Research-oriented series: a portal into the culture of biomedical research for junior medical students at Alfaisal University in Saudi Arabia

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Shareef MA, Dweik LM, Abudan Z, Gazal AM, Abu-Dawas RB, Chamseddin RA, Albali NH, Ali AA, Khan TA, AlAmodi AA. Research-oriented series: a portal into the culture of biomedical research for junior medical students at Alfaisal University in Saudi Arabia. Adv Physiol Educ 39: 32–38, 2015; doi:10.1152/advan.00148.2013.—Student contributions to research have been shown to effectively reflect on their communication and critical thinking skills. Short-term research courses offer opportunities for medical students to advance their research experience in subsequent high-demanding long-term research opportunities. The purpose of the present study was to describe the development, implementation, and evaluation of a research-oriented series (ROS) on undergraduate students at Alfaisal University in Saudi Arabia. The ROS was designed to comprise eight sessions. Each session addressed core principles and the practice of research concepts and was based on theoretical morning sessions supplemented by afternoon practical sessions delivered by experienced senior medical students and faculty members. Students were assessed comprehensively by the end of the ROS. The series was conducted twice, and 35 students were involved each time. A total of 70 enrolled students (35 men and 35 women) with grade point averages of >3.5 and <3.5 were asked to fill out an anonymous, online, self-administered questionnaire assessing their perception of knowledge, skills, and confidence after attending the ROS and evaluating their senior peers. Ninety percent of the medical students responded to the online survey and rated the ROS highly in improving their research knowledge, skills, and confidence. Male students reported significant gains compared with their female peers (P < 0.05). Grade point averages did not play a role in student gains after attending the ROS. Qualitative responses were in support of three recurring themes favoring the unique learning environment in the ROS. In conclusion, the ROS offers a short-term systematic approach to fundamental steps and concepts of biomedical research.

undergraduate research; research-oriented series; biomedical research

The research universities have often failed, and continue to fail their undergraduate populations, thousands of students graduate without seeing the world–famous professors or tasting genuine research.

Boyer Commission (7). THIS ALARMING STATEMENT by the Boyer Commission in 1998 was driven by the inability of graduating students to exhibit sufficient communicative and critical thinking skills (7). Consequently, taking due note of the gravity of this declaration, many research-intensive universities in the United States laid greater emphasis on undergraduate research (UR) as a means to overcome this crisis by integrating research in curricular and cocurricular activities (12). Subsequent evidence in literature has well documented the benefits of UR, claiming that it can reach up to 40 gains. Generally, these benefits include improving undergraduate students’ research skills, enhancing postgraduate education preparation, and breeding a generation of competent and nonisolated physicians (2, 17, 19, 22, 23, 31). Further stress was laid on the importance of research by the National Academies Bio Report in 2010, which stated that “All students should be encouraged to pursue independent research as early as is practical in their education” (27).

Despite the significance and numerous educational gains of UR, medical students still encounter some challenges. These challenges include 1) feeling isolated in research-oriented discussion (junior students in particular), 2) initiating or joining and coping with a research project with the aim of knowledge production in a peer-reviewed journal, 3) effective and sufficient exposure to the research mentor, and 4) finding protected time to contribute to scholarly driven activities specific to medical students (10, 21, 24, 26).

One of the most widely accepted definitions of UR was developed by the Council on UR (CUR) in the United States. According to this definition, UR is an inquiry or investigation conducted by undergraduate(s) that makes intellectual or creative contributions to the discipline (32). However, the CUR definition does not incorporate prime challenges such as devoting financial and human resources as well as permitting accessibility to research for every undergraduate (16). Therefore, investigators such as Healy et al. (15) developed and described a broader definition of what is perceived as UR: Healy et al.’s definition focused on the development of a curriculum that not only well integrates research but also incorporates the dissemination and acquisition of research-based skills through well-structured teaching and learning practices.

