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ORIGINAL ARTICLE

Correlation between students' Bruininks–Oseretsky test scores and cavity preparation performance on layered base plate blocks

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ABSTRACT

Background: Hand skills are a crucial competency for practicing dentistry. However, assessing candidates' skill levels during dental school admissions in the United States is not a standard criterion due to the absence of accurate tools. Consequently, some students struggle to develop these skills, leading to dropouts, financial losses (i.e., tuition and living expenses), and an increased burden on the faculty to support struggling students.
Aim: This study aims to assess the correlation between student scores on the Bruininks–Oseretsky Test of Motor Proficiency 2 (BOT-2) and cavity preparation performance on Learn-A-Prep II (LAP II) layered base plate blocks.
Methods: First-year dental students completed the BOT-2. A total score and subtest scores, evaluating fine motor precision (seven tasks), fine motor integration (eight tasks), and manual dexterity (five tasks), were calculated. Students were also given basic handpiece training and visual and verbal project criteria for using the LAP II. They were then instructed to independently prepare LAP II patterns within the pattern lines at a specified depth. Scores for the BOT-2 were compared with LAP II performance (excellent, moderate, or poor).
Results: Forty-two students participated in the study. A general linear model (a combination of both regression and analysis of variance tests) was used to compare outcomes between students with excellent and poor performance. A strong correlation was found between the BOT-2 total scores and LAP II performance ($P = 0.04$). No correlation was found when comparing the performance of moderate students with that of excellent and poor students. The manual dexterity BOT-2 scores were correlated with LAP II performance ($P = 0.01$), but fine motor precision and fine motor integration BOT-2 scores were not (both $P > 0.12$).
Conclusion: Results of the current study suggested that scores for the BOT-2 manual dexterity subtest reliably identified dental students with either excellent or poor hand skills. Dental educators should consider using the BOT-2 as a predictive tool to identify the innate hand skills of students.
Relevance for Patients: Identifying candidates with strong hand skills during dental school admissions enables schools to select students better equipped to excel in clinical training and enhance the quality of patient care provided.

1. Introduction

Dental education involves a complex combination of didactic and practical training. Worldwide, dental school admission is often based on academic success, cognitive factors, and interpersonal characteristics. In the United States of America (USA), dental schools offer 4-year programs that traditionally rely on the predental cumulative

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and science grade point averages of applicants and their dental admission test scores [1]. However, these factors have been found to have limited predictive value for academic performance in dental school [2]. Thus, when dental schools are considering applicants for admission, the American Dental Education Association recommends the use of non-cognitive methods alongside traditional cognitive measures [3]. Dental schools assess students' hand skills through a series of regularly administered practical exams that increase in difficulty each semester of the program to ensure students' clinical readiness for patient procedures.

Several studies have attempted to identify a screening tool that can precisely predict the future performance of students in preclinical practical courses [4,5]. However, there is no consensus on the best predictive test of manual dexterity [6]. In a previous study [7], the Bruininks–Oseretsky Test of Motor Proficiency, Second Edition (BOT-2) was used as a screening tool to assess the manual dexterity of prospective and preclinical dental students. The study [7] employed this test because it is a norm-referenced, standardized tool that assesses motor performance. More specifically, it measures fine manual control, manual coordination, body coordination, strength, and agility [8-10]. However, results of the study [7] suggested BOT-2 was not completely predictive of the manual skills of prospective or preclinical dental students. Further, a stated limitation was the comparison of results between different classes of students [7]. Therefore, additional research is necessary to assess the validity of the BOT-2 tool for predicting the preclinical performance of dental students in a single cohort of participants, such as 1st-year students. More research is also necessary to identify and validate standardized, non-cognitive instruments that predict dental student performance during admissions.

In addition to identifying screening tools that assess the manual dexterity of dental students, tools are also needed to develop their hand skills. A variety of lead-up activities have been developed to assist in the early development of psychomotor skills for operative dentistry [11]. For instance, the Learn-A-Prep II (LAP II) was developed as a training aid for use during the initial instructional levels of dental education. This tool uses layered base plate blocks of different colors and material hardness to mimic enamel, dentin, and pulp tissue. The overall goal of the design of these blocks is to foster student understanding of movement through vertical and horizontal spaces as they develop the ability to create precise 3D preparations. To the best of our knowledge, few studies have investigated the potential benefit of using the LAP II as a predictive tool of student performance during the dental admission process [12,13]. Further, based on our experience, a high percentage of students drop out of dental school due to failure to achieve competency in the practical exams required for progression through the program. Therefore, having tools that could identify students with poor hand skills before they are admitted to dental school would be beneficial. Such knowledge could save students' time and money, while reducing monetary losses dental schools face due to dropouts. Ultimately, better predictive tools would improve the quality of oral care services provided by dental school students and graduates [14].

