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Reliability and Validity of the Turkish Version of Virtual Reality Sickness Questionnaire: Methodological Study

Sanal Gerçeklik Rahatsızlığı Anketinin Türkçe Versiyonunun Güvenilirlik ve Geçerliği: Metodolojik Çalışma

Hatice ÇETİN[a], Hatice Yağmur ZENGİN[b], Nezire KÖSE[a]

[a]Department of Physiotherapy and Rehabilitation, Hacettepe University Faculty of Physical Therapy and Rehabilitation, Ankara, Türkiye
[b]Department of Biostatistics, Hacettepe University Faculty of Medicine, Ankara, Türkiye

ABSTRACT Objective: This study aimed to investigate reliability and validity of the Turkish version of Virtual Reality Sickness Questionnaire (VRSQ). **Material and Methods:** Hundred participants, between the ages of 18-30, were included in this study (57 female, 43 male). All participants experienced virtual reality (VR) for 20 minutes. VRSQ and Graybiel Scale scores were asked five times; before VR, at 1st, 10th, 20th and 60th mins-after VR. Cronbach's alpha for the internal consistency, Kaiser-Meyer-Olkin (KMO) and Bartlet't tests for confirmatory analysis, the correlation efficient for concurrent validity were performed. **Results:** The Cronbach-α values indicated moderate internal consistency for VRSQ at the 1st and 10th mins-after VR (α=0.674, α=0.633). KMO (0.653) and Bartlett tests showed that data is adequate. The correlations between VRSQ and Graybiel Scale were very good at the 1st and 10th mins-after VR (r=0.786, r=0.657). **Conclusion:** This study presents the Turkish version of VRSQ is reliable and valid for evaluating motion sickness in the VR environment. To assess motion sickness with an objective measurement tool can improve the quality of studies about VR. The inclusion of the Turkish version of this questionnaire to the literature can be a guide for many researchers who will investigate VR.

Keywords: Virtual reality; motion sickness; reproducibility of results; physical therapy modalities; surveys and questionnaires

ÖZET Amaç: Bu çalışmanın amacı, Sanal Gerçeklik Rahatsızlığı Anketi'nin (SGRA) Türkçe versiyonunun güvenilirlik ve geçerliliğini araştırmaktır. **Gereç ve Yöntemler:** Bu çalışmaya 18-30 yaş arası 100 katılımcı (57 kadın, 43 erkek) dâhil edildi. Tüm katılımcılar 20 dk boyunca sanal gerçeklik (SG) deneyimi yaşadı. SGRA ve Graybiel Ölçeği puanları SG'den önce, SG'den sonra 1, 10, 20 ve 60. dk'larda olmak üzere 5 kez sorgulandı. İç tutarlılık için Cronbach alfa, doğrulayıcı faktör analizi için Kaiser-Meyer-Olkin (KMO) ve Bartlett testleri, eş zamanlı geçerliliği için korelasyon etkililiği uygulandı. **Bulgular:** Cronbach-α değerleri SGRA için SG sonrası 1 ve 10. dk iç tutarlılığının orta düzeyde olduğunu gösterdi (α=0,674, α=0,633). KMO (0,653) ve Bartlett testleri ise verilerin yeterli olduğunu gösterdi. SGRA ile Graybiel Ölçeği arasındaki korelasyonlar SG sonrası 1 ve 10. dk'larda çok iyiydi (r=0,786, r=0,657). **Sonuç:** Bu çalışma, SGRA'nın Türkçe versiyonunun SG ortamında hareket hastalığını değerlendirmek için geçerli ve güvenilir olduğunu göstermektedir. Hareket hastalığını objektif bir ölçüm aracı ile değerlendirmek, SG ile ilgili çalışmaların kalitesini artırabilir. Bu anketin, Türkçe versiyonunun literatüre dâhil edilmesi SG konusunda çalışma yapacak birçok araştırmacı için yol gösterici olabilir.

