Equating Parallel Forms of the Health-Related Physical Fitness Knowledge Test Using Confirmatory Factor Analysis and Rasch Model According to the Trait Latent Theory

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Most of researchers are building and standardization the parallel forms of knowledge tests in the physical education and sport areas by assessing the psychometric characteristics according to the classical measurement theory, which may lead to low equating levels. It directs to use advanced strategy treatment to investigate the internal and external equating, latent structural and psychometric characteristics of the parallel forms of knowledge tests to solve the problems and weaknesses related to parallel forms equating for knowledge test. The study aims to use the Rasch Model under the Modern Measurement Theory and the Confirmatory Factorial Analysis as the advanced strategy treatment. The Health-Related Physical Fitness Knowledge Test used as experimental model in this study, which have two parallel forms and each of them includes 50 items spread over six major dimensions. The study used the descriptive survey approach. Non-probability sample selected by voluntary participation style of youth aged stage, who enrolled in secondary school and university. The results showed the goodness of fit for parallel forms of knowledge test according to Rasch Model and structural equation modeling, which refers to the quality level of the internal and external structural equating for both forms of the knowledge tests.

Keywords: Physical fitness, Knowledge test, Measurement, Evaluation

Introduction

Since the psychometrics movement ware found, the scientific researchers interested to achieve the validity and reliability of the tests and scales, sought to achieve the highest degree of objectivity in these tools, when used in the measurement process. The measurement is essential to physical education and sport sciences. It must be trustworthy and accurate. It must tell something about the persons who were measured and be conceptually useful for testing theoretical contentions about how people behave in sport and exercise settings. The purpose of measurement in sport and exercise knowledge domain is to provide the state of knowledge about central issues in measurement as well as to outline and review existing tools and methods in research areas in the knowledge domain. (Gershon & ET. Al., 2012).

According to the measurement classical theory, it can express true score of individual's ability, which appeared through his performance in the test. Therefore, it will change according to change in the test level. Therefore, the test and items will change according to change in individual's characteristics.

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So, the scientist's efforts have resulted in the emergence of some new trends in the measurement and evaluation fields, and among these trends to respond to the single Item Response Theory or Latent Traits Theory has received this new entrance interest for the researchers to overcome many of the measurement traditional problems. (Slah, 2005; Laila, 2005; Ayman, 2006; Ahmed, 2012)

The Latent Trait Theory is a general framework that examines individual ability based on both individual responses to items and properties of item difficulty and discrimination parameters. The theory focuses on the features of items used to construct reliable scores for a knowledge test. Item responses linked to the ability of the individual, and the matrices of the item difficulties and individual ability are the same typically in z-score units. The item difficulty requires two features approaches, the first is probabilistic models and the second is matrices of individual ability as an items difficulty. The item discrimination under latent trait theory related to relationship between responses to an item and performance on the rest of the knowledge test forms. In the Item Response Theory, it describes how well an item can differentiate the probability that individuals with different ability levels will endorse the positive response. The basic idea of Rasch Model is the probability of responding to an item correctly increases as the latent variable increases. (Slah, 2005a; 2011b; Nasr, 2006)

For a long time Pearson's correlation was the only method for validation. Therefore, another notable validity-related change occurring over the past several decades is the richness of statistical methods for test validation and reliability. The test construction validation replaced by factor analysis techniques. Thereafter, the factor analysis was extended too many other construct approaches or variable modeling techniques, such as path analysis, confirmatory factor analysis, structural equation modeling, latent variables analysis and Rasch item response curve model. Therefore, the new software specific for factor analysis became available and convenient to use for validation process. (Sobhy, 2005)

The multiple forms of a knowledge test are often used to measuring the same trait construction. To enable comparisons among scores from different forms, it must be set on the same scale. The statistical process of setting two or more forms onto the same scale is called equating. The equivalence reliability coefficient calculates a traditional equating procedure or modern equating procedure under the Item Response Theory, when developed to one or more parallel or equivalent forms of a knowledge test in physical education and sport domains. Therefore, it should first determine the internal and external equating of two forms by analysis the items test content validation, difficulty and discrimination coefficients.

