Original Article

Development of a method to assess compliance with ergonomic posture in dental students

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Abstract:

CONTEXT: The ergonomic posture protocol is extremely important for the maintenance of occupational health in dentistry. The lack of compliance with this protocol results in a high risk of developing musculoskeletal disorders.

AIMS: This study developed a direct observation method for the evaluation of dental student compliance with ergonomic posture protocol.

SUBJECTS AND METHODS: The method is named compliance assessment of dental ergonomic posture requirements (CADEP). During the development of the method, 14 items were elaborated considering the theory of dental ergonomics. Each item should be classified as appropriate, partially appropriate, or inappropriate. After evaluation, all item values should be added, and the final score expressed as the percent of compliance with correct postures, with a score range of 0%–100%.

STATISTICAL ANALYSIS USED: The reliability of CADEP was assessed through intra- and interobserver reproducibility. For the CADEP application, 73 senior year students from the undergraduate course in dentistry were evaluated. The intra- and interexaminer concordance was estimated using the intraclass correlation coefficient (ρ). A descriptive statistical analysis was performed.

RESULTS: The reproducibility of evaluator 1 (ρ =0.90; confidence interval [CI] 95%: 0.83–0.94), evaluator 2 (ρ = 0.83; CI 95%: 0.70–0.90), the interexaminer in the first evaluation (ρ = 0.81; CI 95%:0.67–0.89), and in the second one (ρ = 0.76; CI 95%: 0.59–0.87) was classified as good. In the analysis of the compliance, it was verified that moderate compliance was the most prevalent among the evaluated students (65.6%, CI 95%: 60.3%–70.7%).

CONCLUSIONS: CADEP was valid and reliable for the assessment of dentistry students' compliance regarding ergonomic posture requirements.

Keywords:

Compliance, dental education, dental ergonomics, dental student, occupational health

Introduction

Compliance in the health-care context refers to the extent to which a person acts in accordance with prescribed health recommendations.[1,2] Compliance assessment can be used for different purposes in the health area, acting as an important strategy to stimulate habit change.[3] However, for this purpose, rules and/or recommendations should serve as a reference so that deviations can be identified.[2]

In the dental ergonomics area, there are some requirements that are taught to students for the adoption of ergonomic,[4] and therefore, healthy posture. The implementation of a periodic control of the compliance of these requirements can be advantageous in the dental educational. This would allow for

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observation of the evolution of students' practice over time and give feedback to students accordingly. There is also the possibility of identifying the students' difficulties in applying the requirements. According to Offner *et al*.,[5] the barriers for adequate compliance are related to individuals' awareness and motivation. Anders *et al*.[6] reinforce that compliance in the school environment may be below teachers' expectations. However, if students are given enough feedback and motivation, they may be able to change their habits and behaviors.

The requirements for ergonomic work posture in dentistry are rules taught during the professional training phase with the objective of maintaining musculoskeletal health.[7] These rules are related to the adequate positioning of the patient in the dental chair, the equipment and instruments, as well as the posture of the operator's head, neck, trunk, arms, forearms, hips, thighs, legs, and feet during clinical care.[4]

Although these posture requirements are extremely important for the maintenance of occupational health in dentistry, it has been shown that students fail to adopt them.[4] The lack of compliance with these requirements results in a high risk of developing musculoskeletal disorders.[8,9]

Garcia *et al*.[7] found that teaching of ergonomic posture requirements to students alone is not sufficient for the establishment of ergonomic posture habits. Thus, strategies should be implemented so that healthy postural habits can be maintained over time.

Considering that the work posture is one of the main risk factors related to musculoskeletal disorders in dentistry,[10,11] observing its compliance may be an interesting strategy to implement at the level of dental education. Anders *et al*.[6] suggest that direct observation methods be used for the evaluation of compliance because they present a real picture of the behavior of the individuals involved. However, the method must be applicable to the academic context, that is, it must present an educational facet and reach a large number of people.[5]

There are no specific methods in the literature for assessing the compliance of dentistry students with regard to posture. Thus, the aims of this study were (i) to develop a direct observational method to evaluate dental student compliance with ergonomic posture protocol, (ii) evaluate the validity and reliability of the developed method, and (iii) to assess compliance of students in their final year of dentistry education during the execution of clinical activities using the proposed method.