Research-oriented series (ROS), an indigenously developed term, was initiated to introduce a student-run alternative that could possibly help overcoming some of the above-mentioned challenges in UR. Therefore, it is very crucial to assess the participants’ perceptions on the impact and effectiveness of ROS on their knowledge, skills, and confidence. The objectives of the present study were to 1) describe the development, implementation, and evaluation of ROS; 2) examine if there are sex- or grade point average (GPA)-specific related differences in gains of knowledge, skills, and confidence in research; and 3) assess student perceptions of their senior colleagues as research tutors.

METHODS

Motivation and objectives. To the best of our knowledge, the concept of UR in the Middle East is still in its maturing phase, and hence UR in the Middle East is not vastly well represented in the...
existing literature (29). Alfaisal University is a 6-yr-old, private, nonprofit, research-based institute located in Riyadh, the capital city of the Kingdom of Saudi Arabia. It serves ∼700 undergraduate medical students. Although the College of Medicine at Alfaisal University has established an UR Committee (URC) that facilitates students’ contributions to variable high-quality research-based activities, at present, the URC can accommodate only 50% of the total medical student body (1, 2). As a consequence of this limited capacity, most students who get selected to pursue research programs offered by the URC tend to be relatively senior students with previous involvement in research activities, although all undergraduate students have the opportunity to apply. Therefore, the ROS was developed to 1) teach medical students the basic principles and skills of clinical and biomedical research, 2) offer a unique enjoyable learning experience by allowing significant interactions between senior and junior medical students, and 3) promote students to be active members of prospective research projects.

Structure, content, and delivery. The structure and content of the ROS were developed following input from the existing literature as well as nine faculty members from the College of Medicine at Alfaisal University and senior medical students with significant contributions to research-based activities. These senior students were selected based on their research curriculum vitae. It is required for each senior student to have published in peer-reviewed journals (minimum of 3 papers) as well as have authentic research experience in international research institutes (duration: 5 mo) with active local research endeavors. These senior medical students were allocated 1 h per session to express and share their experiences in research and offer advice on how to overcome barriers in research, what aspects you need to develop to persist, and tips in getting the most out of a research experiences.

The ROS was conducted in eight different sessions that were conducted biweekly over the weekend from 8:00 AM to 3:00 PM and were taught by faculty members and senior medical students with significant research experience. Each session was further subdivided into theoretical (morning) and practical components (afternoon). The theoretical component of the ROS was conducted in the form of formal lectures and informal discussions, whereas the practical aspect entailed guided task-based workshops and laboratory visits. Moreover, the two subcategories were integrated together as students were encouraged to apply the theoretical knowledge they learned to the practical elements of the series. Each session covered one or two essential aspects of the research process, such as generating a research idea and question, data collection and analysis, reading and criticizing peer-reviewed articles, and tips for writing research proposals and articles. Various topics were discussed in biomedical research with a special focus on high-quality original research topics. The ROS was conducted once each semester with multiple sessions covering different aspects of research and had no academic credit; however, it is currently under the process of acquiring an approval for academic credit to be given by the College of Medicine. The learning objectives and course outline of the ROS are shown in Table 1.

