Psychometric Analysis of the SPEED Questionnaire and CLDEQ-8

Andrew D. Pucker,[1] Bradley E. Dougherty,[2] Lisa A. Jones-Jordan,[2] Justin T. Kwan,[3] Carolina M. E. Kunnen,[4] and Sruthi Srinivasan[5]

[1]School of Optometry, University of Alabama at Birmingham, Birmingham, Alabama, United States
[2]College of Optometry, Ohio State University, Columbus, Ohio, United States
[3]Southern California College of Optometry, Marshall B. Ketchum, Fullerton, California, United States
[4]The Ocular Surface Institute, College of Optometry, University of Houston, Houston, Texas, United States
[5]Centre for Ocular Research and Education (CORE), School of Optometry and Vision Science, University of Waterloo, Waterloo, Ontario, Canada

Correspondence: Andrew D. Pucker, University of Alabama at Birmingham, School of Optometry, 1716 University Boulevard, Birmingham, AL 35233, USA; apucker@uab.edu.

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Purpose. This study reports on the ability of the Standard Patient Evaluation of Eye Dryness (SPEED) questionnaire to detect dry eye (DE) symptoms in contact lens (CL) and non-CL wearers.

Methods. The SPEED questionnaire was administered to all subjects while the Contact Lens Dry Eye Questionnaire-8 (CLDEQ-8) was only administered to CL wearers. Tear meniscus heights (TMH) were measured, and the phenol red thread (PRT) test was conducted. These tests along with self-reported DE were used to identify subjects with dry eye disease (DED). Rasch analysis was performed to evaluate the questionnaires for measurement precision and unidimensionality, and the scores from these Rasch analyses were used to understand their ability to predict measures of DED.

Results. We enrolled 284 subjects (150 CL and 134 non-CL wearers). Mean subject age was 39.4 ± 14.2 years. Rasch analysis yielded a multidimensional short form of the SPEED questionnaire (8-items) and a unidimensional short form of the CLDEQ-8 (4-item). Scores from both questionnaires were significantly associated with self-reported DE in CL and non-CL wearers. Scores of the 8-item SPEED questionnaire were associated with DED status in non-CL wearers but not in CL wearers while 4-item CLDEQ scores were associated with DED status in CL wearers. TMH or PRT were not associated with either questionnaire in CL or non-CL wearers.

Conclusions. The 8-item SPEED questionnaire demonstrated adequate measurement precision with evidence of quantifying multiple symptoms categories while the 4-item CLDEQ-8 primarily quantified DE symptoms. Questionnaire scores were associated with self-reported DE, which suggests that they may have utility in both populations analyzed.

Keywords: standard patient evaluation of eye dryness (SPEED), contact lens dry eye questionnaire-8 (CLDEQ-8), dry eye disease, Rasch analysis, contact lenses

Dry eye disease (DED) is a multifactorial condition that results in ocular surface symptoms that stem from a lack of tear homeostasis.[1] Advanced DED, as seen with some Sjögren syndrome subjects, can even result in severe ocular discomfort, decreased vision, and poor overall quality of life.[2] Clinically, the symptoms associated with DED are a primary reason why patients seek medical care.[3,4] Tracking chronic symptoms is a difficult task, yet it is necessary and possible with validated questionnaires.[5] The Ocular Surface Disease Index (OSDI) questionnaire is a survey that is designed to specifically probe visual symptoms, visual performance, and the environment's effect on ocular comfort, and it is one of the most frequently used questionnaires for quantifying ocular surface–related complaints.[6] However, a Rasch analysis of the OSDI performed by Dougherty et al.[6] in postmenopausal women found a lack of unidimensionality (i.e., the survey is measuring more than one underlying trait) when all items are used together, and poor measurement precision if individual subscales (which are quite short) are used alone. McAlinden et al.[7] came to a similar conclusion regarding the performance of the OSDI in a group of Chinese adults, finding that none of the subscales had adequate measurement precision. In addition to the OSDI, the clinical and scientific community has a number of other ocular surface surveys available such as the Dry Eye Questionnaire-5 (DEQ-5), Ocular Comfort Index (OCI), McMonnies Dry Eye Questionnaire (MQ), and the Standard Patient Evaluation of Eye Dryness (SPEED) questionnaire.[4,8–10] Of the above instruments, the SPEED questionnaire is emerging as an instrument of choice for many because it is relatively quick to administer, a feature that makes it amenable to clinical practice, and because the SPEED questionnaire is a repeatable instrument for quantifying the severity of the most common dry eye symptoms experienced by patients.[11–13]