The Confirmatory Factor Analysis is used to study the relationships between a set of observed variables and a set of continuous latent variables. When the observed variables are categorical, Confirmatory Factor Analysis is also referring to as the Item Response Theory analysis. The Confirmatory Factor Analysis is a type of the Structural Equating Modeling that deals specifically with measurement models and a structural model that is, the relationships between observed measures and latent variables or factors. The measurement model for both confirmatory factor analysis and

structural equating modeling are a multivariate regression models that describes the relationships between a set of observed dependent variables and a set of continuous latent variables. The observed dependent variables are referring to as factor indicators and the continuous latent variables are referring to as factors. The relationships are described as a set of Linear Regression Equations for continuous factor indicators, a set of censored normal or censored-inflated normal regression equations for censored factor indicators. The Confirmatory Factor Analysis framework provides many other analytical possibilities or invariance of the factor model over time or informants. Therefore, the Confirmatory Factor Analysis should conduct prior to the specification of the Structural Equation Model. (Slah, 2005; Mohmed, 2012; Timothy, 2015; Jerry & ET. Al., 2015).

Hierarchical confirmatory factor analysis models depict at least one construct as a second-order factor, which is not directly measure by any indicator. This exogenous second-order factor is also presumed to have direct effects on the first-order factors, which have indicators. These first-order factors are endogenous and thus do not have unanalyzed associations with each other. Instead, their common direct cause, the second-order factor, is presumed to explain the covariance among the first-order factors. Hierarchical models of trait, in which a general ability factor is presumed to underlie more specific ability factors, are examples of theoretical models that have been tested with hierarchical confirmatory factor analysis. (Rex, 2011; Timothy, 2015; Jerry & ET. Al., 2015)

So that, it directs to use advanced strategy treatment to investigate the internal and external equating, latent structural and psychometric characteristics of the parallel forms knowledge tests to solve the problems and weaknesses related to parallel forms equating for knowledge tests. Thus, the current study aims to investigate the advanced strategy treatment to equating process for parallel forms of the Health-Related Physical Fitness Knowledge Test by using the Rasch model under the modern measurement theory or the Trait Latent Theory and the Confirmatory Factorial Analysis.

Method

The study used the descriptive survey approach with the new measurement theory and the confirmatory factorial analysis method to achieve the study aims.

Participants

Non-probability sample selected by voluntary participation style of youth aged stage. The sample core categories and the total number of 165 students are from Egyptian male students residing in Qatar and different social, cultural and economic levels, who enrolled in secondary school and university during the academic year 2014/2015. The following table (1) shows the basic sample demographics.

Table (1) the study sample demographic characteristics (n=165)

Variables	Mean	S.D.	Asymmetry	Kurtosis
Age	19.64	1.51	1.28	1.81
Height	168.12	14.79	1.67	1.34
Weight	71.95	6.83	1.32	1.92
BMI	23.81	2.27	1.64	1.76

Measures

The Health-Related Physical Fitness Knowledge Test was used as experimental model in this study, because it is consistent with the Rasch model hypotheses. It has been also construction, standardization, adjusting and applied periodically on a large scale in some countries of the world. It has been a good psychometric characteristics and scientific transactions, which are acceptable to measure the knowledge and information of physical fitness related health. The knowledge test have two parallel forms and each of them includes 50 items spread over six major dimensions, which are the concept of fitness, scientific principles of exercise, physical fitness components, the effects of exercise on the diseases risk factors, exercise prescription and the other factors. The two forms translated from English to Arabic version, to use in the current study as a data collection after standardization process. (Zhu, 1999; Xiaofen & et. Al., 2009a; 2013b, Castilli, 2007; James, 2013; Elena, 2014)

Procedure

The data are collected through different ways to calculate the internal and external equating of knowledge test parallel forms. The psychometric characteristics - validity, reliability and objectivity – are evaluated in two ways, which are the Classical Measurement Theory and the Latent Trait Theory. The items are analyzed by calculating the difficulty and discrimination coefficient. They calculated according to the Rasch model. The components structural of knowledge test parallel forms are estimated by exploratory factorial analysis to investigate the structure validity of two parallel forms after translation into Arabic language by principle components method. The Confirmatory Factorial Analysis used to examine the structural equation modeling and evaluate the results for goodness of fit about model, which indicates the quality level of the equating for knowledge test parallel forms. Once the study described, the participators had an opportunity to participate in the study by completing the Health-Related Physical Fitness Knowledge Test. The researcher did instruction and testing. Data analyzed according the aim phases and steps of the study.

