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Progress testing in postgraduate education in medical microbiology and virology

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Abstract

Background: Modern postgraduate training in medical microbiology requires more objective tools to monitor knowledge during the training than interviews by responsible educational supervisors.
Aim: Evaluation of the feasibility and validity of a progress test (PT) to enable formative assessment of the knowledge development in a postgraduate training in medical microbiology.

Methods: Data consisted of the scores of all trainees attending the annual PTs in the 5-year postgraduate Medical Microbiology training in the Netherlands from 2005 until 2010. Knowledge development as measured by the PT was analysed per PT by one-way ANOVA over year groups. In addition a longitudinal analysis (repeated measures ANOVA) was applied to the scores of the subgroup of trainees who participated in a four year sequence of PTs.

Results: Up until the fourth training year residents who were further advanced in their training, in general scored significantly higher than trainees of lower years (one-way ANOVA, $p<0.001$), but fifth year trainees scored as well or worse than fourth year trainees. Analysis of the within-student progress knowledge during the first 4 years of training showed significant linear growth.

Conclusion: The six year experience with construction and use of the Medical Microbiology PT shows that the procedure is feasible for application in postgraduate training. The obtained results indicate the potential of the PT to provide valuable feedback on the knowledge development of postgraduate trainees.

Practice Points

1. Training of the speciality medical microbiology and virology is liable to modernization to meet current societal needs; in 2004 this resulted in a general curriculum in accordance with the CanMed model.
2. A national formative test consisting of case based questions was developed to assess the level of knowledge for all subdomains of medical microbiology in each consecutive year during the 5 years of training.
3. The test proved to be a valid and useful feedback instrument allowing trainees to receive

developmental feedback in medical microbiology including virology.
4. We suggest that besides the feedback to the individual resident per training centre aggregated test results will be disclosed to the educational supervisors to adapt local training programs.

Keywords: Progress test, postgraduate education and assessment.

Article

Introduction

As described by Scheele et al. the necessity to reform postgraduate medical education has been recognized worldwide as well as in the Netherlands Scheele et al., 2013). Recently the postgraduate training of the specialty medical microbiology and virology in the Netherlands has been modernized to better meet current societal and professional needs. A new accreditation system was developed for postgraduate training institutions and clinical teachers focussing on a competency-based, modular set-up, providing an appropriate balance between work-based and theoretical training in accordance with the Can Med model (CCMS, Kaderbesluit, 2004; Frank, 2005).

Regarding postgraduate training in medical microbiology, the curriculum for resident training of five years is divided into two phases. The first phase with duration of 35 months encompasses practical skills in bacteriology, virology, mycology, parasitology, public health and hospital infection prevention. The second phase of 25 months includes the training in clinical syndromes, advice and management as well as research and a four months period for the in depth study of a topic of choice. The educational supervisor undertakes regular formative and supportive appraisals with the trainee at least once a year, and during the first year every three months. After consultation of a resident's trainers the supervisor assesses annually whether the trainee is allowed to continue the training in medical microbiology.

Before the modernization of the curriculum, written or oral examinations were not in use and the feedback was subjective and only provided at the end of each rotation by the responsible staff member and/or the supervisor. As part of the modernization it was decided that annual formative assessment should be established for all residents, in order to provide trainees and supervisors with information on the trainees' level of knowledge and diagnostic reasoning by means of multiple choice questions. The residents receive the outcome of the assessment of their individual performance in comparison to the outcome of the other participants. The responsible educational supervisors receive the aggregated national results per year group, and are only allowed access to the individual results after agreement with the resident.

Purpose

The purpose of this report is to present the feasibility and results of a national, annual formative assessment of trainees in microbiology over a period of six years. A formative test consisting of case based questions was developed every year to assess the level of knowledge of the residents in medical microbiology and virology during the 5 years of training, thus providing the trainees with a guide to further learning (Shen et al. 2000, Muijtjens et al. 2010, Norman et al. 2010). The aim of the report was to investigate whether the test enabled the resident to measure progress of knowledge over time.

Methods

Development of the annual, formative assessment

A national committee, consisting of experienced medical microbiologists, and external experts, was installed to develop test items. The yearly formative test consisted of at least 60 newly constructed multiple choice questions, which were based on short case reports in the stem covering the following ten subdomains of medical microbiology: bacteriology (10 questions), virology (12), infection control (6), mycology (6), parasitology (6), infectiology (8), knowledge of antibiotic use (3), public health (3), statistics and epidemiology (3) and immunology (3). All questions were developed and reviewed by the committee prior to use (Schuwirth et al. 2010). For each question the learning aim was formulated and references were stated. An example of a multiple choice question is shown in figure 1, and an example of feedback given to an individual trainee on his/her test performance, relative to the results of his/her year group, is shown in table 1. Immediately after the assessment the intended answers were disclosed to the participants.

