker–Lewis index (TLI), root mean square error of approximation (RMSEA) with 90% confidence interval (CI), and standardized root mean square residual (SRMR). More specifically, CFI and TLI >0.9 with RMSEA and SRMR <0.08 indicate satisfactory construct validity (Cheng et al., 2016; Lin et al., 2012). The average variance extracted (AVE) and composite reliability (CR) were additionally calculated using the factor loadings and the uniqueness values retrieved from the CFA, and the recommended values are AVE > 0.5 and CR > 0.6 (Bagozzi & Yi, 1988; Fornell & Larcker, 1981).

After the four-factor structure was confirmed using CFA, multigroup CFA was applied to test the measurement invariance across gender of the NMP-Q in the scale level. Three models were constructed in the multigroup CFA; these were a configural model (Model 1: a four-factor structure of NMP-Q), a metric invariance model (Model 2: a model constrains all factor loadings to be equal across gender based on Model 1), and a scalar invariance model (Model 3: a model constrains all factor loadings and item intercepts to be equal across gender based on Model 1). The three models were then mutually compared to assess the measurement invariance: fit indices (i.e., CFI, RMSEA, and SRMR) of Model 1 were compared with those of Model 2 for metric invariance and fit indices of Model 2 were compared with those of Model 3 for scalar invariance (Bagheri, Jafari, Tashakor, Kouhpayeh, & Riazi, 2014). The measurement invariance is supported when ΔCFI > −0.01, ΔRMSEA < 0.015, and ΔSRMR < 0.01 in the model comparisons (Chen, 2007).

IBM SPSS 23.0 (IBM Corp., Armonk, NY) was used to perform descriptive statistics, ceiling and floor effects, internal consistency, and concurrent validity. CFAs including multigroup CFAs were analyzed using the lavaan package (Rosseel et al., 2017) in R software; the Rasch analyses including the DIF were carried out using WIN-STEPS 3.75.0; AVE and CR were calculated using Excel based on the CFA results; standard error of measurement was calculated using Excel based on the internal consistency results.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki, and the study was approved by the research team's university ethics committee. All participants were informed about the study, fully understood the study purpose, and all provided informed consent. As noted earlier, parental consent was sought for those participants younger than 18 years.

RESULTS

The mean age of the participants was 15.54 years ($SD =$ 1.20), and slightly more than half of them were males (53.2%). The scores of NMP-Q, DASS-21, MPIQ, and ADHDRS are shown in Table 1. Table 1 also reports the family characteristics of the participants.

The unidimensionality of the four NMP-Q factors was supported by the PCA on the standardized residuals of Rasch models. The first contrasts of the unexplained variance were between 1.6 and 1.8 among the four NMP-Q factors. In addition, all the separation reliability (>0.7) and separation indices (>2) were satisfactory for the four NMP-Q factors. The difficulty values were between −0.39 and 0.66 for the first factor of NMP-Q; −0.28 and 0.26 for the second factor; −0.11 and 0.11 for the third factor; and −0.30 and 0.21 for the fourth factor. All the items had acceptable fit statistics in both infit and outfit MnSq, except for Item 14 ("*I would be nervous because I could not know if someone had tried to get a hold of me;*" infit MnSq = 1.57 and outfit

Table 1. Characteristics of participants and their families
($N = 3,216$)

Participant characteristics	
Age (years), $M \pm SD$	15.54 ± 1.20
Gender (male), n (%)	1,710 (53.2)
Nomophobia Questionnaire score, $M \pm SD$	74.65 ± 18.80
Depression score[a], $M \pm SD$	8.53 ± 5.10
Anxiety score[a], $M \pm SD$	8.23 ± 1.43
Stress score[a], $M \pm SD$	8.72 ± 3.49
Mobile Phone Involvement Questionnaire score, $M \pm SD$	29.50 ± 7.33
Inattention score[b], $M \pm SD$	6.74 ± 5.21
Hyperactivity score[b], $M \pm SD$	4.65 ± 2.97
Family characteristics	
Father's education (years), $M \pm SD$	7.80 ± 3.86
Mother's education (years), $M \pm SD$	6.30 ± 3.59
Socioeconomic status (poor), n (%)	78 (2.4)
Socioeconomic status (fair), n (%)	2,133 (66.3)
Socioeconomic status (good), n (%)	997 (31.0)

Note. [a]Depression, anxiety, and stress were measured using Depression, Anxiety, and Stress Scale-21.
[b]Inattention and hyperactivity were measured using ADHD Rating Scale.

