Ergonomics Calibration Training Utilizing Photography for Dental Hygiene Faculty Members

Brian B. Partido, MS, RDH

Abstract: Dental and dental hygiene clinical faculty members often do not provide consistent instruction, especially since most procedures involve clinical judgment. Although instructional variations frequently translate into variations in student performance, the effect of inconsistent instruction is unknown, especially related to ergonomics. The aim of this study was to determine whether photography-assisted calibration training would improve interrater reliability among dental hygiene faculty members in ergonomics evaluation. The photography-assisted ergonomics calibration program incorporated features to improve accessibility and optimize the quality of the training. The study used a two-group repeated measures design with a convenience sample of 11 dental hygiene faculty members (eight full-time and three part-time) during the autumn 2016 term at one U.S. dental school. At weeks one and seven, all participants evaluated imaged postures of five dental students using a modified-dental operator posture assessment instrument. During weeks three and five, training group participants completed calibration training using independent and group review of imaged postures. All pre-training and post-training evaluations were evaluated for interrater reliability. Two-way random effects intraclass coefficient (ICC) values were calculated to measure the effects of the training on interrater reliability. The average measure of ICC of the training group improved from 0.694 with a 95% confidence interval (CI) of 0.001 to 0.965 ($F(4,8)=3.465$, $p>0.05$) to 0.766 with a 95% CI of 0.098 to 0.972 ($F(4,8)=7.913$, $p<0.01$). The average measure of ICC of the control group improved from 0.821 with a 95% CI of 0.480 to 0.978 ($F(4,28)=7.702$, $p<0.01$) to 0.846 with a 95% CI of 0.542 to 0.981 ($F(4,28)=8.561$, $p<0.01$). These results showed that the photography-assisted calibration training with the opportunity to reconcile different opinions resulted in improved agreement among these faculty members.

Prof. Partido is Assistant Professor, Division of Dental Hygiene, College of Dentistry, The Ohio State University. Direct correspondence to Prof. Brian Partido, Division of Dental Hygiene, College of Dentistry, The Ohio State University, 3039C Postle Hall, 305 W. 12th Avenue, Columbus, OH 43210; 614-688-2629; partido.1@osu.edu.

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Dental and dental hygiene clinical faculty members often do not provide consistent instruction, especially since most procedures involve clinical judgment.[1-15] These variations of instruction frequently translate into variations of student performance in, for example, the diagnosis and treatment of periodontal conditions.[10] Although the effect of inconsistent instruction is yet unknown, students may experience detrimental effects from the delivery of inconsistent faculty instruction.[2,7,16-18] In one study, North American dental students identified inconsistent faculty instruction as a major concern because of the unfairness of different standards enforced by different faculty members and the inefficiency of appointments when changes were made to approved treatment plans by different supervisors.[7]

Calibration training can help improve the consistency of clinical instruction. The outcome of effective calibration training is to promote the ability of faculty members to consistently use specific criteria-based standards to evaluate student performance and to consistently apply those standards with students.[5] Many faculty members understand the need for calibration training but do not always have access to quality calibration training, and training that provides the most realistic clinical conditions tends to yield more effective outcomes.[1-3] In addition, the incorporation of opportunities to discuss areas of disagreement among instructors or areas beyond the range of the gold standard has been found to improve the quality of calibration training.[5,8,12,13] However, the effect of inconsistent faculty instruction on the student learning remains unknown.

Many calibration training programs have been designed to improve consensus among dental and dental hygiene faculty members. For example,

calibration training programs including didactic and clinical components with typodonts have been used to improve rater reliability with calculus detection[4,13] and amalgam preparations.[5] Simulated patient conditions have also been used to improve consensus with the diagnosis and treatment planning of periodontal disease.[9-11] Another study found that the use of clinical patients helped to improve agreement with periodontal probing among faculty and students.[3] However, at the present time, no calibration training program has been suggested to improve the ergonomic posture of dental and dental hygiene students.

