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Original Article

Equating Two Health-related Quality of Life Instruments Applied to Cancer Survivors Who Underwent Palliative Care

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Background: Equating is a statistical procedure used to create a common measurement scale across two instruments. Item-level information should be taken into consideration so that scores can communicate interchangeably across the instruments.

Objects: To investigate a common measurement scale across two health-related quality of life questionnaires (HRQOL) applied to various cancer survivors who underwent palliative care in healthcare institutions.

Methods: A total of 139 cancer survivors who underwent palliative care were recruited from two rehabilitation hospitals and an oriental medicine hospital. Participants consisted of various cancer survivors who presented to the sites for palliative care. They were asked to fill out Korean versions of the World Health Organization Quality of Life (WHOQOL-BREF) and EuroQOL-5 dimension (EQ-5D) questionnaires following the palliative care. For the item level comparison, the Rasch rating scale model was used to investigate how participants regarded individual test items of two instruments in relation to item difficulty calibrations.

Results: All items except the three items fit the Rasch model. One item (anxiety/depression) of the EQ-5D and two items (dependence on medical aids and negative feelings) of the WHOQOL-BREF are misfit. The WHOQOL-BREF targets the survivors well, while the EQ-5D is able to target the survivors with lower HRQOL levels with some ceiling effects. By inspecting the item difficulty calibrations of the two instruments, five items of the WHOQOL-BREF are selected as common items in relation to the EQ-5D. These five items are considered compatible with each other. Differential item functioning (DIF) analysis reveals that the healthcare item of the WHOQOL-BREF vs the self-care item of the EQ-5D exhibits significant DIF.

Conclusion: Findings suggest that one paired item should be taken into consideration when equating the WHOQOL-BREF and the EQ-5D applied to cancer survivors who underwent palliative care.

INTRODUCTION

Globally, cancer is the second leading cause of death and the burden of cancer is estimated at 18.1 million new cases and 9.6 million deaths [1]. The number of new cancer cases in Korea is 282.8 per 100,000 per year, and cancer mortality is slightly higher among men than women. It is estimated that 37% of Korean are projected to have cancer at some in point their lifetimes [2]. In recent decades, as progress in the early detection and treatment of cancer has led to a dramatic increase in the number of cancer survivors, palliative care for cancer survivors is now an inevitable part of care in the course of the disease. Palliative care helps the survivors to manage the symptoms and the side effects resulting from cancer treatments. In 2019, the World Health Organization (WHO) calls for the integration of early palliative care being implemented not only for managing adverse effects and complications from cancer treatments, but also for improving quality of life (QOL) [1,2]. Palliative care is now being practiced in many clinical settings across the world and primarily focuses on survivor's adaptation to such an overwhelming circumstance. Evidence proves that palliative care can enhance health-related quality

of life questionnaires (HRQOL) in the course of illness [3-7]. Therefore it is essential to determine how palliative care impacts on HRQOL and optimally measure the HRQOL over time in a suitable manner [8-10].

HRQOL measures an individual's perceived levels of satisfaction and general well-being in relation to either specific or general health conditions [9-11]. The generic HRQOL instrument is applicable across a wide range of various illness populations. Of these generic HRQOL instruments, an instrument developed by the World Health Organization Quality of Life (WHOQOL) group is the most widely accepted instrument focusing on a need for a genuinely international use of HRQOL and holistic aspects of person's well-being [10-12]. Later, the abbreviated version of the WHOQOL instrument (i.e., WHOQOL-BREF) is developed with reduced number of items (i.e., 26 items) and considered a gold standard for cancer-related populations [12]. The EuroQOL 5-dimension (EQ-5D) instrument with five items is another widely used and well-established instrument to measure HRQOL in cancer-related conditions [13-17]. Other than these two instruments for measuring HRQOL, a myriad of HRQOL instruments has been developed and tested for use in various disease groups [18-22].

