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Impact of preclinical laboratory training on physical examination skills during the first clinical year: a single-centre analysis of differences in objective structured clinical examination scores among the first two matriculating classes of a reformed curriculum

Impact of preclinical laboratory training on physical examination skills during the first clinical year: a single-centre analysis of differences in objective structured clinical examination scores among the first two matriculating classes of a reformed curriculum

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ABSTRACT

Objective: As a result of a curriculum reform launched in 2012 at our institution, preclinical training was shortened to two years instead of the traditional three years, creating additional incentives to optimize teaching methods. In accordance with the new curriculum, a semester-long preclinical module of clinical skills lab training takes place in the second year of study, while an introductory clinical course (i.e. brief introductory clerkships) is scheduled for the Fall semester of the third year. Objective structured clinical examinations (OSCEs) are carried out at the conclusion of both the preclinical module and the introductory clinical course. Our aim was to compare the scores at physical exam stations between the first and second matriculating classes of a newly reformed curriculum on preclinical second-year OSCEs and early clinical third-year OSCEs.

Design: Analysis of routinely collected data.

Setting: One Polish medical school.

Participants: OSCE records for 462 second-year students and 445 third-year students.

Outcome measures: OSCE scores by matriculation year.

Results: In comparison to the first class of the newly reformed curriculum, significantly higher (i.e. better) OSCE scores were observed for those students who matriculated in 2013, a year after implementing the reformed curriculum. This finding was consistent for both second-year and third-year cohorts. Additionally, the magnitude of the improvement in median third-year OSCE scores was proportional to the corresponding advancement in preceding second-year preclinical OSCE scores for each of two different sets of physical exam tasks. In contrast, no significant difference was noted between the academic years in the ability to interpret laboratory data or electrocardiograms – tasks which had not been included in the second-year preclinical training.

Conclusion: Our results suggest the importance of preclinical training in a clinical skills lab to improve students' competence in physical examination at the completion of introductory clinical clerkships during the first clinical year.

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Strengths and limitations of this study

- We retrospectively compared OSCE scores at physical exam stations between the first and second matriculating classes of a reformed undergraduate curriculum on preclinical 462 second-year OSCEs and 445 early clinical third-year OSCEs at the completion of introductory clinical clerkships.

- Stations in both OSCEs were highly standardized and identical checklists were used throughout the analysed period.

- That we analysed OSCE records from only one medical school, limits the generalisability of our findings.

- Extension of the observation period into later clinical years and a longitudinal assessment of individual students' performance are lacking.

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INTRODUCTION

Recent decades have witnessed a well-recognized international decline in physical examination skills among medical students and residents.[1–6] This has largely been ascribed to an increasing reliance on advanced imaging technologies and laboratory markers. Notably, the inability to properly perform and interpret a physical exam can not only expose the patient to redundant and costly procedures but also, more importantly, may lead to a missed or delayed diagnosis with potential deadly consequences.[3] Therefore, in order to prevent the physical examination from becoming merely a lost art, a remedial intervention is necessary. This intervention should be planned early, preferentially already at undergraduate level,[7] keeping in mind that junior doctors – engaged in administrative tasks and paperwork – spend 3–5 times more time in front of a computer screen than in direct contact with patients.[8,9]

"To resuscitate clinical skills among clinicians", S. Ramani[7] proposed – among "twelve tips for excellent physical examination teaching" – integration of simulation with bedside learning as well as systematic assessment of clinical skills, the latter elegantly summarized in a lapidary phrase "Assessment drives curriculum". Objective structured clinical examinations (OSCEs) are a recognized assessment tool in medical education. OSCEs are increasingly valued for their ability to predict students' future performance in the clinical setting.[10–15] The approach of using OSCEs has practical implications, providing a basis for the optimization of clinical education and offering insight into remedial strategies to improve students' poor clinical performance.[10,16,17]

Of note, although scores on OSCEs done in the second and third year of study were related to performance on the United States Medical Licensing Examination (USMLE) Step 2 Clinical Skills (CS) component,[14] this association was not strong, and the OSCE scores in years two and three were only weakly interrelated.[12] Additionally, USMLE Step 2 CS scores and second-year OSCE scores correlated moderately with each other, but this relationship lost significance in a multivariate analysis.[11]

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On the other hand, of the OSCE components taken at the end of the first clinical year (year 3), skills in physical examination and data interpretation exhibited the highest ability to predict students' performance in five subsequent clinical examinations during the fourth and fifth years of study.[10] Scores on an OSCE in the first clinical year have a unique property: not only can they be linked to future clinical competence, but also they may be used to estimate the contributions of preclinical training in a clinical skills lab and subsequent bedside teaching to early clinical competence. Surprisingly, there is limited data available comparing second and third-year OSCE scores between various academic years. Chima and Dallaghan[15] recently compared OSCE scores for graduates of the 2013 and 2014 classes and described a discordance between class-to-class variation in scores obtained during second-year preclinical OSCEs and OSCEs completed at the conclusion of the third-year internal medicine clerkship.

