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Validating the Coping Scale for Chinese Athletes using Multidimensional Rasch Analysis

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Abstract

Objective: The Coping Scale for Chinese Athletes (CSCA) was developed and validated using classic testing theory in 2004 (Chung, Si, Lee, & Liu, 2004). This study aimed to validate CSCA using multidimensional Rasch analysis with the ConQuest software programme.

Method: The sample in this study comprised 367 athletes from mainland China. A Multidimensional Rating Scale model was applied to investigate the validity of the four-dimension scale. Standard fit statistics (Infit and Outfit MNSQ) and Differential item functioning (DIF) were computed to examine the model-data fit. Test reliability and category functioning were also checked.

Results: The item difficulty and the athletes' trait level of coping were calibrated along the same latent trait scale. Three items were removed from the scale due to misfit with the Rasch model. No DIF across gender was found for the remaining 21 items. Test reliabilities for the four subscales ranged from 0.66 to 0.76. The results also indicated that the orginal 5-category rating scale structure did not function well.

Conclusion: The multidimensional Rasch analysis supported that the 21-item CSCA measures four latent traits of coping of Chinese athletes as expected. The results also domstrated advantages of multidimensional Rasch analysis over unidimensional Rasch analysis as well as traditional approach in examing the quality of multidimensional scale in sport settings.

Key words: Coping; Chinese athlete; multidimensional Rasch analysis; model-data fit

Validating the Coping Scale for Chinese Athletes using Multidimensional Rasch Analysis

Individuals often experience stress when they perceive an internal or external demand as taxing, exceeding their resources, and threatening to their well-beings (Lazarus & Folkman, 1984). Although it is beyond question that stress exists in everybody's daily life, special attention should be paid to athletes, given that they have to meet demanding physical and psychological requirements during long-lasting and difficult training sessions and are often exposed to highly stressful events during contests. Stress could have negative impact on athletes' performance by causing nervousness, attention deficit, misbehavior, low-confidence, undesirable levels of anxiety, psychological burnout, and sports injury (Hoar, Kowalski, Gaudreau, & Crocker, 2006; Scanlan, Stein, & Ravizza, 1991). In general psychology, coping is defined as "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" (Lazarus & Folkman, 1984, p.141). How athletes appraise and cope with stressful events across a variety of sports has attracted much attention (e.g., Campen & Roberts, 2001; Gaudreau, Nicholls, & Levy, 2010; Giacobbi, Foore, & Weinberg, 2004; Hammermeister & Burton, 2001; Holt & Hogg, 2002; Lafferty & Dorrell, 2006; Nieuwenhuys, Hanin, & Bakker, 2008; Thelwell, Weston, & Greenlees, 2007) in recognition of the detrimental subsequences of stress, and of its relationship with coping.

Conceptual framework for coping

Various coping strategies are frequently categorized into higher-order dimensions concerning conceptualization and measurement of coping. In their pioneer study, Lazarus and Folkman (1984) made a distinction between two dimensions of coping: problem-focused coping (PC) and emotion-focused coping (EC). PC aims at problem-solving, and refers to minimizing the distress by relieving or eliminating the source of threat through cognitive and behavioral efforts. EC refers to strategies which are used to control emotion and distress, even if the source of threat remains unchanged. In addition to Lazarus and Folkman's two-dimensional structure, a third dimension of coping, namely avoidance coping (AC), was proposed by Endler & Parker, (1990a, 1990b, 1994). AC refers to perceptive and behavioral avoidance of stressors, such as cognitive distancing from the stressors to reduce tension caused.

However, the application of these frameworks, which were developed in western culture, to different cultural contexts is debatable. As pointed out by Gauvin and Russel (1993), cultural factors need to be taken into account when studying and measuring constructs in sport. Aldwin (2007) also argued that culture is a key factor influencing individuals' coping with stress because coping is a social process. It is clear that the societal influences should be carefully studied when investigating athletes' coping (Anshel & Si, 2008). Unfortunately, very few studies on coping for athletes in eastern cultures have been conducted and reported in the international sport psychology literature (Anshel, Kim, Kim, Chang & Eom, 2001). Notable exceptions include those carried out by Korean researchers. For example, Yoo and his associates (Yoo, 2000; Yoo & Park, 1998) proposed a fourth dimension in addition to the three coping dimensions mentioned (i.e., PC, EC, AC); namely, transcendence coping (TC). TC refers to a unique psychological mechanism of self-acceptance that is deeply rooted in eastern culture and values harmony, modesty, self-discipline, self-restraint, and transcendence (Yoo, 2000).

Measurement of coping

Based on the two-dimension (PC and EC) model, Lazarus and Folkman (1985) developed the 'Ways of Coping Questionnaire' (WOCQ). This questionnaire was modified in versions to accommodate sport contexts. For example, Madden and colleagues (Madden, Kirkby, & McDonald, 1989; Madden, Summers, & Brown, 1990) developed the 'Ways of Coping for Sport'; however, very little validity evidence was available (Crocker, Kowalski, & Graham, 1998). By adding some sport relevant items, and deleting or rewording some other items in the original WOCQ, Crocker (1992) modified the WOCQ to measure athletes' coping. Nevertheless, there are criticisms (e.g., Crocker et al., 1998; Gaudreau & Blondin, 2002) concerning the validity of data collected with these measures since these questionnaires failed to replicate the factorial model of the original WOCQ, and the factor structure varied across different research settings.