Anahtar Kelimeler: Sanal gerçeklik; hareket tutması; sonuçların tekrarlanabilirliği; fizik tedavi modaliteleri; sörveyler ve anketler

Virtual reality (VR) has been used in the fields of education, engineering and health as well as being used for gaming, with the rapid development of today's technology.[1] VR system offer a VR environment to people with multi-sensory inputs. People can navigate in different places and manipulate objects in the artificial world.[2,3] VR can be experienced with a headset, computer system and interactive video games.[4] VR can also be used for many purposes such as improving gait, balance and proprioception, and reducing pain in many neurological, musculoskeletal and orthopedic problems in healthcare.[5-8] While VR

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Correspondence: Hatice ÇETİN
Department of Physiotherapy and Rehabilitation, Hacettepe University Faculty of Physical Therapy and Rehabilitation, Ankara, Türkiye
E-mail: haticebitirim@hacettepe.edu.tr

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is more rapidly usable, many studies revealed that VR can cause motion sickness (MS) in VR environments as a result of incompatibility with the virtual and real environment.[9] VR applications and simulation devices may cause MS after using it.[10]

Gianaros et al. suggested that the Motion Sickness Assessment Questionnaire (MSAQ) which evaluates MS is a valid questionnaire and MS should be viewed as a multidimensional construct with gastrointestinal, central, peripheral, and sopite-related components.[11] They stated that the MS history of their sample was representative of the general population and future investigations should examine the extent to which specialized questionnaires. Another questionnaire that "Simulator Sickness Questionnaire" also evaluates MS.[12] These questionnaires are appropriate for evaluating the symptoms that develop after MS or the use of simulation devices. However, these questionnaires may not be appropriate surveys to evaluate the MS symptoms after VR applications. Therefore, MS symptoms are different between VR and simulation systems. "Virtual Reality Sickness Questionnaire (VRSQ)" has been developed that can assess these symptoms. This questionnaire includes symptoms such as fatigue, eye strain, headache, and dizziness. Kim et al. indicated that VRSQ can be used to measure and design MS using VR devices in future studies.[13]

However, there is no Turkish version of the VRSQ in the literature. For this reason, this study was conducted for reliability and validation of the Turkish version of VRSQ.

MATERIAL AND METHODS

PARTICIPANTS

Participants included in this study were recruited through Hacettepe University announcement boards. Hundred participants, between the ages of 18-30, were included in this study (57 female, 43 male). The exclusion criteria were having neurological, cardiovascular and vestibular disease, impairment of oculomotor and gastrointestinal systems.

This study was carried out in accordance with the Declaration of Helsinki. The protocol of this study was approved by Hacettepe University Non-Invasive Clinical Research Ethics Committee (date: May 31, 2022; no: 22/323). Participants were required to sign the study's informed consent form before answering the questionnaire.

SAMPLE SIZE CALCULATION

The minimum sample size required for the validity and reliability study was determined as 90, with 10 individuals per item (N:p ratio 10) for a total of 9 items, and the study was completed with 100 individuals.[14] This sample size provides 80% power at 95% confidence level in the two-way significance test of the correlation coefficient used in the study, considering Cohen's large effect size.[15]

TRANSLATION PROCEDURE

The permission was obtained from Kim et al. for the translation of VRSQ into Turkish.[13] Firstly, the translation and cultural adaptation process and then the reliability process was completed in the study. Two different people (a doctor who was aware of the study and a linguistic scientist who was unaware of the study) first translated the original form of the VRSQ from English into Turkish. Afterwards, two people (faculty members) translated the questionnaire into a single version. Two bilingual translators again translated back to English. There was no difference between the questionnaires. And a researcher controlled for consistency. Five experts including two medical doctors, two physiotherapists, and one specialist in public health science, evaluated the questionnaire for content validity. We conducted a pilot study with 10 participants before the study. As a result, we observed the points that were not understood about the questions in the survey. We did not make any changes to the questionnaire after the expert committee and the pilot study (Figure 1). The Turkish version of the VRSQ was indicated in Appendix 1.