In 2012, a new curriculum was launched at our institution, where the preclinical course is scheduled for a period of two, instead of the traditional three, years. Our final year of the medical curriculum (year 6) is dedicated to internships in teaching hospitals during which final-year students assist junior doctors by performing similar tasks under direct clinical supervision. The new curriculum includes a preclinical module of clinical skills lab training in year two, supplemented with bedside teaching of basic clinical skills in the Fall semester of year three, as an introduction to further clinical exposure. The curricular reform has created an additional incentive to make the best possible use of existing educational resources within a limited timeframe. To reach our ultimate goal of maximizing early clinical proficiency, continuous optimization of teaching methods based on an ongoing assessment of the effects of our curriculum reform is necessary.

Our aim was to compare the scores obtained by medical students at physical examination stations between the first and second matriculating classes of the reformed curriculum on preclinical second-year OSCEs and third-year OSCEs at the completion of an introductory clinical course. We hypothesized that differences in the performance between classes on preclinical OSCEs may be reflected in the results of early clinical OSCEs.

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METHODS

Characteristics of the redesigned curriculum

Within the new curriculum, a 30-hour preclinical module of training in a clinical skills lab takes place in the Department of Medical Education of our university in either the Fall or Spring semester of year two (15 weeks; 2 hours per week) (table 1). This module includes practical exercises with simulated patients and mannequin-based learning. In the Fall semester of year three, students enter a 12-week module in bedside teaching of basic clinical skills (i.e. mini-clerkships in the departments of Internal Medicine, Surgery, Paediatrics and Obstetrics/Gynaecology for three weeks each) as an introduction to the core clinical rotations in years three through six (table 1).

Table 1 Traditional and reformed medical curriculum at our university

Type of curriculum	Year of study					
	1	**2**	**3**	**4**	**5**	**6**
Previous curriculum						
Preclinical courses	x	x	x			
Clinical skills lab training			x			
Introductory clinical course			x			
Core clinical clerkships				x	x	x
Reformed curriculum						
Preclinical courses	x	x				
Clinical skills lab training		x				
Introductory clinical course			x			
Core clinical clerkships			x	x	x	
Internship						x

An OSCE was carried out at the conclusion of both teaching modules, starting from the academic year 2013-2014 and onwards. Each OSCE was composed of several stations covering history taking, physical examination, and students' skills in cardiac/pulmonary auscultation.

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Additionally, the third-year OSCE included stations assessing students' ability to interpret laboratory data and a typical electrocardiogram (ECG), as well as two surgical stations (assessing suturing skills). Our highly-standardized physical examination stations did not differ between the second and third-year OSCEs, and they remained unchanged throughout the analysed period, including all tasks randomly chosen from a set of 19 (stations set I) and those from a different set of 16 tasks (stations set II).

Data analysis

We analysed previously collected examination data from second-year OSCEs (Feb/Jun 2014 and Feb/Jun 2015 exam sessions) and third-year OSCEs (Feb 2015 and Feb 2016 exam sessions). As a data source, we used examination records stored in the Department of Medical Education at our university using existing institutional protocols. For the purpose of our analysis, fully anonymized data sets were used in order to ensure personal data protection. Because data sets were anonymous, we were not able to longitudinally estimate individual student performance on the second and third-year OSCEs. An individual OSCE score for each physical exam station and data station was calculated from OSCE grades as a relative value, with the reference being an optimal result for the given task, assumed to be 100%.

The accordance of OSCE scores with a normal distribution was estimated by means of the Shapiro-Wilk's test. Owing to the non-normal distribution, the data was presented as medians and interquartile ranges. Then, OSCE scores were compared separately between the classes who matriculated in 2012 and 2013, for preclinical second-year OSCEs and third-year early clinical OSCEs respectively. Between-class differences in OSCE scores were assessed by the Mann-Whitney U test. A p-value below 0.05 was considered significant. The analysis was performed using STATISTICA (data analysis software system), version 12 (StatSoft, Inc., Tulsa, OK, USA).

RESULTS

OSCE records with complete data points were available for 462 second-year students and 445 third-year students from the first two matriculating classes of the reformed curriculum, for a total of 907 OSCEs that entered our final analysis.

Compared to the first class of the new curriculum who matriculated in 2012, higher (i.e. better) OSCE scores in physical examination skills were observed for students who matriculated one year later in 2013. Improved OSCE scores were noted during both the second year of study (Feb/Jun 2015 vs. Feb/Jun 2014 exam sessions) and the third year (Feb 2016 vs. Feb 2015 exam sessions) (table 2).

