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Research article

The Thai version of the Nijmegen questionnaire

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ABSTRACT

Purpose: The Nijmegen questionnaire is a screening tool for detecting hyperventilation syndrome. The present study aimed to cross-culturally adapt the questionnaire to Thai language and test its psychometric properties for screening hyperventilation syndrome, in which the prevalence is increasing due to the impacts of the COVID-19 pandemic.

Design/methodology/approach: The Thai version of the Nijmegen questionnaire (NQ-TH) was generated following a cross-cultural adaptation guideline including initial translation, synthesis of forward translation, back translation, expert committee review, and prefinal testing. Fifty control participants and one-hundred patients with symptoms related to hyperventilation syndrome were enrolled in this study for the determination of psychometric properties. Content validity, construct validity, internal consistency reliability, and test-retest reliability of the NQ-TH were assessed. Its discriminant ability and cutoff point for screening hyperventilation syndrome were also revealed.

Findings: The obtained IOC and disappeared floor and ceiling effects indicated excellent content validity of the questionnaire. There were significant correlations between the total scores of the NQ-TH and other questionnaires and recorded respiratory measurements obtained from the patients, i.e., SF-36-TH ($r = -0.257$), HADS-TH ($r = 0.331$), RR ($r = 0.377$), and BHT ($r = -0.444$). This supported the construct validity of the NQ-TH. An acceptable internal consistency was also observed (Cronbach's alpha = 0.789). Test-retest repeatability of the questionnaire was high (ICC = 0.90). Moreover, the NQ-TH reliability was also ensured by calculated MDC (2.68). The cutoff point of the NQ-TH was at 20 with 98% sensitivity and 94% specificity.

Originality/value: The NQ-TH established by the present study is a valid and reliable tool for screening hyperventilation syndrome among Thais.

1. Introduction

There are accumulating evidence showing dysfunctional breathing (DB) in various populations worldwide, including approximately 80% occurrence among anxiety sufferers [1, 2, 3]. Hyperventilation syndrome (HVS) is one form of DB characterized by a suddenly repeated over-breathing in response to anxiety or fear without an underlying physical abnormality [4, 5, 6]. Interestingly, it has been reported that the prevalence of HVS is considerable among COVID-19 patients [7]. Although HVS is generally reversible, post-hyperventilation apnea resulting in death has been reported [5]. In addition, chronic and recurrent episodes of this unrelated physiological hyperventilation also has an impact on the quality of life through sleep disturbance and a decrease of activities in daily living [1, 6, 8]. Early detection and treatment of HVS thus has been reported to reduce risks for patients [5, 6, 7, 8]. Respiratory rehabilitation may also improve functional capacities and quality of life for patients [7].

There are various methods used to diagnose HVS such as an arterial blood gas (ABG) test, hyperventilation provocation test (HVPT), and capnography [9, 10]. However, these measurements are not appropriate for screening HVS due to its costly or invasive procedure. The Nijmegen questionnaire (NQ) was developed at the University of Nijmegen in the Netherlands and was introduced as a screening tool to detect HVS in patients [11]. Many studies have reported that it is a valid and reliable tool which can help identify HVS quickly and easily [12, 13, 14].

Besides a screening tool, the NQ also has been used to assess clinical and research interventions in patients with HVS [15, 16, 17]. It was translated into several languages including Korean, Greek, and Iranian. Psychometric properties of the translated versions have been shown, in

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which it can be implemented in various populations in those countries, e.g., patients with asthma, dizziness, and DB [6, 18, 19].

Since the NQ has not been translated to Thai and mental symptoms have been widely observed among Thais and the world population due to the impacts of the COVID-19 pandemic [20, 21], the present study therefore aimed to translate the English version of the NQ to Thai and determine its psychometric properties in helping to screen for HVS, especially among anxiety sufferers. In addition, the effects of HVS on respiratory measurements including respiratory frequency and breath-holding capability were also observed.

2. Research methods

2.1. Translation and cross-cultural adaptation of the NQ

The NQ was translated and cross-culturally adapted to the Thai version according to the recommended standard guideline for translation and cross-cultural adaptation. This included the following five steps.

