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Original Article

Validity and Reliability of the Turkish Version of the Nijmegen Questionnaire in Asthma

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Abstract

OBJECTIVE: The Nijmegen Questionnaire (NQ) enables the assessment and identification of symptoms related to respiratory dysfunction and hyperventilation syndrome. The aim was to investigate the validity of the Turkish version of the NQ in asthmatics.

MATERIAL AND METHODS: Fifty-four individuals with asthma were included. Spirometry was performed. Dyspnea was assessed using the modified Borg and modified Medical Research Council scales. Breath-holding time was recorded. End-tidal carbon dioxide was measured using a portable capnograph. Oxygen saturation and heart rate were recorded. Asthma Control Test was used to evaluate the asthma control level. Quality of life was assessed using the Asthma Quality of Life Questionnaire and Nottingham Health Profile. Beck Depression Inventory was used to determine depression.

RESULTS: Bartlett's test of sphericity (360.749, *df* 105, $P < .001$) and Kaiser–Meyer–Olkin criterion (0.752) for 15-item NQ supported a single-factor model with 36.38% of explained variability through principal component analysis and explanatory factor analysis. For 15-item NQ with this single-factor model, Cronbach's alpha was 0.872, and the test–retest reliability was 0.628. There was a significant negative correlation between NQ and Asthma Control Test ($r = -0.448$), and Asthma Quality of Life Questionnaire ($r = -0.743$) and a significant positive association with Beck Depression Inventory ($r = 0.477$), Nottingham Health Profile—energy ($r = 0.370$), Nottingham Health Profile—pain ($r = 0.313$), Nottingham Health Profile—sleep ($r = 0.294$), and Nottingham Health Profile—physical activity scores ($r = 0.406$) ($P < .05$).

CONCLUSIONS: The 15-item Turkish version of the NQ is valid and reliable in asthmatics. Individuals with uncontrolled asthma have higher NQ scores than those with well-controlled asthma. NQ is associated with asthma control level, asthma-related quality of life, health profile, and depression.

KEYWORDS: Asthma, Nijmegen Questionnaire, respiratory dysfunction
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INTRODUCTION

Asthma is a heterogeneous condition characterized by variable respiratory symptoms and airflow limitation. These features may arise through several underlying mechanisms typically associated with airway inflammation and remodeling.[1] Asthma symptoms are non-specific and include wheezing, shortness of breath, chest tightness, and cough.[1]

Hyperventilation syndrome (HVS) is a complex disease defined as breathing beyond metabolic requirements.[2] Hyperventilation syndrome is the most widely recognized dysfunctional respiratory form in which chronic changes in respiratory pattern lead to dyspnea with non-respiratory symptoms.[3] These changes can occur with or in the absence of respiratory, cardiovascular, and other disorders.[3]

The HVS pathophysiology is controversial. It has been stated that its symptoms emerge from hypocapnia associated with excessive breathing and that low carbon dioxide in arterial blood is considered a need for diagnosis.[4]

Hyperventilation syndrome causes decreased carbon dioxide pressure in the arterial blood, respiratory alkalosis, and increased symptoms.[5] Complex symptoms such as shortness of breath, chest tightness, paresthesia, anxiety, and dizziness may occur.[5]

Nijmegen Questionnaire (NQ) allows the assessment and identification of respiratory dysfunction and unexplained respiratory symptoms and signs of HVS.[6,7] The NQ has an essential place in determining and monitoring respiratory dysfunction. The NQ has been validated in non-asthmatics with a diagnosis of HVS.[8] Many physiological, inflammatory, environmental, psychological, and behavioral factors play a role in controlling asthma. The NQ subjectively evaluates breathing and respiratory response to stress and provides a valuable perspective in interpreting the result. The NQ was used to determine HVS prevalence in asthmatics.[9]

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The questions are related to different systems, such as cardiovascular, neurological, respiratory, gastrointestinal, and psychological factors.[8,9] There are 16 items, and each item is answered with a 5-item scale ranging from 0 to 4. The total score ranges between 0 and 64. Higher scores indicate respiratory dysfunction and increasing probability of HVS.[8] The NQ reveals the factors that cause HVS or respiratory pattern disorder. Identifying these factors helps prevent respiratory pattern disorder and correct musculoskeletal and motor pattern changes. In asthma, symptoms may be accompanied by anxiety.