Since tools that predict dental students' hand skills and performance have the potential to advance both dental education and clinical practice, studies are necessary to identify these tools. Therefore, the purpose of the current study was to assess the correlation between student BOT-2 scores and cavity preparation performance on LAP II layered base plate blocks. We hypothesized that the correlation between BOT-2 and LAP II scores would serve as a non-cognitive indicator of innate hand skills, helping dental schools make more efficient student admission decisions. There is no information on any dental school utilizing the BOT-2 test for dental school students or its validity in the discussed context.

2. Methods

The current study was reviewed by the local institutional review board and considered exempt. Only 1st-year dental students from a single class were eligible for participation, and all participants signed an approved informed consent form before the study. Demographic information about the gender and age of students was collected. Participation was voluntary/mandatory, and student performance in the study did not affect course grades.

All students in the class were included in the study; inclusion criteria were simply being part of the cohort of the dental students that was enrolled that year. There were no exclusion criteria set for this study. Students can only be excluded if they choose not to participate and do not consent to their scores being used in the study.

To assess the manual dexterity of dental students, we used BOT-2 as it is the most precise and comprehensive measure of motor skills (both gross and fine). BOT-2 is an easy-to-administer test and contains subtests and challenging game-like tasks. We included three of the BOT-2 subtests in the current study: fine motor precision (seven tasks), fine motor integration (eight tasks), and manual dexterity (five tasks); each administered to 1st-year dental students (D1 class 2017 and D1 class 2018 [n = 42]). Scores for tasks within each subtest were added to obtain a total score for each subtest, and those scores were also compared. An experienced faculty member, calibrated in administering and scoring BOT-2, conducted the tests.

To evaluate the hand skills of dental students, LAP II layered base plate blocks (Whip Mix Corporation, USA) were used as a cavity preparation project (Figure 1). For this test, students used the LAP II to prepare a cavity representing class I on the lower molar tooth on the LAP II block. The preparation criteria included following the outline provided, with 2-mm depth, straight smooth walls, and a flat smooth floor. Students were instructed to prepare the various shapes up to, but not into or beyond, the pattern outline, while maintaining a constant depth throughout the artificial enamel without penetrating the dentin. The outlined shape used for this test was chosen because it resembled an operative dentistry class I preparation. Before the task, students were introduced to LAP II and received the same instructions from a single faculty member about using a dental handpiece. Specifically, students were taught how to hold a handpiece and use the simulation unit. Next, verbal instructions and a live demonstration were provided to teach students the

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steps for LAP II pattern preparation. They were taught how to prepare a flat pulpal floor, produce a proper outline form, achieve a proper cavity wall angulation outline for the preparation, reach the ideal pulpal depth and smoothness, and use a perio probe to measure the height of the walls.

Students then practiced preparing a specific LAP II pattern under direct faculty supervision. This practice exercise was designed for students to familiarize themselves with the handpiece and LAP II preparation. The supervising faculty did not provide feedback on the preparation quality but did provide feedback about the proper use of the simulation unit, handpiece, and bur. During the activity, dental handpieces were preset to the same settings and speed (20000 rpm) for all students, and all students used the same bur (330 Carbide). A faculty member, who was experienced with the standardized parameters of the LAP II, administered and scored the activity.

The BOT-2 and LAP II tests were administered to 1st-year students during orientation. Both tests were introduced to students as "a fun activity." Student results for BOT2 were calculated as a total score and as separate total scores for each subtest. Student scores for LAP II performance were categorized as excellent (when the preparation was perfect or had one minor deviation from ideal), moderate (when the preparation had only one moderate error or multiple minor deviations from ideal), or poor (when the preparation had a major error or multiple moderate errors, resembling a clinically unacceptable performance). A single, blinded faculty member graded the work of all students using a simplified rubric.

Overall BOT-2 scores were calculated using the median and interquartile range (IQR). The Wilcoxon rank sum test was used to compare the BOT-2 total score and the total score for each subtest. Analysis of variance was used to compare total BOT-2 scores for each subtest with student performance category scores on the LAP II. The Tukey test was used for *post-hoc* comparisons, and data were reported as the mean difference with the associated 95% confidence interval (CI). A generalized linear model was used to investigate the correlation between student performance on the LAP II preparation activity and their total BOT-2 score or total BOT-2 subtest scores. Analyses were performed using SAS version 9.4 (SAS Inc., USA). A $P < 0.05$ was considered statistically significant.