MnSq = 1.54) in Factor 1 and Item 9 ("*If I could not check my smartphone for a while, I would feel a desire to check it;*" infit MnSq = 1.55 and outfit MnSq = 1.51) in Factor 4 (Table 2).

The ceiling (0.0%–5.2%) and floor effects (0.0%–3.2%) of the four factors were none to minimal. The internal consistency was satisfactory for all the factors ($\alpha = 0.86$ for Factor 1; 0.70 for Factor 2; 0.91 for Factor 3; and 0.89 for Factor 4) and the entire NMP-Q ($\alpha = 0.92$). CFA results further supported the four-factor structure of the NMP-Q: CFI = 0.988; TLI = 0.986; RMSEA [90% CI] = 0.038 [0.035, 0.040]; SRMR = 0.044. Table 3 additionally reports the AVE and CR results calculated from the CFA factor loadings. All the AVE and CR values achieved the suggested cut-off, except for the second factor, which had a slightly lower AVE value (0.336). In addition, the standard error of measurement of the NMP-Q was satisfactory (i.e., 0.271) and was much smaller than the half of its SD (i.e., 0.470). Because Items 9 and 14 were misfit in the Rasch analysis, we reanalyzed the internal consistency, CFA, CR, AVE, and standard error of measurement. The results were similar but slightly improved: $\alpha = 0.88$, AVE = 0.598, and CR = 0.880 for revised Factor 1; $\alpha = 0.90$, AVE = 0.695, and CR = 0.901 for revised Factor 4; $\alpha = 0.91$ for revised entire NMP-Q; CFI = 0.991; TLI = 0.989; RMSEA [90% CI] = 0.035 [0.032, 0.038]; SRMR = 0.041; standard error of measurement = 0.280 (half of *SD* = 0.475).

Table 2. Results from Rasch models

Item no.	Difficulty	Infit MnSq	Outfit MnSq	DIF contrast
F1: Not being able to communicate				
I10	−0.39	1.19	1.13	−0.36
I11	0.11	0.79	0.79	0.12
I12	−0.26	0.65	0.65	0.32
I13	−0.27	0.80	0.80	0.41
I14	0.66	1.57	1.54	−0.15
I15	0.15	0.94	0.94	−0.27
F2: Losing connectedness				
I16	−0.28	0.96	0.95	0.24
I17	−0.07	0.92	0.91	−0.18
I18	0.05	0.78	0.78	−0.05
I19	0.26	1.12	1.07	−0.10
I20	0.04	1.23	1.24	0.00
F3: Not being able to access information				
I1	−0.05	1.00	0.96	−0.09
I2	0.05	0.99	0.90	−0.15
I3	−0.11	0.94	0.92	0.10
I4	0.11	1.05	1.04	0.14
F4: Giving up convenience				
I5	0.21	1.03	1.00	0.07
I6	0.09	0.71	0.71	0.16
I7	0.04	0.83	0.79	0.00
I8	−0.30	0.87	0.86	0.00
I9	−0.05	1.55	1.51	−0.23

Note. DIF contrast = difficulty for females−difficulty for males; and a value >0.5 indicates substantial DIF. MnSq: mean square error; DIF: differential item functioning.

Table 3. Average variance extracted (AVE) and composite reliability (CR) values for Nomophobia Questionnaire (NMP-Q)

	AVE[a]	CR[b]
F1: Not being able to communicate	0.542	0.873
F2: Losing connectedness	0.336	0.708
F3: Not being able to access information	0.707	0.906
F4: Giving up convenience	0.633	0.896
F1r: Removing Item 14	0.598	0.880
F4r: Removing Item 9	0.695	0.901

Note. [a]Suggested cut-off for AVE = 0.5.
[b]Suggested cut-off for CR = 0.6.

After the four-factor structure of the NMP-Q was confirmed, the measurement invariance and DIF of the NMP-Q across gender were tested. No items displayed substantial DIF (DIF contrasts ranged between −0.36 and 0.41; Table 2). In addition, the measurement invariance was supported in both factor loadings (ΔCFI = −0.004; ΔSRMR = 0.004; ΔRMSEA = 0.003) and item intercepts (ΔCFI = −0.003; ΔSRMR = 0.003 and 0.002; ΔRMSEA = 0.002; Table 4) under the four-factor structure of NMP-Q irrespective of removing Items 9 and 14 or not. Moreover, zero-order correlations and partial correlations (Table 5) showed that all NMP-Q factors and their entire scale score were highly correlated with MPIQ score ($r = .363–.673$) and anxiety ($r = .360–.561$); moderately correlated with stress ($r = .206–.365$); and weakly correlated with depression ($r = .127–.176$), inattention ($r = .076–.224$), and hyperactivity ($r = .137–.240$).