The Turkish version of the NQ may be useful for assessing respiratory dysfunction, unexplained respiratory symptoms, and HVS signs. Turkish version of the NQ for asthmatics may be helpful to guide researchers for further studies to identify appropriate treatment approaches for asthma and develop different management strategies. Therefore, we aimed to investigate the validity and reliability of the Turkish version of the NQ to evaluate respiratory dysfunction in asthma.

MATERIAL AND METHODS

The present study was carried out at Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Cardiopulmonary Rehabilitation Unit, between March 2020 and January 2021.

Hacettepe University Non-Interventional Clinical Research Ethical Board approved the study (approval date: 17.03.2020 and approval number: GO 20/199). All participants were informed about the study protocol and signed an informed consent form.

Inclusion criteria were having been diagnosed with mild–moderate asthma in the Hacettepe University, Department of Chest Diseases Division of Allergy and Clinical Immunology and being referred to Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Cardiopulmonary Rehabilitation Unit for physiotherapy and rehabilitation, being aged ≥18 years, clinically stable, and able to cooperate. Inability to read and write, presence of severe orthopedic, neurological, and cardiovascular disorders, and cognitive problems were determined as exclusion criteria.

Based on the sample size calculation conducted by Bonett DG, with a two-way hypothesis setup accepting a power of 90% (1 - β) and a type 1 error (α) of 0.05, the analysis from the pilot study revealed a Cronbach's alpha coefficient of 0.814 for the H1 hypothesis. Considering the acceptance of the H0 hypothesis as 0.500, the study determined that the participation of 54 individuals was required.[10]

MAIN POINTS

- The 15-item Turkish version of the Nijmegen Questionnaire (NQ) is valid and reliable in asthmatics.
- Individuals with uncontrolled asthma have higher NQ scores than those with well-controlled asthma.
- The NQ provides a useful tool for healthcare professionals in research and clinical settings regarding its association with health status, asthma control, asthma-related quality of life, and depression.

The Brislin method was used in the translation phase of the questionnaire.[11] This method includes the first translation into the target language, the evaluation of the first translation, the translation back to the source language, re-evaluation of the translation, and receipt of expert opinions.[11] In this context, the questionnaire was first translated from English to Turkish by 2 experts whose native language is Turkish and who had good English command. The first translation was evaluated by 2 experts in the questionnaire items' intelligibility field. The Turkish translation of the questionnaire, which was created as a result of the first evaluation of the experts, was translated into English by a linguist whose native language is English. The questionnaire was obtained due to back-translation to the source language and was compared with the original questionnaire. Two experts who have a good command of English re-evaluated the translation in the field. Pre-final NQ was administered to 5 individuals with asthma for intelligibility and perceptibility.[12] In line with expert opinions and all evaluations, the final version was created, used, and re-administered 1 week apart.

The age, height, and weight of the participants were recorded. Smoking history and asthma symptoms were questioned. A pulmonary function test was performed using a spirometer (Spirodoc, Medical International Research, Rome, Italy). The parameters were expressed as percentages of predicted values.[13]

Dyspnea perception at rest was evaluated using a modified Borg scale (mBorg) and a modified Medical Research Council dyspnea scale (mMRC). The mBorg is a category scale evaluating shortness of breath between 0 and 10.[14] Participants were asked to choose the expression that best describes their dyspnea level using mMRC. Scoring in mMRC varies between 0 and 4 points; "0" means that the individual does not have dyspnea, while "4" indicates that dyspnea perception is present during basic daily life activities such as dressing.[15]

Participants were asked to breathe up to tidal volume at the end of light exhalation and hold their breath until the first involuntary movement of respiratory muscles in a sitting position. Three repetitions were performed to measure the breath-holding time (BHT), and an average value was recorded.[16]

A portable capnograph (MD-660P, Comdek Industrial Corp., Taipei, Taiwan) with a nasal cannula was used to measure end-tidal carbon dioxide ($ETCO_2$) and resting respiratory rate (RR) over a 10-minute period. Participants were asked to breathe through their noses and not to speak during measurement.[17] The $ETCO_2$, oxygen saturation (SpO_2), and heart rate were recorded using this device.