VR PROCEDURE

The VR environment was provided using Oculus Go apparatus (Menlo Park, California, United States of America). The resolution of the screen was 1280Å~1440 for each eye. "Roller coaster" application was used to create the virtual environment and observe MS for 20 minutes. The participants performed head movements in all neck directions. We

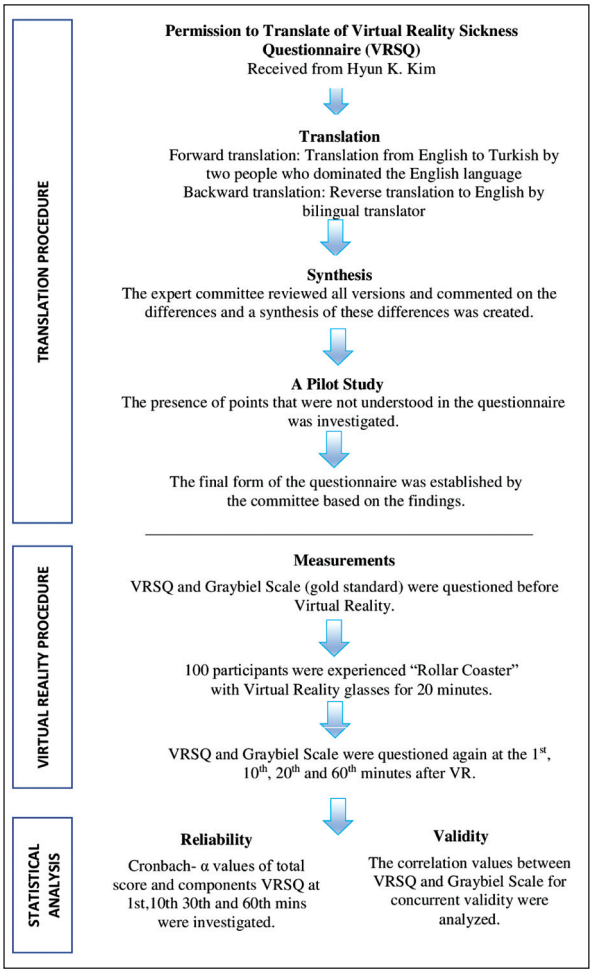

FIGURE 1: The flowchart of the study.

were careful about that each patient experienced VR in the same environmental conditions. The environment was calm and quiet. Participants experienced VR while in a chair that allowed 360-degree movement. We asked the participants "How is it going? Do you have any sickness" at 5th and 10th min. Some participants were very prone to MS and these participants only watched the "Rollar Coaster" without using remote control. However, some participants did not have any sickness at 5th and 10th min. We tried to reveal VR sickness by selecting the targets in the VR environment with using remote control. The participants were asked to complete the VRSQ 5 times; before VR, at 1st (immediately after VR), 10th, 20th and 60th mins-after VR (Figure 1). The participants were informed about avoiding smoking and not consuming caffeine at least 3 hours before the VR. The measurements are described in the following part.

MEASUREMENTS

Age, gender, body mass index (BMI), $VRSQ_{(before\ VR)}$ and $Graybiel\ Scale_{(before\ VR)}$ scores of all participants were recorded at the beginning of the study. VRSQ and Graybiel Scale scores were also asked at 1st, 10th, 20th and 60th mins-after VR.

VRSQ: This questionnaire consists of 9 items and two components as oculomotor and disorienta-

APPENDIX 1: Sanal Gerçeklik Rahatsızlığı Anketi.

Alt başlıklar		0	1	2	3
Semptomlar		Hiç	Hafif	Orta	Şiddetli
Okülomotor	1. Genel rahatsızlık				
	2. Yorgunluk, tükenmişlik, bitkinlik hissi				
	3. Gözlerde yorgunluk				
	4. Odaklanma zorluğu				
Oryantasyon bozukluğu	5. Baş ağrısı				
	6. Kafada basınç hissi				
	7. Bulanık görme				
	8. Sersemlik (gözler kapalı)				
	9. Baş dönmesi				

*Okülomotor komponenti 1) Genel rahatsızlık, 2) Yorgunluk, tükenmişlik, bitkinlik hissi, 3) Gözlerde yorgunluk, 4) Odaklanma zorluğu olmak üzere 4 parametreden oluşmaktadır. Toplam puan 12'dir.