Oral health clinicians are at high occupational risk for the development of work-related musculoskeletal disorders (WMSDs).[19-22] In measuring muscle strain, electromyography and photography have quantitatively determined the most common locations of pain and risk for WMSDs, including the neck, shoulders, upper back, lower back, and wrists.[21,22] Despite the improvement in ergonomic posture from adoption of magnification loupes by dental professionals, the risk of WMSDs still remains high among them.[23-26] With expected improvement arising from the incorporation of magnification loupes by dental and dental hygiene students, many faculty members may provide inconsistent formative feedback regarding postures. Therefore, the aim of this study was to determine whether photography-assisted calibration training would improve interrater reliability among dental hygiene faculty members in ergonomics evaluation.

Materials and Methods

Upon expedited approval from The Ohio State University Biomedical Institutional Review Board, the study utilized a two-group repeated measures design that involved a convenience sample of 11 dental hygiene faculty members from The Ohio State University Dental Hygiene Program during the autumn 2016 term. Faculty participants were assigned to one of two groups (control and training) based on convenience. The photographs of 32 dental hygiene students (front and profile), who were part of a companion study of ergonomic self-assessment utilizing photography (#2016H0239), were used during the calibration training sessions. Five predoctoral dental students from The Ohio State University College of Dentistry were also recruited and photographed (front and profile) for pre-training and post-training evaluations. All student and faculty participants were provided with the rationale and design of both studies and signed written informed consent forms prior to the start of the study.

All 11 faculty participants were assigned as clinical instructors in The Ohio State University Dental Hygiene Program. The participants consisted of eight full-time (≥75%) and three part-time (<75%) faculty members. They possessed a range of clinical dental hygiene experience and clinical teaching experience from less than five years to over 20 years. Nine faculty members had received ergonomics instruction during their dental hygiene education, and on average, the participants provided students with ergonomic feedback about half the time. They also had no previous experience as clinical instructors for the five predoctoral dental students whose photographed images were used for the pre-training and post-training evaluations. The three faculty members in the training group had had no previous contact as clinical instructors with the 32 dental hygiene students whose photographs were used for the calibration training.

A Modified-Dental Operator Posture Assessment Instrument (M-DOPAI) with 12 components was used for the pre-training and post-training evaluations. The M-DOPAI was based on Branson et al.'s Posture Assessment Instrument (PAI), which included ten components that were tested for validity and reliability for imaged and real-time postures,[19] and Maillet et al.'s Posture Assessment Criteria (PAC), which had two additional components that involved the upper arms.[27] Table 1 explains the criteria in evaluating each component of the M-DOPAI. Each component could be assessed as only one of three categories: acceptable (1 point), compromised (2 points), or harmful (3 points). Only eight components included a harmful category. Thus, within the range of 12 to 32 points, the most ideal postures received 12 points, and the most harmful postures received 32 points.

The collection of data occurred over the course of seven weeks (Figure 1). At week one, all faculty participants independently completed a pretest evaluation using a secure Qualtrics survey (Provo, UT, USA). Each survey consisted of five question blocks of an M-DOPAI and the imaged postures of five predoctoral dental students. During weeks three and five, the training group underwent ergonomics calibration training. At week seven, all faculty participants completed a posttest ergonomic evaluation using the same secure Qualtrics survey, which included the M-DOPAI and the same imaged

Table 1. Criteria of Modified-Dental Operator Posture Assessment Instrument

	Acceptable (1 point)	Compromised (2 points)	Harmful (3 points)
Hips	Level on stool; upper thighs parallel; feet flat	Hips not level on stool; upper thighs not parallel; feet crossed, not flat on floor	
Trunk	Front to back <20° Side to side <20° Rotation between planes <20°	Front to back >20°, <45° Side to side >20°, <45° Rotation between planes >20°, <45°	Front to back >45° Side to side >45° Rotation between planes >45°
Head and neck	Front to back <20° Side to side <20° Rotation between planes <20°	Front to back >20°, <45° Side to side >20°, <45° Rotation between planes >20°, <45°	Front to back >45° Side to side >45° Rotation between planes >45°
Upper arms	Upper arms parallel to long axis of torso Elbows at waist level	<20° abduction away from body Elbows at waist level but <60°	>20° abduction away from body Elbows at waist but >60°
Shoulders	Relaxed Both shoulders level with line of trunk	Slumped forward One or both shoulders elevated above line of trunk	
Wrists	Flexion or extension <15° (either wrist)	Flexion or extension >15° (either wrist)	

postures of five dental students used in the pretest. At the conclusion of the study, the participants in the training group completed a three-question survey that included five-item rating-scale questions and an area for comments.