Statistical Analysis

The study used different statistics methods to achieve the aims. The data were analyzed by using three statistical analysis program packages for the social sciences. They are SPSS -version 20.0 package, Winsteps - version 3.73- Rasch model item analysis and LISERAL -v8.80-programs. The statistical analysis of the data variables consists of a means, standard deviations, asymmetry, kurtosis, two-way ANOVA, Pearson correlation coefficient, exploratory factorial analysis by principle components method and confirmatory factorial analysis. The level of statistical significance was set at 5%. (Jerry & ET. Al., 2015)

Results and Discussion

The phase one of study: The data was analysis according to the research problem, objectives, methodology and the research sample characteristics. Therefore, the following table (2) shows the Psychometrics characteristics statistically significant values.

Table (2) the Psychometrics Characteristics for Two Test Forms Specification (N1=47)

	Knowledge test Dimensions	Form1				Form2			
		No. items	Dimension Mean	Item difficulties Mean	Item *discrimination Mean*	No. items	Dimension Mean	Item difficulties Mean	Item *discrimination Mean*
1	Concept of fitness	4	1.87	0.44	0.47	4	2.19	0.52	0.47
2	Scientific principles of exercise	11	6.72	0.57	0.41	12	7.48	0.46	0.44
3	Physical fitness components	12	6.18	0.49	0.45	12	7.28	0.58	0.46
4	Effects of exercise on the diseases risk factors	3	1.83	0.51	0.42	3	1.74	0.48	0.51
5	Exercise prescription	11	6.94	0.59	0.48	10	5.15	0.56	0.53
6	Other factors	9	5.17	0.53	0.43	9	5.83	0.57	0.49
	Total score	**50**	**30.71**	**0.52**	**0.44**	**50**	**31.14**	**0.53**	**0.48**

The previous table shows the knowledge test specification and psychometric parameters according to classical measurement theory. The knowledge test is covering the three cognitive levels, which they are a knowledge, comprehension and application.

Reliability

According to the Classical Measurement Theory, the knowledge test forms were standardized into the Arabic version. The data were collected in pilot study to calculate the reliability coefficients by using Split-half method, the Cronbach's Alpha coefficient and interclass correlation Coefficient, which reflects the reliability of the knowledge test forms and internal consistency. The table (3) shows the reliability and validity coefficients for forms.

Table (3) the Reliability and Self-Validity Coefficients for knowledge Test forms (n1=47)

Knowledge test	items	Mean	S.D.	Spearman - Brown coefficient	Interclass correlation Reliability	Guttman coefficient	Alfa coefficient	Self - validity	Forms Correlation
Form1	Odd	14.28	1.57	0.82	0.91	0.77	0.91	0.95	90.8
	Even	14.79	1.63						
Form2	Odd	14.76	1.71	0.80	0.88	0.75	0.88	0.94	
	Even	14.55	1.76						

** r value is statistically significant at the level 0.05*

The reliability coefficients of the knowledge test forms were at high values with small measurement errors in, which indicates the statistically acceptance of the knowledge test for use in current study as collection tool data. The reliability and self-validity coefficient values were statistically significant at ($p<0.05$) and that reflects the high internal consistency validity and reliability of the Health-Related Physical Fitness Knowledge Test forms.

Construct Validity (validation process)

The phase two of study: The validation process included two steps. The first step involved the production of an Arabic version of the knowledge test, which is semantically equivalent to the original version. A forward-backward translation was performed. A native English bilingual translator produced the first Arabic draft from the original version. An Arabic bilingual expert check the Arabic draft then back translated the items into English to cross-validate them. In the second step, we evaluated the psychometric properties of the Arabic version, including its internal consistency validity and reliability, differential item functioning, external validity, and acceptability. It used also the data from pilot study to calculate the matrix of correlation coefficients between the items and their dimensions. The correlation between each item and its contributive dimension was higher than the correlation with other dimensions. Internal consistency was acceptable for each dimension. In addition, the total of knowledge test scores for each form was determined the internal consistency of the Health-Related Physical Fitness Knowledge Test. The results appeared that all correlation coefficients were statistically significant ($p> 0.05$) and all of which fulfilled the conditions of internal consistency with the overall degree. Item-discriminated validity results were acceptable for every dimension of the knowledge test. The construct validity used to compare between the high and low quartile of sample in the Health-Related Physical Fitness Knowledge Test.