Asthma control test (ACT) was used to assess asthma control. The ACT score ranges from 5 (weak control) to 25 (fully controlled).[18] A total score of <20 indicates uncontrolled asthma. Turkish version of the ACT was used.[19]

Global Initiative for Asthma (GINA) assessment of asthma symptom control was determined as well-controlled, partly controlled, and uncontrolled.[20]

Disease-specific quality of life (QoL) using the Asthma QoL Questionnaire (AQLQ) and health-related QoL using Nottingham Health Profile (NHP) were determined.[21,22] The AQLQ is a 32-item disease-specific questionnaire with 4 domains: activity limitation, symptoms, emotional function, and environmental stimuli. The AQLQ has Turkish validity and reliability.[23] The NHP is related to general QoL and consists of 38 items and has 6 sub-sections: energy, pain, emotional reactions, sleep, social isolation, and physical mobility. Scores for each subsection range from 0 to 100. Higher scores indicate more restrictions in QoL. Turkish version of NHP was used.[24]

Beck Depression Inventory (BDI) measures the physical, emotional, cognitive, and motivational symptoms of depression. The BDI is a scale varying between 0 and 63.[25] Turkish validity and reliability of the BDI were conducted. Higher scores indicate a higher level of depression.[26] The permissions to use all the questionnaires were obtained.

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 20.0 (IBM, Armonk, NY, USA) was used to analyze the data. Descriptive statistics were calculated. Explanatory factor analysis was used to determine whether the questionnaire had single or multiple dimensions. The suitability of data for factor analysis was evaluated using the Bartlett sphericity test and Kaiser–Meyer–Olkin (KMO) coefficient.[27] Invariance and internal consistency over time were evaluated to determine the reliability. Test–retest reliability was calculated for invariance against time, and the Cronbach's alpha reliability coefficient was calculated for internal consistency. Structural validity, test–retest reliability, and internal consistency analysis were used to test the validity and reliability of the NQ. Factor analysis was performed to identify the relevant factors. The criteria for eigenvalues above 1.00, scree plot, percentage of variation explained, and content of extracted factors were used to determine the number of extracted factors.[28] The criterion of having a factor load of >0.30 was used to determine the relevant items.[29] A variable's factor load of 0.30 indicates that the variance explained by the factor is 9%. A factor load of ≥0.60 can be defined as high, while a factor load between 0.30 and 0.59 can be defined as moderate.[30] Internal consistency of the NQ was tested using the Cronbach's alpha coefficient. Test–retest reliability was tested using the intraclass correlation coefficient. For cross-sectional validity, the relationships between NQ total score, ACT, $ETCO_2$, BHT, predicted percentage of forced expiratory volume in 1 second (FEV_1%), RR, mBorg dyspnea score, AQLQ, Beck Depression Inventory, and NHP were analyzed using the Spearman correlation test. The Mann–Whitney *U* -test and Kruskal–Wallis *H*-test were used to compare 2 or more independent variables. Wilcoxon signed-rank test was used to compare 2 related samples. The probability of error was taken as $P < .05$.[27]

RESULTS

Fifty-four individuals with asthma aged between 19 and 65 years were included. The participants' characteristics, spirometric parameters, dyspnea perception, BHT, heart rate, RR, SpO_2, $ETCO_2$, ACT, AQLQ, NHP, and BDI values are given in Table 1.

Table 1. The Characteristics of Participants

	Asthma (n = 54)	
Parameter	**Mean ± SD**	**(Minimum–Maximum)**
Age (years)	42.59 ± 13.71	19-65
Sex (female/male), n (%)	43/11	79.6/20.4
Height (m)	1.63 ± 0.09	1.49-1.94
Weight (kg)	72.07 ± 17.89	48-138
Body mass index (kg/m^2)	27.15 ± 6.38	16.14-47.75
Smoking history (package year)	4.33 ± 10.75	0-45
Duration of asthma (years)	9.80 ± 7.95	1-31
Level of asthma control		
Well-controlled, n (%)	26	48.1
Not well-controlled, n (%)	28	51.9
FVC (%)	97.35 ± 16.51	65-141
FEV_1 (%)	89.88 ± 17.21	56-126
FEV_1/FVC	80.39 ± 10.49	63-127
PEF (%)	81.11 ± 20.52	26-133
$FEF_{25-75\%}$ (%)	68.46 ± 23.58	20-126
mMRC (0-4)	1.25 ± 0.78	0-3
Modified Borg dyspnea score (0-10)	2.73 ± 1.84	0-7
Breath-holding time (s)	23.55 ± 14.34	4.11-77.33
Heart rate (bpm)	78.72 ± 12.98	54-104
Respiratory rate (breath/min)	17.37 ± 5.09	7-32
SpO_2 (%)	96.87 ± 1.15	94-99
$ETCO_2$ (mmHg)	20.27 ± 3.73	10-29
Asthma Control Test (5-25)	18.66 ± 4.09	8-25
Asthma Quality of Life Questionnaire (1-7)	5.21 ± 1.08	2.42-7
Symptom	5.62 ± 1.05	3.25-7
Activity	5.01 ± 1.22	1.9-7
Emotional	5.41 ± 1.26	1.8-7
Environment	4.69 ± 1.59	1-7
Nottingham Health Profile (0-100)		
Energy	41.95 ± 35.75	0-100
Pain	20.89 ± 29.61	0-100
Emotional reactions	27.54 ± 26.15	0-100
Social isolation	17.70 ± 24.50	0-100
Sleep	18.57 ± 20.10	0-72.74
Physical activity	21.47 ± 17.14	0-54.47
Beck Depression Inventory (0-63)	12.53 ± 10.50	0-45