2.1.1. Step 1: initial translation

An English version of the NQ was translated to Thai by two independent translators. One is a licensed physical therapist who is an expert in respiratory disorders. Another is from the Language Institute of Chiang Mai University, Thailand, who does not have clinical experience and so is not aware of the concepts of the NQ.

2.1.2. Step 2: synthesis of the forward translation

The translations obtained from Step 1 were reviewed independently by the research team members. Thereafter, a forward translation version of the questionnaire was developed by making a consensus among the members in a meeting. Besides making a consensus, a meeting was also conducted to ensure the content equivalence compared to the English version of the NQ.

2.1.3. Step 3: back translation

The forward translation version of the NQ was translated back to English. The back translation was performed by two other independent translators who were not involved in Step 1; therefore, there was no bias with the translation. As well as in Step 1, one translator is a physical therapist, and another is from the Language Institute of Chiang Mai University.

2.1.4. Step 4: expert committee review

Three well-known experts, consisting of licensed physical therapists and a linguist, were requested for determining the content validity of the NQ-TH established by the present study. Herein, the English version of the NQ and all the translations were provided to the expert committee for their consideration. The item-objective congruence (IOC) was used to help evaluate each item of the questionnaire by scoring from -1 to $+1$, in which -1 was incongruent , 0 was questionable , and $+1$ indicated congruent . All experts in the committee also joined in a meeting to consider the content equivalence between the English and Thai version of the questionnaire according to semantic (meaning), idiomatic (colloquialism), experiential, and conceptual areas. The prefinal Thai version of the NQ thus was developed and proofed by the expert committee.

2.1.5. Step 5: testing the prefinal version

Testing the prefinal version was aimed to ensure that all items in the questionnaire were comprehensive and applicable. The prefinal NQ-TH was tested among 30 patients from the Klonghoikong health promoting hospital, Songkhla, Thailand, in which they were selected by a purposive sampling method. These patients were requested to completely answer the questionnaire and then were interviewed on how they felt about the language proficiency, clarity of the questions, and ease in answering the questions in the prefinal NQ-TH. They also were asked to comment on whether the sentences and layout were well organized. The feedback from this test was then used for fine-tuning the NQ-TH. Finally, the NQ-TH was completed.

2.2. Questionnaires and respiratory measurements

The English version of the NQ was used for translation to the Thai version. The Thai version of the 36-item short form survey (SF-36-TH) and the Thai version of the hospital anxiety and depression scale (HADS-TH) and respiratory measurements including respiratory rate (RR) and breath-holding time (BHT) were collected to test the construct validity of the NQ-TH. In addition, all these variables were compared between the controls and the patients with symptoms related to HVS in order to observe any differences and the effects of hyperventilation symptom on respiratory functions. It was hypothesized that hyperventilation syndrome may impair respiratory functions and affect the RR and BHT of the patients.

2.3. NQ

The NQ has been used to help assess the frequency of symptoms related to HVS. The questionnaire consists of 16 items asking about the symptoms, e.g., chest pain, tense feeling, blurred vision, dizzy spells, confused feeling, faster and deeper breathing, shortness of breath, tightness in chest, bloated feeling in stomach, tingling fingers, inability to breathe deeply, stiff fingers or arms, tight feeling round mount, cold hands or feet, palpitations, and feelings of anxiety [11, 12]. To use the NQ, participants were asked to grade how often they suffered from each item through a five-point Likert scale ranging from 0 to 4, in which 0 is never , 1 is rarely , 2 is sometimes , 3 is often , and 4 is very often . The total score ranged from 0 to 64; herein, 0 is free symptoms related to HVS and 64 indicated the severest symptoms. A score of at least 3 in each item was considered as a major daily life complaint [11, 12].

2.4. SF-36-TH

The SF-36-TH has been usually used to determine quality of life regarding health status among Thais. Its validity and reliability have been reported in many studies. The SF-36 also has been widely used for testing construct validity of other questionnaires. This questionnaire consists of 36 questions reflecting 8 domains of health, i.e., physical functioning, role limitations due to physical problems, social functioning, role limitations due to emotional problems, bodily pain, general mental health, vitality, and general health perception [22]. After participants complete the questionnaire, the score of each dimension is directly transformed and scaled from 0 to 100 according to the recommendation. Higher total scores represent less impairments or higher quality of life [22].