*Oryantasyon bozukluğu komponenti 5) Baş ağrısı, 6) Kafada basınç hissi, 7) Bulanık görme, 8) Sersemlik (gözler kapalı), 9) Baş dönmesi olmak üzere 5 parametreden oluşmaktadır. Toplam puan 15'dir.

PUANLAMA

Okülomotor puan=[(1.+2.+3.+4.)/12]* 100

Oryantasyon bozukluğu puanı=[(5.+6.+7.+8.+9.)/15]*100

$$\text{Toplam puan} = \frac{(\text{Okülomotor puanı} + \text{oryantasyon bozukluğu puanı})}{2}$$

tion. The items are scored on a 4-point ranging from 3 to 0 (3=very, 2=moderately, 1=slightly, 0=not at all). The oculomotor component consists of 4 items including 1) General discomfort, 2) Fatigue, 3) Eyestrain, and 4) Difficulty in focusing (Total obtainable score: 12). The disorientation component consists of 5 items including 1) Headache, 2) Fullness of head, 3) Blurred vision, 4) Dizziness with eyes closed, and 5) Vertigo (Total obtainable score: 15). As a result of the VRSQ, oculomotor, disorientation and total scores are obtained. Oculomotor and disorientation scores are calculated by dividing the individual's component score with the total obtained score (as percentage). Total score is calculated by simple averaging method and the higher score indicates the higher MS.[13]

Graybiel Scale: Graybiel scale was developed to demonstrate the tendency to MS.[14] This scale consists of the following components; gastrointestinal, cold sweating, skin color, increased salivation, drowsiness, headache and dizziness. Each component is scored within itself. The sum of the scores in each complaint and symptom component demonstrates the degree of tendency to MS. The scores in this scale are between 0-50. According to this scale; 1-2 points are interpreted as "mild tendency to MS", 3-7 points as "moderate tendency to MS", 8-15 points as "high tendency to MS", and values 16 and above as "definite MS".[15]

STATISTICAL ANALYSIS

Statistical analyses were performed using IBM SPSS Statistics Version 23.0 for Windows (IBM Corp., Armonk, NY, USA) and IBM SPSS AMOS Version 23.0.0. Frequency and percentage (n, %) were used as descriptive statistics for categorical variables. Kolmogorov-Smirnov normality test was used for assessing normality in numerical variables when sample size was equal or greater than 50. Otherwise, Shapiro-Wilk normality test was used for evaluation. Mean±standard deviations were used for numerical variables distributed normally. Otherwise, descriptive statistics are represented as median (minimum-maximum). Friedman test was used for changing VRSQ and Graybiel Scale scores over time. The statistical significance level was set at 0.05.

INTERNAL CONSISTENCY

Cronbach's alpha coefficient was used to examine the internal consistency of the questionnaire. Cronbach values higher than 0.90 indicate excellent internal consistency. Values between 0.90 to 0.80 are considered to be good, and values higher than 0.60 are considered to be moderate.[16]

CONSTRUCT VALIDITY

Kaiser-Meyer-Olkin (KMO) measures for sampling adequacy and Bartlett's test of sphericity were performed for evaluating the factorability of the data before Exploratory Factor Analysis (EFA). The general acceptance index of KMO is over 0.6.[17] EFA was conducted using the Principal Component Method with Varimax rotation. Construct validity was evaluated using Confirmatory Factor Analysis (CFA) along with the EFA. For evaluating the fit of the model in CFA, several measurements were used such as c^2/degree of freedom (df), Goodness of Fit Index (GFI), Comparative Fit Index (CFI), root mean square error of approximation (RMSEA), standardized root mean square residual (RMR). Criteria for goodness-of-fit indices are considered as $c^2/df < 5$, CFI>0.90, GFI>0.90, RMSEA<0.10, standardized RMR<0.08 acceptable fit for the model where $c^2/df \leq 2$, CFI>0.99, GFI>0.99, RMSEA <0.05, standardized RMR<0.05 were considered perfect fit.[18]