Table 1: Example of feedback given to a trainee on his/her test *performance compared to his/her class-mates in the same year group on the national annual progress test*

Score per subtest				
Subtest	**Questions (n)**	**Individual Participant**	**Year group (n=14)**	
		% correct	**Mean % correct**	**Std***
Bacteriology	10	90	61.43	19.94
Parasitology	5	100	50.00	28.01
Mycology	6	83	55.95	24.11
Infectiology	7	100	64.29	20.78
Hospital infection control	7	71	71.43	15.85
Public Health	3	100	40.48	29.75
Immunology	3	0	38.10	31.64
Statistics/epidemiology	2	50	78.57	25.68
Antimicrobial therapy	3	33	52.38	25.20
Virology	15	87	64.76	15.12
Total	**61**	**80**	**60.19**	**12.22**

*Std: standard deviation

Figure 1: Example of a case based question in the national exam of 2009
A 72 year old male patient, who underwent a heart valve replacement nearly 20 years ago (bioprothesis), is seen with the following complaints: fatigue, loss of weight and fever. Three blood cultures show slow growth of a Gram-negative rod, which is catalase positive, and oxidase slowly positive. The urease test is negative. After 5 days of incubation the colonies on the blood agar demonstrate a centrally located, star shaped figure (see figure). Which bacterial species has most probably been identified?

a. *Haemophilus aphrophilus*
b. *Haemophilus parahaemolyticus*
c. *Aggregatibacter* (*Actinobacillus*) *actinomycetemcomitans*
d. *Capnocytophaga* spp.

Annual evaluation of the formative assessment

Taking into account the question characteristics, and the post-test comments of participants and supervisors, all questions and answers were reviewed by the committee after every test administration. As a result, each year one or two questions were excluded from scoring, due to non-conclusive discussion about the correct answer. After evaluation of the questions and answers the trainees received their individual results.The responsible educational supervisors received the aggregated national results per year group.

Analysis of results and yearly feedback to trainees and local educational supervisors

For the analysis and feedback of the results the trainees were categorized according to their training year (year 1 – 5). Each participant received an analysis of his/her test results as follows. The proportion of correctly answered questions was reported for the test as a whole, and separately for each of the ten microbiological subdomains; both in comparison to the results of residents in the same year of training. In addition each participant received his or her ranking, based on the percentage of questions correctly answered, within the entire group of trainees. Educational supervisors received information on how their residents of different year groups performed as a group in each of the subdomains. It was the own responsibility of the trainees to act on their feedback. In addition, the questions and answers were discussed within the local training institutes.

Statistics

Statistical analyses were performed using SPSS 19; statistical tests with $p<0.05$ were considered significant.

Reliability and validity

For each question mean scores, standard deviation, and corrected item-total correlation were calculated. Cronbach’s alpha values were calculated to establish the reliability of the test. Mean scores and standard deviations for all trainees were calculated according to year group as well as for each sub domain of medical microbiology. An increase of scores with increasing year group is considered to be supportive for the construct validity of the PT. Therefore the between year group (1-5) differences of the scores per PT were analysed in a one-way ANOVA. In addition, a longitudinal analysis (repeated measures ANOVA) was applied to the scores of a subgroup of trainees who participated in a four year sequence of PTs.