The 'COPE Inventory' was developed by Carver, Scheier, and Weintraub (1989) as a response to concerns of the WOCQ, including ambiguous item meaning and factor instability. Subsequently, Crocker and Graham (1995) developed a sport version of the COPE entitled the ‘Modified-COPE’ (MCOPE). MCOPE comprises nine scales from the original COPE and three additional scales. Each scale has four 5-point Likert-type items. Studies (e.g., Crocker & Graham, 1995; Eklund, Grove, & Heard, 1998) provided reasonable empirical support for the reliability of MCOPE.

Endler and Parker (1990a) developed the ‘Coping Inventory for Stressful Situations’ (CISS), which contains 48 items and measures three dimensions of coping; i.e., task-oriented coping, emotion-oriented coping, and avoidance-oriented coping. The internal consistency for the three subscales is above 0.80 for all. Test-retest reliability over a 6-week period ranged from 0.59 to 0.72 (Endler & Parker, 1990b). Prapavessis, Grove, Maddison, and Zillmann (2003) used CISS in sport settings with necessary modifications. In their study, the Cronbach’s Alpha coefficients for the three subscales ranged from 0.82 to 0.94.

Nonetheless, measurement of athletes’ coping in the Chinese culture still faced two major challenges. First, most of the available instruments were borrowed from general psychology or health disciplines and, therefore, some items might not be appropriate for applications in sport settings. Such contextually irrelevant items might lead to psychometrical problems (Ben-Porath, Waller, & Butcher, 1991). Second, when administering instruments based on western culture to Chinese athletes special attention needs to be paid to cultural factors.

Based on Yoo's (2000) culturally-specific model, Chung, Si, Lee, and Liu (2004) developed the 'Coping Scale for Chinese Athletes' (CSCA) which incorporated the conceptual coping framework developed in western culture with elements of Chinese culture. For example, unlike the Western societies emphasize individualism and pragmatic positivism, the Chinese traditional cultures value the harmonious social relationships and life stresses were often regarded as "suffering" determined by fate (Phillips & Pearson, 1996). Consequently, acceptance of such suffering might act as a coping strategy due to belief that it repays the debts of previous lives and is a kind of self-cultivation or self- transcendence (Chung, Si, Lee, & Liu, 2004; Phillips & Pearson, 1996). The CSCA takes into account the four dimensions of coping highlighted earlier, namely PC, EC, AC, and TC, which have strong cultural relevance to the Chinese. In the conceptual framework of the CSCA, and in line with Yoo's (2000) conception, PC refers to efforts in recognition and/or behavior to change the source of stress; EC refers to efforts in controlling negative emotion caused by stressors; AC refers to efforts in recognition and/or behavior to escape from stressors; and TC refers to strategies from Confucianism and Taoism, which emphasize self-cultivation and transcendence, to deal with stressors.

Items of CSCA came from interviews with Chinese athletes (e.g., Si, Chung, & Lee, 2002; Yan, 2004) and from existing coping scales (e.g., Carver et al., 1989; Folkman &

Lazarus, 1985; Yoo, 2000), with necessary modifications to ensure content relevance to sport settings, as well as culture relevance to Chinese respondents. The final version of CSCA comprises four subscales designed to measure athletes' PC, EC, AC, and TC respectively. Each subscale contains six 5-point Likert-type items, ranging from 1 (Never) to 5 (Always). Some example items are: "Solve the problem step by step" (PC); "Try to calm myself down" (EC); "Escape from the stressful environment or situation" (AC); "It's my fate" (TC). In a validation study of CSCA using data from Chinese athletes, Chung et al. (2004) found that the CSCA subscales have reasonable internal consistency. The Cronbach's Alpha coefficients for PC, EC, AC, and TC are 0.73, 0.78, 0.75, and 0.73 respectively. Confirmatory factor analysis conducted to assess the construct validity of the scale with a four-factor model showed that the model had acceptable fit for the data. The χ^2/df equals to 1.56,Comparative Fit Index (CFI) for the model is 0.911, and the Root Mean Square Error of Approximation (RMSEA) is 0.046.

Although the CSCA has been validated using classical test theory, further investigation of the measurement properties of the CSCA using modern test theory (e.g., Rasch analysis; Wright & Masters, 1982) will equip researchers with more robust confidence in applying the scale in a wider context. This is especially meaningful considering that the CSCA is the first culturally-specific instrument for measuring Chinese athletes' coping and, as such, its remarkable application potential to a huge population of athletes in China.

Rasch model

The arithmetical property of interval scales is fundamental to any meaningful measurement (Wright & Linacre, 1989). Nevertheless, traditional analytical techniques are usually based on true-score theory and the raw data are not interval data, which only indicate ordering without any proportional meaning. In this sense, it is not appropriate to apply a factor analytic approach, which has been widely used for exploring or confirming the factor structure of measurement scales directly to non-interval raw data. These non-interval raw data must be constructed into sample-distribution free and item-distribution free measures before they can be analysed using statistics requiring linear, interval data input (Wright, 1997). The Rasch model (1960, 1980) overcomes this problem by transforming non-interval raw data into logit scale measures, which have constant interval meaning and provide objective and linear measurement from ordered category responses (Linacre, 2006a). Furthermore, the Rasch analysis prevails over traditional psychometric analysis of measurement by calibrating the individuals and items on a unidimensional scale. In other words, both individuals and items can be placed on an ordered trait continuum (Bond & Fox, 2007). In such a way, direct comparisons between person abilities and item difficulties can be easily conducted, based on their locations on the trait continuum.