While the community has built a wealth of knowledge related to the SPEED questionnaire, there is still a dearth of evidence related to how SPEED scores (or scores of similar

instruments) are related to clinical measures of dry eye in contact lens (CL) wearers.[6,11,13–16] This is problematic because CL studies frequently use non–CL-wearing subjects as a control group and the community currently lacks a dry eye instrument that has been validated for use in both populations, an issue that stands even though the DEQ-5 and Contact Lens Dry Eye Questionnaire-8 (CLDEQ-8) contain many of the same stem questions for studying symptoms in non-CL and CL wearers, respectively.[9,17,18]

Rasch analysis has been used widely across health and other disciplines for the development and evaluation of questionnaires.[19] Briefly, it allows for the conversion of the ordinal-level responses on Likert-type questionnaires to interval-level measures of the amount of a trait possessed by an individual, allows for valid statistical testing of those scores, and can be used to guide the creation of new questionnaires and determine whether existing questionnaires have good measurement properties.[19] While brief explanations of some of the various aspects of the analysis are provided in the Methods section below, there are a number of very useful introductory works on Rasch analysis for interested readers who would like to learn more.[5,20–22]

The purpose of this report is to use Rasch analysis to describe the SPEED questionnaire's ability in a sample of CL- and non–CL-wearing adults to predict dry eye signs, assigned dry eye, and ocular symptoms. The SPEED questionnaire data collected in CL wearers are then compared to Rasch-analyzed CLDEQ-8 data collected in the same group of CL-wearing subjects to further evaluate the SPEED questionnaire's usefulness for characterizing DED in CL wearers.[18]

Methods

Study Design

The Mei Gland Adventure Booth was a cross-sectional study that was conducted at the American Academy Optometry's 2015 annual meeting (New Orleans, LA, USA). This study was open to all meeting attendees who were over the age of 18 years. Subjects were only excluded if they were unable to understand the study's documents (e.g., fluency in English was required). Institutional review board approval was obtained from the University of Waterloo (Office of Research Ethics application number [ORE#]: 20693), who approved all investigators who participated in this study. The conduct of this study was in accordance with tenets of the Declaration of Helsinki.

Informed consent was obtained from all subjects interested in participating in the study. The subjects were asked to complete a health privacy document before being officially enrolled in the study. Enrolled subjects were given an identification code; this allowed their data to be collected in a deidentified manner with an electronic tablet (iPad; Apple, Inc., Cupertino, CA, USA). The electronic tablet was first used to administer an investigator-designed survey (Qualtrics, Provo, UT, USA; in the public domain, https://www.qualtrics.com/) that asked the subjects about their demographics, self-reported dry eye status, self-reported meibomian gland dysfunction (MGD) status, and CL use. It was assumed that the self-reported disease statuses were relatively accurate since the preponderance of the subjects were optometric professionals. All subjects were asked to electronically complete the SPEED questionnaire and the CL wearers were also requested to complete the CLDEQ-8. Upon request, study personnel were allowed to help the subjects with the survey. When the survey was completed, the subject proceeded to a trained examiner (licensed optometrists) for the clinical assessment.

Objective testing was performed on the right eye only. CL-wearing subjects were allowed to wear their CLs during testing; this was allowed for convenience and to avoid disrupting the subject's tear film directly before testing. Tear meniscus height (TMH) (Keratograph 5M; Oculus, Inc., Arlington, WA, USA) and a phenol red thread test (PRT) (Zone-Quick; FCI Ophthalmics, Pembroke, MA, USA) were sequentially completed. Past research suggests that there are no significant differences between CL and non-CL wearers for TMH or PRT.[23,24] A single TMH image was taken for each subject, and TMH height was determined directly below the pupil by the examiner with the machine's embedded software.[17] A value greater than 0.2 mm was considered normal.[25] Investigators were trained to verify the quality of each TMH image, and they were instructed to obtain additional images if the first attempt did not meet study standards. PRT was completed and graded by the examiner as instructed by the manufacturer. Values greater than 10 mm after 15 seconds of testing were considered normal. After the study, subjects were classified as having assigned dry eye if they self-reported dry eye or MGD and had at least one clinical sign (TMH and/or PRT).