During the one-hour ergonomics calibration training session #1 (week three), the participants in the intervention group received group didactic instruction on ideal neutral ergonomic positioning[28,29] and recognition of any deviations from neutral positioning. Each M-DOPAI component was explained using an imaged posture for preliminary data. The participants then evaluated twice the imaged postures of 32 students photographed from a companion ergonomics study. For the first set of 32 images, the participants evaluated student photographs, as a group, to achieve consensus on the first 20 imaged postures. For the remaining 12 imaged postures, the participants independently evaluated the image postures embedded in a secure Qualtrics survey. With the faculty evaluations, consensus scores were achieved with the agreement of two of the three raters.

For the second set of 32 student photographs, the faculty participants independently evaluated the first 20 student images embedded in a secure Qualtrics survey prior to the one-hour ergonomics calibration training session #2 (week 5). Based on

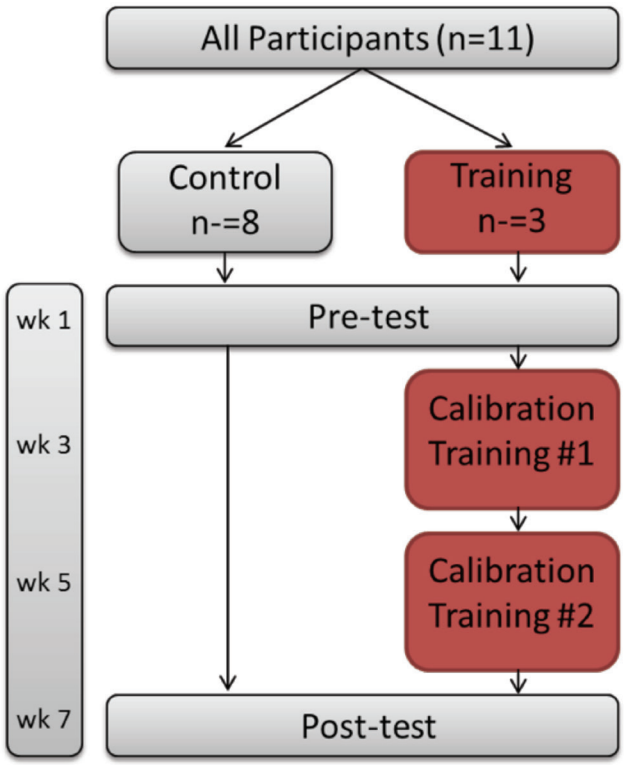

Figure 1. Testing and training protocol

the independent ratings, consensus was not achieved for four components among three students from the first set of photographs and 20 components among six students from the second set of photographs. The specific components were reconciled, and consensus was achieved as a group. The remaining 12 student images were evaluated as a group, based on consensus.

All statistical analysis was conducted using SPSS Version 24 (IBM, Chicago, IL, USA). To measure the absolute agreement among more than two raters evaluating the same group of subjects, two-way random-effects intraclass coefficient (ICC) values were calculated.[30,31] ICC values were determined using the raters' evaluations for the five student postures. ICC values less than 0.5 indicated poor reliability, values between 0.5 and 0.75 indicated moderate reliability, values between 0.75 and 0.9 indicated good reliability, and values greater than 0.9 indicated excellent reliability.

Results

Table 2 shows the interrater reliability of the raters' ergonomic evaluation scores using the M-DOPAI. The data suggested improvement in both groups. The training group remained in the moderate reliability range, and the control group remained in the good reliability range. The average measure of ICC of the training group improved from 0.694 with a 95% confidence interval (CI) of 0.001 to 0.965 ($F(4, 8)=3.465$, $p>0.05$) to 0.766 with a 95% CI of 0.098 to 0.972 ($F(4,8)=7.913$, $p<0.01$). The average measure of ICC of the control group improved from 0.821 with a 95% CI of 0.480 to 0.978 ($F(4,28)=7.702$, $p<0.01$) to 0.846 with a 95% CI of 0.542 to 0.981 ($F(4,28)=8.561$, $p<0.01$).