Both general methods in the factor analytic approach for instrument construction – exploratory factor analyses and confirmatory factor analyses – have deficiencies in building objective measurement. Exploratory factor analyses, stated by Marsh (1993), give researchers little control over the resulting factor solutions. Researchers have no way to test any a priori factor structure; what the data produces is the final result. This limitation is also echoed in sport studies (e.g., Crocker et al., 1998). In terms of confirmatory factor analyses, although it allows researchers to test their a priori factor structures, and provides indices to judge the degree of match between the proposed factor structure and the empirical data, it fails to construct an objective and fundamental measurement. This is because the data serve as a "reality" and the proposed factor model is used to account for those data only. In other words, in confirmatory factor analysis, when the proposed model cannot explain the data properly, the model is modified and parameters redefined until the revised model fits the data well enough. Even though this is done for one sample of data, more modification and redefinition is necessary for a new sample. Consequently, it is almost impossible to obtain a stable and unique structure of a construct because the samples change and the factor loadings vary among the different studies. In this sense, it is no wonder that the modified versions of WOCQ for sport settings had unstable factorial structure across research settings (Crocker et al., 1998; Gaudreau & Blondin, 2002). Thus, instead of building up an objective scale that can be used to measure coping under the inevitable variety of different circumstances, researchers relied on factor analysis to form the scale factor. In general, IRT models including the two-parameter models, three-parameter models, and the graded response model share in common a “the model fits the data” position, and in the application process, these models manipulate different parameters in order to accommodate different observed data sets (Linacre, 2003). In contrast, the Rasch model requires that “the data fit the model”. This means the collected data must meet specific a prior requirements in order to achieve fundamental measurement (Andrich, 2004; Yan & Bond, 2011). Two- or three-parameter IRT models do have analytical advantages. For instance, these models tend to have better data-model fit than the Rasch model has because in the model fitting procedures used by two- or three-parameter IRT methods, a model that best fits the data is selected. Instead, in the Rasch approach, the data are compared against the (a prior specified) Rasch model in computing the model-fit. However, item response curves of different items can cross in two- or three-parameter IRT models since variant discrimination parameters are allowed. This results in sample-dependent estimation of item difficulties and violates the assumptions of invariant measurement (Linacre, 2003). In contrast, in Rasch analyses, persons and items can be calibrated onto the same invariant scale (Wright, 1992). The prior standards make sure that a scale constructed in one study can be applied directly to data collected in another context. The measurement results under different circumstances can then be communicated in a stable framework. This feature provides a stronger basis for constructing fundamental measures from raw data.

As argued by Tenenbaum, Strauss, and Büsch (2007) that the application of Rasch model in sport sciences is promising from both a methodological and a content-related perspective, Rasch analysis has been increasingly applied in sport and exercise studies in recent years (e.g., Anshel, Weatherby, Kang, & Watson, 2009; Strauss, Büsch, & Tenenbaum, 2007; Tenenbaum & Fogarty, 1998; Zhu, Timm, & Ainsworth, 2001). However, no attempt has been found to investigate the coping construct in sport settings with Rasch models. As argued by Waugh (2003), the advantages of constructing a scale of coping include: calibrating a measure of coping from low to high as the item difficulty increases from easy to hard along the same scale; transforming the ordered responses into interval data; and checking the functioning of response categories.

In this study, the CSCA measurement scale, comprising 5-point Likert-type items, was to be validated for Chinese athletes. Further, the ordered response alternatives were kept invariant for all items in the scale. Consequently, the Rating Scale model (Wright & Masters, 1982) was considered appropriate for fitting the data collected through CSCA. Nevertheless, given that coping is a multidimensional self-regulation construct in theory (Lazarus & Folkman, 1984; Endler & Parker, 1990a; 1994) and most of instruments for measuring coping - including CSCA - comprise different but correlated dimensions, a multidimensional Rasch model (Adams, Wilson, & Wang, 1997) is considered more appropriate than a unidimensional Rasch model to assess the measurement properties of CSCA. A multidimensional model can simultaneously calibrate all subscales and increase the measurement precision by taking into account the correlations between subscales.

The advantages of multidimensional approach are especially salient when the lengths of the subscales are short and the correlations among them are generally high (Wang, Yao, Tsai, Wang, & Hsieh, 2006). Therefore, a multidimensional Rasch Rating Scale model was used in the present study.

The present study aims to make use of multidimensional Rasch analysis to validate the dimensionality of the CSCA, and to investigate the measurement properties of the scale, such as: reliabilities of subscales; model-data fit of items; the coverage of item difficulty; and category functioning of the rating scale.

Method

Participants

Participants for this study comprised a sample of 367 Chinese athletes from national- or provincial-level sport teams at the time of survey, including 226 (61.6%) males and 141 (38.4%) females within the age range 14 to 37 years (mean age = 20.5 years, SD = 3.3 years). The participants had a mean of 6.6 years (SD = 3.6) of sports training experience, and a range of 1 to 22 years of training. Participants spread across 17 types of sport including both individual events, e.g., athletics, badminton, boxing, chinese kickboxing, taekwondo, archery, swimming, cycling, shooting, kayak, and chess, and team events, e.g. water ballet, water polo, basketball, baseball, football, and rowing.