CONCURRENT VALIDITY

The linear relationship between the VRSQ and the Graybiel Scale which is used as the gold standard were investigated with Spearman's correlation coefficient before and at the 1st, 10th, 20th and 60th minutes-after VR. The concurrent validity coefficients were accepted as: r_s=0.81 to 1.0, excellent; 0.61 to 0.80, very good; 0.41 to 0.60, good; 0.21 to 0.40, fair; and 0 to 0.20, poor.[19]

RESULTS

DEMOGRAPHIC CHARACTERISTICS AND BASELINE RESULTS

The means and standard deviations (minimum-maximum values) of age and BMI were respectively; 22.36±2.86 (19-30) years and 23.60+2.74 (17.30-

29.75) kg/m^2. The study group consisted of 57 female and 43 male participants. The medians of VRSQ and Graybiel Scale were demonstrated in Table 1.

INTERNAL CONSISTENCY

The Cronbach-α values of VRSQ total score at the 1st, 10th, 20th and 60th mins after VR were respectively 0.674, 0.633, 0.272, 0.313. These values indicate moderate internal consistency for VRSQ at the 1st and 10th mins-after VR. Therefore, Cronbach- α values of components and items were analyzed using the VRSQ results at 1st and 10th mins.

According to results at the 1st min, Cronbach-α values were 0.786 for the oculomotor component and 0.753 for the disorientation component. A value of 0.7 or higher indicates that internal consistency was sufficient.[20] At the 10th min, Cronbach-α values were 0.561 for the oculomotor component and 0.694 for the disorientation component (Table 2).

TABLE 1: Patients' demographic characteristics and descriptives for VRSQ (0-36) and Graybiel Scale (1-50).

n=100	Descriptive statistics
Age (X̄±SD)	22.36 ±2.86
Gender n (%)	
Female	57 (57)
Male	43 (43)
Body mass index (kg/cm^2) (X̄±SD)	23.60±2.74
Before VR [median (minimum-maximum)]	
VRSQ-oculomotor	0.16 (0-8.33)
VRSQ-disorientation	0.2 (0-7)
VRSQ-total score	0.18 (0-4.16)
Graybiel Scale	0 (0-1)
at 1st min-after VR [median (minimum-maximum)]	
VRSQ-oculomotor	56.83 (33.3-75)
VRSQ-disorientation	51.4 (33.3-73.3)
VRSQ-total score	54.11 (33.3-67.5)
Graybiel Scale	9.55 (6-14)
at 10th min-after VR [median (minimum-maximum)]	
VRSQ-oculomotor	19.41 (0-41.67)
VRSQ-disorientation	14.6 (0-33.3)
VRSQ-total score	17.0 (0-30.83)
Graybiel Scale	1.05 (0-2)
at 20th min-after VR [median (minimum-maximum)]	
VRSQ-oculomotor	0.83 (0-8.3)
VRSQ-disorientation	2.13 (0-13.3)
VRSQ-total score	1.48 (0-7.5)
Graybiel Scale	0.11 (0-1)
at 60th min-after VR [median (minimum-maximum)]	
VRSQ-oculomotor	0.16 (0-8.3)
VRSQ-disorientation	0.6 (0-13.3)
VRSQ-total score	0.38 (0-6.67)
Graybiel Scale	0.02 (0-1)
Friedman test*	
VRSQ-oculomotor	<0.001
VRSQ-disorientation	<0.001
VRSQ-total score	<0.001
Graybiel Scale	<0.001

*Friedman test was used for analysing the scores of VRSQ and Graybiel scale at different times (at the 1st, 10th, 20th and 60th mins after VR); VRSQ: Virtual Reality Sickness Questionnaire; SD: Standard deviation; VR: Virtual reality.

EXPLORATORY AND CONFIRMATORY ANALYSIS

The KMO value was 0.653 and Bartlett's test of sphericity p<0.001 in this study. KMO value close to 1.0 and significant Bartlett's test of sphericity result suggest that data is adequate and appropriate to proceed further with the dimension reduction procedure (Table 3).