Table 2 Comparison of OSCE scores (%) between the classes who matriculated into the new curriculum in 2012 and 2013

Year of study	Year of matriculation		Between-class comparison of OSCE scores p Value*
	2012	**2013**	
Year 2 – preclinical OSCE	Feb/Jun 2014	Feb/Jun 2015	
Physical exam (stations set I)	86 (67–100)	89 (78–100)	0.007
Physical exam (stations set II)	82 (60–92)	90 (83–100)	<0.001
Cardiac/pulmonary auscultation	100 (75–100)	100 (75–100)	0.5
Year 3 – early clinical OSCE	Feb 2015	Feb 2016	
Physical exam (stations set I)	82 (67–90)	86 (78–100)	<0.001
Physical exam (stations set II)	81 (67–100)	90 (83–100)	<0.001
ECG interpretation (basics)	100 (80–100)	100 (80–100)	0.7
Interpretation of laboratory data	88 (75–100)	100 (75–100)	0.8
Cardiac auscultation	80 (60–80)	80 (60–80)	0.6
Pulmonary auscultation	60 (60–80)	100 (80–100)	<0.001

OSCE scores (%) are shown as median and interquartile range.
OSCE, objective structured clinical examination; ECG, electrocardiogram.
*By Mann-Whitney U test.

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Additionally, the magnitude of the improvement in median third-year OSCE scores was proportional to the corresponding changes between academic years in the preceding second-year preclinical OSCE for each of two different sets of physical exam tasks (stations set I: 4% and 3%; stations set II: 9% and 8%; for third-year OSCEs and second-year OSCEs respectively) (table 2). In contrast, no significant changes between academic years were found for the ability to interpret laboratory data or ECGs (i.e. tasks which had not been included in preclinical teaching during the second year of the curriculum) (table 2). In regards to auscultation skills, the only significant between-class change was an improved competence in pulmonary auscultation for the second matriculating class of the new curriculum during their third year of study (table 2).

DISCUSSION

Our most salient finding was that OSCE scores at physical examination stations were higher for students matriculating into the newly reformed curriculum in 2013 compared to those matriculating in 2012. A proportional improvement was noticed between the 2012 and 2013 cohorts in both preclinical second-year OSCE scores and early clinical third-year OSCE scores. Additionally, the magnitude of the improvements in physical examination competence between classes during the early clinical year correlated with the differences in scores attained by students in the 2012 and 2013 matriculating classes during the preclinical second-year OSCE for each of two different sets of physical exam tasks.

The observed association differs from the results of a recent study reporting significantly higher internal medicine clerkship OSCE scores in the first clinical year (year 3 of study) despite a trend of lower second-year preclinical OSCE scores for graduates of the class of 2014 compared to the class of 2013.[15] Additionally, the authors observed no association between student performance on preclinical OSCEs and OSCEs completed after an internal medicine clerkship.[15] Admittedly, similar to the previously mentioned report, it would be appropriate to estimate the effects of preclinical OSCE scores on the results of early clinical OSCEs. However, since our data sets were

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anonymized, we were not able to analyse individual students' performance, therefore, a longitudinal assessment of student performance was not possible.

Our observation has several potential explanations. First off, inconsistencies in OSCE administration and grading between academic years could account for the observed differences in OSCE scores, as suggested previously.[15] However, stations in both OSCEs were highly standardized and identical checklists were used throughout the analysed period. Secondly, the OSCEs were monitored and supervised by different teams of faculty members affiliated with either the Department of Medical Education (second-year OSCE) or the departments supervising the introductory clinical courses (third-year OSCE). Thirdly, even when considering the possibility of non-uniform grading across the study period, hypothetical year-to-year differences in OSCE scores might be expected for all OSCE components. Nevertheless, we observed a significant year-to-year variation exclusively in OSCE scores reflecting physical examination skills. Finally, the previously described influence of the timing of clinical clerkships in the academic year[15] could be excluded because the introductory clinical course was scheduled in the Fall semester for both the 2012 and 2013 matriculating class.