Statistical Analysis

Standard SPEED questionnaire and CLDEQ-8 scores were calculated (Supplementary Figs. S1, S2).[11,18] Rasch analyses were then used to score and evaluate the two questionnaires. Specifically, item fit to the Rasch model, functioning of the response categories, measurement precision, and unidimensionality of the questionnaires were assessed and evaluated using Winsteps Version 3.69.[5,21,26] "Item fit" is an indicator of how well each individual survey question adheres to the Rasch model expectations. For questions with poor fit to the Rasch model, the actual measured responses are not well predicted by the model, indicating something may be amiss with the characteristics of the particular question. Item fit was examined using the item infit mean square statistic; values between 0.6 and 1.4 were considered acceptable. In cases where an item had poor fit statistics, that item was removed and the analysis was repeated without it. Response category functioning was evaluated by determining whether respondents use the various response categories (e.g., "never" or "often") in a logical way, whether each category is actually used, and whether various categories should be collapsed to create a response structure that has fewer options. Response category functioning was examined by plotting the probability of a response in each response category against the Rasch person measure. Response category structures were deemed to be properly functioning if they were ordered, with the high probability of responding with a low category for those with low amounts of the measured trait and high probability of a response in high categories being for subjects with high amounts of the measured trait, and if there was a person measure location at which each response category was most likely to be used. Response category options were collapsed if there was disorder or if there were categories that were not used. Measurement precision is an indicator of the accuracy of a questionnaire is measuring a trait of interest. Questionnaires with good measurement precision allow for good discrimination between subjects with different amounts of the trait of interest. Measurement precision was assessed using the person-separation statistic, which is a ratio of the standard deviation of the measures to the error standard deviation,[27] with values greater than 2.0 considered acceptable. "Unidimensionality" is a fundamental assumption of Rasch analysis and means that a questionnaire measures only one trait of interest. Conversely, "multidimensionality" means that a

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Table 1. Demographics Information of Sample

Characteristic	CL Wearers (Mean ± SD)	Non-CL Wearers (Mean ± SD)
Subjects, *n*	150	134
Age, y	34.5 ± 12.6	40.6 ± 15.1
Female, %	66.7	55.3
Ethnicity		
White, %	63.3	72.4
African American, %	0.7	4.5
Asian, %	30.7	18.7
Other, %	5.3	3.5

questionnaire is measuring at least two, and possibly more, distinct traits. The unidimensionality of the questionnaires was assessed using a principal component analysis of the Rasch model residuals, with eigenvalues for the first contrast greater than 2.0 considered indicative of a second measured trait with the strength of at least two questions.

Once the item fit, category structure, measurement precision, and unidimensionality of the surveys was established, Rasch analysis was used to generate person measures for analyses of the relationships among survey scores and various clinical characteristics of subjects. The Rasch person measure is akin to the traditional sum score, but it is an interval-level measure that allows for valid statistical testing. Essentially, it is a single, interval-level score of the amount of the trait measured by the questionnaire possessed by an individual subject. Person measures in logits, or log of the odds of a particular response, which is the unit produced by the analysis, were transformed to a 0 to 100 scale for ease of interpretation. Higher scores were indicative of more severe symptoms.

A Mann-Whitney *U* test was used to determine if a survey was able to discriminate between disease and non-disease states. A Spearman's rank correlation analysis was used to evaluate the relationship between the SPEED-8 questionnaire and CLDEQ-4 (instruments described below) Rasch person measure scores and dry eye tests or status. The SPEED-8 questionnaire and CLDEQ-4 scores of CL wearers only were compared to determine the usefulness of the SPEED-8 questionnaire for understanding dry eye symptoms in CL wearers. Statistical testing was performed using statistical software (SPSS Version 24; IBM Corp., Armonk, NY, USA). Values of $P < 0.05$ were considered significant.

Results

Subjects

This study recruited a total of 284 subjects (150 CL and 134 non-CL wearers) over a 3-day period. The majority of the subjects were females (66.7%). The CL wearers (34.5 ± 12.6 years) were statistically significantly younger ($P < 0.001$) than the non-CL wearers (40.6 ± 15.1 years; Table 1), though the two groups were clinically similar in age. The CL and non-CL-wearing participant were similar in self-reported DED ($P = 0.71$), self-reported MGD ($P = 0.65$), diagnosed dry eye ($P = 0.052$), SPEED questionnaire scores ($P = 0.82$), and PRT ($P = 0.43$; Table 2). However, TMH measurements were significantly different between groups ($P = 0.0004$; Table 2), though both groups had TMH measurements that were within normal limits and the noted difference is not clinically significant because a clinician could not observe this small of a difference without advanced imaging.[25] The CL wearers had mildly symptomatic CLDEQ-8 scores of 13.3 ± 6.6 (symptomatic cut point is ≥12; Table 2).[28]

Table 2. Clinical Signs and Symptoms

Test	CL Wearers (Mean ± SD) *N* = 149	Non-CL Wearers (Mean ± SD) *N* = 130	*P* Value
TMH, mm	0.22 ± 0.11	0.27 ± 0.12	0.0004
PRT, mm	4.34 ± 5.08	3.93 ± 3.80	0.43
Self-reported DE, %	36.9	39.1	0.71
Self-reported MGD, %	19.6	17.3	0.65
Diagnosed DE, %	66.7	55.2	0.052
SPEED 8-item sum score	7.4 ± 4.7	7.3 ± 5.0	NA
SPEED 8-item Rasch score*	30.6 ± 14.1	30.2 ± 14.5	0.82
CLDEQ-8 sum score	13.3 ± 6.6	NA	NA
CLDEQ-8 Rasch score*	47.4 ± 11.4	NA	NA
CLDEQ 4-item sum score	7.6 ± 3.8	NA	NA
CLDEQ 4-item Rasch score*	42.6 ± 20.6	NA	NA

* Logits were converted to a 0 to 100 scale. Values of $P < 0.05$ were considered significantly different.