According to the results of the EFA, 59% of the total variance was explained by two factor solution and the rotated factor loadings indicate that item 1, 2, 3 and 4 are loaded mainly the oculomotor dimension where item 5, 6, 7, 8 and 9 are loaded mainly the disorientation dimension as expected from the original scale (Table 4).

Two factor structure was evaluated using CFA. Model statistics were CFA c^2/df=1.821; GFI=0.919; CFI=0.948; RMSEA=0.091, standardized RMR= 0.0767 which indicates that the two factor solution is valid and acceptable for the Turkish version of the scale (Figure 2).[21]

CONCURRENT VALIDITY

The correlation coefficients were VRSQ and Graybiel Scale respectively for before VR, at the 10th, 20th and 60th mins after VR; r=0.786, r=0.657, r=0.274, r=0.222. These results indicated that the correlations between VRSQ and Graybiel Scale were very good at the 1st and 10th mins after VR (Table 5).

FRIEDMAN TEST

Friedman test indicated that the scores of VRSQ and Graybiel Scale were significantly different among different times (p<0.05). The scores of VRSQ and Graybiel Scale were the highest at the 1st min-after VR (Table 1). And VRSQ and Graybiel Scale scores decreased over time.

TABLE 2: Item analysis results of the Turkish version of VRSQ at 1st and 10th mins after VR.

	VRSQ items	Cronbach's alpha if item deleted	Cronbach alpha of the subscale	Cronbach alpha of scale
VRSQ at 1st min after VR	Item 1	0.654	-	0.674
	Item 2	0.659		
	Item 3	0.664		
	Item 4	0.640		
	Item 5	0.615		
	Item 6	0.626		
	Item 7	0.688		
	Item 8	0.653		
	Item 9	0.616		
VRSQ at 10th min after VR	Item 1	0.560	-	0.633
	Item 2	0.636		
	Item 3	0.635		
	Item 4	0.639		
	Item 5	0.559		
	Item 6	0.608		
	Item 7	0.644		
	Item 8	0.588		
	Item 9	0.555		
VRSQ at 1st min after VR	Item 1	0.639	0.786	-
	Item 2	0.668		
	Item 3	0.733		
	Item 4	0.863		
	Item 5	0.649		
	Item 6	0.668		
	Item 7	0.811	0.753	
	Item 8	0.707		
	Item 9	0.686		
VRSQ at 10th min after VR	Item 1	0.355	0.561	-
	Item 2	0.542		
	Item 3	0.400		
	Item 4	0.609		
	Item 5	0.559		
	Item 6	0.634		
	Item 7	0.734	0.694	
	Item 8	0.673		
	Item 9	0.580		

Item 1, 2, 3, 4 was considered oculomotor component where item 5, 6, 7, 8, 9 was considered as disorientation component items; VR: Virtual reality; VRSQ: Virtual Reality Sickness Questionnaire.

TABLE 3: Kaiser-Meyer-Olkin and Barlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.653
Bartlett's test of sphericity	Approx. Chi-Square	397.221
	Df	36
	Sig.	<0.05

Regardless of all these results, the symptom of "nausea", which was not included in the original version of VRSQ, was observed in almost 60% of the individuals participating in the study according to our records. However, the participants scored the severity of the nausea parameter as slightly (1 point) according to 4-point ranging from 3 to 0 (3=very, 2=moderately, 1=slightly, 0=not at all).

DISCUSSION

This study was conducted for the reliability and validity of the Turkish version of the VRSQ. The re-

TABLE 4: Factor loadings and rotated factor loadings of the VRSQ at 1st min-after VR.

	Factor Loadings		Rotated factor loadings	
	Factor 1	Factor 2	Factor 1	Factor 2
Item 1	-0.40	0.84	-0.09	0.92
Item 2	-0.40	0.82	-0.09	0.90
Item 3	-0.32	0.72	-0.06	0.79
Item 4	0.12	0.58	0.31	0.50
Item 5	0.79	0.30	0.85	0.02
Item 6	0.78	0.27	0.83	-0.02
Item 7	0.31	0.10	0.33	-0.01
Item 8	0.75	0.16	0.76	-0.11
Item 9	0.66	0.35	0.74	0.10
Variance	2.722	2.539	2.745	2.566
% of Variance	30.801	28.209	30.497	28.513

VRSQ: Virtual Reality Sickness Questionnaire.