Data analysis

First of all, Winstep version 3.0 software (Linacre, 2006b) was used to check whether the items in each subscale satisfy the two basic assumptions of Rasch measurement: unidimensionality and local independence. Unidimensionality requires that the measurement should target one attribute or dimension at one time (Bond & Fox, 2007, p. 32), and local independence refers to the assumption that the response to one item should have no influence on the responses to any other item within the same test (Wright, 1996). At the same time, the point-biserial coefficient, which is an index of item discrimination, for each item was computed to show whether all items had empirically equal item discrimination as is required by Rasch analysis. A multidimensional Rasch Rating Scale model was then fit to the data in this study. The ConQuest version 2.0 software (Wu, Adams, Wilson, & Haldane, 2007) was used to conduct the multidimensional Rasch analysis. The CSCA was treated as a multidimensional scale containing four unidimensional subscales and the calibration of the four subscales are conducted simultaneously in ConQuest. A number of indices including the Outfit statistics, the Infit statistics, and the Rasch reliability were utilized to check the quality of the scale from a Rasch measurement perspective. Both Outfit and Infit mean square error (MNSQ) are measures of the extent to which the data match specifications of a Rasch model. Mathematically, they are the mean value of the squared residuals. A residual is the difference between the observed value and the value predicted by the model. Consequently, the larger the squared residual, the larger was the misfit between data and model. The difference between Outfit and Infit statistics lies only in the way they are computed. Computation for the Infit statistics takes into account how closely the item difficulty level aligns with the person's ability level. More weight is given to those items that have better alignment to the person's ability level in computing the Infit statistics because, it is argued, that responses to these items carry more information about the person's ability. On the other hand, computation for Outfit statistics is not weighted (Bond & Fox, 2007, p. 43; Linacre, 2006a). Values of Outfit and Infit MNSQ can range from 0 to positive infinity. The ideal value is 1.0, which means the data fit the Rasch model perfectly. In reality, values of Outfit and Infit MNSQ are usually different from 1.0. Values much higher than 1.0, indicate that variation in the observed data is greater than that predicted by the Rasch model. On the other hand, values much lower than 1.0 suggest that the variation in the observed data is over predictable from the Rasch perspective. In other words, there is redundancy between the information carried by the item in question and the other items in the scale, making them superfluous (Linacre, 2006a). Previous studies usually selected the cut off value of MNSQ by rule of thumb and different acceptable ranges were used for indicating good fit. Some researchers (e.g., Anshel et al., 2009; Linacre, 2006a) suggested that MNSQ falling in the range of 0.5 to 1.5 indicated a productive measurement, while many studies adopt a stricter standard; for example, a range of 0.6 to 1.4 (Wright, Linacre, Gustafson, & Martin-Lof, 1994); a range of 0.8 to 1.4 (Wolfe & Chiu, 1999); or a range of 0.7 to 1.3 (Mok, Cheong, Moore, & Kennedy, 2006; Wang et al., 2006). This study adopted a relatively strict standard, between 0.7 and 1.3, for MNSQ values to be an acceptable indication of good fit between data and model.

In a systematic review of studies on coping in sport, Nicholls and Polman (2007) concluded that the coping strategies adopted by athletes vary across gender. On this basis, they suggested that development of instruments measuring coping should take into consideration the variable of gender so as to assure reliability and validity of the instruments for diverse groups of samples. Differential item functioning (DIF) analysis could check the construct equivalence across groups (Wang, 2000). The existence of DIF indicates that different groups may have different interpretation or perspectives on the items and, therefore, it is impossible to derive comparable measures over groups. In this study, DIF analysis was used to investigate the extent to which male and female athletes have perform differently on the same items, after controlling their difference in the latent trait levels.

Results

Examination of assumptions of Rasch model

A principal components analysis (PCA) of Rasch residuals (Linacre, 1998; Wright, 1996) using Winsteps was conducted on each subscale to check the unidimensionality of the subscales of CSCA, and the analysis was repeated for the whole scale to check whether or not it satisfied unidimensionality. According to Linacre (2006a), a small (usually less than 2.0) eigenvalue of the first contrast, i.e., first PCA component in the correlation matrix of the residuals, indicates that the residuals are random noise, whereas, a big (usually more than 2.0) eigenvalue means that there is probably a "second dimension" besides the Rasch dimension. Table 1 presents the eigenvalues of Rasch dimension and the first contrast for each subscale and for the whole CSCA scale. The eigenvalues of first contrast for the four subscales were all less than 2.0 which mean that the items in the four subscales measure a single latent trait. The eigenvalue of the first contrast for the CSCA whole scale was 3.7 (furthermore, the eigenvalue of second contrast was 2.0) which indicates that items in CSCA contains more than one dimension. Therefore, from both theoretical and empirical perspectives, CSCA should be considered as a multidimensional scale. The correlation of residuals, also known as Q_3 statistic (Yen, 1984, 1993), is a commonly used index to examine the local independence among items. The expected value of Q_3, when local item independence holds, is approximately $-1/(L-1)$, where L is test length. That means the ideal value is -0.20 for a 6-item scale. Winsteps provided the correlation of residuals for each item pair. The results showed that, for the four 6-item subscales of CSCA, the correlation of residuals ranged from -0.36 to -0.18, and were not too much deviated from the expected value. Furthermore, the highest correlation (-0.36) indicated that those two items only shared about 13% of their variance. Therefore, no substantial evidence of violation of the assumption of local independence was found. The point-biserial coefficient, as an index of item discrimination, for all the items ranged from 0.29 to 0.58. The small range of item discrimination should be regarded as equal enough to justify the use of Rasch model on the data set for an empirical study.