Although these instruments have proved to be valid and reliable, scores obtained from two instruments cannot be compared to one another. This lack of communication across the instruments impedes clinicians from using two test scores interchangeably [23]. The incompatible scores often occur when an instrument is developed by targeting the average patients. That is, the instrument commonly becomes more likely to be sensitive to the patients with average ability than one with low or high ability. Although both instruments are solely designed to measure the impact on HRQOL, scores are often incompatible in the sense that the measures on the same trait have their own separate yardstick [24]. Therefore, these two instruments cannot communicate one another. Moreover, in most cases, total scores obtained from different instruments are not compatible with each other despite measuring the same construct, but must be equated [10,25,26].

Equating is a procedure used to create a common measurement scale across two or more instruments so that two scores obtained from the instruments become compatible with each other. While the WHOQOL-BREF and EQ-5D instruments are developed to examine the impact of health status on QOL, both instruments are created differently in many aspects, such as the number of items and item definitions. Therefore, investigators may have to focus on creating a conversion table between two instruments by equating methods (e.g., creating a translation table between TOEFL and TOEIC scores for language proficiency testing). However, the conversion table commonly reveal that equated scores vary. Additionally, despite measuring the same construct, total scores obtained from two instruments often fail to be sensitive to a wide range of various severity levels. These psychometric characteristics generally arises from applying a difficult instrument to population groups with a low ability or vice versa. These are inherited drawbacks of classical test theory (CTT)-based HRQOL instruments, which are unable to provide information about the HRQOL at the item level [9]. Hence, most scores, if not all, obtained from CTT-based HRQOL instruments typically lead to ceiling or floor effects due to a lack of sensitivity to the wide range of various ability groups. These limitations have prompted authors to call for optimal measures that directly scrutinize individual test items rather than total scores of the HRQOL instruments [23,27-29].

Rasch measurement model (1-parameter item response theory [IRT] model) focuses on item level psychometric properties estimated by probability of an individual's response to test item. Using the probabilistic mathematical model, the person ability and item difficulty can be estimated. These estimated measures are presented as a unit of measurement called a logit (i.e., log-odds unit) providing invariant measures over time. That is, the invariant property represent that the logit scale never changes: 1) to whomever one may apply and 2) with whichever the measurement assesses. These properties enable one to investigate how well the item difficulty match with the person ability (i.e., item person match) and how differently the items of two instruments respond with respect to different abilities for survivors (i.e., differential item functioning [DIF]) which identifies items might be measuring different [30]. Thus. the DIF allows comparing the response patterns and the consistency of item performance across two instruments.

The purposes of this study are: 1) to investigate how the Rasch model can be applied to determine the item level psychometric properties, 2) to demonstrate how the item difficulty calibrations differently function, and 3) to present how the common items to selected for equating the Korean versions of WHOQOL-BREF and EQ-5D instruments applied to cancer survivors.

MATERIALS AND METHODS

1. Measurement

As two means of HRQOL measurement, the Korean versions of WHOQOL-BREF developed by the WHOQOL group and the EQ-5D instruments developed by the EuroQOL group. The WHOQOL-BREF is one of the best-known instruments that has been developed for a QOL and is available in more than 40 languages. The instrument consists of two items on general QOL and 24 items on four domains representing physical capacity, psychological, social relationships, and environmental domains. Twenty-four items of the four domains are rated with a 5-point frequency of experience rating scale (i.e., 1: not at all and 5: completely) for the past 2 weeks following the palliative cares provided by the institutions. While all items are positively phrased except for three items, the negatively phrased questions are reversely scored. Thus, scores indicate that the higher the score and the greater the status of HRQOL of the survivors. The Korean version of the WHOQOL-BREF used in this study is validated by Min et al. [31]. The EQ-5D consists of five items representing five domains of HRQOL: 1) mobility, 2) self-care, 3) usual activities, 4) pain and discomforts, and 5) depression and anxiety. The items are rated on five categories of severity on each question. The scores of the EQ-5D can be converted into an index score ranged from 0 to 1, which can provide insight into ways to determine the status of HRQOL. For the present study, raw scores are used for direct comparisons with the WHOQOL-BREF. For the interpretation of the scores, this indicates that the higher the score, the greater the status of HRQOL. The Korean version of EQ-5D used in this study is validated by Kim et al. [17]. The WHOQOL-BREF and the EQ-5D instruments were administered simultaneously to the participants after the EQ-5D upon completion of institution visit for the palliative care.

