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Incoming residents' knot-tying and suturing skills: Are medical school boot camps sufficient?

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ABSTRACT

Introduction: Many medical schools offer M4 boot camps to improve students' preparedness for surgical residencies. For three consecutive years, we investigated the impact of medical school boot camps on intern knot-tying and suturing skills when measured at the start of residency.

Methods: Forty-two interns completed questionnaires regarding their boot camp experiences. Their performance on knot-tying and suturing exercises was scored by three surgeons blinded to the questionnaire results. A comparison of these scores of interns with or without boot camp experiences was performed and statistical analysis applied.

Results: 26 of 42 (62%) interns reported boot camp training. There were no differences in scores between interns with or without a M4 boot camp experience for suturing [9.6(4.6) vs 9.8(4.1), $p < 0.908$], knot-tying [9.1(3.6) vs 8.4(4.1), $p = 0.574$], overall performance [2.0(0.6) vs 1.9(0.7), $p = 0.424$], and quality [2.0(0.6) vs 1.9(0.7), $p = 0.665$]) (mean(SD)).

Conclusions: We could not demonstrate a statistically significant benefit in knot-tying and suturing skills of students who enrolled in M4 boot camp courses as measured at the start of surgical residency.

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Introduction

Inadequate preparation for internship is a concern shared by both residency program directors and incoming residents.[1] Medical students graduate with a broad background in medicine, but matriculate into internship with variable levels of preparedness for this abrupt increase in clinical responsibility.[2] First year residents often have limited experience in many of the cognitive and technical skills required of them, which can result in anxiety and lack of confidence.[3,4] These outcomes have led to the development of medical school boot camps in an effort to increase students' readiness for the duties at the start of residency.

Medical school boot camps have been increasing in numbers in recent years. In 2004, the American Surgical Association Blue Ribbon Committee emphasized the need for high quality resident preparedness courses.[5] Then in 2014, a statement of support was published by the American Board of Surgery (ABS), American College of Surgeons (ACS), Association of Program Directors in Surgery (APDS), and Association for Surgical Education (ASE).[6] Subsequently, in 2015 the ACS/APDS/ASE published a rigorous Resident Prep Curriculum consisting of modules designed to be used in medical school boot camps. The well-defined goals and modular design of this curriculum can be adapted to the needs of individual institutions.[7] Popularity of this curriculum is increasing, but there is still wide variability in surgical boot camp length and curricula.[8–10]

Reviews of medical school boot camps report a variety of benefits, primarily measured by survey or assessment of skills immediately after the course.[9–11] However, this body of literature is still relatively small with additional investigation of the technical skills

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Table 1
Items included in questionnaire completed by incoming categorical and preliminary residents.

Medical School Attended
Undergraduate School Attended
Number of weeks on surgical rotations during medical school
Number of weeks on General surgery rotations including subspecialties
Did you participate in a medical school "boot camp" or prep program as an incoming surgery resident?
If not a boot camp, was there a pre-surgical prep program at your medical school?
How long was the "boot camp" in days?
Did it include clinical scenarios?
Did it include standardized patient encounters?
Did it include a skills portion?
Did it include suture and knot-tying?
How many hours of suture skills were performed in a structured environment with either a resident or staff supervision during this event?
Did it include clinical didactics on common postoperative management topics like chest pain, low urine output, postoperative pain management, etc.?
Have you practiced suturing and surgical skills on your own?
How many hours have you dedicated to this in the year prior to starting residency?

component needed, particularly related to the durability of these skills or the methods available to mitigate skill decay.[10,12–15] The aim of this study was to determine the association of medical school boot camp participation on suturing and knot-tying skills of incoming categorical and preliminary general surgery interns assessed at the time they begin residency.

Materials and methods

A 15-item questionnaire was developed to obtain information about medical school boot camp experiences (Table 1). It was completed by 42 incoming preliminary and categorical general surgery interns over three consecutive years during intern orientation, from 2016 to 2018. The interns' technical skills were evaluated using a modified version of a previously validated assessment form published by the APDS/ACS for Objective Structured Assessment of Technical Skill (OSATS).[16]

Interns were scored concurrently by three faculty surgeons who were blinded to the questionnaire responses on suturing (18 items) and knot-tying (16 items), with overall performance and quality being rated using a 5-point Likert scale (5 = high). The sessions were recorded for additional review as needed by evaluators and for further research and data collection, but were not used for the primary evaluator scoring. Faculty observed interns performing three surgical tasks. First, interns performed two simple interrupted sutures and tied them with a two-handed square knot technique. Second, they performed two simple interrupted sutures with an instrument-tied square knot. Finally, a simple running suture including two locking stitches with square knots at each end was completed. All tasks were performed on foam boards using 3-0 nylon sutures (Ethicon) on an FS-1 reverse cutting needle.