### Table 1. Description and outline of the ROS

<table>
<thead>
<tr>
<th>Sessions</th>
<th>Theoretical/Practical Classes (Mentors)</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Literature search and approach to research idea development</td>
<td>Theoretical: 2 (1 faculty member and 1 senior student) Practical: 2 (1 senior student)</td>
<td>Introduction to basic terms used in research Understand the process of research Identify common types of research studies and their implications</td>
</tr>
<tr>
<td>2. Reading and criticizing a research article</td>
<td>Theoretical: 2 (1 senior student) Practical: 2 (1 senior student)</td>
<td>Identify basic elements of an article and their purposes Effective strategy of scanning and skimming a research article Read and understand each segment of a research paper Understand the fundamentals of evidence-based medicine and criticizing a clinical research paper*</td>
</tr>
<tr>
<td>3. Research methodology and study and proposal design</td>
<td>Theoretical: 2 (1 faculty member and 2 senior students) Practical: 2 (1 senior student)</td>
<td>Strategies for effective data collection Knowledge of fundamental principles of study design Conduct and analyze common psychometric scales used in questionnaires (e.g., Likert scale)</td>
</tr>
<tr>
<td>4. Introduction to statistics and data analysis (1)</td>
<td>Theoretical: 1 (2 senior students)</td>
<td>Identify major segments of a proposal and what each signifies Introduction to molecular laboratory techniques Exposure to common statistical tests used in biostatistics (e.g., paired and independent-samples t-tests, mean, mode, confidence interval, ±SD, etc.)</td>
</tr>
<tr>
<td>5 and 6. Data analysis and interpretation (2)</td>
<td>Theoretical: 1 (1 senior student) Practical: 2 (1 senior student) Practical: 6 (1 senior student)</td>
<td>Usage of the Excel program for data analysis Usage of Statistical Package for the Social Sciences (SPSS) to analyze data</td>
</tr>
<tr>
<td>7. Principles of writing a manuscript</td>
<td>Theoretical: 1 (1 faculty member) Practical: 2 (1 senior student)</td>
<td>Practice to interpret and explain the results of analyzed data Make a plan to write a manuscript and discussing core ideas to present in the paper Understand the core objective of what to be written in each segment of a research paper</td>
</tr>
<tr>
<td>8. Assessment and presentations</td>
<td>Practical: 2 (1 senior student)</td>
<td>Structure an abstract after reading a research article and comparing it with the original one Understand the fundamentals of citation and references using Endnote Effective approach of selecting journals suiting the quality of work</td>
</tr>
</tbody>
</table>

The main theme of each session, number of theoretical and practical classes given by mentors, and the objectives of each session are shown. *This topic was added in the second round of the research-oriented series (ROS).
Assessment process. Students enrolled in the ROS were assessed based on the following:

1. Attendance and in-class participation (10%)
2. Assignments and scientific presentations (30%)
3. Final comprehensive examination (60%)

Students were required to achieve an overall score of >60% to pass the ROS successfully. Furthermore, students had to attend 75% of the overall sessions conducted during the semester to obtain eligibility to sit the final examination. Students’ performance on the assignments and scientific presentations was evaluated carefully with feedback from faculty members and senior medical students on both satisfactory areas as well as those requiring improvement. The final comprehensive examination included problem-based multiple-choice questions (35 total), short-answer questions (10 total), and practical oriented questions, which entailed the execution of five tasks by the students. All students who were enrolled in the series completed it successfully. The two objectives of the assessment were to 1) determine the high achievers to be awarded a research travel grant into the Summer Program for International Research Internship and Training (SPIRIT; a major program that helps students to gain 2 mo of research experience internationally) and 2) assess how much knowledge and skills students gained from their overall participation in the series.

Acknowledgment and commendations. At the end of every ROS, students were acknowledged and awarded certificates of attendance by the College of Medicine at Alfaisal University. These certificates were awarded in a special ceremony attended by the Dean of the College of Medicine and senior faculty members. Exceptionally high achievers were awarded with direct enrollment in SPIRIT (2). SPIRIT allows students to participate in 2 mo of intensive research training in North America during the summer. SPIRIT students are funded by the Undergraduate Research Committee at Alfaisal University’s College of Medicine. This added award, thus, had a significant impact on raising the level of competition and drive to excel between ROS students.

Over the passage of time, the ROS has become so popular on campus that to further accommodate students, in addition to the sessions during the academic year, a summer leg of the series was organized in 2013. Thirty-five students, of which half were men and half women, were enrolled both times. In this study, we present the results of the first and second runs of the ROS.