Rasch Analysis

A Rasch analysis containing all SPEED items, including the first items about timeframe of symptoms in addition to the questions about the frequency and severity of symptoms, was found to be multidimensional, or measure more than one trait, (first contrast eigenvalue = 7.7) and had poor measurement precision (person separation index = 0.42). Similar results were found with an attempt to include only the 3-month timeframe questions along with the frequency and severity of symptoms questions. An analysis without any of the symptom timeframe items showed that all remaining 8 items had acceptable response category functioning (the probability of responses by amount of the measured trait in each category was ordered in a logical way and all categories were utilized), infit statistics (all questions showed good fit to the Rasch model), and measurement precision (accuracy). Analysis of this 8-item set (SPEED-8) still showed evidence of slight multidimensionality, with the first contrast of the principal component analysis of model residuals having a value of 2.4 eigenvalues, indicating the measurement of a second trait with the strength of more than two questions. This was not improved by repeating the analysis after removal of items loading most strongly onto the first contrast of the principal component analysis (the two "fatigue" items). The SPEED-8 was used in all subsequent analyses (Supplementary Fig. S3). The Rasch analysis results for the published SPEED and SPEED-8 versions are reported in Table 3.

For the CLDEQ-8 in CL wearers, we found that the response category probability curves for item 8 ("removing your lenses") were disordered. Combination of categories 3 and 4 resulted in good functioning. With this category structure, item infit statistics and measurement precision were acceptable; however, principal component analysis of the residuals indicated the possibility of multidimensionality, with a first contrast eigenvalue of 2.2. The items most strongly loading onto this first contrast were those related to the frequency (loading = 0.80) and intensity (loading = 0.71) of blur. Removal of these two items and analysis of the remaining six items revealed evidence of unidimensionality (first contrast of principal component analysis eigenvalue = 1.6) with measurement precision intact (person separation index = 2.35); however, there was some evidence of slight misfit of the item on frequency of closing eyes (infit mean square = 1.42). An

Table 3. Rasch Analysis Summary Statistics for the Full SPEED and SPEED-8 Questionnaires, CLDEQ-4, and CLDEQ-8

Item Set	Mean Rasch Person Measure (SE)	Mean Rasch Item Measure (SE)	Person Separation Index	Item Reliability	Mean Item Infit Mean Square	Principal Component Analysis First Contrast Eigenvalue
SPEED (all items)	43.0 (0.2)	43.4 (2.5)	0.42	0.99	1.0	7.7
SPEED (8-item short form)	30.4 (0.8)	48.0 (2.0)	2.03	0.98	1.0	2.4
CLDEQ-8	47.2 (1.0)	54.4 (1.8)	2.40	0.97	1.0	2.2
CLDEQ (4-item short form)	42.6 (1.6)	53.7 (2.8)	2.55	0.96	0.99	1.6

analysis with this item removed revealed a similar misfit of the item on frequency of removal of CLs (infit mean square = 1.41). Removal of that item resulted in a four-item instrument (CLDEQ-4) with good measurement precision (person separation index = 2.55) and unidimensionality (first contrast of principal component analysis eigenvalue = 1.6). The CLDEQ-8 and CLDEQ-4 Rasch analysis results are reported in Table 3. The CLDEQ-4 was used in all subsequent analyses in this manuscript (Supplementary Fig. S4).

Questionnaire Associations with Self-Reported Disease

The Rasch person measure SPEED-8 questionnaire scores for self-reported dry eye and self-reported MGD for the overall population, CL and non-CL wearers are listed in Tables 4 and 5, respectively, and SPEED-8 questionnaire correlations with self-reported disease and clinical signs are reported in Table 6. In all cases, SPEED-8 questionnaire scores were significantly higher if a subject who indicated that they had self-reported DED or self-reported MGD (All P values < 0.001). SPEED-8 scores were also significantly associated with self-reported DED or self-reported MGD (All P values < 0.001), which indicates that the SPEED-8 questionnaire is a reasonable measure of patient-reported dryness symptoms in both CL- and non-CL wearing subjects.