Table 3 shows the interrater reliability of the raters' ergonomic evaluations using all 12 criteria of the M-DOPAI. The data suggested an improvement

Table 2. Interrater reliability of ergonomic evaluations using Modified-Dental Operator Posture Assessment Instrument total scores

Test by Group	ICC	95% CI Lower Bound	95% CI Upper Bound	F-test	df1	df2	p-value	Change
Pretest (training group)	0.694	0.001	0.965	3.465	4	8	>0.05	
Posttest (training group)	0.766	0.098	0.972	7.913	4	8	<0.01	0.072
Pretest (control group)	0.821	0.480	0.978	7.702	4	28	<0.01	
Posttest (control group)	0.846	0.542	0.981	8.561	4	28	<0.01	0.025

Note: Intraclass coefficient (ICC) values have the following interpretations: <0.5 poor reliability, 0.5-0.75 moderate reliability, 0.75-0.9 good reliability, and >0.9 excellent reliability.

Table 3. Interrater reliability of ergonomic evaluations using Modified-Dental Operator Posture Assessment Instrument components

Test by Group	ICC	95% CI Lower Bound	95% CI Upper Bound	F-test	df1	df2	p-value	Change
Pretest (training group)	0.548	0.315	0.712	2.337	59	118	<0.01	
Posttest (training group)	0.677	0.500	0.797	3.360	59	118	<0.01	0.129
Pretest (control group)	0.792	0.700	0.863	5.402	59	413	<0.01	
Posttest (control group)	0.811	0.727	0.875	5.823	59	413	<0.01	0.014

Note: Intraclass coefficient (ICC) values have the following interpretations: <0.5 poor reliability, 0.5-0.75 moderate reliability, 0.75-0.9 good reliability, and >0.9 excellent reliability.

for both groups, but the training group experienced a greater change than the control group. The training group remained in the moderate reliability range, and the control group remained in the good reliability range. The average measure of ICC of the training group improved from 0.548 with a 95% CI of 0.315 to 0.712 ($F(59, 118)=2.337$, $p<0.01$) to 0.677 with a 95% CI of 0.500 to 0.797 ($F(59,118)=3.360$, $p<0.01$). The average measure of ICC of the control group improved from 0.792 with a 95% CI of 0.700 to 0.863 ($F(59,413)=5.402$, $p<0.01$) to 0.811 with a 95% CI of 0.727 to 0.875 ($F(59,413)=5.823$, $p<0.01$).

Analysis of results on the participant questionnaire was based on responses (Table 4) and comments (Table 5). Due to the nature of the data (ordinal), the median and interquartile ranges are shown for all three questions. The data from the responses and comments suggested that participants perceived that, overall, the photography-assisted calibration training helped improve their agreement and consistency with ergonomic evaluations. However, they also felt that the in-person training was more effective than the independent review of the photographs.

Discussion

Although dental and dental hygiene educators share the overarching goal of producing competent dental professionals, evaluation of student ergonomics is varied and often neglected. Since all dental professionals have an increased risk of developing work-related musculoskeletal disorders, attention is needed to the development of ergonomic calibration training programs for dental and dental hygiene clinical faculty members. Thus, this study assessed whether a photography-assisted calibration training

Table 4. Participants' median scores regarding calibration training and delivery method

Item	N	Median (IQR)
I believe that the photography-assisted calibration training program helped improve agreement and consistency regarding ergonomic evaluations for my colleagues and myself.	3	4 (1.5)
I believe that the independent review of the photographs was more effective than the in-person training in regards to improving agreement and consistency with ergonomic evaluations for my colleagues and myself.	3	2 (1.5)
I believe that the in-person training was more effective than the independent review of the photographs in regards to improving agreement and consistency with ergonomic evaluations for my colleagues and myself.	3	5 (1.0)

Note: Items were ranked on a Likert scale in which 5=strongly agree, 4=agree, 3=neutral, 2=disagree, and 1=strongly disagree.