Evaluation of student gains from the ROS. To assess the impact of the ROS on students’ gains in skills, knowledge, and confidence in research, an anonymous, online, self-administered survey was sent to 70 students who were enrolled in the first and second ROS. The survey included 25 items adopted and modified from a previously conducted study (22) in semiquantitative format. It also sought to collect student perceptions about the senior students who served as tutors for some of the ROS sessions. The survey was designed based on a Likert scale of 1–5 as follows: 5 = “strongly agree,” 4 = “agree,” 3 = “neutral,” 2 = “disagree,” and 1 = “strongly disagree.” Students were asked to compare their gains in skills (8 items), knowledge (6 items), and confidence (5 items) in research after joining the ROS. The Likert scale was then summated into a three-part scale as follows: 4 and 5 = “agree,” 3 = “neutral,” and 1 and 2 = “disagree” (Table 2). Data analysis was performed using the SPSS software package (version 20).

Both male and female medical juniors were given an equal opportunity to enroll in the series. Because of the limited availability of coeducation in Saudi Arabia, lectures were conducted in a two-floored classroom with women in the upper floor and men in the lower floor. All students were taught the material by the same tutors and were given equal opportunity to interact.

To understand whether sex would play a role in influencing the gains made by students in the ROS, we compared female and male medical students’ responses after joining the ROS. Moreover, we also studied differences between student perceptions based on their academic performance as indicated by their GPA. At our institute, a GPA that equals or lies above 3.5/4 places a medical student on the honor student roll. We compared two groups of students in light of their last available cumulative GPA before ROS enrollment. The first group included students who achieved a GPA equal or above 3.5. The second group was composed of students whose GPA was between 2.75 and 3.5. A comparison after students joined the ROS was consequently made. For the purposes of this comparison, we used a

<table>
<thead>
<tr>
<th>Themes</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Knowledge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familiar with different types of research articles</td>
<td>87.30</td>
<td>55</td>
<td>9.52</td>
</tr>
<tr>
<td>Know what are different segments of an article</td>
<td>84.13</td>
<td>53</td>
<td>12.70</td>
</tr>
<tr>
<td>Know the basic outlines for constructing a proposal</td>
<td>68.25</td>
<td>43</td>
<td>23.81</td>
</tr>
<tr>
<td>Have sufficient knowledge on common lab techniques</td>
<td>69.84</td>
<td>44</td>
<td>28.57</td>
</tr>
<tr>
<td>Know common statistical tests</td>
<td>79.37</td>
<td>50</td>
<td>12.70</td>
</tr>
<tr>
<td>Know how to interpret the results from the analyzed data</td>
<td>77.78</td>
<td>49</td>
<td>15.87</td>
</tr>
<tr>
<td>Skills</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can formulate research hypothesis</td>
<td>79.37</td>
<td>50</td>
<td>15.87</td>
</tr>
<tr>
<td>Can develop a research project</td>
<td>55.56</td>
<td>35</td>
<td>38.10</td>
</tr>
<tr>
<td>Can find research articles using common search engines</td>
<td>80.95</td>
<td>51</td>
<td>15.87</td>
</tr>
<tr>
<td>Can read and understand a research article</td>
<td>88.89</td>
<td>56</td>
<td>9.52</td>
</tr>
<tr>
<td>Can construct a questionnaire or survey</td>
<td>88.89</td>
<td>56</td>
<td>9.52</td>
</tr>
<tr>
<td>Can use statistical programs to analyze the data</td>
<td>68.25</td>
<td>43</td>
<td>25.40</td>
</tr>
<tr>
<td>Can do proper citation and references for an article</td>
<td>79.37</td>
<td>50</td>
<td>7.94</td>
</tr>
<tr>
<td>Can present a research article</td>
<td>74.60</td>
<td>47</td>
<td>19.05</td>
</tr>
<tr>
<td>Confidence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can make significant contribution to research team/s</td>
<td>68.25</td>
<td>43</td>
<td>28.57</td>
</tr>
<tr>
<td>Can explain a research project to scientists</td>
<td>65.08</td>
<td>41</td>
<td>25.40</td>
</tr>
<tr>
<td>Can provide feedback from a research project to peers</td>
<td>68.25</td>
<td>43</td>
<td>20.63</td>
</tr>
<tr>
<td>Can suggest future directions of a study</td>
<td>57.14</td>
<td>36</td>
<td>30.16</td>
</tr>
<tr>
<td>Can become a successful researcher in the future</td>
<td>68.25</td>
<td>43</td>
<td>25.40</td>
</tr>
</tbody>
</table>