Figure 1. Learn-A-Prep II layered base plate block

3. Results

A total of 42 dental students (22 males and 20 females) from the D1 class of 2017 participated in this study; one female student was excluded due to her inability to perform some of the BOT-2 tasks required for the study. The mean age of the students was 24 years old. Using the general linear model, which is a mixture of both regression and analysis of variance, a correlation was found between the total BOT-2 scores and LAP II cavity preparation performance (Figure 2).

Student scores on the BOT-2 are presented in Table 1. For the fine motor precision subtest, only drawing lines through a path (curved; median [IQR]: 7 [1]) and connecting dots (median [IQR]: 7 [0]) were significant (both $P < 0.001$). For the fine motor integration subtest, only copying overlapping circles (median [IQR]: 5 [1]; $P = 0.03$) was significant. For the manual dexterity subtest, only the total score was significantly different (median [IQR]: 34 [3]; $P = 0.007$).

For LAP II, 17 students had excellent scores, 16 had moderate scores, and nine had poor scores. Comparisons between the BOT-2 subtest scores and the LAP II scoring categories are presented in Table 2. A mean difference in total scores was found only for the BOT-2 manual dexterity subtest ($P = 0.01$). Using the Tukey test adjustment, a difference was found between students with excellent and poor scores (mean difference [95% CI]: 3.5 [0.7 – 6.2]; $P = 0.01$).

4. Discussion

The current study assessed the correlation between student BOT-2 scores and cavity preparation performance on LAP II layered base plate blocks to determine whether these tests could be used as a non-cognitive indicator of preclinical operative dentistry performance during the dental school admissions process. The mean age of the students was 24 years old, which

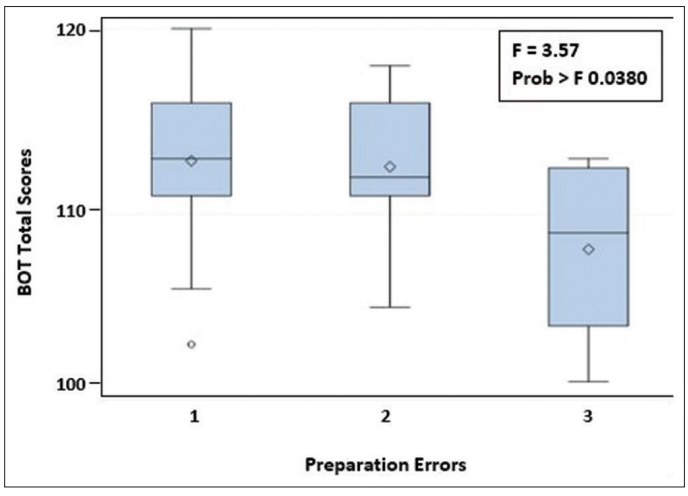

Figure 2. General linear model results for the correlation between the Bruininks–Oseretsky test of motor proficiency 2 and learn-A-prep II

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is higher than that of students in other nations, due to the differences in the admission criteria and processes followed in the USA. Results suggested that the manual dexterity subtest of BOT-2 was able to differentiate between students with excellent (innate hand skills) and poor (no innate hand skills) LAP II scores. No statistically significant differences between scores for the BOT-2 and LAP II were found for the other two BOT-2 subtests, i.e., fine motor precision and fine motor integration.

Table 1. Comparison of Bruininks–Oseretsky test of motor proficiency 2 (BOT-2) scores from two different classes

BOT-2 subtest	Median (IQR)		*P*-value
	D11	D12	
Fine motor precision	40 (2)	40 (2)	0.4
Filling in shape (circle)	3 (0)	3 (1)	0.7
Filling in shape (star)	3 (0)	3 (0)	0.3
Drawing lines through a path (crooked)	7 (0)	7 (0)	0.3
Drawing lines through a path (curved)	7 (1)	7 (0)	0.0007
Connecting dots	7 (0)	6 (1)	< 0.0001
Folding paper	7 (0)	7 (0)	0.2
Cutting out a circle	7 (0)	7 (0)	0.4
Fine motor integration	37 (3)	38 (3)	0.4
Copying a circle	4 (1)	4 (0)	0.7
Copying a square	5 (0)	5 (0)	0.09
Copying overlapping circle	5 (1)	6 (1)	0.03
Copying a wavy line	4 (0)	4 (0)	0.1
Copying a triangle	5 (0)	5 (0)	0.2
Copying a diamond	5 (0)	5 (0)	1.0
Copying a star	4 (1)	4 (1)	0.3
Copying overlapping pencils	5 (0)	5 (1)	0.3
Manual dexterity	34 (3)	35 (4)	0.007
Making dots in a circle	9 (1)	9 (1)	0.3
Transferring pennies	7 (1)	8 (2)	0.08
Placing pegs into a pegboard	6 (2)	6 (1)	0.08
Sorting cards	7 (0)	7 (1)	0.1
Stringing blocks	5 (0)	5 (1)	0.07
Overall	110 (8)	112 (6)	0.09