The Rasch person measure CLDEQ-4 scores were significantly different between people with and without self-reported DED (55.50 vs. 34.82; $P < 0.001$) and with and without self-reported MGD (55.22 vs. 39.23; $P < 0.001$). CLDEQ-4 scores were significantly associated with self-reported DED or self-reported MGD (All P values < 0.001; Table 7). Together, these data suggest that the CLDEQ-4 shows promise as a measure of patient-reported dryness symptoms in CL wearers.

Questionnaire Associations With Clinical Signs

SPEED-8 questionnaire scores in the overall sample were not significantly associated with TMH ($r = 0.007$, $P = 0.90$) and PRT ($r = 0.004$, $P = 0.94$; Table 6). Similarly, SPEED-8 questionnaire scores were not associated with TMH ($r = -0.01$, $P = 0.88$) or PRT ($r = -0.01$, $P = 0.91$) in CL or non-CL wearers (TMH: $r = 0.005$, $P = 0.95$), PRT ($r = 0.02$, $P = 0.81$). Likewise, CLDEQ-4 scores in CL wearers were not significantly associated with TMH ($r = 0.025$, $P = 0.77$) or PRT ($r = 0.09$, $P = 0.28$; Table 7).

Table 4. SPEED-8 Questionnaire Scores by Self-Reported DE Status

Response	Overall (Mean ± SD)	CL (Mean ± SD)	Non-CL (Mean ± SD)
Dry eye ($n = 107$)	38.45 ± 10.93	38.11 ± 10.09	38.81 ± 11.84
No dry eye ($n = 175$)	25.56 ± 13.63	25.99 ± 14.11	25.06 ± 13.13

Positive and negative groups were significantly different for all conditions ($P < 0.001$). Rasch analysis was scaled to make all scores a maximum of 100.

Questionnaire Associations With Assigned DE Status

SPEED-8 questionnaire scores were found to be associated with assigned dry eye status (≥2 positive tests) in the overall sample (Spearman rho = 0.20, $P = 0.001$; Table 6) and in non-CL wearers (Spearman rho = 0.35, $P < 0.001$), yet SPEED-8 questionnaire scores were not found to be associated with assigned dry eye in CL wearers (Spearman rho = 0.06, $P = 0.47$). CLDEQ-4 scores were found to be associated with assigned dry eye in CL wearers (Spearman rho = 0.20, $P = 0.02$; Table 7). CLDEQ-4 scores correlated well with SPEED-8 questionnaire scores ($n = 150$, $r = 0.73$, $P < 0.001$).

Discussion

While the SPEED questionnaire has been previously validated, past work has primarily compared it to other commonly used dry eye questionnaires (e.g., OSDI).[11,15] The current study extends our knowledge by including CL wearers and by determining how the SPEED-8 questionnaire is associated with dry eye signs, self-reported DED, and assigned DED status. Specifically, this study performed a Rasch analysis of the SPEED questionnaire in 150 CL- and 134 non–CL-wearing subjects, an analysis that found evidence of significant multidimensionality. Furthermore, this study found that after removing the SPEED questionnaire's timing questions (1, at this visit; 2, within past 72 hours; 3, within past 3 months), the remaining 8 items (sections 2 and 3 of the questionnaire) showed acceptable measurement precision but still some evidence of slight multidimensionality, consistent with the recent Rasch analysis of Asiedu et al.[13] (127 subjects) of the 8-item SPEED questionnaire, which also found some evidence of multidimensionality.[11,13] Asiedu et al.[13] subsequently excluded the eye fatigue frequency and severity questions to produce a 6-item SPEED questionnaire, which they noted to have good measurement properties including unidimensionality. Our

Table 5. SPEED-8 Questionnaire Scores by Self-Reported MGD Status

Response	Overall (Mean ± SD)	CL (Mean ± SD)	Non-CL (Mean ± SD)
Meibomian gland dysfunction ($n = 52$)	38.76 ± 10.33	36.49 ± 10.44	41.62 ± 9.66
No meibomian gland dysfunction ($n = 229$)	28.50 ± 14.19	28.87 ± 14.40	28.09 ± 14.01

Positive and negative groups were significantly different for all conditions (all P values < 0.002). Rasch analysis was scaled to make all scores a maximum of 100.

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Table 6. Correlations Between SPEED-8 Questionnaire Scores and Clinical Factors

Test	SPEED-8	Self-Reported DE	Self-Reported MGD	TMH	PRT Test	Diagnosed DE
SPEED-8						
Correlation coefficient	1.000	**–0.458**	**–0.288**	0.007	0.004	**0.202**
P value	N/A	**<0.001**	**<0.001**	0.901	0.943	**0.001**
Subjects, *n*	284	**282**	**281**	283	283	**284**
Self-reported DE						
Correlation coefficient		1.000	**0.456**	−0.011	0.036	**–0.526**
P value		N/A	**<0.001**	0.851	0.553	**<0.001**
Subjects, *n*		282	**280**	281	281	**282**
Self-reported MGD						
Correlation coefficient			1.000	0.001	0.072	**–0.355**
P value			N/A	0.989	0.230	**<0.001**
Subjects, *n*			281	280	280	**281**
TMH						
Correlation coefficient				1.000	0.093	**–0.489**
P value				N/A	0.120	**<0.001**
Subjects, *n*				283	283	**283**
PRT Test						
Correlation coefficient					1.000	−0.060
P value					N/A	0.317
Subjects, *n*					283	283
Diagnosed DE						
Correlation coefficient						1.000
P value						N/A
Subjects, *n*						284