Subjects and Methods

Method development

The method presented is an observational method called the compliance assessment of dental ergonomic posture requirements (CADEP). Its use can be in person, that is, while the student performs the procedure or through photographs of the students that can be analyzed later.

For its development, a review of the literature related to Ergonomics and Occupational Health in Dentistry was performed.[12] From this, and considering the teaching experience of one of the researchers in the area of ergonomics in dentistry, we chose to follow the theoretical proposal of ergonomic posture requirements proposed by Porto.[13] This option was selected because this theory follows the ergonomics in classic dentistry, which has been used by the Araraquara Dental School for 50 years.

Initially, the items to be evaluated were elaborated based on the selected theory. Fourteen items related to external factors that may interfere with working postures, such as the position of the patient chair, dental operator light, hand instruments, as well as the posture of the upper and lower limbs and trunk were elaborated. Care has been taken to relate each item to a form of prevention of one or several occupational problems related to work posture. One item deals with the way of sitting in the dental operator stool comprising both the vertical and horizontal positioning of the operator's legs concerning the use of the seat and backrest and is aimed at preventing spinal problems. The items that address the positioning of the operator's arms relate to the prevention of problems in the shoulders, arms, and forearms. The items related to the positioning of the patient's head, the reflector, distance between the patient's mouth and the operator's eyes, and positioning of hand instruments were included because they relate to the prevention of problems in the spine, neck, shoulders, arms, and forearms.

With the items elaborated the mode of evaluation was considered next. The objective of the method is to observe the degree of compliance in relation to the assessed requirements. Therefore, we established that each item should be classified as appropriate, partially appropriate, or inappropriate. One point is assigned for items classified as appropriate (1 point for meeting the basic requirements for ergonomic posture purposed by Porto 1994), ½ point for partially appropriate posture (rated item not entirely correct), and 0 point for inappropriate posture (requirements are not met).

For the calculation of students' compliance with ergonomic posture requirements, all evaluated item values should be added for a sum of up to 14 points.

The final score should then be adjusted and expressed as the percent of compliance with correct postures, with a score range of 0%–100%. Depending on the percentage of correct answers, the level of student compliance was classified as very low (0%–<25% of correct answers), low (25%–<50%), moderate (50%–<75%), and high (75%–100%). Arai *et al*. (2016) originally proposed this classification system for evaluating compliance of biosafety procedures.

After determining compliance classification, an educational action must follow. It is proposed that for students with moderate-to-very low compliance, the ergonomic posture requirements should be reviewed, especially those related to items classified as partially adequate and inadequate during the evaluation.

Validity and reliability of compliance assessment of dental ergonomic posture requirements

After the CADEP development, its face and content validity was evaluated, as well as its reliability through reproducibility.

For the face and content validity, a committee of experts was invited to participate. This expert committee was composed of 8 dental surgeons with experience in the dental ergonomic area.

For the face validity, the judges were asked to verify whether the items addressed and the classifications (adequate, partially adequate, and inadequate) were comprehensive, clear, and compatible with the basic principles of dental ergonomic.

For content validity, judges were asked to individually evaluate each of the items according to their essentiality and classify them as "essential," "useful but not essential," and "not necessary."[14] The number of judges who categorized the item as "essential" was used as the basis for the calculation of the content validity ratio (CVR) proposed by Lawshe.[14]

For the decision of possible item exclusion, the proposal of Wilson *et al*.[15] (CVR8; 0.05 = 0.693) was considered.

Reliability was assessed through intra- and interobserver reproducibility. For this, two researchers, one with great experience in dental ergonomic posture (Rater 1-PPNSG) and another without great experience (Rater 2-DW), examined, in duplicate, the posture adopted by undergraduate students as they performed 50 clinical procedures, with 1-week intervals between assessments. Before the beginning of analyses, a 60-min calibration session was performed between the two. In this session, the classification of each posture to be

evaluated in the CADEP was discussed and possible doubts were clarified.

Application of the compliance assessment of dental ergonomic posture requirements

For the CADEP application, an observational study with 73 male and female students enrolled in their final year of the degree program at Araraquara Dental School was conducted.

The working postures of students were evaluated during several routine clinical tasks during the practical activities of the General Dentistry course.