Internal structure analysis

After that, it investigated the correlation matrix, which was used in the exploratory factorial analysis process to display the relationships between individual items at each form. Prior to the extraction of the factors, several tests were used to assess the suitability of the respondent data for the factor analysis. These tests included the Kaiser Measure of Sampling Adequacy, and the Bartlett's Test of sphericity. The principal components analysis method used as extraction method to determine the factor structure simplifying of each form items. The orthogonal rotation used by the Varimax technique, which maximizes high item loadings and minimizes low item loadings. The table (4) shows the factorial analysis results.

Table (4): Total Variance Explained by Exploratory Factorial Analysis (n_1=47)

Components	Form (1)				Form (2)			
	Before Rotation		After Rotation		Before Rotation		After Rotation	
	Eigenvalues	Variance	Eigenvalues	Variance	Eigenvalues	Variance	Eigenvalues	Variance
1	16.92	33.84%	8.17	16.34 %	14.81	29.62%	8.14	16.28%
2	3.97	7.94%	7.19	14.38 %	4.39	8.78%	5.97	11.94%
3	2.71	5.42%	6.11	12.22 %	2.83	5.66%	5.75	11.50%
4	2.53	5.06%	4.22	8.44%	2.26	4.52%	3.99	7.98%
5	1.13	2.26%	1.59	3.18%	1.08	2.16%	1.43	2.86%
6	1.02	2.04%	1.001	2.00%	1.00	2.00%	1.09	2.18%
	Cumulative%	**56.56%**	**Cumulative %**	**56.56 %**	**Cumulative%**	**52.74%**	**Cumulative%**	**52.74%**

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy and the Bartlett's Test of Sphericity ($p<0.05$) were also used to assess the suitability of the respondent data for factor analysis. The researcher interoperated the results, which knowledge test items load and attribute to a factor, therefore he give each factor a suitable name according to the items meaning and conception. The structure of the six factors fixed and supported by principal components analysis with the Varimax Rotation and accounted the total variance. The names of factors are concept of fitness, scientific principles of exercise, physical fitness components, and effects of exercise on the diseases risk factors, exercise prescription, and other factors.

Statistical analysis of items

The phase three of study: A according to modern measurement theory and Rasch model assumption, the knowledge test Item forms were analysis by calculated the difficulty and discrimination parameters according to the Rasch model. Reliability and validity of measures meaning and interpretation provided within the framework of Rash model analysis. The items of knowledge test for each form parameters were estimating, which they are the difficulties and discrimination parameters. In addition, the item calibration, ability estimation, items characteristic curve model parameter, items information function, and test information function, and item-person map were estimating for each form of the Health-Related Physical Fitness Knowledge Test. Finally, the goodness of fit was estimating according to Rasch model assumption. The table (5) shows the Rasch Model summery analysis results.

Table (5) Rasch Model Summery Analysis Fit Statistics of Person and Item for Test Forms

	Parameters (n_2=106)		Model S.E.	INFIT		OUTFIT		PTMEA CORR.	RMSEA	S.E.	Separation
				MNSQ	ZSTD	MNSQ	ZSTD				
Form1	Item	M.	0.18	1.02	0.0	1.03	0.0	0.92	0.21	0.19	4.53
		S.D.	0.03	0.30	1.2	0.40	1.6				
	Person	M.	0.22	0.96	-0.4	1.02	-0.1		0.23	0.15	5.46
		S.D.	0.04	0.48	1.9	0.64	2.3				
Form2	Item	M.	0.19	1.01	0.0	1.04	0.0	0.91	0.19	0.18	4.48
		S.D.	0.02	0.40	1.3	0.38	1.5				
	Person	M.	0.23	0.98	-0.3	1.01	-0.2		0.23	0.14	5.32
		S.D.	0.03	0.47	1.8	0.62	2.1				

Table (5) presents the summary statistics for the Health-Related Physical Fitness Knowledge Test based on the analysis of data using Rasch model. The statistics show the mean Infit and Outfit of two knowledge test forms for person and item, the mean squares are close to 1.0, which indicate that in general the data had shown acceptable fit to the model. In current study, the researcher adopted the range of acceptable fit between 0.7 and 1.3, for both fit indices, because Infit values greater than 1.30 and smaller than 0.70 are labeled problematic. The mean standardized Infit and Outfit for person is between -0.4 and -0.1 for form1 and between -0.3 and -0.2 for form2.