Descriptive statistics are reported with means (*Mn*) and standard deviation (*s*). The association of skills was determined with Spearman rho (*SpR*) correlations and inter-rater reliability was measured using intraclass correlation coefficients (*ICC*). Analysis was performed with IBM® SPSS® 24.0. The Medical College of Wisconsin Institutional Review Board approved this study.

Results

Forty-two incoming general surgery interns completed the questionnaire regarding boot camp experiences during each June from 2016 to 2018. They represented 25 different medical schools from 18 states. Table 2 reports results of technical skills evaluations for incoming interns. There was no statistical difference in suturing, knot-tying, overall performance, or quality between boot camp participants and those who did not report a boot camp experience.

Descriptive statistics of questionnaire responses are reported in Table 3. Twenty-six of 42 (62%) reported participation in a boot camp during their fourth year of medical school. Of the 26 interns, 16 participated in a course ≤10 days in length (range 1–30 days) and 15 had ≤ 5 h of supervised instruction (range 0–32). All 42 interns were asked about total hours of independent unsupervised suturing and knot-tying practice in the year prior to internship. Twenty-five of 42 reported ≤10 h of annual practice and 11 > 10 h (range 0.25–50), with the remaining having no responses. There were no differences in technical skills assessment scores between any of these groups (Table 4).

Secondary outcomes included association of skills and inter-rater reliability. Results are shown in Tables 5 and 6. There was significant correlation in all skill evaluations. Spearman rho

Table 2
Technical skills performance scores based on boot camp participation.

Evaluation	Score	
Suturing		
Yes[a]	9.6 (4.6)	p = 0.908
No	9.8 (4.1)	
Knot-Tying		
Yes	9.1 (3.6)	p = 0.574
No	8.4 (4.1)	
Overall Performance		
Yes	2.0 (0.6)	p = 0.424
No	1.9 (0.7)	
Quality		
Yes	2.0 (0.6)	p = 0.665
No	1.9 (0.7)	

*Results reported in Mean (standard deviation).
[a] Yes/No denotes boot camp participation. Twenty-six participated in a boot camp. Nineteen did not.

Table 3
Parameters of boot camp instruction and practice.

Questionnaire Response	n (%)
Boot Camp (n = 42)	
Yes	26 (61.9)
No	16 (38.1)
Length of Boot Camp (n = 26)	
≤10 Days	16 (61.5)
>10 Days	10 (38.5)
Length of Supervised Instruction (n = 24[a])	
≤5 Hours	15 (62.5)
>5 Hours	9 (37.5)
Annual Hours of Practice (n = 36[a])	
≤10 Hours	25 (69.4)
>10 Hours	11 (30.6)

[a] Some questionnaires had incomplete responses.

Table 4
Technical skills scores based on questionnaire responses.

Questionnaire Response	n (%)	Suturing	Knot-Tying	Overall Performance	Quality
Length of Boot Camp (n = 26)[a]					
≤10 Days	16 (61.5)	10.0 (4.6)	9.9 (3.2)	2.2 (0.6)	2.1 (0.6)
>10 Days	10 (38.5)	9.1 (4.9)	7.7 (4.1)	1.8 (0.7)	1.8 (0.7)
		P = 0.634	p = 0.141	p = 0.143	p = 0.285
Length of Supervised Instruction (n = 24[b])[a]					
≤5 Hours	15 (62.5)	9.6 (4.6)	9.0 (4.5)	2.1 (0.7)	2.0 (0.7)
>5 Hours	9 (37.5)	10.8 (4.7)	9.7 (1.9)	2.1 (0.5)	2.0 (0.5)
		P = 0.545	p = 0.675	p = 0.737	p = 0.879
Annual Hours of Practice (n = 36[b])					
≤10 Hours	25 (69.4)	10.0 (4.7)	9.2 (3.8)	2.1 (0.7)	2.0 (0.7)
>10 Hours	11 (30.6)	9.1 (4.4)	7.1 (3.2)	1.7 (0.5)	1.7 (0.3)
		p = 0.613	p = 0.126	p = 0.088	p = 0.126

Score results reported in mean (standard deviation).
[a] Includes only boot camp participants.
[b] Some questionnaires had incomplete responses.

correlations ranged from 0.745 to 0.951 with $p < 0.0001$ for all correlations. Inter-rater reliability was reported with intraclass coefficients of 0.234–0.625 (all $p < 0.002$), indicating a significant and consistent set of ratings between faculty.