2.5. HADS-TH

The HADS is used for the determination of anxiety and depression symptoms. It has been widely adapted for both research and clinical purposes [23, 24]. The reliability and validity of the HADS-TH also has been reported in many studies and among various Thai populations [23, 24]. Since HVS also occurs in response to intolerant mental symptoms, the HADS-TH was thus used in the present study for determining the correlation between its scores and the scores of the NQ-TH. The HADS consists of 14 items, 7 items asking about anxiety symptoms and the other 7 items asking about depression symptoms [23, 24]. Participants are asked to scale 0 to 3 for all questions, and the legend of the scales is different for all questions. The total score in each item equal to or higher than 11 indicates mental disorders, i.e., anxiety or depression. The higher total scores represent severer mental symptoms [23, 24].

2.6. Respiratory measurements

It has been reported that patients with HVS have a rate of breathing that varies between 15 and 20 breaths per minute, and their RR can rise to 30 breaths per minute during an attack [25]. These high normal RRs may be explained by an overuse of the upper chest and diaphragmatic

dysfunction [25]. Besides an overuse of the upper chest and diaphragmatic dysfunction, common presentation of erratic respiratory rhythm, noisy breathing out, sighs, and yawns may affect the RR of patients [25]. BHT is considered as one of the indicators of breathing efficiency [26]. Normally, breathing can be voluntarily held for 25 30 s. BHT less than 15 s indicates low tolerance of the body to increase in blood carbon dioxide [26]. Together, the RR and BHT of the participants were observed in the present study.

2.7. Assessment of psychometric properties and ethical approval

The present cross-sectional study was approved by the Ethics Committee of Walailak University (Approval Number: WUEC 20-078-01 and WUEC 20-078-02 (extended)). Thereafter, it was conducted from May 2020 to January 2022 at three public hospitals in Thailand, i.e., Klonghoikong health promoting hospital, Songkhla; Thepha Hospital, Songkhla; and Sungaikolok Hospital, Narathiwat. Written informed consents were obtained from all participants prior to commencement of the study.

2.8. Participants

The field test of the NQ-TH for psychometric properties analysis was conducted by recruiting respondents other than the participants in the prefinal test. The participants were recruited by convenient sampling and were examined according to the inclusion and exclusion criteria. The inclusion criteria consisted of age 18 years and above and ability to communicate using Thai. Patients with organic cardiac, neurological, or severe respiratory diseases were excluded. A total of 150 participants, aged 18 65 years, were enrolled in the present study. The participants were divided into two groups, comprising of the control group and hyperventilation group based on the information from medical records. Fifty participants in the control group had never complained of hyperventilation. In contrast to the control, 100 participants in the hyperventilation group were patients who had medical records of hyperventilation syndrome and complained of symptoms related to HVS within a week before the test. All participants were asked to complete the NQ-TH, SF-36-TH, and HADS-TH. Thereafter, the RR and BHT of the participants were recorded by a physical therapist working at the hospital. Half of the patients with hyperventilation symptoms were evaluated and asked to join the second visit, in which the NQ-TH scores and respiratory variables were collected again. The sample size of the present study was estimated for testing the psychometric properties based on the recommendation, in which the number of participants was appropriate enough to determine the psychometric properties of the questionnaire [27].

2.9. Testing psychometric properties of the NQ-TH

A total of 100 patients with hyperventilation symptoms had completed the NQ-TH, SF-36-TH, and HADS-TH. Thereafter, the RR and BHT of the patients were examined. All answers and recorded measurements obtained from all patients were used to determine floor or ceiling effects, construct validity, and internal consistency of the NQ-TH.