The standardized outfit is within acceptable range of Rasch measurement (± 1.0). The mean standardized Infit and Outfit for items is located at zero for two forms. This indicates the items measures are slightly over-fit and that the data fit the model somewhat better than expected for each form. The standard deviation of the standardized Infit is an index of overall misfit for persons and items. For the form1, the standardized Infit/Outfit standard deviation for persons is between 1.9 and 2.3 and standardized Infit/Outfit standard deviation for items is between 1.2 and 1.6. For the form2, the standardized Infit/Outfit standard deviation for persons is between 1.8 and 2.1 and standardized Infit/Outfit standard deviation for items is between 1.3 and 1.5. All show an overall acceptable fit.

Separation is the index of spread of the person or item positions. Separation of 1.0 or below indicates the items may not have sufficient breadth in position. For persons and item, separation index is indicating approximately the number levels of person ability and item difficulty. Person and item separation and reliability of separation assess instrument spread across the trait continuum. Separation also

determines reliability. Higher separation in concert with variance in person or item position yields higher reliability. The form1 reliability estimate for this data is 0.92 and the form 2 reliability estimate for this data is 0.91, which indicate items forms are replicable for measuring similar traits. That means a equating of two forms for measuring the health related physical fitness knowledge.

The structural equation modeling:

The phase fourth of study: The confirmatory factorial analysis used to examine the structural equation modeling and evaluate the results for goodness of fit about multidimensional conceptual model, which they indicate the quality level of the equating for the Health-Related Physical Fitness Knowledge Test parallel forms. By using the Likelihood Maximum method, the estimation and testing goodness of fit of hypothesized models calculated by LISERAL programs, which is show the descriptive fit of goodness absolute and comparative index values. The table (6) shows the values of fit of goodness indexes.

Table (6) The Absolute and Comparative Fit of Goodness Indexes (n_2=106)

Indexes	/df x2	GFI	AGFI	NFI	PNFI	CFI	IFI	RFI	RMSEA
Criterion	**2.0:5.0**	**0:1**	**0:1**	**0:1**	**0:1**	**0:1**	**0:1**	**0:1**	**0.05:0.08**
Form1	3.25	0.92	0.87	0.95	0.85	0.96	0.92	0.84	0.047
Form2	2.91	0.93	0.91	0.92	0.88	0.97	0.94	0.86	0.041

Table (6) presents the summary statistics for the structure of the Health-Related Physical Fitness Knowledge Test established with a confirmatory factor analysis providing satisfactory indicators, which they classified to absolute and comparative indexes. Strongest correlations of each item in their own dimension and between dimensions showed in statistics results. Finally, the Arabic version of the Health-Related Physical Fitness Knowledge Test forms was established by a confirmatory factor analysis. Results of the Confirmatory Factor Analysis showed that the model converged with a good index of overall fit and confirmed the satisfactory structure of the Arabic version of two forms. The Confirmatory Factor Analysis showed an interesting correlation between different knowledge test dimensions.

Conclusion

The study aims to use the Rasch model under the modern measurement theory and the confirmatory factorial analysis as the advanced strategy treatment. The both forms Arabic version of the Health-Related Physical Fitness Knowledge Test is valid and reliable according to classical and modern measurement theory. In the point view of validity and reliability parameters, the Arabic version of the Health-Related Physical Fitness Knowledge Test forms has good psychometric characteristics. It is a certain and safe scale, so it can be used to measure the knowledge level of health-related physical fitness. The two forms are equable according to the results from the Confirmatory Factor Analysis and Rasch characteristics model. The results showed the goodness of fit for parallel forms of knowledge test according to the trait latent theory and structural equation modelling, which refers to the quality level of the internal and

external structural equating for both forms of the Health-Related Physical Fitness Knowledge Test.

Therefore, the recommendation from current study could use the proposal of advanced strategy technique, which refer to a scientific treatment approach, and it can used when the researchers need to investigate and standardize the internal and external parallel forms equating for knowledge test in the physical education and sport domains. It could be a practical step to solve the problems and weaknesses related to the parallel forms equating process for knowledge test. In addition, it supports the improvement of the psychometrics quality and applied sustainability of knowledge test parallel forms.

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