Significant ($P < 0.05$) correlations are shown in bold.

analysis of this same six-item set found that there was still some evidence of multidimensionality, and further refinement failed to improve the instrument. Ngo et al.[11] found that the eight-item set was unidimensional. It should be noted that these studies were conducted in subject samples with different characteristics. Asiedu et al.[13] may have come to a slightly different result because they analyzed glaucoma patients who all had dry eye symptoms while Ngo et al.[11] may have come to a slightly different conclusion because they had a smaller sample that likely had moderate to severe DED. Nevertheless, the amount of multidimensionality detected with the six and eight-item sets in the present study was relatively minimal, and all three studies could be considered to have come to similar conclusions with regard to the psychometric properties of the

Table 7. Correlations Between CLDEQ-4 and Clinical Factors

Test	CLDEQ-4	Self-Reported DE	Self-Reported MGD	TMH	PRT Test	Diagnosed DE
CLDEQ-4						
Correlation coefficient	1.000	**–0.502**	**–0.317**	0.025	0.088	**0.198**
P value	N/A	**<0.001**	**<0.001**	0.765	0.283	**0.015**
Subjects, *n*	150	**149**	**148**	150	150	**150**
Self-reported DE						
Correlation coefficient		1.000	**0.456**	−0.011	0.36	**–0.526**
P value		N/A	**<0.001**	0.851	0.553	**<0.001**
Subjects, *n*		281	**280**	281	281	**282**
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Correlation coefficient				0.001	0.072	**–0.355**
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Correlation coefficient					1.000	−0.060
P value					N/A	0.317
Subjects, *n*					283	283
Diagnosed DE						
Correlation coefficient						1.000
P value						N/A
Subjects, *n*						284

Significant ($P < 0.05$) correlations are shown in bold.

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SPEED questionnaire short forms. Overall, the present and past studies suggest that the first three timing questions on the SPEED questionnaire should be removed because they do not add value to the metric.

The current study also found that in CL and non-CL wearers the SPEED-8 questionnaire is a good predictor of self-reported DED and self-reported MGD, though the SPEED-8 questionnaire was not individually associated with the dry eye signs investigated in this study (PRT or TMH). Ngo et al.[11] likewise failed to consistently find an association between SPEED-8 questionnaire scores and dry eye signs, which is consistent with other commonly used dry eye surveys such as the OSDI.[17] Furthermore, the SPEED-8 questionnaire was associated with assigned DED in non-CL wearers, but not in CL wearers, a difference that may have occurred because dry eye and CL discomfort are similar conditions that likely have a differently underlying etiology.[29] While the underling etiology of these conditions may be different, as is the case with the many other type of dry eye that are evaluated with these questionnaires, having an instrument that is validated for evaluating symptoms from both populations is of great value to the studies that need to include both groups.

The SPEED-8 questionnaire's correlation with dry eye status in non-CL wearers is also corroborated by the past work of Ngo et al.[11] The somewhat contradictory results related to a lack of association between signs and symptoms is not entirely unexpected since it has been previously noted in the literature.[30] Nevertheless, the SPEED-8 questionnaire's positive association with self-reported DED in both CL and non-CL wearers and its association with assigned DED in non-CL wearers suggests that the SPEED-8 may be a good measure of dry eye symptoms in both populations, a conclusion that is also supported by our noted association between SPEED-8 questionnaire and CLDEQ-4 scores.

The CLDEQ-8 was thoughtfully synthesized from the CLDEQ (long form) to be able to quickly understand a CL wearer's symptoms and their CL coping mechanism while at the same time being able to measure changes in these metrics over time.[18,28] A CL-specific instrument is useful because CL wearers likely have a different underlying symptoms etiology than subjects who do not wear CLs.[31] Nevertheless, it would be beneficial for the scientific community to have an instrument like the SPEED questionnaire that was validated for use in both CL and non-CL wearers because both of these populations are frequently compared to each other in clinical studies. Therefore, this study attempted to understand the SPEED questionnaire's usefulness in CL wearers by comparing a Rasch-validated version of the SPEED questionnaire to a Rasch-validated contact lens questionnaire (CLDEQ-8), which this study used as a standard to determine if the SPEED was correctly detecting symptoms in subjects who were wearing CLs. Rasch analysis of the CLDEQ-8 resulted in a unidimensional 4-item questionnaire (contained the 2 dryness and 2 discomfort items) that had the ability to discriminate between people with and without self-reported DED and assigned DED. CLDEQ-4 scores were also highly correlated with SPEED-8 scores, suggesting that they were measuring a similar trait. Much like the SPEED-8 questionnaire, the CLDEQ-4 scores were not associated with dry eye signs, suggesting that the CLDEQ-4 may only be a good instrument for describing a CL wearer's dry eye symptoms status.