2. Study Participants

This study is a part of a project to explore the impact of health status on the QOL for various cancer survivors underwent palliative cares at two rehabilitation and an oriental medicine hospital between April 16, 2018 and October 11, 2019. This study was conducted with convenience samples from the three health care institutions during the periods. The palliative care consists of: 1) consultations with a team of health care professionals who develop individualized care plan to ameliorate common side effects that can be caused by cancer related treatments and 2) to improve QOL for the survivors. All participants provided written informed consent to participate in this study. After obtaining the consent, participants are asked to fill out the Korean versions of WHOQOL-BREF and EQ-5D instruments. An inclusion criterion was that the cancer survivors who completed medical interventions for their cancer conditions underwent any palliative care in the institutions at least more than once. Participants were excluded if the survivors' condition was not indicated for the palliative care by their physicians. The study was approved by the Institutional Review Board of College of Health and Welfare, Woosong University (IRB no. 1041549-170711-SB-52).

Following a year and 6-month data collection period, useable data was received from the hospitals. While data was received on a total of 156 survivors, only data from survivors with completing two instruments (N = 139) were used for the present study. Sixty-five percent (n = 91) of the participants were females and 45% (n = 48) were males with an average age of 57.2 (ranged from 42.0 to 90 years of age). Nearly 30% (n = 42) were diagnosed with breast cancer and 64.7% (n = 90) were diagnosed with various cancers (in the order of stomach, lung, and other cancers) while 5% (n = 7) were not specified on diagnosis.

3. Data Analysis

Winsteps® software program (ver. 3.57.2; Winsteps.com, Chicago, IL, USA) using rating scale model was used to determine: 1) the dimensionality with fit statistics, 2) the item difficulty calibrations, and 3) the item-person map of the WHOQOL-BREF and the EQ-5D instruments. The criteria for optimal fit statistic of the survey data were determined by Bond and Fox [32]'s suggestion, where mean squares (MnSq) fall between 0.6 and 1.4. If fit statistics of individual items are out of ranges, it is considered to be misfit. These indicate that the survivor's responses to the particular items may be considered as an unexpected way. That is, the survivors may interpret those items in differently ways than the items originally intended to measure.

By applying the Rasch model to the raw scores, the estimate of person ability and item difficulty can be obtained in a log-odd unit (i.e., logit). Logits are logarithmic transformation of item and person ability scores converted into interval scales, where the scales are based on the ratio of the probability of success over failure on an item at a particular rating scale.

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Thus, items that are of greater challenge receive higher item calibrations, while items that are less challenge receive lower item calibrations. These converted logits scales can now produce the same results no matter who applies it and whichever the instrument is used. One can logically expect that items with greater difficulty require more challenges, while items with less difficulty require less challenges. For example, it is generally known that women underwent surgery of the breast may tend to report increased problems in emotional functioning rather than other physical-related problems due to the better prognosis [33]. Logically, it would be expected that for cancer survivors with breast cancer, items of negative feeling and bodily image would be more challenging than items of transport and home environment in the context of HRQOL.

RESULTS

Tables 1 and 2 present item difficulty calibrations, fit statistics, and Z-score standardized to determine the dimensionality of the EQ-5D and the WHOQOL-BREF (excluding two general items) instruments. All items, except the three items (anxiety/depression item of the EQ-5D and dependence on medical aids and negative feelings items of the WHOQOL-BREF), exhibit acceptable fit statistics. Item difficulty calibrations of the two instruments are ranged from 39.06 to 53.39 for the WHOQOL and from 32.87 to 52.94 for the EQ-5D.