In conclusion, the association of year-to-year improvements in scores at physical exam stations in preclinical OSCEs and OSCEs in the middle of the first clinical year is suggestive of the importance of preclinical training in a clinical skills lab to improve competence in basic physical examination at the completion of early bedside teaching. A preclinical skills lab teaching module appears to be easier to standardize and more responsive to quality-oriented interventions in comparison to the previous clinical bedside teaching approach. Additionally, as to second-year students, it was suggested that an incorporation of formal clinical instruction to their training could be easier compared to those who have already begun clinical clerkships and elective rotations.[3] Moreover, the effectiveness of clinical bedside teaching is known to depend on multiple factors, and studies on the relationship between clinical exposure and early clinical OSCE scores have brought conflicting results.[18–21] Of note, Martin *et al*[19] reported no correlation between self-reported clinical

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exposure to patients and students' performance on an OSCE taken at the end of the first clinical year. Importantly, Kim and Myung[21] described a high variation in the number of patients for whom a medical history was taken or physical examination was performed during clerkships, which is also likely to limit the efficacy of bedside teaching in some departments. This observation could also be responsible for the differences between the 2012 and 2013 matriculating classes in cardiac and pulmonary auscultation skills after the introductory clinical course – probably due to inter-clinic t variation in the characteristics of patients hospitalized in individual internal medicine departments.

Whether the observed trends will be maintained in later clinical years, requires further investigations. Nevertheless, our findings might have practical implications before future data become available. The results of this assessment can serve as a stimulus for further improvements in teaching physical examination skills, OSCE planning, and implementing a remedial intervention for low-scoring students. Our curriculum reform offers a promising and realistic opportunity to put these plans into practice as the new curriculum promotes a continuous optimization of preclinical and clinical education based on an ongoing assessment of teaching effects. Improved undergraduate education is the starting point to interrupt a vicious cycle of undervaluation and underuse of the physical examination in clinical decision making with regard to real-world patients.

Authors' contributions: Study conception and design: JŚ, MN, AnS; study supervision: MN, AnS; data entry: JŚ, ASP, KJ, TC, AgS, KC; data analysis and interpretation: JŚ, AS, MN, EWS, OK, BC, MK; manuscript drafting: JŚ, AnS; contribution to discussion and manuscript revision: MN, MK, EWS, OK, ASP, KJ, TC, AgS, BC, KC; approval of the final version of the manuscript: all the co-authors.

Competing interests: The authors have declared that no competing interest exists.

Data: A fully anonymous data set is available from the authors (surdacki.andreas@gmx.net) on request.

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REFERENCES

1. Mangione S. Cardiac auscultatory skills of physicians-in-training: a comparison of three English-speaking countries. *Am J Med* 2001;110:210–6.

2. Fred HL. Hyposkillia: deficiency of clinical skills. *Tex Heart Inst J* 2005;32:255–7.

3. Max J. The lost art of the physical exam. *Yale Medicine* 2009;43:30–5.

4. Ramani S, Ring BN, Lowe R, Hunter D. A pilot study assessing knowledge of clinical signs and physical examination skills in incoming medicine residents. *J Grad Med Educ* 2010;2:232–5.

5. Oliver CM, Hunter SA, Ikeda T, Galletly DC. Junior doctor skill in the art of physical examination: a retrospective study of the medical admission note over four decades. *BMJ Open* 2013;3:e002257.

6. Haring CM, Cools BM, van der Meer JW, Postma CT. Student performance of the general physical examination in internal medicine: an observational study. *BMC Med Educ* 2014;14:73.

7. Ramani S. Twelve tips for excellent physical examination teaching. *Med Teach* 2008;30:851–6.

8. Block L, Habicht R, Wu AW, *et al*. In the wake of the 2003 and 2011 duty hours regulations, how do internal medicine interns spend their time? *J Gen Int Med* 2013;28:1042–7.

9. Mamykina L, Vawdrey DK, Hripcsak G. How do residents spend their shift time? A time and motion study with a particular focus on the use of computers. *Acad Med* 2016;91:827–32.

10. Martin IG, Jolly B. Predictive validity and estimated cut score of an objective structured clinical examination (OSCE) used as an assessment of clinical skills at the end of the first clinical year. *Med Educ* 2002;36:418–25.

11. Simon SR, Bui A, Day S, *et al*. The relationship between second-year medical students' OSCE scores and USMLE step 2 scores. *J Eval Clin Pract* 2007;13:901–5.

12. Dong T, Saguil A, Artino AR, Jr., *et al*. Relationship between OSCE scores and other typical medical school performance indicators: a 5-year cohort study. Mil Med 2012;177: 44–6.

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13. Graham R, Zubiaurre Bitzer LA, Anderson OR. Reliability and predictive validity of a comprehensive preclinical OSCE in dental education. *J Dent Educ* 2013;77:161–7.

14. Dong T, Swygert KA, Durning SJ, *et al*. Validity evidence for medical school OSCEs: associations with USMLE(R) step assessments. *Teach Learn Med* 2014;26:379–86.

15. Chima M, Dallaghan GB. Does student performance on preclinical OSCEs relate to clerkship grades? *Med Educ Online* 2016;21:31724.