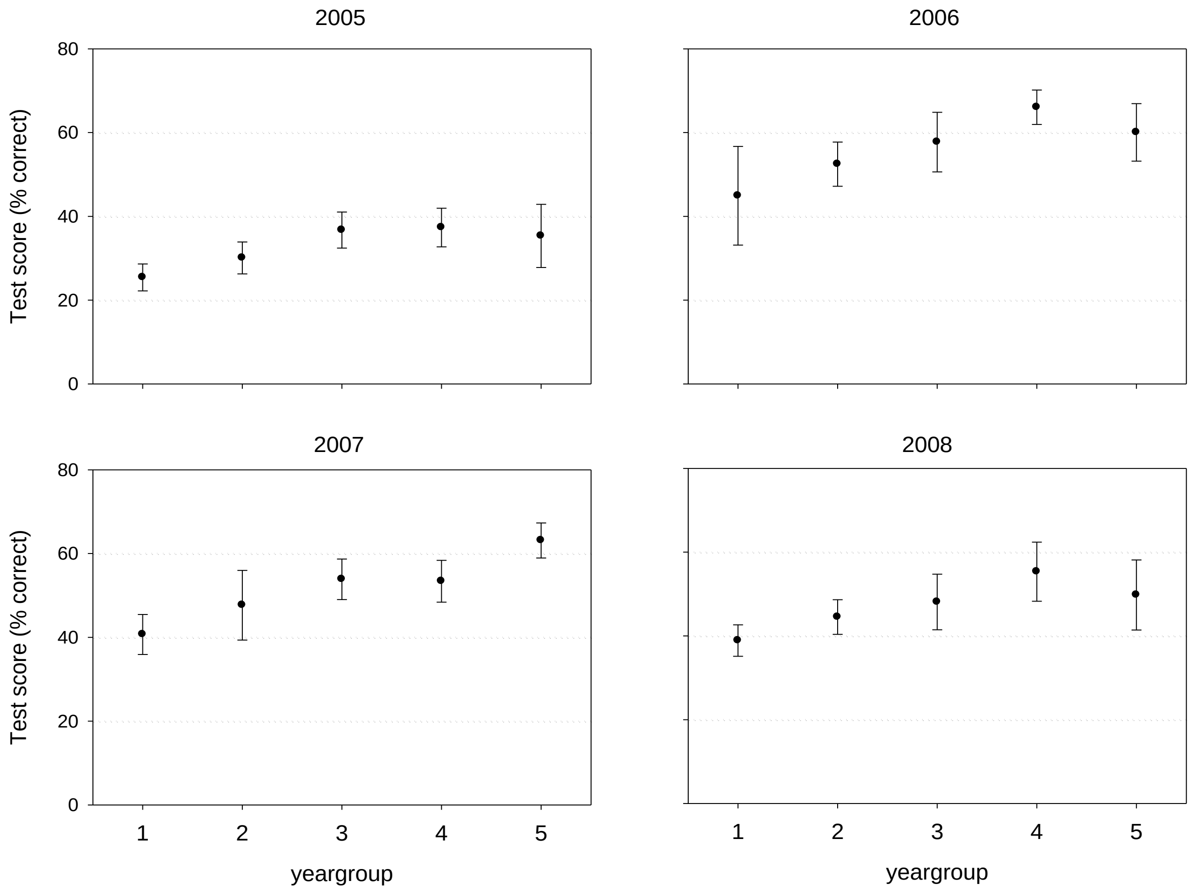
Longitudinal analysis

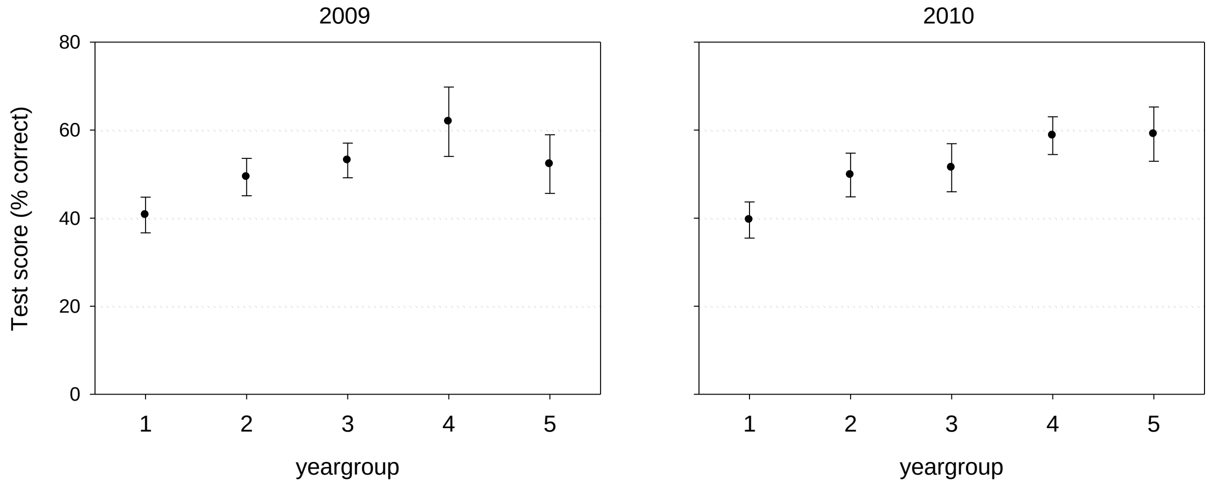
To test the within-student progress in knowledge during the training years a longitudinal analysis was performed for the 22 students in cohorts 2005, 2006, and 2007, who participated in four sequential annual tests. Insufficient numbers of trainees participating continuously over five years were available to allow for analysis of five consecutive tests. Growth patterns were investigated for sequences of intra-individual measurements in repeated measures ANOVA using polynomial components. To reduce the effect of variation in test difficulty, for the longitudinal analysis the test scores (expressed as the proportion of correct answers) were standardized. For each test a reference group of 33 residents was formed consisting of fixed numbers of first, second, third, and fourth year group. Using the mean and standard deviation of the reference group standardized scores (Z-scores) were calculated for the trainees involved in the longitudinal analysis.