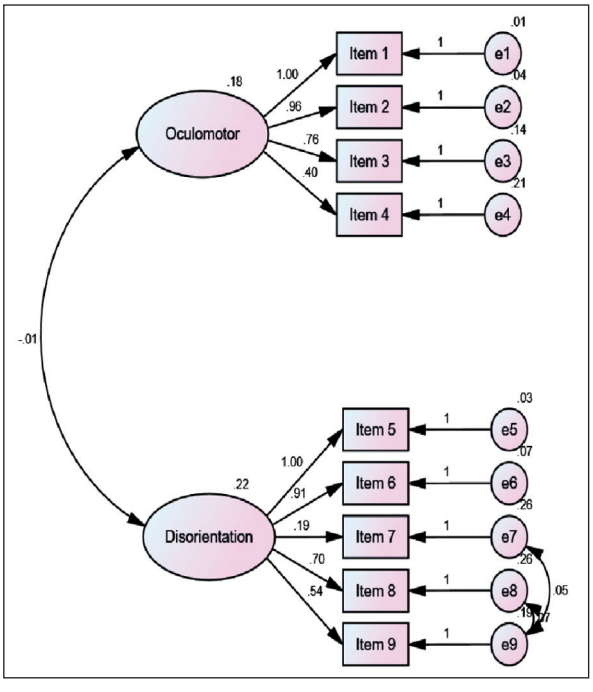

FIGURE 2: Confirmatory factor analysis diagram.

sults of the current study present the Turkish version of VRSQ is reliable and valid for evaluating the sickness in a VR environment.

We included the individuals between the ages of 18-30 without any health problems in this study. We preferred an application such as "roller coaster" to reveal VR sickness. The averages of the oculomotor, disorientation and total scores were calculated as 0.16, 0.2 and 0.18 %, because two participants scored

TABLE 5: The correlation coefficients between VRSQ and Graybiel Scale at different times.

	Graybiel Scale	
VRSQ	r value	p value
Before VR	0.023	0.82
at 1st min-after VR	0.786**	**<0.001**
at 10th min-after VR	0.657**	**<0.001**
at 20th min-after VR	0.274**	**<0.001**
at 60th min-after VR	0.222**	**<0.001**

**Indicates p<0.001, Spearman correlation test was used for correlation analysis; VRSQ: Virtual Reality Sickness Questionnaire; VR: Virtual reality.

their "fatigue" item as "1" (slightly) before VR. However, we do not consider that this is significant to affect VR sickness, since fatigue can occur for different personal reasons.

The present study showed that the Turkish version of the VRSQ has moderate internal consistency (Cronbach-α values were 0.674 at 1st min- after VR, 0.633 for 10th min- after VR). Cronbach-α values were 0.786 for the oculomotor component and 0.753 for the disorientation component in this study. Cronbach-α values were 0.847 for the oculomotor axis; 0.886 for the disorientation in the original article.[13] And the authors stated that a value of 0.7 or higher indicates that internal consistency was sufficient.[22] Our results were also consistent with these results. There is no study about reliability and validity of the other languages of VRSQ, however there is a study of the Greek version of MSAQ.[23] Cronbach's alphas were

respectively 0.948, 0.793, 0.832, and 0.731 for the scales of gastrointestinal, the central nervous system, the peripheral symptoms, and the sopite-related symptoms in the Greek version study. VRSQ items do not consist of gastrointestinal symptoms (vomit, sick to stomach, nauseated, queasy, upset stomach). The other subscales of this questionnaire include the VRSQ items. Moreover, Cronbach-α values of the other subscales of MSAQ were similar to our study. A VR version of the Cybersickness Questionnaire (CSQ-VR) has been developed to evaluate VR sickness in another study. A CSQ-VR includes nausea, vestibular and oculomotor components. Pearson's test results indicated that the total score of the VRSQ showed the strongest correlations with the total scores of the CSQ-VR versions (r=0.77). The authors indicated that CSQ-VR provides more advantages by facilitating an assessment of cybersickness in the VR environment.[24]