16. White CB, Ross PT, Gruppen LD. Remediating students' failed OSCE performances at one school: the effects of self-assessment, reflection, and feedback. *Acad Med* 2009;84:651–4.

17. Cleland J, Mackenzie RK, Ross S, *et al*. A remedial intervention linked to a formative assessment is effective in terms of improving student performance in subsequent degree examinations. *Med Teach* 2010;32:e185–90.

18. Jolly BC, Jones A, Dacre JE, *et al*. Relationships between students' clinical experiences in introductory clinical courses and their performances on an objective structured clinical examination (OSCE). *Acad Med* 1996;71:909–16.

19. Martin IG, Stark P, Jolly B. Benefiting from clinical experience: the influence of learning style and clinical experience on performance in an undergraduate objective structured clinical examination. *Med Educ* 2000;34:530–4.

20. Wimmers PF, Schmidt HG, Splinter TA. Influence of clerkship experiences on clinical competence. *Med Educ* 2006;40:450–8.

21. Kim JY, Myung SJ. Could clinical experience during clerkship enhance students' clinical performance? *BMC Med Educ* 2014;14:209.

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How does preclinical laboratory training impact physical examination skills during the first clinical year? A retrospective analysis of routinely collected objective structured clinical examination scores among the first two matriculating classes of a reformed curriculum in one Polish medical school

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ABSTRACT

Objective: As a result of a curriculum reform launched in 2012 at our institution, preclinical training was shortened to two years instead of the traditional three years, creating additional incentives to optimize teaching methods. In accordance with the new curriculum, a semester-long preclinical module of clinical skills lab training takes place in the second year of study, while an introductory clinical course (i.e. brief introductory clerkships) is scheduled for the Fall semester of the third year. Objective structured clinical examinations (OSCEs) are carried out at the conclusion of both the preclinical module and the introductory clinical course. Our aim was to compare the scores at physical exam stations between the first and second matriculating classes of a newly reformed curriculum on preclinical second-year OSCEs and early clinical third-year OSCEs.

Design: Analysis of routinely collected data.

Setting: One Polish medical school.

Participants: OSCE records for 462 second-year students and 445 third-year students.

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Results: In comparison to the first class of the newly reformed curriculum, significantly higher (i.e. better) OSCE scores were observed for those students who matriculated in 2013, a year after implementing the reformed curriculum. This finding was consistent for both second-year and third-year cohorts. Additionally, the magnitude of the improvement in median third-year OSCE scores was proportional to the corresponding advancement in preceding second-year preclinical OSCE scores for each of two different sets of physical exam tasks. In contrast, no significant difference was noted between the academic years in the ability to interpret laboratory data or electrocardiograms – tasks which had not been included in the second-year preclinical training.

Conclusion: Our results suggest the importance of preclinical training in a clinical skills lab to improve students' competence in physical examination at the completion of introductory clinical clerkships during the first clinical year.

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Strengths and limitations of this study

- We retrospectively compared OSCE scores at physical exam stations between the first and second matriculating classes of a reformed undergraduate curriculum on preclinical 462 second-year OSCEs and 445 early clinical third-year OSCEs at the completion of introductory clinical clerkships.

- Stations in both OSCEs were highly standardized and identical checklists were used throughout the analysed period.

- That we analysed OSCE records from only one medical school, limits the generalisability of our findings.

- Extension of the observation period into later clinical years and a longitudinal assessment of individual students' performance are lacking.

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INTRODUCTION

Recent decades have witnessed a well-recognized international decline in physical examination skills among medical students and residents.[1–6] This has largely been ascribed to an increasing reliance on advanced imaging technologies and laboratory markers. Notably, the inability to properly perform and interpret a physical exam can not only expose the patient to redundant and costly procedures but also, more importantly, may lead to a missed or delayed diagnosis with potential deadly consequences.[3] Therefore, in order to prevent the physical examination from becoming merely a lost art, a remedial intervention is necessary. This intervention should be planned early, preferentially already at undergraduate level,[7] keeping in mind that junior doctors – engaged in administrative tasks and paperwork – spend 3–5 times more time in front of a computer screen than in direct contact with patients.[8,9]

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On the other hand, of the OSCE components taken at the end of the first clinical year (year 3), skills in physical examination and data interpretation exhibited the highest ability to predict students' performance in five subsequent clinical examinations during the fourth and fifth years of study.[10] Scores on an OSCE in the first clinical year have a unique property: not only can they be linked to future clinical competence, but also they may be used to estimate the contributions of preclinical training in a clinical skills lab and subsequent bedside teaching to early clinical competence. Surprisingly, there is limited data available comparing second and third-year OSCE scores between various academic years. Chima and Dallaghan[15] recently compared OSCE scores for graduates of the 2013 and 2014 classes and described a discordance between class-to-class variation in scores obtained during second-year preclinical OSCEs and OSCEs completed at the conclusion of the third-year internal medicine clerkship.