The sampling unit was the clinical procedures. The study variable was the working posture adopted by each student in his or her role as "operator."

Records of working postures were made using a digital camera. The photographs were taken at least 10 min after the activities started, allowing the students to become comfortable in their postures.[16] The most frequent posture during execution of a procedure was selected for the assessment. The photographs were taken sequentially from 5 basic points to allow viewing of the posture and position of the dental student operator [Figure 1]: point A – position of the hand instruments and thigh/thigh angles; point B – thigh/thigh angle; point C – thigh/leg angle, feet position, tilt and lumbar support, use of the seat dental stool, patient position on patient chair, dental operator light position, distance between mouth's patient and operator eye, and posture of the right and left arms of the operator; point D – posture of the left arms and tilt and twist of the spine of the operator; and point E – head's dental chair position.

The photographic recordings were performed with the photographer holding the camera close to the eyes at a distance of about 1.5 m from the ground, orthogonally. Photographic analysis was performed
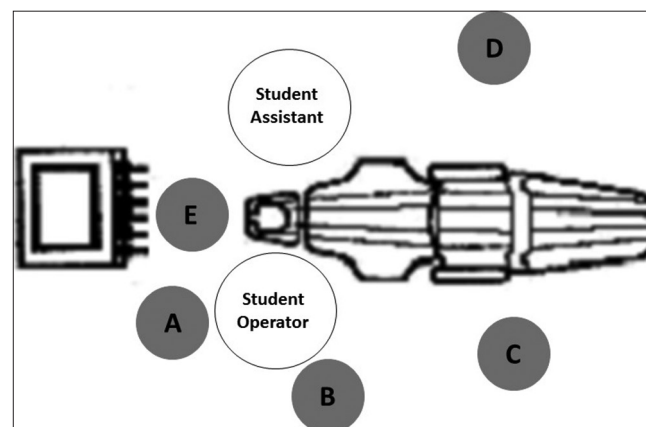

Figure 1: Basic points to take photographs

by visual examination. A researcher did the analysis after calibration, considering a level of intra-examiner concordance classified as at least "good," according to Fermanian.[17]

The dental procedures performed by the students were analyzed and each procedure assigned an evaluation using CADEP (ranged from 0% to 100% of compliance).

Ethical aspects

This study was approved by the Ethics Research Committee of the AraraquaraDental School, (Protocol number 12/2011).

Statistical analysis

The intra- and interexaminer concordance was estimated using the intraclass correlation coefficient (ρ).

Descriptive statistical analysis was performed. The prevalence of the level of compliance with the ergonomic posture requirements of the students assessed during the execution of the clinical procedures was estimated per point and by a 95% confidence interval (CI).

Results

The items used in the proposed method as well as the postures considered appropriate, partially adequate, and inadequate are shown in Table 1.

Considering Table 1, in item 1, the appropriate, partially appropriate, and inappropriate postures were options 2, 1, and 3, respectively. For item 2, the appropriate, partially appropriate, and inappropriate postures were options 1, 3, and 2. In item 3, the appropriate, partially appropriate, and inappropriate postures were options 1, 3, and 2. In item 4, the appropriate posture was option 1; partially appropriate, options 4 and 5; and inappropriate postures, options 2, 3, 6, 7, 8, 9. For items 5 and 6, the appropriate posture was option 1, the inappropriate option 2, and there were no partially appropriate scores recorded. In item 7, the appropriate, partially appropriate, and inappropriate postures were options 1, 3, and 2, respectively. For item 8, the appropriate postures were options 1, 2, and 6; partially appropriate 4 and 7; and inappropriate, options 3 and 5. In item 9, the appropriate posture was option 1, the inappropriate option 2, and there was no partially appropriate record. In item 10, the appropriate posture was option 1 or 2, and the inappropriate posture was option 3. For item 11, the appropriate, partially appropriate, and inappropriate postures were options 1, 3, and 2; and 1, 2 and 3, respectively, for item 12. In item 13, the appropriate posture was 1 or 5; partially appropriate, 2 or 4; and the inappropriate posture was option 3. Finally, in item 14, the appropriate, partially appropriate, and inappropriate postures were options 1, 2, and 3.