Put Table 1 about here

Model-data fit

The CSCA containing four unidimensional subscales was calibrated simultaneously in ConQuest and standard fit statistics (i.e., Infit and Outfit MNSQ) were computed for each item in order to inspect the model-data fit of the scale. In the first round of ConQuest analysis, the values of Outfit and Infit MNSQ for all items in PC, EC, and AC subscales were greater than 0.7 and less than 1.3. Only one item (item 20: The victory or defeat is the routine matter) in the TC subscale showed misfit to the Rasch model (Infit MNSQ = 1.30 and Outfit MNSQ = 1.32). After deleting this item and reanalyzing the new data set, one item (item 3: Think about something else that I like) in AC and one item in TC (item 17: Take a step back and one will find more space) showed misfit to the Rasch model. After deleting these two items, the remaining 21 items exhibited good fit. DIF analysis was then performed to investigate the construct equivalence across gender of the remaining 21 items. As suggested by previous researchers (e.g., Wang et al., 2006), a difference equal to or larger than 0.5 logits was regarded as evidence of substantial DIF. The results indicated that no substantial DIF was found. This means that for each item, male and female athletes with the same trait level of coping would have similar responses. Table 2 presented the Infit, Outfit MNSQ, and gender DIF for the remaining 21 items.

Put Table 2 about here

The distribution of item difficulty and person ability

One of advantages of the Rasch model is its capacity to calibrate a person's measure from low to high, as item difficulty changes from easy to hard along the same latent trait scale. As shown in the item-person map (Fig. 1), the four continuums on the left side indicate the athlete's measures in the four dimensions of coping. The athletes who had higher levels in coping were placed at the top of the continuum and those who had lower levels in coping were placed at the bottom of the continuum. In addition, the items that fell into each of the four dimensions were clustered on the right side. The items with higher difficulty level (less easily endorsed by athletes) were placed at the top, and the items with lower difficulty level (more easily endorsed by athletes) were placed at the bottom. The item thresholds are indicated by the notation of x.y presented on the right side of the map. For example, 6.4 is used to represent the 4^{th} threshold of the item 6.

The item-person map (in Fig. 1) and the item difficulty in Table 3 revealed that the item difficulty ranged from -0.43 to 0.72 logits. The most difficult item came from PC (item 8: Construct a plan to overcome difficulties and follow it through). The least difficult items spread across the four subscales: item 4 (Focus attention on what needs to be done) and item 5 (Put in more effort) in PC; item 16 (Maintain a pleasant attitude) in EC; item 11 (Do other things that I like) in AC; and item 6 (Wait and see what happens next) in TC.

Put Table 3 about here

The item-person map (Fig. 1) also showed that both athletes' coping trait levels and item difficulty spread a wide and reasonable rage along the latent trait scale. Furthermore, the distributions of items in all subscales were well-targeted to the athletes' coping traits (M±SD of logit: PC = 0.73±0.03; EC = 0.73±0.03; AC = -0.04±0.04; and TC = -0.25± 0.04).

Put Figure 1 about here

Scale reliability

In classic test theory, the reliability of a scale is defined as true variance divided by observed variance. However, in latent trait model including Rasch model, the concept of item information is introduced. In this conception, each item provides a different level of measurement precision at each difficulty (θ) level, and test information is the summation of item information across all items in a test (Wang, Chen, & Cheng, 2004). The reliability in Rasch approach is defined as:

$$\rho = 1 - \frac{\bar{T}^{-1}}{\sigma_\theta^2} \quad (1)$$

where $\bar{T}$ is the average test information and σ_θ^2 is the variance of θ distribution.

In this study, the scale reliabilities for the four subscales were computed in both multidimensional and unidimensional Rasch analysis. The Average Relative Efficiency (ARE, Wang et al., 2004) could be computed according to the following formula to examine the relative measurement efficiency of multidimensional approach over unidimensional approach:

$$ARE_{M/U} = \frac{\overline{T}_M}{\overline{T}_U} \qquad (2)$$

Where $\overline{T}_M$ and $\overline{T}_U$ denote the averaged test information from the multidimensional approach and unidimensional approach, respectively. ARE depicts the ratio of measurement precision between multidimensional approach and unidimensional approach. It also implies how many times test length is needed for the unidimensional approach to achieve the same level of precision as the multidimensional approach does. For example, if ARE equals to 1.5, it means that the unidimensional approach needs 1.5 times test length as the multidimensional approach does in order to achieve the same level of precision.

Put Table 4 about here

The results in Table 4 showed that the differences in reliabilities of PC and EC favored the multidimensional model. The ARE for PC and EC are 1.30 and 1.20 respectively. That means the unidimensional approach needs around 8 items for PC and 7 items for EC to achieve the same level of measurement precision achieved by 6 items using multidimensional approach. However, there is no substantial difference of reliabilities of AC and TC between multidimensional and unidimensional approach. The ARE for AC and TC are 1.02 and 1.01 respectively, indicating that measurement precision of AC and TC are almost equivalent in multidimensional and unidimensional approach.

The multidimensional approach could simultaneously calibrate all subscales and increase the measurement precision by taking into account the correlations between subscales (Wang et al., 2004; Wang et al., 2006). Consequently, if the correlations among subscales are low, for example, the correlations involving AC and TC (Table 5), little improvement could be achieved by multidimensional approach.

Put Table 5 about here

Category function

Researchers (eg., Linacre, 2002; Lopez, 1996) suggest an important step in Rasch analysis is checking the category's function of the rating scale. According to Linacre and Wright (1998), the step calibrations (the intersection points of adjacent probability curves) of the rating scale must increase monotonically to ensure that higher measures on the items represent higher traits under measurement. Linacre (2002) further suggested that step calibration must advance by at least 1.4 logits for items with a 3-category scale. For 4- or 5-category scales, however, a shorter distance between the consecutive step calibrations is acceptable.