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Reformed curriculum						
Preclinical courses	x	x				
Clinical skills lab training		x				
Introductory clinical course			x			
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Internship						x

An OSCE was carried out at the conclusion of both teaching modules, starting from the academic year 2013-2014 and onwards. Each OSCE was composed of several stations covering history taking, physical examination, and students' skills in cardiac/pulmonary auscultation. Additionally, the third-year OSCE included stations assessing students' ability to interpret

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Data analysis

We analysed previously collected examination data from second-year OSCEs (Feb/Jun 2014 and Feb/Jun 2015 exam sessions) and third-year OSCEs (Feb 2015 and Feb 2016 exam sessions). As a data source, we used examination records stored in the Department of Medical Education at our university using existing institutional protocols. For the purpose of our analysis, fully anonymized data sets were used in order to ensure personal data protection. Because data sets were anonymous, we were not able to longitudinally estimate individual student performance on the second and third-year OSCEs. An individual OSCE score for each physical exam station and data station was calculated from OSCE grades as a relative value, with the reference being an optimal result for the given task, assumed to be 100%.

The accordance of OSCE scores with a normal distribution was estimated by means of the Shapiro-Wilk's test. Owing to the non-normal distribution, the data was presented as medians and interquartile ranges. Then, OSCE scores were compared separately between the classes who matriculated in 2012 and 2013, for preclinical second-year OSCEs and third-year early clinical OSCEs respectively. Between-class differences in OSCE scores were assessed by the Mann-Whitney U test. In order to deal with missing data, the analysis was first performed for OSCE records with complete data points and then repeated including also incomplete OSCE records with at least one available data point. A p-value below 0.05 was considered significant. The analysis was performed using STATISTICA (data analysis software system), version 12 (StatSoft, Inc., Tulsa, OK, USA).

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RESULTS

Out of potentially eligible 513 second-year and 466 third-year OSCE records, we had excluded 51 and 21 incomplete records, respectively, due to missing data. OSCE records with complete data points were available for 462 second-year students and 445 third-year students from the first two matriculating classes of the reformed curriculum, for a total of 907 OSCEs that entered our final analysis.

Compared to the first class of the new curriculum who matriculated in 2012, higher (i.e. better) OSCE scores in physical examination skills were observed for students who matriculated one year later in 2013. Improved OSCE scores were noted during both the second year of study (Feb/Jun 2015 vs. Feb/Jun 2014 exam sessions) and the third year (Feb 2016 vs. Feb 2015 exam sessions) (table 2).

Table 2 Comparison of OSCE scores (%) between the classes who matriculated into the new curriculum in 2012 and 2013

Year of study	Year of matriculation		Between-class comparison of OSCE scores p Value*
	2012	**2013**	
Year 2 – preclinical OSCE	Feb/Jun 2014	Feb/Jun 2015	
Physical exam (stations set I)	86 (67–100)	89 (78–100)	0.007
Physical exam (stations set II)	82 (60–92)	90 (83–100)	<0.001
Cardiac/pulmonary auscultation	100 (75–100)	100 (75–100)	0.5
Year 3 – early clinical OSCE	Feb 2015	Feb 2016	
Physical exam (stations set I)	82 (67–90)	86 (78–100)	<0.001
Physical exam (stations set II)	81 (67–100)	90 (83–100)	<0.001
ECG interpretation (basics)	100 (80–100)	100 (80–100)	0.7
Interpretation of laboratory data	88 (75–100)	100 (75–100)	0.8
Cardiac auscultation	80 (60–80)	80 (60–80)	0.6
Pulmonary auscultation	60 (60–80)	100 (80–100)	<0.001

OSCE scores (%) are shown as median and interquartile range. OSCE, objective structured clinical examination; ECG, electrocardiogram. *By Mann-Whitney U test.

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Additionally, the magnitude of the improvement in median third-year OSCE scores was proportional to the corresponding changes between academic years in the preceding second-year preclinical OSCE for each of two different sets of physical exam tasks (stations set I: 4% and 3%; stations set II: 9% and 8%; for third-year OSCEs and second-year OSCEs respectively) (table 2). In contrast, no significant changes between academic years were found for the ability to interpret laboratory data or ECGs (i.e. tasks which had not been included in preclinical teaching during the second year of the curriculum) (table 2). In regards to auscultation skills, the only significant between-class change was an improved competence in pulmonary auscultation for the second matriculating class of the new curriculum during their third year of study (table 2).