Table 1: Compliance assessment of dental ergonomic posture requirements assessment form

1. Legs in upright position (thigh/leg angle) ( )[1] less than 90° ( )[2] equal to 90° ( )[3] greater than 90°	2. Feet resting on the floor ( )[1] both feet flat on the floor ( )[2] only one foot flat on the floor ( )[3] both feet on the stool	3. Thighs in a horizontal position (angle between the thighs) ( )[1] equal to 90° ( )[2] equal to zero (parallel) ( )[3] equal to 70°
4. Tilting of the spine ( )[1] posterior position ( )[2] anterior position ( )[3] middle position ( )[4] posterior position tilted to the right ( )[5] posterior position tilted to the left ( )[6] anterior position tilted to the right ( )[7] anterior position tilted to the right ( )[8] middle position tilted to the right ( )[9] middle position tilted to the left	5. Spine in relation to lumbar support ( )[1] support on the back of the stool ( )[2] no support on the back of the stool 6. Use of the seat of dental stool ( )[1] occupied the entire seat of the stool ( )[2] did not occupy the entire seat of the stool 7. Patient position in the patient chair ( )[1] reclined with mouth at the knee level ( )[2] reclined with the knee above the mouth ( )[3] semi-reclined	8. Position of the headrest of the patient chair ( )[1] on the long axis during examination work on the upper or lower anterior teeth ( )[2] tilted forward working on the jaw ( )[3] tilted back working on the jaw ( )[4] on the long-axis working on the jaw ( )[5] tilted forward working on the maxilla ( )[6] tilted back working on the maxilla ( )[7] on the long-axis working on the maxilla
9. Seat height in relation to the leg of the operator located under the backrest ( )[1] thigh/leg without pressure of dental chair ( )[2] thigh/leg with pressure of dental chair	10. Dental operator light ( )[1] at the head of the patient for work on the maxilla ( )[2] perpendicular to the patient's head for work on the jaw ( )[3] without respect to the work area	11. Distance between patient's mouth and operator's eyes ( )[1] 30 to 40 cm ( )[2] <30 cm ( )[3] >40 cm
12. Working arm ( )[1] next to the body ( )[2] partially raised ( )[3] fully raised	13. Supporting arm ( )[1] next to the body ( )[2] partially raised ( )[3] fully raised ( )[4] embracing the patient's head ( )[5] raised to support the chair	14. Position of hand instrument used to perform clinical procedures ( )[1] ideal space to be achieved ( )[2] maxim space to be achieved ( )[3] outside the space to be achieved

In the process of face validity, all items were considered comprehensive, clear, and compatible with the requirements of ergonomic posture established by the judges. Some suggestions were given in the wording of the items to improve clarity.

The value of the CVR was above the cutoff point for all items (CVR = 0.75–1.00), except for item 6 (CVR = 0.50).

In the reliability analysis, it was verified that both evaluator 1 (ρ = 0.90; CI 95%:0.83–0.94) and 2 (ρ = 0.83; CI 95%:0.70–0.90) presented intra-examiner reproducibility classified as good. The interexaminer reproducibility in both the first evaluation (ρ = 0.81; CI 95%:0.67–0.89) and the second evaluation (ρ = 0.76; CI 95%: 0.59–0.87) was also classified as good.

In the application of the CADEP, a total of 319 clinical procedures were observed. Of these, 73.40% were conducted by female students, 64.6% were restoration/rehabilitation, 74.6% were performed using four hands, and 62.0% were performed on teeth in the upper jaw.

It was found that the average of compliance considering the CADEP was 57.3% (±13.0).

The prevalence of the level of compliance with the students' ergonomic posture requirements during the execution of clinical procedures according to the CADEP estimated by point and by 95% CI is shown in Figure 2.

Attention is drawn to the high prevalence of procedures performed by students with moderate compliance regarding the ergonomic posture requirements assessed by the CADEP.
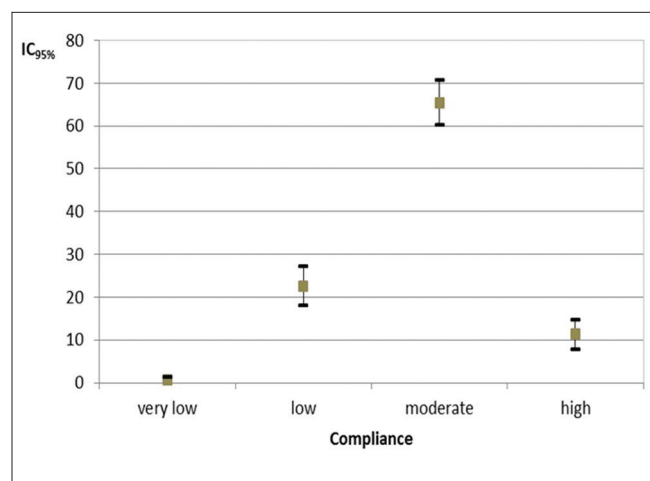