DISCUSSION

This study translated the NMP-Q, developed by Yildirim and Correia (2015), into Persian and tested its psychometric properties among a large number of Iranian adolescents to investigate whether the Persian NMP-Q can be applied to Persian ethnicity. This is the first study to use advanced psychometric methods (including Rasch models and CFA) to investigate the psychometric properties of NMP-Q, and demonstrated that the properties were robust. The results from Rasch analysis and CFA demonstrated that the Persian NMP-Q had a four-factor structure and that the structure was invariant across male and female adolescents. However, two misfit items were identified in the Rasch models, and the AVE of factor in the NMP-Q was slightly lower than the recommended cut-off. Other psychometric testing of the properties also supported the use, reliability, and validity of the Persian NMP-Q, including satisfactory internal consistency, promising concurrent validity, and nearly negligible floor and ceiling effects.

The previous two studies tested the psychometric properties of the NMP-Q and showed that NMP-Q had excellent internal consistency ($\alpha = 0.79–0.92$ in González-Cabrera et al., 2017; 0.814–0.945 in Yildirim & Correia, 2015). The results of this study corresponded to these previous findings and extended prior findings in a number of ways. First, in addition to the traditional Cronbach's α, the internal

Table 4. Measurement invariance across gender on social media through confirmatory factor analysis

Models and comparisons	χ^2 (df) or $\Delta\chi^2$ (Δdf)	p value	CFI or ΔCFI	SRMR or ΔSRMR	RMSEA or ΔRMSEA
			Fit statistics		
Using all items					
Models					
M1: configural	1,682.576 (328)	<.001	0.976	0.053	0.051
M2: plus all loadings constrained	1,929.759 (344)	<.001	0.972	0.057	0.054
M3: plus all intercepts constrained	2,128.949 (360)	<.001	0.969	0.059	0.056
Model comparisons					
M2−M1	247.18 (16)	<.001	−0.004	0.004	0.003
M3−M2	199.19 (16)	<.001	−0.003	0.002	0.002
Removing Items 9 and 14					
Models					
M1: configural	1,209.827 (258)	<.001	0.981	0.050	0.048
M2: plus all loadings constrained	1,412.738 (272)	<.001	0.977	0.054	0.051
M3: plus all intercepts constrained	1,578.665 (286)	<.001	0.974	0.057	0.053
Model comparisons					
M2−M1	202.91 (14)	<.001	−0.004	0.004	0.003
M3−M2	165.93 (14)	<.001	−0.003	0.003	0.002

Note. M1 is a configural model; M2 is a model based on M1 to additionally constrain all factor loadings being equal across gender; M3 is a model based on M2 to additionally constrain all item intercepts being equal across gender. CFI: comparative fit index; SRMR: standardized root mean square residual; RMSEA: root mean square error of approximation.

Table 5. Concurrent validity of NMP-Q with other external criteria

	F1	F2	F3	F4	NMP-Q	F1r	F4r	NMP-Qr
Zero-order Pearson's correlations								
MPIQ	0.451	0.382	0.660	0.604	0.669	0.452	0.610	0.673
Depression[a]	0.152	0.130	0.130	0.143	0.176	0.150	0.139	0.174
Anxiety[a]	0.531	0.380	0.419	0.431	0.561	0.528	0.440	0.560
Stress[a]	0.346	0.219	0.282	0.292	0.365	0.335	0.290	0.358
Inattention[b]	0.159	0.089	0.179	0.224	0.211	0.126	0.218	0.197
Hyperactivity[b]	0.189	0.201	0.214	0.154	0.237	0.194	0.149	0.240
Partial correlations (adjusted for age)								
MPIQ	0.422	0.363	0.647	0.589	0.657	0.423	0.596	0.661
Depression[a]	0.151	0.127	0.127	0.139	0.175	0.149	0.136	0.173
Anxiety[a]	0.510	0.360	0.398	0.408	0.541	0.506	0.419	0.540
Stress[a]	0.338	0.206	0.270	0.279	0.355	0.326	0.278	0.347
Inattention[b]	0.139	0.076	0.166	0.211	0.196	0.102	0.206	0.180
Hyperactivity[b]	0.166	0.187	0.199	0.137	0.219	0.171	0.133	0.222