Note: D11 denotes the D1 class of 2017; D12 denotes the D1 class of 2018.
Abbreviation: IQR: Interquartile range.

Our findings support a previous study by Boushell *et al*., [12] which reported the potential benefits of using LAP II as a predictive training tool of psychomotor performance in an operative dentistry course. However, in that study, [12] students were instructed to independently prepare LAP II patterns within the pattern lines and at a specified depth only. In the current study, we had students prepare a flat pulpal floor, produce a proper outline form, achieve a proper cavity wall angulation (convergence), and reach the ideal pulpal depth (2 mm) and smoothness, allowing us to compare the various components of cavity preparation to better clarify the predictive value of LAP II.

The findings of the current study contradict the results of a similar study by Musawi *et al*. [7] In that study, [7] BOT-2 was not a reliable predictor of the hand skills of new dental students. However, the study [7] compared the BOT-2 scores of 1st-year and 2nd-year students to determine a correlation. The study found no differences, which may be due to the different hand skill levels between the two groups of students. [7] Therefore, the current study only compared the scores of 1st-year students.

The current study had several limitations. The main limitation was our small sample size of 42 students. Since data from one student were excluded, data from only 41 students were included in our analyses. A larger sample size or repeating the study with more classes would be useful to verify current findings. The wide age range of the participants might also be an influential factor in the results of the study. Although our findings for student performance during the LAP II activity were similar to those of Boushell *et al*. and Khalaf *et al*., [12,13] the results may not accurately represent the actual hand skills of students. Instead, our results may be a better representation of their hand skill level and comprehension of the provided instructions for preparing the cavity. To better determine the source of LAP II results, future studies should investigate student comprehension of instructions. Data from such studies would be particularly useful for dental

Table 2. Correlation between Bruininks-Oseretsky test of motor proficiency 2 (BOT-2) scores and students' performance on the Learn-A-Prep II (LAP II) block

BOT-2 subtest	LAP II performance comparison	Mean difference	*P*-value	95% CI	
				Lower bound	Upper bound
Fine motor precision	Overall *F*-test	-	0.1	-	-
	Excellent versus moderate	0.01	1.0	−1.2	1.3
	Excellent versus (major) poor	1.2	0.2	−0.3	2.7
	Moderate versus poor	1.2	0.2	−0.4	2.7
Fine motor integration	Overall *F*-test	-	0.4	-	-
	Excellent versus moderate	−1.0	0.5	−3.0	1.0
	Excellent versus poor	0.1	1.0	−2.4	2.5
	Moderate versus poor	1.1	0.6	−1.4	3.6
Manual dexterity	Overall *F*-test	-	0.01	-	-
	Excellent versus moderate	1.3	0.3	−0.9	3.5
	Excellent versus poor	3.5	0.01	0.7	6.2
	Moderate versus poor	2.2	0.1	−0.6	5.0

Abbreviation: CI: Confidence interval.

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educators, as comprehension is considered a crucial factor for excellent performance as a dental student and future professional.

5. Conclusion

Results of the current study suggested that the manual dexterity subtest of BOT-2 may be able to reliably predict the level of innate hand skill and task comprehension abilities of prospective dental students during the admissions process. Therefore, dental educators should consider using BOT-2 as a predictive tool to identify the innate hand skills of students. However, additional studies with larger sample sizes are necessary to verify the findings of the current study. Further, dental schools should consider using this combination of BOT-2 and LAP II as part of the admissions process to improve student retention and, ultimately, the quality of oral care provided to patients.

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Conflicts of Interest

The authors reported no competing interests.

Ethics Approval and Consent to Participate

This study was exempted by the ATSU IRB (A.T. Still University) under section 45CFR46.101(b)(2). No further review was necessary. Consent was provided by the students participating in the study and their signatures were acquired.

Consent for Publication

Consent was acquired from the study participants to publish their data.

Availability of Data

Data is available from the corresponding author upon reasonable request.

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