Values are presented as percentages with the number of responses (n). Students evaluated all items of each domain after completion of the ROS. Responses were divided into three groups based on the agreement level.

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Changing students' perception about research

Review Board of Alfaisal University.

DISCUSSION

nonparametric Mann-Whitney U-test. P values of <0.05 were considered statistically significant.

The survey also included an open-ended question to know which aspect students favored the most in the ROS. Directed content analysis was used to identify the most valued and repeated themes.

Ethical approval. This project was approved by the Institutional Review Board of Alfaisal University.

RESULTS

The response rate from ROS students was 90% (63 of 70 students). Respondents included 47.61% (n = 30) male students and and 52.39% (n = 33) female students.

Student self-assessment of skill, knowledge, and confidence. The majority of respondents' self-rating responses rated their skill, knowledge, and confidence. Average percentages of agreement responses toward the three domains were 77.78%, 76.98%, and 65.40% for knowledge, skills, and confidence, respectively. Further examinations of individual items under each domain also showed that the majority of items were rated highly (Table 2).

Student evaluation of ROS tutors. When asked to evaluate the senior students as tutors, junior students perceived sufficient knowledge and understanding of research as the most valued aspects. Senior students as tutors playing an important role in changing junior student perceptions about research was perceived to have lowest veracity (Fig. 1).

Sex-specific differences in gains of skill, knowledge, and confidence in research. Upon evaluation based on sex after students attended the ROS, male medical students’ self-ratings showed significant improvement in knowledge (P = 0.004), skill (P = 0.015), and confidence (P = 0.032) compared with the self-ratings of female medical students (Fig. 2).

GPA-dependent differences in gains of skill, knowledge, and confidence in research. When evaluated considering the GPA of respondents, knowledge, skill, and confidence did not show any significant differences in the gains of all items after students joined the ROS (Fig. 3).

Student evaluation of the ROS. As per the qualitative analysis, there were three important repeated themes in student responses. These themes were ranked and expressed in percentages based on the central theme included in student responses. Interestingly, 27% of student responses included that the ROS provided an enjoyable environment for learning research (Table 2).

DISCUSSION

As mentioned above, the benefits of involving students in research are numerous and can exceed 40 gains (22). However, most literature reporting the benefits of undergraduate research is based on students’ involvement in long-term mentored research opportunities. In the present study, we describe and evaluated a short-term, student-driven initiative called the ROS. Overall, our survey shows that the ROS helped the students in many ways manifested by their high ratings of their research background in three domains, which are knowledge, skills, and confidence (Table 2).

With regards to the knowledge domain, upon completion of the ROS, the majority of students showed positive responses toward their gains in understanding types of different research articles (87.30%, n = 55), the composition of a research article (84.13%, n = 53), and common statistical tests (79.37%, n = 50; Table 2). Within the skills domain, after completion of the ROS, students also highly rated their gains in reading and understanding a research article (88.89%, n = 56). In addition, the same figure was represented for evaluation of student skills in completing a questionnaire (Table 2). These findings are similar to those reported by Blaster et al. (4) from a similar research course. We believe that the potential explanation for such findings lies in the fact that the ROS offers structured research sessions that strive to acclimatize students to the process of research from its very inception by imparting knowledge and skills about developing a research idea to its end-stage dissemination (Table 1). Such programs or courses have been reported to result in better outcomes compared with nonstructured independent research activities (6, 20). In addition, offering research courses that greatly emphasize on the integration of theoretical and practical knowledge via the application of the former to the latter play a significant role in the effectiveness and outcome of a given research training