In an item level comparison to select common items between the two instruments, the hierarchically paired items are listed (Tables 1, 2). Five items of the WHOQOL-BREF are selected with respect to the item difficulty calibrations with items of

Table 1. Fit statistics of the EQ-5D in descending order of difficulty

EQ-5D	Difficulty	Infit MnSq	Infit ZSTD	Outfit MnSq	Outfit ZSTD
EQ-5D 4 pain/discomfort	52.94	0.84	−1.2	0.85	−1.1
EQ-5D 3 usual activities	51.33	0.74	−2.2	0.64	−2.9
EQ-5D 1 mobility	44.25	0.97	−0.1	1.12	0.6
EQ-5D 5 anxiety/depression	43.37	1.66	4.1	1.53	3.5
EQ-5D 2 self-care	32.87	0.64	−2.0	0.46	−1.8

EQ-5D, EuroQOL-5 dimension; MnSq, mean square standardized residuals; ZSTD, Z score standardized.

Table 2. Fit statistics of the WHOQOL-BREF in descending order of difficulty

WHOQOL	Difficulty	Infit MnSq	Infit ZSTD	Outfit MnSq	Outfit ZSTD
WHOQOL 4 Dependence of medical aids	53.39	1.59	4.7	1.89	6.4
WHOQOL 21 Sexual activity	53.20	0.98	−0.1	1.03	0.3
WHOQOL 18 Work capacity	51.74	0.88	−1.1	0.84	−1.4
WHOQOL 14 Leisure activity	51.54	1.10	0.9	1.08	0.7
WHOQOL 12 Financial support	50.49	1.08	0.7	1.13	1.0
WHOQOL 16 Sleep and rest	50.09	1.30	2.6	1.43	3.4
WHOQOL 11 Bodily image	49.31	0.93	−0.6	0.93	−0.6
WHOQOL 5 Positive feeling	48.80	0.86	−1.3	1.03	0.3
WHOQOL 10 Energy for daily life	48.77	0.82	−1.6	0.80	−1.6
WHOQOL 13 Accessibility of information	48.08	0.96	−0.3	0.95	−0.4
WHOQOL 17 Activities of daily living	47.68	0.70	−3.0	0.73	−2.6
WHOQOL 8 Security	47.16	0.82	−1.5	0.81	−1.5
WHOQOL 23 Home environment	46.96	1.02	0.2	1.05	0.5
WHOQOL 19 Self-esteem	46.88	0.70	−2.8	0.70	−2.8
WHOQOL 15 Mobility	45.93	0.87	−1.2	0.84	−1.3
WHOQOL 9 Physical environment	45.84	0.92	−0.6	0.90	−0.7
WHOQOL 22 Social support	44.02	1.16	1.3	1.16	1.2
WHOQOL 7 Concentration	43.51	1.07	0.6	1.06	0.5
WHOQOL 3 Pain	43.39	1.22	1.8	1.41	2.7
WHOQOL 20 Personal relationship	42.22	0.81	−1.6	0.81	−1.6
WHOQOL 6 Personal belief	41.90	1.09	0.8	1.07	0.5
WHOQOL 26 Negative feeling	40.47	1.30	2.1	1.56	3.3
WHOQOL 24 Health care	39.63	0.95	−0.3	0.93	−0.5
WHOQOL 25 Transport	39.06	0.88	−0.9	0.88	−0.9

WHOQOL-BREF, World Health Organization Quality of Life; MnSq, mean square standardized residuals; ZSTD, Z score standardized.

pain, physical environment, financial support, work capacity, and healthcare (Table 3).

The hierarchical order of item difficulty calibrations of the two instruments is visually investigated using item-person map. The Rasch model places the survivors and items on to the same linear continuum with anchored to zero value (Figure 1). The average item difficulty of the WHOQOL-BREF target the survivors throughout their person ability (i.e., HRQOL levels), while that of the EQ-5D target only the survivors with low ability with some ceiling effects (Figure 2). The five common paired items of two instruments are listed in boxed.