Table 5. Representative examples of comments on three survey items

Survey Item	Positive Comments	Negative Comments
I believe that the photography-assisted calibration training program helped improve agreement and consistency regarding ergonomic evaluations for my colleagues and myself.	"It allowed me to take the time to evaluate and familiarize myself with all components of evaluating ergonomics."	"There were things that were difficult to view and evaluate on my own."
I believe that the independent review of the photographs was more effective than the in-person training in regards to improving agreement and consistency with ergonomic evaluations for my colleagues and myself.	"Discussing with others was helpful. We frequently saw things differently."	"Not clearly understanding the rubric and definitions hindered evaluations. [The Qualtrics survey] was difficult to maneuver since the images and the questions were not visible on one screen without scrolling back and forth."
I believe that the in-person training was more effective than the independent review of the photographs in regards to improving agreement and consistency with ergonomic evaluations for my colleagues and myself.	"It was much better to actively discuss with others." "It was helpful to discuss and clarify."	"Ideally, there would be a measuring device to hold up to the screen or drawn on the photos to actually outline the angles to evaluate deviation from normal."

program would improve interrater agreement among dental hygiene faculty members in ergonomics evaluation. The results showed that the training program resulted in a greater increase in interrater agreement for the training group than in the control group.

Since a higher quality of training involving specific details can aid in the calibration of faculty members,[6] the focus of this photography-assisted calibration training in ergonomics was achieving consensus with each component of the evaluation instrument. Although the training group demonstrated overall improvement in interrater agreement, improvement was greater in comparing agreement among the 12 M-DOPAI components: 0.129 (Table 3) versus the overall ergonomic score of 0.072 (Table 2). These results support previous studies that argued calibration training programs should emphasize the consistent application of criteria-based standards in the evaluation of student performance[5] and that found calibration training programs led to significant improvement in interrater agreement.[3,5,13] Ideally, the evaluations made by calibrated faculty members promote student satisfaction, performance, and learning outcomes.[7-9]

The initial interrater agreement in this study may have affected the degree of improvement. Using both the analyses by total score (Table 2) and individual component (Table 3), the training group began and remained in the moderate reliability range (ICC values 0.50-0.75).[30,31] When interrater agreement remains below full agreement, a greater propensity for improvement has been found to exist.[1,5,13] However, when full interrater agreement has already been achieved, there is less potential for increased improvement from calibration training.[4] Although periodic calibration training is always advisable, the assessment of rater agreement levels should continually be monitored, so that training programs can be adjusted if rater agreement levels fall below full agreement.[13]

The photography-assisted ergonomics calibration program incorporated features to improve accessibility and optimize training quality. Faculty participants independently evaluated half of the imaged postures presented on a Qualtrics survey platform as a component of each of the two training sessions. In their study, Dicke et al. found that although the majority of dental hygiene faculty members supported calibration training, complete participation of all full-time and part-time faculty members remained a challenge.[2] Independent calibration training may serve as an option to maximize faculty participation. However, the increased accessibility of training must not inversely affect the quality of the training.

The calibration training program used in this study allowed faculty raters to reconcile components of the ergonomics evaluation in which consensus was not achieved. Faculty members seemed to have appreciated this approach, as shown in the following comments: "Discussing with others was helpful. We frequently saw things differently"; "It was much better to actively discuss with others"; and "It was helpful to discuss and clarify" (Table 5). Previous calibration training programs have used this mastery approach of reconciling faculty errors to improve agreement among faculty members.[12,13] This hybrid approach of independent and collaborative calibration training may improve accessibility with all faculty members and maximize the limited time allocated for collaborative training and discussion.

The limitations of this study included the small sample size, use of a single research site, use of still imaged postures, and the subjective rater evaluations. In addition, the operations of the Qualtrics survey platform may have hindered the raters' ability to evaluate imaged postures. Since the study took place in only one dental hygiene education program, its results may not be generalizable to other programs. Future studies should include larger sample sizes, students at different time points during their educational programs, improved platform for the independent viewing of imaged postures, and the use of technology for the objective measurement of posture.

Conclusion

Although dental and dental hygiene educators understand their primary purpose of developing competent dental professionals, the evaluation of student postures is often varied and overlooked. Since all dental professionals have an increased risk of developing work-related musculoskeletal disorders, attention is needed for the development of ergonomic calibration training programs for dental and dental hygiene clinical faculty members. The photography-assisted ergonomics calibration program used in this study incorporated features to improve accessibility and optimize the quality of the training. The opportunity to reconcile different opinions resulted in improved agreement among the participants.

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