The results were substantially unchanged either upon adjustment for different timing of second-year OSCEs in the academic year (i.e., separate analyses for OSCEs scheduled after the Fall or Spring semester), or after inclusion of incomplete OSCE records with ≥available data point.

DISCUSSION

Our most salient finding was that OSCE scores at physical examination stations were higher for students matriculating into the newly reformed curriculum in 2013 compared to those matriculating in 2012. A proportional improvement was noticed between the 2012 and 2013 cohorts in both preclinical second-year OSCE scores and early clinical third-year OSCE scores. Additionally, the magnitude of the improvements in physical examination competence between classes during the early clinical year correlated with the differences in scores attained by students in the 2012 and 2013 matriculating classes during the preclinical second-year OSCE for each of two different sets of physical exam tasks.

The observed association differs from the results of a recent study reporting significantly higher internal medicine clerkship OSCE scores in the first clinical year (year 3 of study) despite a

trend of lower second-year preclinical OSCE scores for graduates of the class of 2014 compared to the class of 2013.[15] Additionally, the authors observed no association between student performance on preclinical OSCEs and OSCEs completed after an internal medicine clerkship.[15] Admittedly, similar to the previously mentioned report, it would be appropriate to estimate the effects of preclinical OSCE scores on the results of early clinical OSCEs. However, since our data sets were anonymized, we were not able to analyse individual students' performance, therefore, a longitudinal assessment of student performance was not possible.

Our observation has several potential explanations. First off, inconsistencies in OSCE administration and grading between academic years could account for the observed differences in OSCE scores, as suggested previously.[15] However, stations in both OSCEs were highly standardized and identical checklists were used throughout the analysed period. Secondly, the OSCEs were monitored and supervised by different teams of faculty members affiliated with either the Department of Medical Education (second-year OSCE) or the departments supervising the introductory clinical courses (third-year OSCE). Moreover, at equivalent OSCEs, the performance of students matriculating in 2012 and 2013 was assessed by virtually the same teams of examiners, including only lecturers – previously trained by senior teachers in OSCE planning, administration and grading – with a wide and proven experience in the scoring of OSCE stations. Thirdly, even when considering the possibility of non-uniform grading across the study period, hypothetical year-to-year differences in OSCE scores might be expected for all OSCE components. Nevertheless, we observed a significant year-to-year variation exclusively in OSCE scores reflecting physical examination skills. Finally, the previously described influence of the timing of clinical clerkships in the academic year[15] could be excluded because the introductory clinical course was scheduled in the Fall semester for both the 2012 and 2013 matriculating class.

In conclusion, the association of year-to-year improvements in scores at physical exam stations in preclinical OSCEs and OSCEs in the middle of the first clinical year is suggestive of the importance of preclinical training in a clinical skills lab to improve competence in basic physical

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examination at the completion of early bedside teaching. A preclinical skills lab teaching module appears to be easier to standardize and more responsive to quality-oriented interventions in comparison to the previous clinical bedside teaching approach. Additionally, as to second-year students, it was suggested that an incorporation of formal clinical instruction to their training could be easier compared to those who have already begun clinical clerkships and elective rotations.[3] Moreover, the effectiveness of clinical bedside teaching is known to depend on multiple factors, and studies on the relationship between clinical exposure and early clinical OSCE scores have brought conflicting results.[18–21] Of note, Martin *et al*[19] reported no correlation between self-reported clinical exposure to patients and students' performance on an OSCE taken at the end of the first clinical year. Importantly, Kim and Myung[21] described a high variation in the number of patients for whom a medical history was taken or physical examination was performed during clerkships, which is also likely to limit the efficacy of bedside teaching in some departments. This observation could also be responsible for the differences between the 2012 and 2013 matriculating classes in cardiac and pulmonary auscultation skills after the introductory clinical course – probably due to inter-clinic t variation in the characteristics of patients hospitalized in individual internal medicine departments.

Whether the observed trends will be maintained in later clinical years, requires further investigations with a prolonged follow-up. Additionally, that we analysed OSCE records from only one medical school, poses another limitation to the interpretation and generalisability of our results. Nevertheless, even if seems premature to draw any far-going conclusions for the time being, our findings might have practical implications before future data become available. The results of this assessment can serve as a stimulus for further improvements in teaching physical examination skills, OSCE planning, and implementing a remedial intervention for low-scoring students. Our curriculum reform offers a promising and realistic opportunity to put these plans into practice as the new curriculum promotes a continuous optimization of preclinical and clinical education based on an ongoing assessment of teaching effects. Improved undergraduate education is the starting point

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to interrupt a vicious cycle of undervaluation and underuse of the physical examination in clinical

decision making with regard to real-world patients.