$ETCO_2$, end-tidal carbon dioxide; $FEF_{25-75\%}$, forced expiratory flow at 25%-75% of the vital capacity; FEV_1, forced expiratory volume in 1 second (FEV_1); FVC, forced vital capacity; mMRC: modified Medical Research Council dyspnea scale; PEF, peak expiratory flow; SpO_2, saturation of oxygen.

Table 2. Comparison of Nijmegen Questionnaire Scores According to Sex, Asthma Duration, Asthma Control Test, GINA Asthma Control Level, Smoking History, Breath-Holding Time, and End-Tidal Carbon Dioxide Values

			Nijmegen Questionnaire Score	
Parameter		**n**	**Mean ± SD**	***P***
Sex	Female	43	16.77 ± 9.58	.569
	Male	11	15.36 ± 11.48	
Asthma duration	<8 years	29	16.93 ± 9.85	.683
	≥8 years	25	15.96 ± 10.13	
Asthma Control Test	Not well-controlled (≤19)	28	20.39 ± 10.70	**.005***
	Well-controlled (≥20)	26	12.27 ± 6.96	
Asthma control level (GINA)	Well controlled	17	12.59 ± 6.94	.074[k]
	Partly controlled	16	15.25 ± 8.35	
	Uncontrolled	21	20.57 ± 11.71	
Asthma control level (GINA)	Well-controlled and partly controlled	33	12.59 ± 6.94	**.036***
	Uncontrolled	21	20.57 ± 11.71	
Asthma control level (GINA)	Well controlled	17	12.59 ± 6.94	**.029***
	Uncontrolled	21	20.57 ± 11.71	
Smoking	Yes	18	17.11 ± 11.83	.985
	No	36	16.17 ± 8.95	
BHT	<30 s	43	16.14 ± 9.67	.675
	≥30 s	11	17.82 ± 11.15	
$ETCO_2$ (mmHg)	≤35 mmHg	54	16.48 ± 9.89	—
	>35 mmHg	0	0	

Mann–Whitney *U*-test. [k]Kruskal–Wallis *H*-test.
*$P < .05$.
BHT, breath-holding time; $ETCO_2$, end-tidal carbon dioxide; GINA, Global Initiative for Asthma.

The comparison of the NQ scores according to sex, asthma duration, asthma control, asthma severity, smoking history, BHT, and $ETCO_2$ values are shown in Table 2. The NQ scores were similar according to sex, asthma duration, asthma severity, smoking history, BHT, and $ETCO_2$ ($P > .05$), except for asthma control ($P < .05$) (Table 2). There was a significant difference in NQ scores of well-controlled and not-well-controlled asthmatics according to ACT ($P = .005$, Table 2). According to GINA classification, there was a significant difference in NQ scores of well-controlled and uncontrolled asthmatics ($P = .029$, Table 2).

Bartlett's test of sphericity (373.202, df 120, $P < .001$) and the KMO criterion (0.735) provided support for the single-factor model, which accounted for 34.26% of the explained variability.[27] Fifteen items (excluding item 14, cold hands and feet) showed favorable high factor load (>0.30) and commonality. A scree plot supported the decision to keep a single-factor model. A single factor was determined for 15 items and performed for explanatory factor analysis. A single-factor model with 36.38% of the explained variability was supported by Bartlett's test of sphericity (360.749, *df* 105, $P < .001$) and KMO criterion (0.752). For 15 items with a single-factor model, Cronbach's alpha was 0.872, and test–retest reliability was 0.628. No significant difference was found between test and retest NQ items ($P > .05$, Table 3). Loadings and commonalities of 15 items according to the single-factor model were presented in Table 4.