Fig. 2 shows the item characteristic curves for the 5-category rating scale. The five curves in the figure, labeled as '0', '1', '2', '3' and '4', indicate the probability of each of the five possible responses to the item. It can be seen that, although the step calibrations increase monotonically from -0.88, -0.74, 0.44, to 1.18 logits, the distance between step calibrations 1 (intersection points of curves 0 and 1) and 2 (intersection points of curves 1 and 2) was only 0.14 logits. The probability curve of category 1 is almost subsumed under the probability curve of categories 0 and 2, indicating that the category 1 is the single most probable response for very few athletes. The distance between step calibrations 2 and 3 was 1.18 logits and the distance between step calibrations 3 and 4 was 0.74 logits, which were acceptable for a 5-category structure. The results indicated that the 5-category structure did not function well for the CSCA. A better rating scale structure (e.g., 4-category) is needed for further investigation.

Put Figure 2 about here

Coping pattern of Chinese athletes

Although the sample used in this study was mainly for validation purpose, the investigation of the characteristics of participants' responses to four dimensions of coping could contribute to understanding of Chinese athletes' coping pattern. Cluster analysis using K-means method was performed on participants' Rasch scores in logits to examine the coping pattern of Chinese athletes. The results classified athletes into three qualitatively different groups with 76, 106, and 185 cases respectively. As presented in Fig. 3, athletes from cluster 1 had the highest scores on all four dimensions of coping among the three groups. Their patter could be called *Resourceful Coping*. Athletes from cluster 2 had lower, but still positive, scores on PC and EC than cluster 1. However, they had substantially lower, and negative, scores on AC and TC than cluster 1. This group of athletes is more likely to cope using problem-focused and emotion-focused approaches than using avoidance or transcendence as strategies. This pattern could be identified as

Head-on Coping. Cluster 3, labeled as *Balanced Coping*, consists of athletes who had similar and positive scores on four dimensions of coping.

Put Figure 3 about here

Discussion

The CSCA was developed to investigate the coping styles of Chinese athletes and was validated with classic test theory (Chung et al., 2004). The present study aims to find further proof of validity of the scale with multidimensional Rasch analysis.

The results showed that the items in CSCA exhibited good fit to the Rasch model except for one item in the AC subscale (item 3: Think about something else that I like) and two items in the TC subscale (item 17: Take a step back and one will find more space; and item 20: The victory or defeat is the routine matter). After deleting these three items, the remaining 21 items functioned well under four subscales and each subscale measures a single latent trait. However, removing these items does not necessarily indicate that they are not measuring Chinese athletes' coping but means that they does not function the same way with other items in the same subscales. Further investigation could be done to find out how these items contribute to the measurement of coping and the way to improve them.

Additional evidence of good psychometric appropriateness comes from the gender DIF analysis. In response to the previous caution raised in the literature (e.g., Nicholls and Polman, 2007), the impact of gender difference was taken into consideration in this study. DIF analysis was performed to check the construct equivalence across gender. No substantial gender DIF was found for the remaining 21 items. In other words, male and female athletes with the same trait level of coping would have similar responses to the items in the scale. However, this result should be interpreted with caution given the marginal sample size in this study. Further attempt could be made to investigate the DIF with a larger sample.

The test reliabilities of the four subscales of CSCA range from 0.66 to 0.76 in multidimentional model. Under the unidimentional model the test reliabilities for the four subscales fell into the range of 0.65 to 0.70. The differences in reliabilities of PC and EC favored the multidimensional model and the ARE for PC and EC indicated that unidimensional approach needs more items for PC and EC to achieve the same level of measurement precision than the multidimensional approach does. However, there is no substantial difference of reliabilities of AC and TC between multidimensional and unidimensional approach since the correlations between AC/TC and other subscales are quite low. These results lend credence to the use of the multidimensional model over the unidimensional model for the measurement of multidimensional constructs when there are substantial correlations among those constructs.

Through Rasch analysis, athletes' measure of coping were calibrated from low to high as the item difficulty from easy to hard along the same scale. This feature facilitates direct comparisons between person abilities and item difficulties based on their locations on the latent trait continuum. Both athletes' coping trait levels and item difficulty spread a wide and reasonable rage along the latent trait scale. The distributions of items in the four subscales were well-targeted to the athletes' coping traits, indicating these items could tap the athletes' trait level of coping properly and provide accurate estimates.

The functioning of response categories was inspected and the results indicated that the 5-category structure did not function well for the CSCA. The probability curve of category 1 is almost subsumed under the probability curve of categories 0 and 2, suggesting that the category 1 is not a valid option for most athletes. A better rating scale structure (e.g., a 4-category structure) is worth further investigation.

In the attempt to investigate Chinese athletes' coping pattern, three groups of athletes with different coping pattern was roughly classified. It is beyond the scope of the present study to further correlate the three categories of participants' coping level with external criteria. Further study could be done to examine the psychological characteristics underlying this classification as well as the athletic outcomes of different coping patterns.

Cross-subscale comparisons were sometimes undertaken on measures obtained from multiple-subscale instruments. However, such comparison among athletes' scores on PC, EC, AC and EC of the CSCA should be treated with caution. In multidimensional Rasch analysis, the items of the four subscales were calibrated independently. The ConQuest sets the average of item difficulties to 0.0 and individual item's difficulty is expressed relative to this reference point. Athletes' trait levels are calibrated in such a framework which depends on the items of the subscales. Therefore subscale means of 'athlete' cannot be compared across subscales since the four subscales are measuring four qualitatively different latent traits.

In conclusion, multidimensional Rasch analysis has lent support to the 21-item CSCA to measure four latent traits, namely, PC, EC, AC, and TC for Chinese athletes, although further improvement could be made. For example, investigations could be made to check whether another rating scale structure can function better than the current 5-categor for the CSCA. The advantages of multidimensional Rasch analysis in improving measurement precision by taking into account the correlation between subscales in a multidimensional scale demonstrated in the present study lend credence to its application in sport and exercise science in the future.