While this study had a number of strengths, which include a large sample, a comparison of CL and non-CL wearers, and a comparison between questionnaire scores and clinical factors, its limitations should also be considered. First, this study was only able to administer a limited number of tests because it was conducted at a professional meeting on subjects who did not have time set aside for research. Specifically, additional testing may have produced a clearer subject dry eye classification. Nevertheless, data collected by Ngo et al.[11] suggests that tests like corneal staining, tear break up time, and meibomian gland health are not associated with SPEED scores; therefore, if these additional dry eye tests were added, it is unlikely to have altered this study's conclusions. Likewise, the study primarily enrolled optometric professionals who are likely more aware of their ocular symptoms than the general population, which could potential limit this study's generalizability. Nevertheless, inclusion of optometric professionals is unlikely to have affected the main outcomes of this study because the Rasch analysis conducted in this experiment came to a similar conclusion to past work, which included samples that were much different than the present study.[11,13] Additionally, a large sample of subjects was enrolled over a 3-day period, which necessitated the use of trained volunteers. Although the investigators are confident that the data collected are accurate, less data variability may have been present if only one examiner had conducted all the assessments. Nevertheless, the exhibit hall study design has been previously implemented successfully, and it is able to generate clinically meaningful results such as describing the usefulness of using a clinical tear osmolarity instrument for understanding dry eye.[32]

In conclusion, this study found that both the original forms of the SPEED and CLDEQ-8 questionnaires suffer from some measurement deficiencies, though these improved following an item reduction process. Scores from both instruments were found to be associated with self-reported DED and poor predictors of DED signs. The SPEED-8 questionnaire was able to predict diagnosed DED in non-CL wearers, though it was not able to in CL wearers. Additionally, the SPEED showed some evidence of slight multidimensionality (meaning that it appears to measure more than one trait) that could not be eliminated with refinement. CLDEQ-4 scores were associated with DED status in this study of CL wearers. Therefore, while the SPEED-8 questionnaire likely does have some utility for understanding dry eye symptoms in both groups, the CLDEQ-4 may be preferable for evaluating dryness and discomfort in studies of only CL wearers. Nevertheless, this study did overall find that the SPEED-8 questionnaire provides a reasonable measure of dry eye symptoms in both CL and non-CL wearing subjects, which suggests that this instrument can be used as a direct comparison of symptoms when both groups are included in a study. Additional work should be done to see how other commonly accepted dry eye symptoms surveys like the OSDI perform in both CL- and non–CL-wearing subjects,[6,7] and likewise, further work should be performed to create an instrument that is able to predict dry eye signs and DED in both CL and non-CL wearers.