The NQ was re-applied to 51 of the participants 1 week later. The comparison of test and retest values was performed using Wilcoxon signed-rank test, and there was no significant difference between the NQ test and retest values ($P > .05$, Table 5).

The Cronbach's alpha coefficient was found to be 0.872. Intraclass correlation coefficient was determined as 0.628 (Table 5).

Correlations were evaluated between NQ and age, FEV_1%, smoking history, mMRC, $ETCO_2$, BHT, RR, mBorg dyspnea score, BDI, NHP, ACT, and AQLQ scores (Table 6). There was a positive correlation between NQ and BDI ($r = 0.477$, $P < .001$) (Table 6). The NQ was positively correlated with NHP—energy ($r = 0.370$, $P = .006$), NHP—pain ($r = 0.313$, $P = .021$), NHP—sleep ($r = 0.294$, $P = .031$), and NHP—physical activity ($r = 0.406$ $P = .002$) (Table 6). The NQ showed a negative relationship with ACT and AQLQ ($P < .05$, Table 6).

DISCUSSION

The 15-item Turkish version of the NQ is valid and reliable in asthmatics. The individuals with uncontrolled asthma have higher NQ scores compared to the ones with well-controlled asthma. The NQ was related to health status, asthma control, asthma-related QoL, and depression.

The Turkish version of the NQ was determined to fit the single-factor model, and an item (item 14-cold hands and

Table 3. Descriptive Statistics and Comparison of Test and Retest Items of the Nijmegen Questionnaire

	Nijmegen Questionnaire -1 (n = 54)		Nijmegen Questionnaire -2 (n = 51)		
Items	**Mean ± SD**	**Minimum–Maximum**	**Mean ± SD**	**Minimum–maximum**	***P***
Item 1	1.00 ± 1.04	0-4	0.86 ± 1.09	0-4	.494
Item 2	1.50 ± 1.12	0-4	1.31 ± 1.28	0-4	.601
Item 3	0.75 ± 1.02	0-3	0.37 ± 0.79	0-3	.083
Item 4	1.01 ± 1.12	0-4	0.94 ± 0.96	0-4	.758
Item 5	0.98 ± 1.18	0-4	1.00 ± 1.05	0-4	.808
Item 6	1.57 ± 1.07	0-4	1.68 ± 1.24	0-4	.398
Item 7	1.64 ± 1.15	0-4	1.56 ± 1.23	0-4	.868
Item 8	1.03 ± 1.08	0-3	0.84 ± 1.10	0-4	.352
Item 9	1.27 ± 1.25	0-4	1.39 ± 1.29	0-4	.482
Item 10	1.05 ± 1.07	0-3	0.94 ± 1.19	0-4	.872
Item 11	1.18 ± 1.15	0-3	0.96 ± 1.09	0-4	.231
Item 12	0.57 ± 0.96	0-4	0.45 ± 0.85	0-3	.495
Item 13	0.35 ± 0.75	0-3	0.31 ± 0.76	0-3	.537
Item 15	1.16 ± 1.14	0-4	0.96 ± 1.19	0-4	.409
Item 16	1.25 ± 1.23	0-4	1.27 ± 1.28	0-4	.903

Wilcoxon signed-rank test.

feet) should be removed. Asthma-like respiratory disorder symptoms were reported to have a higher score of coldness in hands or feet (3.0 vs. 1.6) than asthmatics.[31] Li Ogilvie et al[32] defined item 14 as an incompatible item to evaluate HVS between males and females. The same study reported that physiotherapists should use the revised 15-item NQ for clinical and research purposes and 15-item NQ represented participants' symptom severity more accurately than original scoring.[32] Similar to the aforementioned study, item 14 was removed and Turkish version of 15-item NQ was created in our study.