As mentioned earlier, content validity of the NQ-TH was determined from translation and cross-cultural adaptation through scoring the IOC. Nevertheless, floor or ceiling effects have been reported to deny content validity of the questionnaire, in which it is present if more than 15% of the respondents achieved the lowest or highest possible score [27]. The present study therefore also performed analysis of these effects. Construct validity was analyzed by finding the significant correlations between the total scores of the NQ-TH, total scores of other questionnaires, RR, and BHT obtained from the patients. Internal consistency was then observed by computation of Cronbach's alpha coefficient.

To evaluate the test-retest repeatability, 50 of 100 patients with stable hyperventilation symptoms (subjective and objective examination, i.e., the symptoms, RR, and BHT between 2 visits) and who had not received new treatment were asked to complete the NQ-TH again on Day 6 after the first test. This interval has been reported to minimize the effects of previous answer memory. RR and BHT were also observed in all patients at the second visit. Test-retest reliability was shown by comparing all data recorded at the first and second visits. In addition, concordance of the measurements was also analyzed by using the technique described by Bland and Altman [28]. The 95% limits of agreement (the mean of the differences ± 2 SD of the differences) between the two tests were computed. Intraclass correlation coefficients (ICCs), standard error of measurement (SEM), and minimal detectable change (MDC) of the NQ-TH were also determined in the present study.

To observe the ability of the NQ-TH for discriminating persons with and without HVS, the data from 50 controls and 50 patients (the patients recruited for the test-retest reliability) were used for receiver operating characteristic (ROC) curve analysis. The sensitivity, specificity, and cut-off point of the NQ-TH were thus revealed.

2.10. Statistical analysis

All data analysis was performed through using the SPSS statistical package Version 23. Unpaired t-test was used to analyze participant characteristic differences between the two groups of participants and to compare all data sets obtained from the control group and that of the hyperventilation group. Spearman's rank correlation was tested to determine correlations between the total scores of the NQ-TH, the other questionnaires, and the respiratory measurements obtained from the patients with hyperventilation. Paired t-test was used to compare the first and second collected NQ-TH scores in the 50 patients. The 95% limits of agreement were analyzed by using the Bland and Altman method [28]. ROC curve analysis was adapted in the present study for determining the discriminant ability of the questionnaire.

3. Analysis and findings

3.1. Participant characteristics and the scores of the NQ-TH, SF-36-TH, HADS-TH, and recorded respiratory measurements

The mean age and gender proportion of the participants between the control and hyperventilation group were not significantly different (Table 1). The results showed that the mean NQ-TH and HADS-TH scores were different between groups (Table 1). This suggested that symptoms related to HVS frequently occurred in concordance with mental symptoms. Both the differences of the total scores of the SF-36-TH and total scores of the NQ-TH between both groups of participants suggested that they suffered from symptoms related to HVS (Table 1); indeed, mean scores of all items were also higher than 3. Approximately 80% of the hyperventilation group reported in the NQ-TH that they frequently faced anxiety symptoms. The most frequent symptom to the less frequent symptom reported through the NQ-TH were sequenced as feelings of

Table 1. Participant characteristics and the scores of the NQ-TH, SF-36-TH, HADS-TH, and recorded respiratory measurements.

Variables	Hyperventilation (n = 100)	Control (n = 50)	*p*-value
Age	36 (13.64)	38 (14.08)	0.926
Gender			
Female	52 (52.00)	27 (54.00)	
Male	48 (48.00)	23 (46.00)	
NQ-TH	37.02 (7.21)	12.88 (5.31)	<0.001***
SF-36-TH	54.69 (14.47)	71.38 (10.08)	<0.001***
HADS-TH	26.82 (7.90)	8.60 (3.70)	<0.001***
RR (breaths per minute)	22 (1.80)	16 (2.32)	<0.001***
BHT (s)	15 (4.02)	28 (7.68)	<0.001***

anxiety, tense feelings, faster and deeper breathing, dizzy spells, shortness of breath, confused feelings, blurred vision, palpitations, tightness in chest, inability to breathe deeply, chest pain, tingling fingers, bloated feeling in stomach, cold hands or feet, tight feeling round mount, and stiff fingers or arms, respectively. The quality of life regarding the health status of the patients was reported at around midpoint, in which the scores in all dimensions are shown in S1 Table. Mental symptoms were highly reported in the patients; herein, 89% of them had symptoms of anxiety and 76% of them faced both anxiety and depression symptoms. Regarding respiratory measurements, only the RR of the patients was abnormal, which was identified as tachypnea (Table 1). However, RR and BHT between the control and the HVS group were significantly different, supporting the perilous effects of HVS on respiratory functions (Table 1).