By plotting those five paired-item difficulty calibrations across two instruments, differential item DIF is investigated. The DIF analysis reveals that the healthcare item of the WHOQOL-BREF vs the self-care item of the EQ-5D exhibits significant DIF (Figure 3).

Table 3. Item difficulty of the WHOQOL-BREF in descending order of difficulty

Item	Difficulty (logits)	Difficulty (logits)	Item
EQ-5D 4	52.94	58.52	WHOQOL 18
EQ-5D 3	51.33	56.99	WHOQOL 12
EQ-5D 1	44.25	49.82	WHOQOL 9
EQ-5D 5	43.37	45.08	WHOQOL 3
EQ-5D 2	32.87	39.59	WHOQOL 24

WHOQOL-BREF, World Health Organization Quality of Life; EQ-5D, EuroQOL-5 dimension.

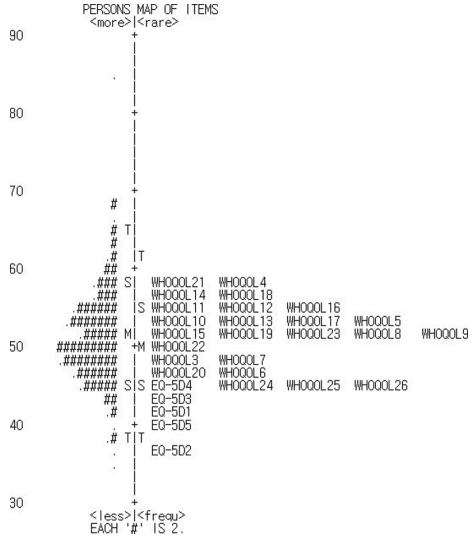

Figure 1. Item-person map of the EQ-5D and the WHOQOL-BREF. The graph shows person ability measures (left) and item difficulty measures (right) with the 0–100 converted score following the Rasch analysis. WHOQOL-BREF, World Health Organization Quality of Life; EQ-5D, EuroQOL-5 dimension.

DISCUSSION

Using Rasch rating scale model (1-parameter IRT), this study explored how item-level analysis might be integrated to select common items across two well-established HRQOL instruments. The primary feature of Rasch rating scale model yields invariant item difficulties calibrations by estimating the probability of selecting a particular rating for an individual item of the WHOQOL and the EQ-5D. Furthermore, the Rasch model places the item difficulty and person ability (i.e., HRQOL levels) on the same linear continuum (i.e., item-person map). These methods permit "connecting" individual's responses to particular items at the survivor's HRQOL level with invariant item difficulty calibrations [32]. The invariance property means that once those instruments are calibrated to a common