Fig. 1. Student self-ratings of research-oriented series (ROS) tutors. The order of items was based on the collective perceptions of each item by respondents (63 of 70 students with a response rate of 90%), with the top bar representing the highest perceived item and the bottom bar representing the item least agreed upon. Ratings of the items are based on a Likert scale, and each bar represents the mean ± SE of student responses.

Fig. 2. Sex-specific differences in student self-assessments of knowledge, skills, and confidence. Each sex-specific group of students (30 male students and 33 female students) was evaluated after the ROS had been completed. Each component was rated based on a Likert scale, and each bar represents the mean ± SE of average student responses. *P < 0.05.
program (29). Moreover, within the confidence domain, students rated themselves highly as becoming confident manifested by making significant contribution to a research team (68.25%, \( n = 43 \)) and provide feedback from a research project to peers (68.25, \( n = 43 \); Table 2). This finding might have arisen due to the involvement of senior medical students with previous research experience in the series. Generally, an improvement in confidence has been an oft-reported outcome of contribution in structured or nonstructured research opportunities (2, 4, 17, 19, 31).

The literature shows that among the recurring challenges faced by undergraduate researchers lies developing the necessary skills to cope with the workload of research and spending sufficient time with a mentor (3, 6, 21, 25, 26). Therefore, the “near-peer” and “peer-mentoring” program emerged as an approach implemented by institutes to combat these challenges. In the peer-mentoring program, the principal investigator often assigns a senior individual in their research team (PhD student, postdoc research fellow, or senior undergraduate student) to take the responsibility of teaching the junior students and form the communication link between the junior students and principal investigator (11). Several studies have demonstrated that such dynamics have resulted in beneficial outcomes for the mentor, mentee, and principal investigator (11, 14, 30). Furthermore, the engagement of senior medical students in the ROS significantly contributes to developing future physicians with the potential to be successful educators in the medical field, especially with the continuing decrease in the number of academic physicians (33). Students enrolled in the ROS rated senior medical students highly in terms of having sufficient levels of knowledge and understanding about research as well as being easily approachable, cooperative, friendly, and able to manage the sessions effectively (Fig. 1). These findings align with similar ones reported in other studies showing that senior students are distinguished because their sessions tend to be more enjoyable and they exhibit effective approach in delivering scientific concepts (8, 14).

Students’ qualitative responses also showed that the ROS offered a healthy and conducive environment for learning as students did not feel pressured to learn and were provided with an easy way of communicating with their senior medical students (Table 3). This may also explain the significant improvement in the knowledge, skills, and confidence of students enrolled in the ROS. Overall, our findings add to the current existing body of knowledge supporting the fact that institutes need more implantation of near-peer and peer-mentoring programs in the teaching process of junior students.

Our study also attempted to answer two important questions, which are as follows: 1) is there a difference between sexes in the gain of knowledge, skills, and confidence and 2) does GPA play a role in the gain of knowledge, skills, and confidence? In regard to the first question, our data shown in Fig. 2 support the current evidence that female students tend to gain less from research training series (such as our ROS) compared with their male peers. One study (9) has reported that male medical students were found to have self-rated themselves better than their female peers in transferrable skills, statistical analysis, and study design and paper presentation. Our study has shown that upon completion of the ROS, female medical students rated themselves significantly less in terms of gains of research knowledge, skills, and confidence compared with their male counterparts.