Authors' contributions: Study conception and design: JŚ, MN, AnS; study supervision: MN, AnS; data entry: JŚ, ASP, KJ, TC, AgS, KC; data analysis and interpretation: JŚ, AS, MN, EWS, OK, BC, MK; manuscript drafting: JŚ, AnS; contribution to discussion and manuscript revision: MN, MK, EWS, OK, ASP, KJ, TC, AgS, BC, KC; approval of the final version of the manuscript: all the co-authors.

Competing interests: The authors have declared that no competing interest exists.

Ethics: We retrospectively analysed routinely collected administrative data, i.e. examination records stored in the Department of Medical Education of our university using existing institutional protocols under the supervision of the Head of the Department (MN), one of the senior authors on this work. For the purpose of our analysis, fully anonymized data sets were used in order to ensure personal data protection.

Data: A fully anonymous data set is available from the authors (surdacki.andreas@gmx.net) on request.

REFERENCES

1. Mangione S. Cardiac auscultatory skills of physicians-in-training: a comparison of three English-speaking countries. *Am J Med* 2001;110:210–6.

2. Fred HL. Hyposkillia: deficiency of clinical skills. *Tex Heart Inst J* 2005;32:255–7.

3. Max J. The lost art of the physical exam. *Yale Medicine* 2009;43:30–5.

4. Ramani S, Ring BN, Lowe R, Hunter D. A pilot study assessing knowledge of clinical signs and physical examination skills in incoming medicine residents. *J Grad Med Educ* 2010;2:232–5.

5. Oliver CM, Hunter SA, Ikeda T, Galletly DC. Junior doctor skill in the art of physical examination: a retrospective study of the medical admission note over four decades. *BMJ Open* 2013;3:e002257.

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6. Haring CM, Cools BM, van der Meer JW, Postma CT. Student performance of the general physical examination in internal medicine: an observational study. *BMC Med Educ* 2014;14:73.

7. Ramani S. Twelve tips for excellent physical examination teaching. *Med Teach* 2008;30:851–6.

8. Block L, Habicht R, Wu AW, *et al*. In the wake of the 2003 and 2011 duty hours regulations, how do internal medicine interns spend their time? *J Gen Int Med* 2013;28:1042–7.

9. Mamykina L, Vawdrey DK, Hripcsak G. How do residents spend their shift time? A time and motion study with a particular focus on the use of computers. *Acad Med* 2016;91:827–32.

10. Martin IG, Jolly B. Predictive validity and estimated cut score of an objective structured clinical examination (OSCE) used as an assessment of clinical skills at the end of the first clinical year. *Med Educ* 2002;36:418–25.

11. Simon SR, Bui A, Day S, *et al*. The relationship between second-year medical students' OSCE scores and USMLE step 2 scores. *J Eval Clin Pract* 2007;13:901–5.

12. Dong T, Saguil A, Artino AR, Jr., *et al*. Relationship between OSCE scores and other typical medical school performance indicators: a 5-year cohort study. Mil Med 2012;177: 44–6.

13. Graham R, Zubiaurre Bitzer LA, Anderson OR. Reliability and predictive validity of a comprehensive preclinical OSCE in dental education. *J Dent Educ* 2013;77:161–7.

14. Dong T, Swygert KA, Durning SJ, *et al*. Validity evidence for medical school OSCEs: associations with USMLE(R) step assessments. *Teach Learn Med* 2014;26:379–86.

15. Chima M, Dallaghan GB. Does student performance on preclinical OSCEs relate to clerkship grades? *Med Educ Online* 2016;21:31724.

16. White CB, Ross PT, Gruppen LD. Remediating students' failed OSCE performances at one school: the effects of self-assessment, reflection, and feedback. *Acad Med* 2009;84:651–4.

17. Cleland J, Mackenzie RK, Ross S, *et al*. A remedial intervention linked to a formative assessment is effective in terms of improving student performance in subsequent degree examinations. *Med Teach* 2010;32:e185–90.

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18. Jolly BC, Jones A, Dacre JE, *et al.* Relationships between students' clinical experiences in introductory clinical courses and their performances on an objective structured clinical examination (OSCE). *Acad Med* 1996;71:909–16.

19. Martin IG, Stark P, Jolly B. Benefiting from clinical experience: the influence of learning style and clinical experience on performance in an undergraduate objective structured clinical examination. *Med Educ* 2000;34:530–4.

20. Wimmers PF, Schmidt HG, Splinter TA. Influence of clerkship experiences on clinical competence. *Med Educ* 2006;40:450–8.

21. Kim JY, Myung SJ. Could clinical experience during clerkship enhance students' clinical performance? *BMC Med Educ* 2014;14:209.

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any pre-specified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	7
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	N/A
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	7

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	N/A
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	8
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	N/A
		Cross-sectional study—Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-9
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	10-12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.