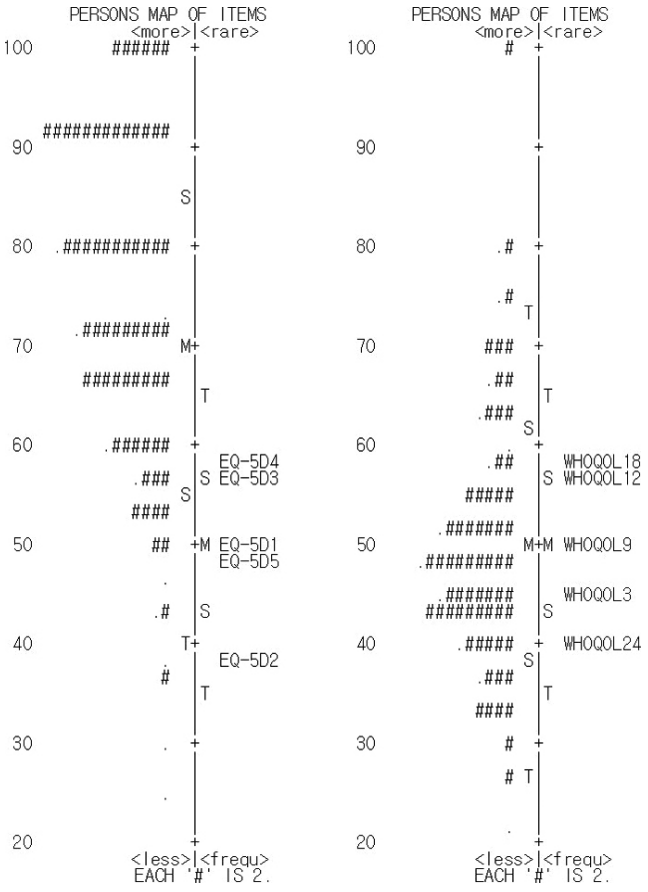

Figure 2. Item-person map of the EQ-5D (left) versus the five items of the WHOQOL-BREF (right). The graph represents item difficulty measures on the right side of each map with 0–100 converted score and the person ability measures on the left side following the Rasch analysis. Each analysis is anchored on the average item difficulty measure to 50 for comparisons. The 'M' represents the average item calibrations for both instruments. WHOQOL-BREF, World Health Organization Quality of Life; EQ-5D, EuroQOL-5 dimension.

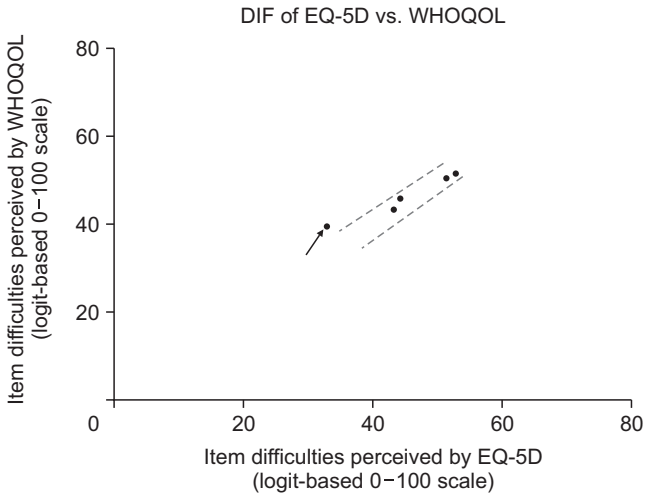

Figure 3. DIF plots for the EQ-5D items versus the five items of the WHOQOL-BREF. The dashed lines connecting the filled dots represent the upper and lower 95% confidence intervals. The measures were converted to 0–100 score from logits following the Rasch analysis. DIF, differential item functioning; WHOQOL-BREF, World Health Organization Quality of Life; EQ-5D, EuroQOL-5 dimension.

metric, estimates of person ability and item difficulty do not vary across test items and the cancer survivors. Additionally, by inspecting the survivors' response pattern, one can visually predict whether particular items are more or less challenging in relation to item difficulty calibrations. This feature is used to determine five common items from the WHOQOL-BREF instrument. As test items are presented in the order of item difficulty calibrations, one can logically expect that easy items require less challenges while difficult items require more challenges. This logical decision-making procedure was taken into consideration in the selection of the common items.

By selecting common items across two HRQOL instruments, scores of a single instrument can be compatible with the scores of the other instrument (i.e., test equating). While traditional equating methods are available on test equating, equating methods using IRT model are known for more accurate and stable [24,25,34,35]. The equating across the instruments may be a promising method. Of those methods, the item-level analysis using 1-parameter IRT model was applied to the WHOQOL-BREF and the EQ-5D on cancer survivors underwent palliative care.