Results

The participation rate of 6 consecutive national progress tests (2005-2010) was 95%, with an annual average of 63 trainees per test occasion. Mean test scores (% correctly answered questions) and 95% confidence intervals are shown for all year groups in Figure 2. Significant ($p<0.001$) between year group differences were found for all six test occasions. In general, the patterns in Figure 2 show a steady increase of the mean score for year groups 1 to 4, and leveling off or decreasing scores for the group in the fifth year of training.
Per test the reliability (Cronbach's alpha) was calculated; mean value and range of alpha were found to be 0.726 (0.674-0.770).

Figure 2: Test scores (% correct) on 6 national progress tests (2005-2010).

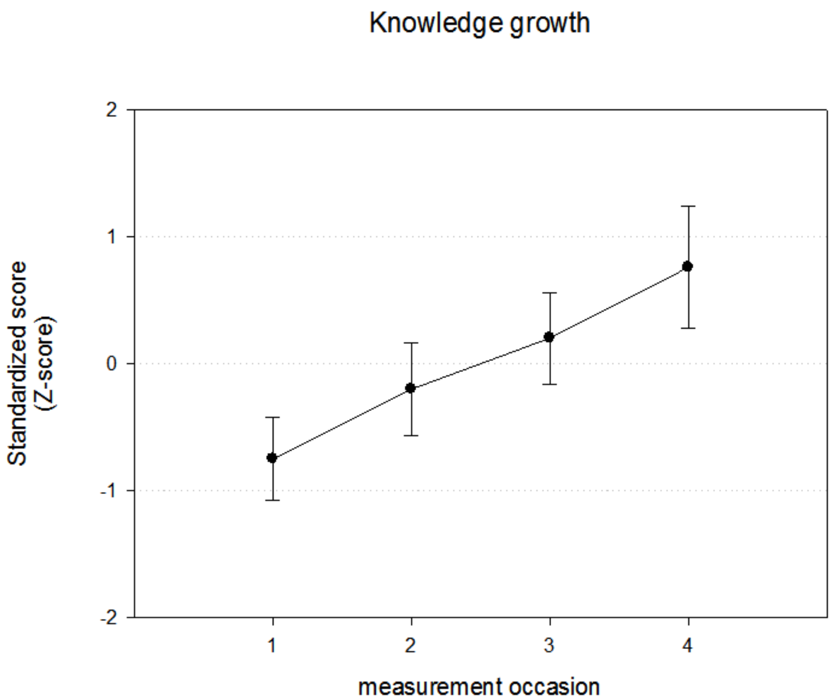




Mean test scores and confidence intervals are shown for all year groups. In year groups 1 to 3 the trainees who were further advanced in their training significantly scored higher than their colleagues of lower year groups (One-way ANOVA, p< 0.05). This increase could also be observed when looking at various domains of knowledge within the medical microbiology field (data not shown). In year group 5, however, the performance is shown to level off indicating saturation or even decrease of knowledge at this stage.

The longitudinal analysis was performed for 22 trainees from cohorts 2005, 2006, and 2007, whose test sequence was complete for the first four measurement occasions. Figure 3 shows the corresponding mean and 95% confidence intervals of the standardized scores (Z-score). A significant linear increase of knowledge was found from the first to the fourth year of testing (ANOVA, repeated measures, p< 0.001 for the linear component; the quadratic and cubic components being non-significant). The knowledge level increased from -0.75 to +0.76 on a Z-score scale during subsequent tests.

Figure 3: Knowledge growth for 22 trainees from cohorts 2005, 2006 and 2007 whose test sequence was complete for the first measurement occasions. .