Table 4. Fifteen-Item Nijmegen Questionnaire Factor Loadings and Communalities

Items	Factor Loading	Factor Communality
Item 9	0.735	0.540
Item 15	0.679	0.461
Item 13	0.665	0.443
Item 8	0.633	0.401
Item 7	0.629	0.396
Item 16	0.625	0.390
Item 1	0.620	0.385
Item 5	0.610	0.372
Item 2	0.601	0.362
Item 11	0.589	0.347
Item 10	0.587	0.345
Item 3	0.545	0.298
Item 6	0.538	0.290
Item 4	0.482	0.232
Item 12	0.443	0.197

An increase in alveolar ventilation causes hyperventilation compared to metabolic carbon dioxide production.[33] As a result, alveolar carbon dioxide pressure tends to drop below normal levels. Hyperventilation includes rapid and deep breathing, or it may be in the form of a combination of both, resulting in a 1-minute ventilation increase above the metabolic requirement of the organism.[5,33] Hyperventilation differs from hyperpnea, which increases minute ventilation without a change in carbon dioxide partial pressure. End-tidal carbon dioxide levels below 35 mmHg typically indicate that breathing is in the hypocapnic range.[33] In our study, the mean $ETCO_2$ of asthmatics was 20.27 ± 3.73 mmHg. Reduced carbon dioxide partial pressure and symptoms suggestive of hyperventilation have been frequently observed in asthmatics.[33] Hypocapnia has adverse effects on asthma and

Table 5. Comparison of Test–Retest Values and Internal Consistency and Intraclass Correlation of the Nijmegen Questionnaire

	Asthma (n = 54)		
Parameter	**First Test, Mean ± SD**	**Second Test, Mean ± SD**	***P***
NQ score	16.48 ± 9.89	14.94 ± 10.25	.446[φ]

Internal consistency and intraclass correlation of the Nijmegen Questionnaire

	Cronbach's α	ICC	95% CI
NQ score	0.872	0.628	0.349-0.788

[φ]Wilcoxon signed-rank test.
ICC, intraclass correlation coefficient; NQ, Nijmegen Questionnaire.

Table 6. The Relationship Between Nijmegen Questionnaire and Evaluated Parameters

	Nijmegen Questionnaire (n = 54)	
Parameter	***r***	***P***
Age	−0.064	.644
FEV_1%	−0.064	.645
Smoking history	−0.003	.986
mMRC	0.163	.240
$ETCO_2$	0.062	.654
Breath-holding time	−0.010	.941
Respiratory rate	−0.100	.470
Modified Borg dyspnea score	0.254	.063
Beck Depression Inventory	0.477	**<.001***
NHP—Energy	0.370	**.006***
NHP—Pain	0.313	**.021***
NHP—Emotional reactions	0.240	.080
NHP—Social isolation	0.249	.069
NHP—Sleep	0.294	**.031***
NHP—Physical activity	0.406	**.002***
Asthma Control Test	−0.448	**<.001***
AQLQ—Total	−0.743	**<.001***
AQLQ—Symptom	−0.804	**<.001***
AQLQ—Activity	−0.629	**<.001***
AQLQ—Emotional	−0.504	**<.001***
AQLQ—Environment	−0.638	**<.001***

Spearman correlation analysis.
*P< .05.
AQLQ, Asthma Quality of Life Questionnaire; $ETCO_2$, end-tidal carbon dioxide; FEV_1%, predicted percentage of forced expiratory volume in 1 second; mMRC, modified Medical Research Council dyspnea scale; NHP, Nottingham Health Profile.

can lead to symptom exacerbations, but there is no clarity on the origin of hypocapnia in asthma.[33]

For internal consistency, the difference between the answers given to items measuring the same concept is calculated using the Cronbach's alpha coefficient and correlation between answers. Cronbach's alpha coefficient close to 1 indicates high internal consistency.[34] We found that 15-item NQ has good internal consistency with a high Cronbach's alpha (0.872), meaning that the NQ can be used reliably in this population. We found that the Cronbach's alpha coefficient was slightly lower than that achieved in the Greek version of the NQ (0.920).[9] In Korean version of the NQ, the Cronbach's alpha coefficient was determined as 0.878.[35] On the other hand, we found a higher Cronbach's alpha coefficient than that of the Iranian version of the NQ (0.702).[36]