Discussion

In our study, interns who participated in pre-residency surgical boot camp showed no difference in suturing or knot-tying skills when compared to those interns who did not participate in a boot camp. There are limited reviews of medical school surgical boot camps, all of which described published literature prior to the implementation of the Resident Prep Curriculum. In a meta-analysis from 2014, Blackmore et al., identified a benefit in technical skills, knowledge acquisition, and confidence in clinical abilities for the boot camp participants, comparing pretest/posttest data. The authors identified significant variability in boot camp design and duration as well as outcomes assessed. Additionally, no information was provided on retention of acquired skills into residency.[10]

In 2015, Singh et al., analyzed existing boot camp literature and identified the primary outcome of most studies being self-assessed confidence. They proposed a strategy for implementing a week-long intensive surgical skills boot camp and reviewed costs which were substantial, and acknowledged that data describing cost effectiveness and durable educational benefits is lacking.[11]

More recently in 2017, Neylan et al., performed a systematic review and analyzed 10 articles meeting their search criteria. They also found significant heterogeneity in boot camp curricula and infrequent use of validated evaluation tools. While they noted consistent positive effects of boot camps in this review, they concluded that no objective data exists showing that boot camps translate into improved performance during internship.[9]

There is a relatively small body of literature that supports durability of boot camp benefits. Confidence and self-assessed performance was been shown to persist up to 6 months post-boot camp.[4,14,17] Conversely, Parent et al., evaluated technical skills including laparoscopy, chest tube placement, cricothyroidotomy, and central venous line placement after boot camp participation. They compared 15 interns who participated in a 3-day boot camp designed by the authors to 13 interns who did not participate. Skill competency was higher in the intervention group at 0 and 1 month, but this difference was no longer present at 6 months. Notably, the cost was $1,356 per resident not including faculty time.[18] While it is encouraging that nontechnical benefits like confidence and self-perception of technical skills may last for 6 months post-boot camp, there is currently little evidence that the same is true for procedural skills. Weis et al., in 2019, studied a pre-internship boot camp looking at durability. They documented the rapid teaching of fundamental surgical skills by pre- and post-testing. However, they noted poor durability as skills significantly regressed when assessed three months later.[15] There are many factors that contribute to the lack of long-term benefit including boot camp design. Faculty oversight, variable practice patterns, and limited clinical exposure all lead to skill decay.

As of November 2017, 71 medical schools reported participation in the ACS/APDS/ASE Resident Prep Curriculum as pilot institutions,[19] representing just over one-third of the 185 medical schools in the United States.[20,21] As this curriculum was published in 2015, a paucity of data prevents drawing conclusions about its effectiveness. However, this curriculum does facilitate a standardized approach to medical school boot camps across institutions. Standardization of boot camp curricula encouraged by the Resident Prep Curriculum may help address students' variable experiences. Furthermore, the heterogeneity of boot camp design could be addressed and inclusion of long-term outcome assessments included as part of this standardization.

Our study has several limitations. We had a relatively low number of study subjects. The sample size was small which results in limited statistical power and statistically significant findings. Continued data collection in the coming years will yield a more powerful data analysis. We also had heterogeneity in our

Table 5
Association of technical skills performance.

		Knot-Tying	Overall Performance	Quality
Suturing	Correlation Coefficient	0.810	0.745	0.800
	p value	p < 0.0001	p < 0.0001	p < 0.0001
Knot-Tying	Correlation Coefficient		0.896	0.911
	p value		p < 0.0001	p < 0.0001
Overall Performance	Correlation Coefficient			0.951
	p value			p < 0.0001

Table 6
Inter-rater reliability.

Suturing	ICC	0.565
	p value	<0.0001
Knot-Tying	ICC	0.625
	p value	<0.0001
Overall Performance	ICC	0.234
	p value	<0.002
Quality	ICC	0.255
	p value	<0.001

ICC, intraclass correlation coefficients.

questionnaire responses on questions regarding specifics of boot camp experiences, including a number of incomplete responses. This result is not surprising, but does create the potential for confounding. Also, answers to these questions depend on students' recollection, which may be subject to error. We did not gather data about the length of time between boot camp participation and enrollment in our study. Variability in this time may make it more difficult to evaluate durability of a technical skills benefit. We also do not know if those who reported boot camp participation received any benefit immediately after boot camp completion. If students did not receive a significant short-term benefit, our results would be skewed towards a lack of a durable benefit. As discussed early, the lack of standardization national regarding boot camp curriculum makes researching impact harder to define reliably across varying boot camp programs.

Conclusions

Our study could not demonstrate a statistically significant benefit in knot-tying and suturing skills of students who enroll in M4 boot camp courses as measured at the start of surgical residency. Furthermore, a substantial number of incoming interns reported no boot camp experiences. For those students who participated in a boot camp, the boot camp curricula are heterogeneous. Residency programs should be prepared to assess and teach these skills to their entering residents. Further study is warranted to evaluate the benefit of medical school boot camps on other technical (psychomotor) skills in addition to cognitive and affective domains of learning in new surgical residents. The validity of a single rater tool will be studied which may lead to facilitation of assessments of incoming residents and decreased use of multiple faculty raters for such assessments. The study purpose was not to discredit the ability of boot camps to impact psychomotor learning. Rather the purpose was to define the relative impact across existing national boot camp experiences, such that residency program directors and curriculum directors do not make assumptions about resident skills performance based on this simple question of binary participation. In this way residency programs can effectively resource to resident's needs based on true skill performance instead of the presumptions of psychomotor skills based on boot camp participation.

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Declaration of competing interest

The authors of this manuscript have no conflicts of interest to report.

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