Scores (%correct) were standardized in order to correct for variation in test difficulty. For each measurement moment a reference group of 33 residents was formed containing a fixed number of first, second, third, fourth and fifth year residents. Using the mean and standard deviation of the reference group standardized scores (Z-scores) were calculated for the 22 residents. Mean and confidence intervals of the standardized scores are shown for the 20 residents. A significant linear growth of knowledge was found (ANOVA, repeated measures, p< 0.001 for the linear component, the quadratic and cubic components being nonsignificant).

Discussion

The observed patterns of increasing test scores over years of training are supportive for the validity of the developed instrument to measure the growth of knowledge and diagnostic reasoning of the trainees during their training in the specialty medical microbiology. This national, transversal and longitudinal tool of progress testing has been shown to be applicable to assess the cognitive skills of the trainees in medical microbiology covering all domains of medical microbiology. It is interesting to observe that the increase in knowledge appeared to level off after the fourth year of the training. A possible explanation is that trainees perform more consultative work as well as research or a four months period for a topic of choice in the fifth and final year at the expense of development and maintenance of basic skills and knowledge. The question might be raised whether a multiple choice test is suitable to measure progress for other competences than knowledge. Therefore, learning over the fifth year might be more visible in another type of test more suitable to measure the competences needed for the consultations or research. The longitudinal analysis of the first four tests of trainees from cohorts 2005, 2006, and 2007 (Figure 3) confirms the increasing scores during the first four years of training in transversal analysis (Figure 2).

Feedback to the trainees and local educational supervisor

Formative feedback ought to entail clear and bidirectional communication between attending staff members or educational supervisor and the resident intended to exchange information that will improve the resident's knowledge or skills. Since it was decided in the past to disclose individual test results only to the resident, it is possible that a struggling trainee is not identified by the supervisor and will miss effective remediation. Therefore, although a formative test is meant to stimulate trainees to catch up on lacks in knowledge, there is an increasing demand that feedback regarding the individual trainee's growth of knowledge during the resident training is reported also to the educational supervisor. For the postgraduate microbiology training in the Netherlands it was recently decided that individual progress test results will be included in the residents' training portfolios, and to be subject of the annual formative appraisal between supervisor and trainee.
At the same time need is felt for information on progress of the knowledge level for each training location in order to improve the local training program. Although at instigation of the trainees' association it was decided in the past that individual results to the supervisors is given only on the basis of national year groups, we suggest that per training centre aggregated test results will in the future be disclosed to the supervisors to adapt local training programs.

Comparison of the test results with assessments of other competences

It would be interesting to compare the results of the formative test with other tools to measure factual knowledge as well as problem-solving skills through the application of this knowledge. However, the results of other assessments of the present group of trainees such as direct observation and in-training reports deemed relevant to establish the level of knowledge-based competencies, are not at our disposal.

International perspective

Due to lack of published reports we were unable to compare our results with those of other progress tests to measure the growth of knowledge during the postgraduate training in medical microbiology. An inquiry into the use of a written formative or summative test among societies of clinical microbiology or infectious diseases 25 European countries showed that in most European countries assessment of knowledge during the training is carried out using oral examinations.

The nearest equivalent seems to be the FRCPath Part1 examination for medical microbiology and virology of the Royal College of Pathology, United Kingdom, which is a three-hour exam consisting of 50 multiple choice questions and 75 extended matching questions (Royal College of Pathologist, 2010). All the trainees in the UK and in Ireland sit the English Royal College of Pathology examinations. However, this test is summative in nature, and must be performed at the end of stage A which is the initial training of 12 months in the principles and practice of medical microbiology and virology. The gain of knowledge during the training period of five years cannot be measured with this test.

Dijksterhuis et al. reported on progress of knowledge testing in postgraduate obstetrics and gynaecology training (Dijksterhuis et al., 2009). Although their progress test appeared disappointing, we believe that the present test used in postgraduate medical microbiology training shows that constructing a formative tests measuring growth of knowledge is quite feasible. The reliability expressed as Cronbach's alpha of the annual tests reached a mean value of 0.737 (0.693-0.792), which can be considered as acceptable for a formative test (Downing, 2004). The growth of knowledge per training year per annum (Figure 2 and 3) is supportive for the construct validity of the instrument.

Conclusion

A valid and useful feedback instrument has been developed to measure progress of knowledge of trainees in medical microbiology including virology. We advocate that feedback of per training centre aggregated test results will be disclosed to the supervisors to adapt local training programs.

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Declaration of interest
The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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Elisabeth G.W. Huijskens was involved in study design and critical revision of the manuscript;
Alje P. van Dam was involved in study design and critical revision of the manuscript;
Frank H. van Tiel was involved in study design and critical revision of the manuscript;

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