The relationship with other variables includes a correlation of assessment tool results with other outcomes that may be similar. If there is a previously accepted gold standard measurement, the outcomes are associated with the results obtained with the gold standard. If there is no gold standard, a comparison is performed with other assessments, such as similar questionnaires that seem reasonable.[34] There is no gold standard for the evaluation of HVS.[9] Our study evaluated correlations between NQ and FEV_1%, $ETCO_2$, RR, mBorg dyspnea score, BHT, BDI, NHP, ACT, and AQLQ. Similar to our results, Courtney et al[37] showed no relationship between NQ with RR and BHT. The NQ had a negative correlation with ACT and AQLQ total scores. In the Greek version study, there was a negative correlation between ACT and NQ following our results.[9]

Although there was a significant relationship between $ETCO_2$ and NQ score (r = −0.680, P < .01) in Greek and Iranian versions of NQ (r = −0.783),[9,36] no relationship was found between $ETCO_2$ and NQ in our study, this may be due to our study's smaller sample size than these studies and the absence of any participant with an $ETCO_2$ value >35 mmHg. There was no significant relationship between $ETCO_2$ and NQ scores in another study (r = −0.12, P = .27), similar to ours.[37] The lack of a significant relationship between $ETCO_2$ and NQ score was reported not to indicate the absence of a relationship between respiratory dysfunction symptoms and $ETCO_2$, and it may be due to a complex relationship between these parameters, and this relationship may be affected by other factors such as anxiety.[37] In addition, the variability of relationship between NQ score and hypocapnia and specifying NQ as a measure of hyperventilation is generally weak.[9,37,38] The correlation between NQ and carbon dioxide pressure is reported to be highly variable.[38] Therefore, defining the NQ score to measure functional respiratory complaints was recommended.[38]

Most asthmatics have high NQ scores.[9,39] High NQ scores have been associated with poor asthma control.[9,40] We found that individuals with uncontrolled asthma had higher NQ scores than individuals with well-controlled asthma. The negative relationship between NQ and asthma control level confirmed this.

Women with asthma have higher NQ scores.[9] It is explained by the decrease in carbon dioxide partial pressure in the second half of the menstrual cycle with the effect of progesterone.[5,9] In our study, most participants were female (79.6%), and there was no difference between NQ scores according to sex. The higher number of females compared to males in our study may explain the lack of significant difference between $ETCO_2$ values of participants according to sex.

Respiratory functional disorder term is used instead of hyperventilation.[38,39] It has led to the concept that breathing can be impaired functionally, beyond or without hypocapnia.[38] Respiration has many functions, such as gas exchange, diffusion, expansion, biomechanical function for posture and movement, and subjective breathing experience, each of which may be impaired.[38] Impairment in any of these functions may cause dyspnea.[38] Considering the multidimensionality of respiration, the necessity of multi-component evaluation is emphasized in evaluating respiratory dysfunction.[38]

The NQ is used as a diagnostic method in most studies evaluating epidemiology to diagnose respiratory dysfunction.[3] The HVS prevalence in the general population is around 6-10.[3]

The HVS prevalence shows a variable range in studies. It may have arisen due to cultural differences, the selection of participants included in the studies from different populations, measurement differences, and different cutoff scores.[9,39] In a study with asthmatics, HVS prevalence was reported as 34%.[9] In the Greek version study, the cutoff score was determined as 17.[9] Thomas et al[41] reported HVS frequency as 29% in participants without an objective asthma diagnosis, using a cutoff score of 23. Van Dixhoorn et al[38] stated the best value as 19 points, without distinguishing individuals with HVS. Thus, they emphasized that complaints are a part of common minor ailments and not a part of normal life.[8,38] In our study, when ≥19 was used as the cut-off point, 20 individuals (37%) had NQ scores of ≥19.

Considering the limitations, the absence of participants with an $ETCO_2$ >35 mmHg limits the generalizability of the findings to this population. In addition, the relationship was determined using similar questionnaires due to the lack of a standard method for diagnosing HVS. Further studies with greater sample sizes, including individuals with severe asthma, are needed to draw a firm conclusion regarding associations.

CONCLUSION

The 15-item Turkish version of the NQ is valid and reliable in asthmatics. Individuals with uncontrolled asthma have higher NQ scores than those with well-controlled asthma. The NQ is associated with asthma control level, asthma-related QoL, health profile, and depression.

Ethics Committee Approval: Hacettepe University, Non-Interventional Clinical Research Ethical Board approved the study (Approval date: 17.03.2020 and approval number: GO 20/199).

Informed Consent: All participants were informed about the study protocol and signed an informed consent form.

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