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ORIGINAL ARTICLE

Development and Evaluation of a Computer Adaptive Test to Assess Anxiety in Cardiovascular Rehabilitation Patients

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Abstract

Objective: To develop and evaluate a computer adaptive test for the assessment of anxiety in cardiovascular rehabilitation patients (ACAT-cardio) that tailors an optimal test for each patient and enables precise and time-effective measurement.

Design: Simulation study, validation study (against the anxiety subscale of the Hospital Anxiety and Depression Scale and the physical component summary scale of the 12-Item Short-Form Health Survey), and longitudinal study (beginning and end of rehabilitation).

Setting: Cardiac rehabilitation centers.

Participants: Cardiovascular rehabilitation patients: simulation study sample (n = 106; mean age, 57.8y; 25.5% women) and validation and longitudinal study sample (n = 138; mean age, 58.6 and 57.9y, respectively; 16.7% and 12.1% women, respectively).

Interventions: Not applicable.

Main Outcome Measures: Hospital Anxiety and Depression Scale, 12-Item Short-Form Health Survey, and ACAT-cardio.

Results: The mean number of items was 9.2 with an average processing time of 1:13 minutes when an SE $\leq$.50 was used as a stopping rule; with an SE $\leq$.32, there were 28 items and a processing time of 3:47 minutes. Validity could be confirmed via correlations between .68 and .81 concerning convergent validity (ACAT-cardio vs Hospital Anxiety and Depression Scale anxiety subscale) and correlations between −.47 and −.30 concerning discriminant validity (ACAT-cardio vs 12-Item Short-Form Health Survey physical component summary scale). Sensitivity to change was moderate to high with standardized response means between .45 and .82.

Conclusions: The ACAT-cardio shows good psychometric properties and provides the opportunity for an innovative and time-effective assessment of anxiety in cardiovascular rehabilitation. A more flexible stopping rule might further improve the ACAT-cardio. Additionally, testing in other cardiovascular populations would increase generalizability.

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Cardiovascular diseases (CVDs) are the leading cause of death in developed countries and one of the main indications in medical rehabilitation.[1,2] Comorbid anxiety has been associated with a poor prognosis in terms of medical complications and cardiac events,[3-5] a decreased quality of life,[6,7] and increased health care costs,[8-10] emphasizing the need for a valid assessment of comorbid anxiety in cardiovascular rehabilitation patients.[5] However, anxiety often remains undiagnosed in cardiovascular patients,[5,11,12] partly because of a lack of awareness for mental comorbidities and restricted time and personnel resources for extensive diagnostic procedures.[5,13,14]

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To improve the recognition of anxiety in cardiovascular health care, a psychodiagnostic routine has been proposed, which provides screening instruments as a first step.[12] Traditionally, paper-pencil self-ratings instruments, such as the Hospital Anxiety and Depression Scale (HADS)[15] or the Cardiac Anxiety Questionnaire,[16] are used for screening. These assessment instruments are based on the classical test theory, which has several limitations, such as its focus on test scores rather than item scores and its sample dependency of item statistics.[17] Accordingly, developing screening instruments with the classical test theory is always a compromise between high measurement precision and test economy.[18] Models of the item response theory (IRT), such as the Rasch model,[19] provide an alternative framework for developing assessment instruments.[17] The Rasch model describes the probability of a certain response to an item as a function of 1 person parameter (latent trait value, eg, anxiety) and 1 item parameter (difficulty of the item).[20,21] Use of IRT models offer possibilities, such as assessing group differences in item and scale functioning, calculating sample invariant item and trait estimates, and transforming ordinal test scores into linear measures.[22,23] These advantages of IRT models allow for the development of innovative assessments, such as computer adaptive tests (CATs).[17,22] A CAT selects only the most informative items for each patient and avoids the administration of items irrelevant in terms of information.[24-27] This procedure can be used to reduce the processing time by 50% to 90% without a loss in measurement precision.[14] Moreover, CATs can be performed automatically in a clinical process and be connected directly with records of clinicians.[28,29]

The use of computer-based tests began in the 1950s and 1960s and has spread substantially since then.[28,30] However, there has been little use in mental health measurement until now.[24] Available CAT procedures either were tested only in simulation studies[31-33] or lacked a focus on cardiovascular patients.[13,25,31-37] Hence, the object of the present study was to develop and evaluate the ACAT-cardio, a CAT for the assessment of anxiety in cardiovascular rehabilitation patients.