Figure 2: Prevalence of the level of compliance with the students' ergonomic posture requirements during the execution of clinical procedures by point (p) and by confidence interval of 95% of compliance assessment of dental ergonomic posture requirements (LS: Upper limit, LI: Lower limit)

The distribution of procedures performed in relation to work posture items evaluated in the CADEP can be observed in Table 2.

It is possible to verify that the items that presented the greatest number of postural inadequacies were related to the positioning of the patient in the dental chair, of the dental light, as well as the positioning of the operator's legs vertically and horizontally.

Discussion

The objective of this study was to develop a direct observation method to evaluate the level of dental student compliance with ergonomic posture protocol to propose a method more focused on the unique postural requirements in dentistry.[18]

The systematic use of observational methods to evaluate the level of dental student compliance with ergonomic posture protocol is essential for monitoring postural habits, particularly of individuals in the training phase such as dental students.[8,9,16,19]

The proposed method is simple, objective, and is specific to the dental area. In the development of CADEP, the requirements for proper body posture during performance of dental work, positioning of instruments and of the dental chair, and workspace lighting conditions were considered.[20] These requirements are part of the course curriculum in Dental Ergonomics.[7-9] Future users of this method are likely to be familiar with the aspects evaluated with this method, which will facilitate its use.

In the validity analysis of the CADEP, all of the evaluated items were considered comprehensive, clear, and important by the judges. Only item 6 "Use of the seat of dental stool" did not present CVR value considered adequate (CVR = 0.50). In spite of this, this item has been maintained because the way the individual sits on the dental stool, occupying, or not all of the seat could have consequences for his spine.[21,22]

Regarding the reliability of the method, it was verified that it presented adequate test–retest reliability, with both intra- and interexaminer reproducibility values classified as good. This demonstrates the easy calibration of the examiner for its application, as well as its stability over time, both of which are important conditions for every method.[12,23]

In the analysis of the compliance of ergonomic posture requirements, it was found that moderate compliance was the most prevalent among the evaluated students. These students had studied the subjects of Ergonomics in Dentistry both in the 2nd and in the 3rd year of

Table 2: Postures according to compliance assessment of dental ergonomic posture requirements items

Observed items	Student, *n* (%)
Legs in upright position (thigh/leg angle)	
<90°	56 (17.6)
Equal to 90°	34 (10.7)
>90°	215 (67.4)
It was not possible to assess	14 (4.4)
Feet resting on the floor	
Both feet flat on the floor	237 (74.3)
Only one foot flat on the floor	19 (6.0)
Both feet on the stool	33 (10.3)
It was not possible to assess	30 (9.4)
Thighs in a horizontal position (angle between the thighs)	
Equal to 90°	216 (67.7)
Equal to zero (paralell)	35 (11.0)
Equal to 70°	63 (19.7)
It was not possible to assess	5 (1.6)
Spine in relation to lumbar support	
Support on the back of the stool	91 (28.5)
No support on the back of the stool	226 (90.8)
It was not possible to assess	2 (0.6)
Use of the seat of dental stool	
Occupied the entire seat of the stool	149 (46.7)
Did not occupy the entire seat of the stool	163 (51.1)
It was not possible to assess	7 (2.2)
Tilting of the spine	
Posterior position	52 (16.3)
Anterior position	12 (3.8)
Middle position	10 (3.1)
Posterior position tilted to the right	75 (23.5)
Posterior position tilted to the left	33 (10.3)
Anterior position tilted to the right	85 (26.6)
Anterior position tilted to the right	39 (12.2)
Middle position tilted to the right	11 (3.4)
Middle position tilted to the left	2 (0.6)
It was not possible to assess	-
Patient position in the patient chair	
Reclined with mouth at the knee level	9 (2.8)
Reclined with the knee above the mouth	-
Semi-reclined	229 (71.8)
It was not possible to assess	81 (25.4)
Seat height in relation to the leg of the operator located under the backrest	
Thigh/leg without pressure of dental chair	256 (80.3)
Thigh/leg with pressure of dental chair	46 (14.4)
It was not possible to assess	17 (5.3)
Position of the headrest of the patient chair	
On the long axis during work on the upper or lower anterior teeth	39 (12.2)
Tilted forward working on the jaw	18 (5.6)
Tilted back working on the jaw	11 (3.4
On the long-axis working on the jaw	55 (17.2)
Tilted forward working on the maxilla	9 (2.8)
Tilted back working on the maxilla	28 (8.8)