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References

1. Craig JP, Nichols KK, Akpek EK, et al. TFOS DEWS II definition and classification report. *Ocul Surf*. 2017;15:276–283.
2. Stapleton F, Alves M, Bunya VY, et al. TFOS DEWS II epidemiology report. *Ocul Surf*. 2017;15:334–365.
3. Methodologies to diagnose and monitor dry eye disease: report of the Diagnostic Methodology Subcommittee of the International Dry Eye WorkShop (2007). *Ocul Surf*. 2007;5: 108–152.
4. Korb DR, Herman JP, Greiner JV, et al. Lid wiper epitheliopathy and dry eye symptoms. *Eye Contact Lens*. 2005;31:2–8.
5. Pesudovs K, Burr JM, Harley C, Elliott DB. The development, assessment, and selection of questionnaires. *Optom Vis Sci*. 2007;84:663–674.
6. Dougherty BE, Nichols JJ, Nichols KK. Rasch analysis of the Ocular Surface Disease Index (OSDI). *Invest Ophthalmol Vis Sci*. 2011;52:8630–8635.
7. McAlinden C, Gao R, Wang Q, et al. Rasch analysis of three dry eye questionnaires and correlates with objective clinical tests. *Ocul Surf*. 2017;15:202–210.
8. McMonnies CW. Key questions in a dry eye history. *J Am Optom Assoc*. 1986;57:512–517.
9. Chalmers RL, Begley CG, Caffery B. Validation of the 5-Item Dry Eye Questionnaire (DEQ-5): discrimination across self-assessed severity and aqueous tear deficient dry eye diagnoses. *Cont Lens Anterior Eye*. 2010;33:55–60.
10. Johnson ME, Murphy PJ. Measurement of ocular surface irritation on a linear interval scale with the ocular comfort index. *Invest Ophthalmol Vis Sci*. 2007;48:4451–4458.
11. Ngo W, Situ P, Keir N, Korb D, Blackie C, Simpson T. Psychometric properties and validation of the Standard Patient Evaluation of Eye Dryness questionnaire. *Cornea*. 2013;32:1204–1210.
12. Lemp MA, Crews LA, Bron AJ, Foulks GN, Sullivan BD. Distribution of aqueous-deficient and evaporative dry eye in a clinic-based patient cohort: a retrospective study. *Cornea*. 2012;31:472–478.
13. Asiedu K. Rasch Analysis of the Standard Patient Evaluation of Eye Dryness Questionnaire. *Eye Contact Lens*. 2017;43:394–398.
14. Yang SN, Tai YC, Sheedy JE, Kinoshita B, Lampa M, Kern JR. Comparative effect of lens care solutions on blink rate, ocular discomfort and visual performance. *Ophthalmic Physiol Opt*. 2012;32:412–420.
15. Asiedu K, Kyei S, Mensah SN, Ocansey S, Abu LS, Kyere EA. Ocular Surface Disease Index (OSDI) versus the Standard Patient Evaluation of Eye Dryness (SPEED): a study of a nonclinical sample. *Cornea*. 2016;35:175–180.
16. Begley CG, Chalmers RL, Mitchell GL, et al. Characterization of ocular surface symptoms from optometric practices in North America. *Cornea*. 2001;20:610–618.
17. Pucker AD, Jones-Jordan LA, Li W, et al. Associations with meibomian gland atrophy in daily contact lens wearers. *Optom Vis Sci*. 2015;92:e206–e213.
18. Chalmers RL, Begley CG, Moody K, Hickson-Curran SB. Contact Lens Dry Eye Questionnaire-8 (CLDEQ-8) and opinion of contact lens performance. *Optom Vis Sci*. 2012;89:1435–1442.
19. Rasch G. *Probabilistic Models for Some Intelligence and Achievement Tests*. Copenhagen: Danish Institute for Educational Research; 1960.
20. Mallinson T. Why measurement matters for measuring patient vision outcomes. *Optom Vis Sci*. 2007;84:675–682.
21. Bond TG, Fox CM. *Applying the Rasch Model. Fundamental Measurements in the Human Sciences*. 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates; 2007.
22. Boone WJ, Staver JR, Yale MS. *Rasch Analysis in the Human Sciences*. Dordrecht: Springer; 2014.
23. Bitton E, Jones L, Simpson T, Woods C. Influence of the blink interval on tear meniscus height in soft contact lens and nonlens wearers. *Eye Contact Lens*. 2010;36:156–163.
24. Miller WL, Doughty MJ, Narayanan S, et al. A comparison of tear volume (by tear meniscus height and phenol red thread test) and tear fluid osmolality measures in non-lens wearers and in contact lens wearers. *Eye Contact Lens*. 2004;30:132–137.
25. Koh S, Ikeda C, Watanabe S, et al. Effect of non-invasive tear stability assessment on tear meniscus height. *Acta Ophthalmol*. 2015;93:e135–e139.
26. Linacre JM. Winsteps Rasch Measurement Computer Program. Available at: www.winsteps.com. Accessed December 1, 2017.
27. Linacre JM. A User's Guide to Winsteps. Available at: http://www.winsteps.com/winman/copyright.htm. Accessed December 1, 2017.
28. Chalmers RL, Keay L, Hickson-Curran SB, Gleason WJ. Cutoff score and responsiveness of the 8-item Contact Lens Dry Eye Questionnaire (CLDEQ-8) in a large daily disposable contact lens registry. *Cont Lens Anterior Eye*. 2016;39:342–352.
29. Nichols JJ, Willcox MD, Bron AJ, et al. The TFOS International Workshop on Contact Lens Discomfort: executive summary. *Invest Ophthalmol Vis Sci*. 2013;54:TFOS7–TFOS13.
30. Nichols KK, Nichols JJ, Mitchell GL. The lack of association between signs and symptoms in patients with dry eye disease. *Cornea*. 2004;23:762–770.
31. Chalmers RL, Begley CG. Dryness symptoms among an unselected clinical population with and without contact lens wear. *Cont Lens Anterior Eye*. 2006;29:25–30.
32. Caffery B, Chalmers RL, Marsden H, et al. Correlation of tear osmolarity and dry eye symptoms in convention attendees. *Optom Vis Sci*. 2014;91:142–149.

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