Methods

This study was part of a project, development and validation of a computer adaptive test for cardiac patients undergoing rehabilitation, RehaCAT-Cardio, which aimed at developing and validating a CAT for cardiovascular rehabilitation patients with the domains of depression, anxiety, activities of daily living, and work capacity.[38-40]

List of abbreviations:

ACAT-cardio	**computer adaptive test for the assessment of anxiety in cardiovascular rehabilitation patients**
AIB-cardio	**anxiety item bank for cardiovascular patients**
CAT	**computer adaptive test**
CVD	**cardiovascular disease**
HADS	**Hospital Anxiety and Depression Scale**
ICD-10	***International Statistical Classification of Diseases and Related Health Problems, 10th revision***
IRT	**item response theory**
RehaCAT-Cardio	**computer adaptive test for cardiac patients undergoing rehabilitation**
SF-12	**12-Item Short-Form Health Survey**
SRM	**standardized response mean**

Samples and data collection

First, we carried out a simulation study with real patient data to evaluate the algorithm of the adaptive testing procedure. Data have already been used to calibrate the item bank[38] and included responses of 106 cardiovascular patients (sample I) from 14 German cardiac rehabilitation centers. Full data sets of patients were entered according to the selected items of the algorithm. Thus, determination of agreement between estimates of total use of items and reduced use of items was possible.

Second, we tested the user-friendliness of the ACAT-cardio in 13 cardiac rehabilitation patients. As a result, the instructions were shortened, color of the selected answering option was intensified, and an external mouse was connected to the laptop.

Third, 138 cardiovascular patients (sample II) were consecutively recruited in 3 German cardiac rehabilitation centers. The ACAT-cardio, the HADS,[15] the 12-Item Short-Form Health Survey (SF-12),[41] and sociodemographic and disease-specific items were administered to the patients on external laptops at the beginning and end of their rehabilitation. The time period between the 2 measurement points was 3 to 4 weeks.

We included adult patients with essential primary hypertension (*International Statistical Classification of Diseases and Related Health Problems, 10th revision* [ICD-10][42]: I10), ischemic heart disease (ICD-10: I20-25), or other forms of heart disease (ICD-10: I30-52). General exclusion criteria for patients participating in this study were inadequate German language skills, dementia, or acute intoxication. All patients took part voluntarily without payment and gave written informed consent. The study was approved by an ethics commission of the German Psychological Society and the German Federal Pension Fund and was in accordance with ethical principles stated in the Declaration of Helsinki.

Materials

A precondition for the ACAT-cardio was an IRT-based, unidimensional, and calibrated item bank.[38,43] An item bank is defined as a collection of a large number of items, which defines and quantifies a common construct.[43] Here, unidimensionality means that all items measure a single construct (eg, anxiety), and calibration means that for each item the difficulty or threshold parameters are estimated with an acceptable level of uncertainty.[17,44]

We developed and calibrated an item bank for the assessment of anxiety in cardiovascular patients.[38] For a better understanding of the present study, a short summary of this process, which has been published in detail elsewhere, is as follows.[38]

The anxiety item bank for cardiovascular patients (AIB-cardio) is based on an initial item pool (1154 items) consisting of adapted items from 56 existing anxiety questionnaires and additional items to cover specific aspects of anxiety in CVD patients (eg, "have you been worried you might need a cardiac pacemaker?"). From this item pool, we excluded a large number of items step by step because of equivalent content, comprehensiveness, or lack of relevance for the assessment of anxiety in patients with CVD.[38] Additionally, items related to somatic aspects of anxiety were eliminated because of the potential symptom overlap between anxiety and CVDs.[38,45,46] The remaining items received a uniform