Contd...

Table 2: Contd...

Observed items	Student, *n* (%)
On the long-axis working on the maxilla	66 (20.7)
It was not possible to assess	93 (29.2)
Dental operator light	
At the head of the patient for work on the maxilla	168 (52.7)
Perpendicular to the patient's head for work on the jaw	66 (20.7)
Without respect to the work area	68 (21.3)
It was not possible to assess	17 (5.3)
Distance between patient's mouth and operator's eyes (cm)	
30-40	49 (15.4)
<30	270 (84.6)
>40	-
Working arm	
Next to the body	193 (60.5)
Partially raised	91 (28.5)
Fully raised	31 (9.7)
Embracing the patient's head	-
Raised to support the chair	4 (1.3)
It was not possible to assess	-
Supporting arm	
Next to the body	114 (35.7)
Partially raised	115 (36.1)
Fully raised	29 (9.1)
Embracing the patient's head	38 (11.9)
Raised to support the chair	22 (6.9)
It was not possible to assess	1 (0.3)
Position of hand instrument used to perform clinical procedures	
Ideal space to be achieved	246 (77.1)
Maxim space to be achieved	55 (17.2)
Outside the space to be achieved	16 (50.0)
It was not possible to assess	2 (0.6)
Total	319 (100.0)

the course.[7,9] Garcia *et al*.[4] demonstrated that the students presented good theoretical knowledge of the requirements of ergonomic posture but did not properly apply their theoretical knowledge in practice, and did not understand their own postural errors. This shows the need for early and constant ergonomic monitoring of dental students; the use of the CADEP allows this.

For compliance evaluations classified as moderate to low, CADEP recommends a differentiated educational action with reinforcement of the items classified as partially adequate or inadequate. For this, CADEP was designed to allow ready observation of not only the level of dental student compliance but also postural inadequacies. The main postural inadequacies of the students evaluated in this study were related to the positioning of the patient and the students themselves.

Regarding patient positioning, it was found that 2.8% of the procedures were performed with the patient

properly positioned on the dental chair and 26.6% with the dental light positioned according to the working region [Table 2]. Concerning the student's positioning, 85.0% of the procedures were not performed with the legs properly positioned in the vertical direction and 30.7% in the horizontal direction.

Considering the information cited above, an educational action should be implemented with the aim of promoting a better understanding about these three important aspects. The first aspect is related to the advantage of the correct positioning of the patient in the dental chair, such as, obtaining an adequate vision of the operative field, good access to the operative field, avoiding damage to the musculoskeletal system. [21,22] Students should be made aware that failure to observe this aspect will reflect on the trunk, neck, arm, and forearm deviated from the neutral position. Reinforcement should also be directed at the angle formed between the thighs/legs to avoid impairment of the venous return of the lower limbs and consequently changes in the circulatory system.[24] The last aspect that should be emphasized to the students evaluated is that the adoption of inappropriate thigh/thigh horizontal angle results in the distribution of body weight in the ischia in an unbalanced way, overloading the spine over time.[22]

As observed, the CADEP can be used to objectively identify neglected ergonomic requirements for dental students, facilitate their understanding, and motivate them to change their habits. Futhermore, it's able to monitor student compliance over time.

Conclusions

The present study shows that CADEP presented adequate validity and reliability. These findings represent an important contribution to the teaching of ergonomics in dentistry. Based on these findings, we propose the use of a method that evaluates students more objectively and identifies difficulties in the practical implementation of theoretical concepts and learning of these skills.

Conflicts of interest
There are no conflicts of interest.

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