Data is expressed as mean (SD) or number (%). NQ-TH is the Thai version of the Nijmegen questionnaire, SF-36-TH is the Thai version of the 36-item short form survey, HADS-TH is the Thai version of the hospital anxiety and depression scale, RR is respiratory rate, and BHT is breath-holding time. n is the number of participants and $^{***}p \leq 0.001$.

3.2. Validity of the NQ-TH

The IOC of the NQ-TH reported in the present study was from the step from the expert committee review. Three experts in the committee scored the content validity of the questionnaire in each item in a similar manner (S2 Table). Therefore, the IOC was very high (0.96) and represented good content validity for the questionnaire. The total score of the NQ-TH obtained from the patients with symptoms related to HVS ranged from 14 to 52, which showed that there was no patient that scored the worst or best possible score. This indicated that floor and ceiling effects of the NQ-TH were not present. Correlations between the total score of the NQ-TH and the SF-36-TH, HADS-TH, RR, and BHT were all significantly observed (Table 2). These results represented convergent validity of the NQ-TH.

3.3. Reliability of the NQ-TH

The reliability of the NQ-TH was determined through the calculation of the Cronbach's alpha coefficient if an item was deleted and for the overall questionnaire. The scores of the NQ-TH obtained from the patients with symptoms related to HVS were used for computation. The results of the present study showed that all the Cronbach's alpha coefficient was greater than 0.7 (Table 3). This indicated that the NQ-TH was a reliable tool, in which all items correlated well within the questionnaire. In other words, all items of the NQ-TH represented internal consistency.

Test-retest reliability of the NQ-TH was determined through comparing the first score of the NQ-TH and the recorded respiratory measurements (NQ-TH1) obtained from the patients with their retest data (NQ-TH2). It was shown that the respiratory measurements between the first and second visits were not significantly different (Table 4). Unchanged RR and BHT found in the second visit supported that the patients answered the questionnaire according to their respiratory status (Table 4). The 95% limits of agreement of the NQ-TH measurements were analyzed to support the test-retest reliability of the NQ-TH. It was found that 96% of the two days of NQ-TH differences were within the limits of agreement. The Bland and Altman plot also represented good agreement between NQ-TH1 and NQ-TH2. Additionally, the ICC of 0.90 with a 95% confidence interval (CI) of 0.824 0.942 was observed in the present study. SEM and MDC were also reported as 0.97 and 2.68 (out of 3 points total score), respectively. Together, the results indicated repeatability of the questionnaire for assessing symptoms related to HVS.

Table 2. Correlations between the scores of the NQ-TH and the SF-36-TH, HADS-TH, and recorded respiratory measurements obtained from the patients with symptoms related to HVS.

Variables (n = 100)		SF-36-TH	HADS-TH	RR	BHT
NQ-TH	Correlation coefficient (*r*)	−0.257**	0.331***	0.377***	−0.444***
	p-value	0.010	0.001	<0.001	<0.001

$^{**}p \leq 0.01$; $^{***}p \leq 0.001$.

Table 3. Internal consistency of the NQ-TH.

NQ-TH (n = 100)	Cronbach's alpha coefficient if an item was deleted	Cronbach's alpha coefficient for the overall questionnaire
Item 1	0.779	0.789
Item 2	0.789	
Item 3	0.772	
Item 4	0.776	
Item 5	0.764	
Item 6	0.769	
Item 7	0.768	
Item 8	0.778	
Item 9	0.773	
Item 10	0.778	
Item 11	0.775	
Item 12	0.780	
Item 13	0.795	
Item 14	0.781	
Item 15	0.777	
Item 16	0.790	

Table 4. Test-retest reliability of the NQ-TH.