The present study demonstrated that acceptable fit statistics, except anxiety/depression item of the EQ-5D, and dependence on medical aids and negative feelings items of the WHOQOL-BREF, were exhibited. This indicates that responses from the cancer survivors were not predictable in terms of item difficulty calibrations. That is, many survivors may misinterpret those items and respond with erratic patterns. In addition, despite the EQ-5D and the WHOQOL-BREF being most widely accepted and proven to be reliable and valid for various populations, there may be some substantial shortcomings due to the property of incompatibility across two result scores. The property, in general, arises from developing an instrument based on CTT. Most CTT-based instruments often lead to ceiling or floor effects when item difficulty and person measures are not considered [8]. With the Rasch rating scale model, the present study provides valuable insight into the concept of item difficulty in which the cancer survivor responses to test items in the order of item difficulty along with the survivor's ability levels. In the present study, the WHOQOL-BREF was able to properly measure the HRQOL of cancer survivors throughout the whole range of HRQOL levels, while the EQ-5D was sensitive only the survivors with low HRQOL levels. Versions of the EQ-5D typically show some ceiling effects [9,15-17].

By inspecting the survivor's responses with respect to the person ability (i.e., HRQOL level), one can logically predict that less or more challenging items would be optimal for a particular survivor with item-person map analysis. The item-person map, hierarchically ordered item difficulty calibrations along with the level of HRQOL of the survivors, was somewhat supported by the previous studies. The most challenging item of the two instruments was item 4 (dependence of medical aids; physical domain) in relation to item difficulty calibrations the present study. Lin et al. [36] tested psychometric evaluation of Taiwanese version of the WHOQOL-BREF across cancer survivors and proposed that the physical domain score was rated with the most challenging within the instrument. The major reason for this finding is may be that physical distress, in general, resulting from the course of the cancer treatments, which would dramatically reduce the chances of getting physical recovery better. As such, cancer survivors may regard the dependence of medical aids as a challenging item.

In addition, we selected five items from the WHOQOL-BREF for common items that exhibited similar item difficulty calibrations and further analyzed to determine whether the paired items across the WHOQOL-BREF and the EQ-5D would differently function in relation to their HRQOL levels (i.e., DIF). The DIF analysis in the WHOQOL-BREF versus the EQ-5D need to be taken into consideration for being equating two instruments. Although these two instruments are developed based

on the same theoretical concept, selected five items are now equated across the two instruments with item-level analysis using Rasch rating scale model. Wang et al. [34] provide convincing arguments to support the equating methods such as mean equating, which is CTT-based method. However, the authors propose that IRT models can resolve the interdependency problem by combining ability and item parameter in one model. By combining person ability (i.e., HRQOL level) and item difficulty calibrations in Rasch rating scale model, item-level analysis of two well-established HRQOL instruments provided some evidence for equating with five items though there was an apparent difference in item difficulty calibrations.

The limitations of the study are: 1) those characteristics of methodology that uses institution-based cohort of various cancer survivors. Needless to say, interpretations drawn from multicenter data may be limited by selection bias, since the survivors' HRQOL levels is influenced by various cancer conditions. 2) In addition, limited sample size cannot produce positive results on this equating study. Thus, future studies with an acceptable sample size can provide insight into equating across a myriad of HRQOL instruments.

CONCLUSIONS

The focus of the present study is primarily on item-level analyses using Rasch rating scale model in measuring HRQOL for cancer survivors who underwent palliative care at institutions. Findings suggest that one paired item, self-care and health care items, should be taken into consideration when equating the WHOQOL-BREF and the EQ-5D applied to cancer survivors who underwent palliative care. In clinical settings, the physical therapist is likely to be strongly based on an HRQOL instrument of cancer survivors, while the HRQOL instrument is likely to be strongly based on the survivor's views of their QOL in everyday life. Physical therapists should realize the discrepancy between the HRQOL instruments in their views.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: BC. Data curation: SB, BK, JS. Formal analysis: BC, HK. Funding acquisition: BC. Investigation: BC. Methodology: BC. Project administration: HK. Resources: HK, SB, BK, JS. Software: HK. Supervision: BC. Validation: BC. Visualization: HK. Writing - original draft: BC, HK. Writing - review & editing: BC, HK, SB, BK, JS.

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