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Figure(s)

Figures

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                  Athlete                                   Item               Item threshold
---------------------------------------------- --------------------------  ---------------------------
         PC         EC         AC         TC        PC    EC    AC    TC
---------------------------------------------- --------------------------  ---------------------------
                |         |         |         |
                |         |         |         |
   3            |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
               X|        X|         |         |                            6.4
   2           X|        X|         |         |
               X|       XX|         |         |                            18.4 23.4
              XX|       XX|         |         |
              XX|      XXX|         |         |                            2.4 8.4 12.4 17.4
            XXXX|      XXX|        X|        X|                            11.4
            XXXX|    XXXXX|        X|        X|                            1.4 7.4 13.4 21.4 22.4 24.4
            XXXX|    XXXXX|        X|        X|                            5.4 9.4 14.4 16.4 20.4
         XXXXXXX|   XXXXXX|       XX|        X|
          XXXXXX|   XXXXXX|       XX|        X|                            19.4
   1    XXXXXXXX| XXXXXXXX|       XX|      XXX|                            3.4 4.4 6.3 10.4 15.4
       XXXXXXXXX|  XXXXXXX|     XXXX|       XX|
        XXXXXXXX|  XXXXXXX|     XXXX|       XX|   8                        18.3 23.3
      XXXXXXXXXX| XXXXXXXX|     XXXX|     XXXX|                            12.3
       XXXXXXXXX|  XXXXXXX|    XXXXX|     XXXX|                            2.3 8.3 17.3
           XXXXX|XXXXXXXXX| XXXXXXXX|    XXXXX|                21   22     11.3
           XXXXX|    XXXXX|  XXXXXXX|    XXXXX|         23     19          1.3 7.3 13.3 21.3 22.3 24.3
            XXXX|    XXXXX|  XXXXXXX|     XXXX|   2     14                 5.3 9.3 14.3 16.3 20.3
         XXXXXXX|   XXXXXX|   XXXXXX|  XXXXXXX|         9 18        24     6.2
   0        XXXX|     XXXX| XXXXXXXX|  XXXXXXX|   1 7          10   13     19.3
             XXX|      XXX|   XXXXXX|   XXXXXX|         15     12          3.3 4.3 10.3 15.3
              XX|      XXX|   XXXXXX|  XXXXXXX|                            18.2 23.2
              XX|       XX|  XXXXXXX|  XXXXXXX|   4 5   16     11   6      2.2 12.2 17.2
               X|        X|   XXXXXX|    XXXXX|                            8.2
                |        X|     XXXX|  XXXXXXX|                            7.2 11.2 13.2 21.2 22.2 24.2
                |         |    XXXXX|    XXXXX|                            1.2 5.2 6.1 14.2 20.2
                |         |      XXX|     XXXX|                            9.2 16.2
  -1            |         |       XX|     XXXX|                            19.2
                |         |      XXX|      XXX|                            3.2 4.2 10.2 15.2 18.1 23.1
                |         |        X|      XXX|                            12.1 17.1
                |         |       XX|      XXX|                            2.1 8.1
                |         |        X|       XX|                            11.1 24.1
                |         |        X|       XX|                            1.1 5.1 7.1 13.1 21.1 22.1
                |         |        X|       XX|                            9.1 14.1 16.1 20.1
                |         |        X|        X|
                |         |         |        X|                            3.1 4.1 10.1 15.1 19.1
  -2            |         |         |        X|
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
  -3            |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
                |         |         |         |
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Fig. 1. Item-Person map for the 21-item CSCA. Note: each “X” represents 3.3 cases.