Note. All p values were <.001. NMP-Q: Nomophobia Questionnaire; MPIQ: Mobile Phone Involvement Questionnaire; F1: not being able to communicate; F2: losing connectedness; F3: not being able to access information; F4: giving up convenience; F1r: removing Item 14; F4r: removing Item 9; NMP-Qr: removing Items 9 and 14.
[a]Depression, anxiety, and stress were measured using Depression, Anxiety, and Stress Scale-21.
[b]Inattention and hyperactivity were measured using ADHD Rating Scale.

consistency was found to be acceptable in the Rasch models: separation person reliability and separation item reliability were >0.7 (Chang et al., 2014). Second, the evidence of the NMP-Q factorial structure was extended from the exploratory factor analysis findings (González-Cabrera et al., 2017; Yildirim & Correia, 2015) to the Rasch and CFA findings. Based on the four-factor solution, the Rasch results in this study first demonstrated that each factor was unidimensional. The CFA results then confirmed the four-factor solution. More importantly, the four factors first emerged from a rigorous procedure in a qualitative design (Yildirim & Correia, 2015). Thus, the four-factor structure has

underlying empirical and theoretical context. Although two misfit items were found based on Rasch analysis, the present authors recommend retaining both of them in the NMP-Q, because the psychometric properties of the NMP-Q without the two items were similar to that of the NMP-Q retaining the two items.

Another important finding in this study was the DIF-free items and the measurement invariant structure of the NMP-Q across gender. Because of different brain structures (Ingalhalikar et al., 2014), males are thought to be more likely to interpret item content and factor structures of an instrument differently from females.

As a result, researchers began to notice the issue of whether self-reports have meaningful comparisons across gender (Gregorich, 2006; Lin, Pakpour, et al., 2017). This study applied the two commonly used methods (DIF in the Rasch and measurement invariance in the CFA) to empirically examine the aforementioned issue and found that NMP-Q has a meaningful comparison across gender.

Because NMP-Q assesses specific anxiety related to mobile phone usage (Yildirim & Correia, 2015), its correlations with MPIQ and anxiety were high as anticipated. Yildirim and Correia (2015) found that the NMP-Q total score was strongly correlated with the MPIQ ($r = .71$), which is comparable with the finding in this study ($r = .657-.673$). The correlation between NMP-Q and stress was also expected (i.e., moderate correlation). However, the correlations between NMP-Q and the other criteria (depression, inattention, and hyperactivity) were lower than expected. One possible reason is the sample characteristics. More specifically, the participants in this study were healthy and without mental health issues or ADHD-related behavioral problems.

There are of course some limitations in this study. First, no data were collected as to when the participants first used a smartphone or their usage pattern during the study period (e.g., how much time they spent on smartphones daily). Hence, the exposure to the smartphone is unknown. Second, the representativeness of the study's sample in terms of the smartphone use is unknown. Third, no data were collected regarding an important confounding factor of psychiatric diagnosis (e.g., anxiety and depression) in the nomophobia in our participants. Fourth, only data from high school student participants were collected in this study, which restrict the generalizability of the findings of NMP-Q's psychometric properties. Fifth, all the participants were Iranian; therefore, the study cannot compare the NMP-Q between Western and Eastern countries or examine the measurement invariance across different cultures. As a result, information for healthcare professionals cannot reliably be provided. Based on the aforementioned limitations, the present authors would encourage future research to examine the psychometric properties of the NMP-Q across different age groups and different ethnicities. In addition, collecting relevant comorbid psychiatric diagnoses is needed.

Despite these limitations, the findings of this study showed that the Persian NMP-Q supported the four-factor structure of the NMP-Q and that the scale is appropriate to assess the nomophobia in Iranian adolescents. Although the Persian NMP-Q had some psychometric flaws (i.e., two items had a slight misfit to their embedded factors and a somewhat low AVE value in Factor 2), most of our results supported the use of Persian NMP-Q. More importantly, all the NMP-Q items were DIF-free, and the factor structure was measurement invariant across gender in the total sample. Also, concurrent validity showed that NMP-Q was more correlated with the scales assessing similar concepts (i.e., MPIQ and anxiety) than to those measuring different concepts (e.g., inattention and hyperactivity). Based on the aforementioned psychometric results, healthcare professionals and researchers can confidently use the Persian NMP-Q score to compare the level of nomophobia in Persian-speaking adolescents.

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