Variables (n = 50)	NQ-TH1	NQ-TH2	*p*-value
NQ-TH	37.02 (7.21)	36.10 (6.81)	0.039*
RR (breaths per minute)	22 (1.80)	22 (1.64)	0.071
BHT (seconds)	15 (4.02)	15 (3.92)	0.343

* $p \leq 0.05$.

3.4. Discriminant ability of the NQ-TH

The ROC curve analysis supported that the NQ-TH can be used to discriminate participants with and without HVS. It was found that the area under the curve (AUC) was 0.988 with a 95% CI of 0.97 1.00, in which the cutoff point was at 20 with 98% sensitivity and 94% specificity.

4. Discussion

The present study suggested that the NQ-TH was appropriate for detecting and assessing HVS among the Thai population. Regarding its psychometric properties, each item in the questionnaire was evaluated by experts, in which the IOC was reported at a high level. In addition, ceiling and floor effects were not observed in the present study. These indicated good content validity of the questionnaire [27]. Results from the pilot test of the prefinal NQ-TH also supported that all items of the NQ-TH were clear and easy to understand. Construct validity was determined by calculating Spearman's correlation coefficients. In agreement with a previous study, correlations between the NQ-TH scores and respiratory measurements (i.e., RR and BHT) obtained from the patients with symptoms related to HVS were observed to be statistically significant. The study of Ravanbakhsh et al. showed the correlations between the scores of the Iranian NQ and the partial pressure of end-tidal carbon dioxide values obtained from 100 asthmatic patients (r = -0.783) [19]. Besides standard measurements of respiratory functions, the scores of the SF-36-TH and HADS-TH were also collected from the patients in the

present study. The significant correlations between the total scores of the NQ-TH and that of the other questionnaires were observed. Overall, the score of the NQ-TH had the same construct as the respiratory function measurements and the scores of other related questionnaires. The NQ-TH therefore can be used for both subjective and objective assessing of HVS.

The Cronbach's alpha of the NQ-TH was high and comparable with that of other versions of the NQ, e.g., Korean version (0.878), Greek version (0.92), and Iranian version (0.702) [6,18 19]. This supported internal consistency reliability and successful translation and cross-cultural adaptation of the questionnaire. It also suggested that all items in the NQ-TH were proposed to measure symptoms related to HVS. Repeatability of the NQ-TH was supported by a high level of ICC. The present study also reported the MDC; herein, it was estimated that a change of at least 3 points of the NQ-TH score can represent whether HVS got better or worse. Finding of the MDC has been reported to support the transparency of the measurements and its interpretation in clinical practice [29].

Regarding the discriminant ability, the ROC curve analysis showed that the NQ-TH had a good discriminant ability. The cutoff point was revealed with very high sensitivity and specificity. The cutoff point reported in the present study was the same as that reported in the study of Looha et al., which was at 20 with 91% sensitivity and 92% specificity [13]. According to the study of van Dixhoorn and Duivenvoorden, a reported cutoff score of the NQ for differentiating patients with HVS from healthy patients was at 19 with 91% sensitivity and 95% specificity [12]. Grammatopoulou et al. showed a cutoff point of the NQ for discriminating the presence of HVS in asthmatic participants at 17 with 93% sensitivity and 92% specificity [14]. The difference of the reported cutoff points of the NQ among these studies may be the result of the differences in the studied population, culture, and environment.

4.1. Limitations and future research directions

Although results from the present study strongly supported using the NQ-TH as a valid and reliable tool for screening HVS among Thais, finding the correlations between the scores of the NQ-TH and the results from the HVS-diagnosed measurements should be considered in future studies to strengthen its applicability for clinical practices. The MDC of the NQ-TH also should be ensured by other objective examinations to determine physiological changes due to HVS.

5. Conclusion

The NQ-TH is a valid and reliable questionnaire for screening HVS. Accurate differentiation of HVS individuals from non-HVS individuals can be performed using the cutoff score at 20 points. The NQ-TH also can be used as a tool for both subjective and objective assessment of symptoms related to HVS, in which the MDC is 3 points.

Declarations

Author contribution statement

Nitita Piya-amornphan, Sirinthip Pakdee: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

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