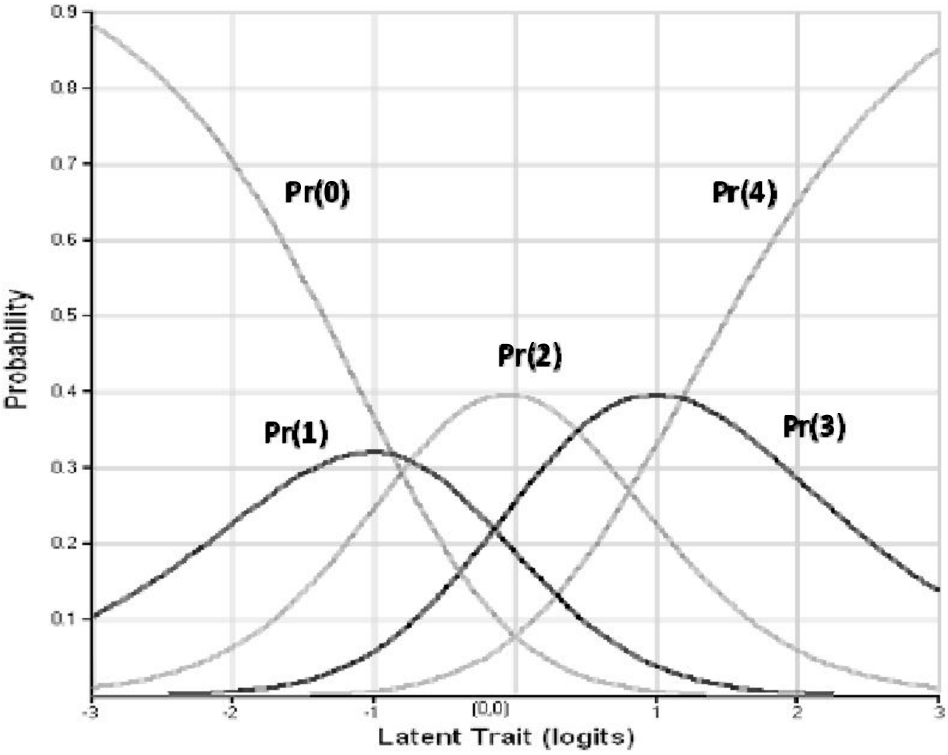

Fig. 2. The item characteristic curves for the 5-category rating scale

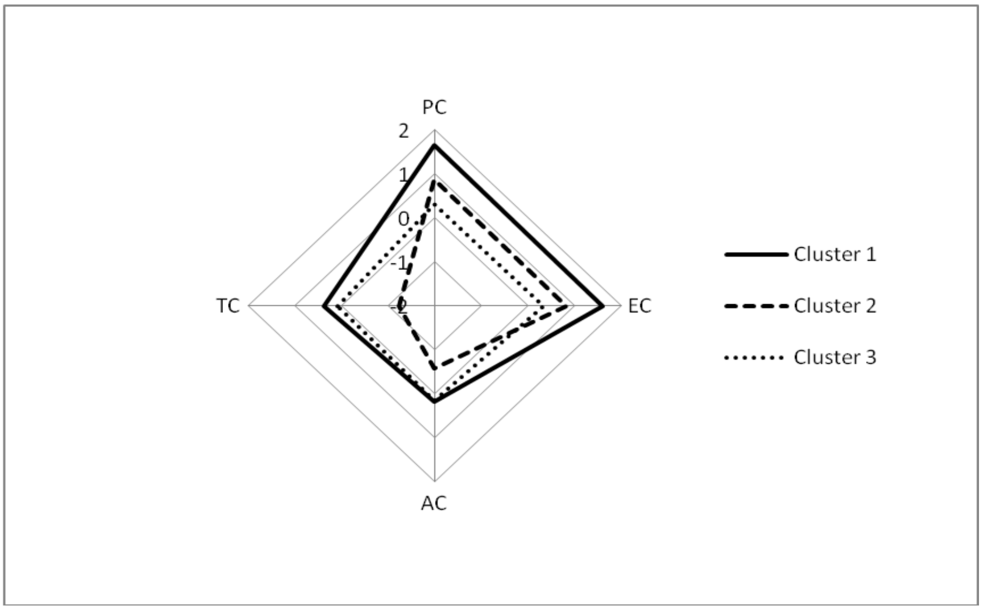

Fig. 3. The three groups of Chinese athletes with different coping patterns

Tables

Table 1

The eigenvalues of Rasch dimension and the first contrast for CSCA and subscales.

	Eigenvalue	
Subscale/Scale	Rasch Dimension	First Contrast
PC	6.9	1.5
EC	6.4	1.5
AC	8.7	1.7
TC	7.4	1.5
Overall CSCA	11.7	3.7

Table 2
Item Infit and Outfit MNSQ, and Gender DIF.

Item	MNSQ		Gender DIF
	Infit	Outfit	(M-F)
Problem-focused Coping			
Item 1	0.86	0.87	-0.04
Item 2	0.86	0.87	0.20
Item 4	0.95	0.96	-0.13
Item 5	0.87	0.87	-0.03
Item 7	0.88	0.87	-0.01
Item 8	1.14	1.15	-0.00
Emotion-focused Coping			
Item 9	0.92	0.91	0.03
Item 14	0.78	0.79	0.17
Item 15	0.81	0.83	0.11
Item 16	0.90	0.89	-0.06
Item 18	0.87	0.89	-0.02
Item 23	0.81	0.83	-0.23
Avoidance Coping			
Item 10	1.03	1.02	0.13
Item 11	1.01	1.01	0.12
Item 12	1.09	1.10	-0.01
Item 19	1.10	1.11	-0.13
Item 21	1.13	1.14	-0.11
Transcendence Coping			
Item 6	1.15	1.17	0.25
Item 13	1.09	1.08	-0.28
Item 22	1.21	1.18	-0.19
Item 24	0.94	0.94	0.15

Note: Three misfit items (item 3, 17, 20) were excluded.

Table 3

Item Difficulty and Standard Error (S.E.).

Item	Item Difficulty (S.E.)	Item	Item Difficulty (S.E.)
Problem-focused Coping		*Emotion-focused Coping*	
Item 8	0.72(0.09)	Item 23	0.27(0.09)
Item 2	0.22(0.04)	Item 14	0.21(0.04)
Item 1	-0.04(0.04)	Item 18	0.08(0.04)
Item 7	-0.08(0.04)	Item 9	0.00(0.04)
Item 4	-0.40(0.04)	Item 15	-0.13(0.04)
Item 5	-0.42(0.04)	Item 16	-0.43(0.04)
Avoidance Coping		*Transcendence Coping*	
Item 21	0.42(0.08)	Item 22	0.41(0.04)
Item 19	0.25(0.04)	Item 24	0.02(0.07)
Item 10	-0.10(0.04)	Item 13	-0.09(0.04)
Item 12	-0.16(0.04)	Item 6	-0.34(0.04)
Item 11	-0.42(0.04)		

Table 4
Scale reliabilities from multidimensional model and unidimensional model.

Subscale	Number of items	Reliability		$ARE_{M/U}$
		Multidimensional	Unidimensional	
PC	6	0.71	0.65	1.30
EC	6	0.76	0.70	1.20
AC	5	0.66	0.66	1.02
TC	4	0.68	0.66	1.01

Table 5
Correlations among subscales of CSCA.

	PC	EC	AC
EC	0.731	-	-
AC	0.046	0.146	-
TC	-0.090	0.047	0.440