For validity, the present study assessed the correlation between the VRSQ and Graybiel Scale (gold standard). According to the item analysis- item 7 has corrected item-total correlation smaller than 0.25. Additionally, it has the smallest KMO measure obtained from the EFA where its highest factor loading is just slightly greater than 0.30 which is considered as minimum meaningful factor loading in practice where in general 0.5 is considered as the acceptable limit for factor loadings.[25] VRSQ and Graybiel Scale were collected at different time points; before VR, at the 1st, 10th, 20th and 60th minutes after VR. The correlations between VRSQ and Graybiel Scale were very good at 1st and 10th minutes.[19] The correlation coefficients decreased over time, because the VR symptoms weakened. In addition to that, the scores of VRSQ and Graybiel Scale changed at different times. We observed that VR sickness had the highest score at the 1st min, and the sickness was rapidly decreasing. These results indicated that VRSQ is a sensitive questionnaire for evaluating VR sickness symptoms and measuring the changes of symptoms. In the Greek version study of MSAQ, the participants were asked to complete the questionnaire immediately after VR and for the second time with an interval of 10 minutes. When asking about the sickness for the second time, the participants were asked to remember how they felt immediately after VR, not how they felt at the 10th min. The authors stated that was a problem.[23] We asked the participants in the VRSQ how they felt about that particular time at different time points. We thought that it would not be possible to test-retest reliability of the questionnaire under the same conditions. Therefore, we aimed to prove that VRSQ was sensitive for measuring VR sickness at different times.

Besides all these results, we would like to discuss one more issue. The nausea component was eliminated from VRSQ in the original article by carrying out the exploratory and CFA. The authors stated that the nausea component contributed less to MS than the oculomotor and disorientation components, this situation was a trend and their results are similar to previous studies. Based on this trend, the authors eliminated the nausea component. However, in this study, we observed that almost 60% of the participants had the nausea symptom even mild severity. We think this result is important and should be mentioned.

LIMITATIONS OF STUDY

This study has several limitations. Firstly, we carried out this study by including individuals between the 18-30 ages group. The results may be different in the older age group or different diseases. Different symptoms such as nausea and imbalance may need to be questioned. Reliability and validity studies are needed in different disease groups in this regard.

Secondly, we used the "Roller Coaster" application to reveal the VR sickness. Some participants did not have any sickness at 5th and 10th min, used remote controls, some did not. We tried to reveal VR sickness by selecting the targets in the VR environment using remote control. This situation can be considered as a limitation.

Thirdly, most of the participants complained of nausea after VR. However, VRSQ doesn't contain the nausea component, while nausea symptoms are the second most frequent symptom in MS. VRSQ was developed from SSQ. SSQ may not be effective in a VR environment, because this questionnaire is a MS measurement tool designed for a simulator envi-

ronment. However, the authors indicated that the nausea component should be removed from the questionnaire in the original article. The absence of nausea in this questionnaire is a limitation.

CONCLUSION

VRSQ is a questionnaire with sufficient validity and reliability for measuring the MS in the VR environment in the Turkish population. Including the Turkish version of VRSQ to the literature will facilitate future studies about VR.

VR has been widely used in many fields such as education, engineering and medicine, including health sciences. However, the use of VR may cause MS for some people or may need to be controlled while VR experiencing. To assess MS with an objective measurement tool will improve the quality of studies about VR. The inclusion of the Turkish version of this questionnaire to the literature can be a guide for many researchers who will investigate the effects of VR.

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Hatice Çetin;* ***Design:*** *Hatice Çetin, Nezire Köse;* ***Control/Supervision:*** *Nezire Köse;* ***Data Collection and/or Processing:*** *Hatice Çetin, Hatice Yağmur Zengin;* ***Analysis and/or Interpretation:*** *Hatice Çetin, Hatice Yağmur Zengin;* ***Literature Review:*** *Hatice Çetin, Nezire Köse;* ***Writing the Article:*** *Hatice Çetin, Hatice Yağmur Zengin;* ***Critical Review:*** *Nezire Köse.*

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