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Table 3. Qualitative assessment of survey responses

<table>
<thead>
<tr>
<th>Theme</th>
<th>Percentage of respondents that Included the Theme in their Response</th>
<th>Representative Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ROS offered fun, easy, and distinguished interactions to learning about research</td>
<td>27</td>
<td>“It presented a comprehensive view on research, did not eat up a lot of valuable time, and because it was not part of our curriculum, we did not feel pressured. It was an interesting, stress-free course.” “It was given by doctors (previously students) who were actually fresh graduates, so it was easier to communicate with them.”</td>
</tr>
<tr>
<td>The ROS helped students to learn basic concepts in biomedical research</td>
<td>25</td>
<td>“All in all, it was extremely beneficial to me as a medical student and perhaps a future researcher because it taught me everything from the basics of research to the ways in which I would be able to incorporate this knowledge into a passion for research.” “It makes you better at research - I knew nothing before ROS but now I believe that I’ve become better than before.”</td>
</tr>
<tr>
<td>Senior students teaching in the ROS motivated junior students</td>
<td>19</td>
<td>“The tutors were well prepared and knowledgeable.” “They made many hard things easy for us, they are very kind and helpful, and they are putting all their efforts in teaching us. They are the best!”</td>
</tr>
</tbody>
</table>
peer medical students (Fig. 2). Kardash (19) also reported that female interns gained significantly less in regard to formulating a research hypothesis compared with their male peers after finishing an undergraduate research experience. These studies suggest that there is a trend showing a difference between male and female medical student gains in research. However, no significant attention has been devoted by investigators to understand the potential causes of such differences. On the other hand, literature has well documented that female graduates do not tend to persist in scientific majors due to various reasons (19). One highlighted reason corresponds to an extent to our finding regarding female students possessing decreased self-confidence in their abilities in science and research (Fig. 2) (19). Among some of the suggested approaches to address this issue are to devote more resources to develop undergraduate research programs that focus toward developing female students’ research skills and understanding the reasons behind this pattern of difference.

Institutes depend highly on GPA in the admission processes and even in selecting students for research opportunities (20). Few studies have attempted to correlate student GPAs with performance in undergraduate research. One study (18) has shown that minority students and women participating in summer research opportunities tend to have subsequently increased GPAs. In the present study, we endeavored to see if there are any differences in student gains based on their GPA. The data shown in Fig. 3 demonstrate that students enrolled in the ROS with a GPA of 3.5 (Honors’ list) and above were not significantly different from students with GPAs ranging between 2.75 to 3.5. The question here arises as to whether to depend on GPA as a predictor that either increases the probability of a student to be enrolled in a research opportunity or the contrary? The finding that high GPA does not necessarily correlate with research performance or acquisition of research opportunities should alert institutes that depend highly on GPA for such purposes to reconsider its weight as a criterion of student’s acceptance into mentored research activities, especially with the limited resources in UR opportunities. Conclusively, GPA is often not an accurate predictor of scientific productivity, as indicated by Polasek (28), who showed that an undergraduate’s GPA is negatively correlated with future scientific productivity and engagement. Further large-based population studies are required to examine this aspect more.

There are several limitations in this study. First, this study is based on a subjective assessment of students who attended the ROS, which might not be a very accurate measure. Second, the study did not compare responses between ROS-enrolled students with prior research experience and those without. Third, although the core objectives and concepts of the first and second leg of the ROS were similar, the second (summer) ROS underwent a slight modification: greater emphasis was placed on clinical research teaching compared with the first. Finally, the lack of students’ self-assessment of knowledge and skills before joining ROS is also considered as a limitation of the study.

The ROS has offered a way to improve subsequent independent and long-term demanding research experience. This effort is expected to help maintain efficient relationship between the research mentor and mentee in the future. Such short-term courses have also emphasized and augmented prior literature-based evidence that female students tend to gain less from long-term research opportunities compared with their male peers, and engaging senior students with sound research activities’ background in the teaching process of junior students seems to be effective. In the future, the ROS aims to develop an approach to facilitate and allow students to form solid research proposals for projects to be conducted after finishing the series as a prerequisite to pass the course successfully.

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS


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