DENTISTRY • ORIGINAL ARTICLE

Seasonality of bruxism: evidence from Google Trends

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Abstract

Objective Seasonality of bruxism and its symptoms has not been tested and reflects a major niche in our understanding and the epidemiology of bruxism. Our aim is to use the Google Trends data to examine whether there was a seasonal pattern in the Google search volumes of bruxism and its symptoms on a population basis.

Methods In the observational, ecological research, we interrogated Google Trends for the following query terms: [bruxism] and [teeth grinding + teeth clenching] to obtain the internet search query volume. These queries were searched within the USA, the UK, Canada, and Australia from January 2004 to December 2017.

Results The cosinor analysis showed statistically significant seasonal patterns in [bruxism] in the USA (amplitude $\{A\} = 1.91$, $p = 0.003$), Canada ($A = 1.91$, $p < 0.001$), and Australia ($A = 2.25$, $p < 0.001$), and a trend towards a seasonal variation in the UK ($A = 1.11$, $p = 0.032$), with a peak in the winter months and trough in the summer months. Similarly, a statistically significant seasonal variation was found in [teeth grinding + teeth clenching] in the USA ($A = 5.54$, $p < 0.001$), the UK ($A = 4.36$, $p < 0.001$), and Australia ($A = 3.11$, $p < 0.001$), and a trend towards a seasonal variation in Canada ($A = 1.53$, $p = 0.034$). The peaks in winter and troughs in summer were reversed by 6 months in countries of northern hemisphere compared to Australia. Time series plots emphasized the consistency of seasonal trend that was ascertained in the cosinor analysis, by repeating in nearly all years.

Conclusion The preliminary evidence showed a seasonal variation in bruxism and its symptoms, with a peak in the winter months. This novel finding in bruxism epidemiology requires to be verified with clinical studies, and further researches are necessary to elucidate the potential mechanism behind seasonal variation in bruxism.

Keywords Seasonality · Season · Bruxism · Teeth grinding · Teeth clenching · Google Trends · Environmental factors · Ecological

Introduction

Bruxism is defined as a repeated jaw muscle activity, which is often manifested as clenching or grinding of the teeth and/ or as bracing or thrusting of the mandible [1]. It can occur while asleep or during wakefulness [1]. The most common consequence of bruxism is tooth wear, including occlusal reconstructions, and it may lead to other musculoskeletal problems [2]. According to a recent systematic review on its epidemiology, the prevalence of the bruxism ranges from about 8 to 31.4% with no gender differences [3]. Although the pathogenesis of bruxism is not completely understood, current evidence suggests it may be related to central events, which are manifested peripherally [4, 5], thus involving both the peripheral (morphological), and central (pathophysiological and psychosocial) factors [6]. While previous epidemiological studies show that bruxism is associated with restless sleep, sleeping with the lights on, loud snoring, heavy alcohol use, caffeine intake, smoking, anxiety, and stress [7–9], seasonal variation in bruxism symptoms has not been tested and reflects a major niche in our understanding and the epidemiology of bruxism.

In recent years, the internet has established as a major resource of information [10]. People have fast access to a vast amount of information through keyword-driven internet searches [10, 11]. Eighty percent of internet consumers have looked for online health information [12]. Searching of a

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specific disease is among the popular online health topics [12]. If analyzed and interpreted correctly, the Big Data might be established as the biggest data in history, possibly major resource of data for medical studies [13]. Google searches data have been available to the public in recent years [14]. The Google searches data could be reached and downloaded from the year 2004 [15]. Several examinations used Google Trends data to examine the seasonal variation in varying health problems, such as depression [16], major mental illnesses [17], restless leg syndrome [18, 19], sleep disordered breathing [20], multiple sclerosis [21], leg cramps [19, 22], brain aneurysms and subarachnoid hemorrhage [23], tinnitus [24], foot and ankle pain [25], ankle swelling [26], vitamin D [27], systemic lupus erythematous [28], gout [29], rhinitis [30], tanning using [31], and cellulitis [32].

Thus, our aim is to use the Google Trends data to examine whether there was a seasonal pattern in the Google search volumes of bruxism, and its symptoms on a population basis.

Methods

The observational, ecological research was performed according to the Helsinki declaration, and the policy of Google [33]. As indicated in earlier researches, an ethics approval was not necessary [18, 20, 23–25, 31], because our study consisted of data that available to the public with no person-identifiable info. We adhered the recommendation of a current overview on Google Trends in health care research [13].

Google Trends interrogation and data gathering

Google Trends produces data on the prevalence of query term when a person searches by entering a term in Google [15]. For making comparisons between queries simpler, Google Trends adjusts the search data to the time, and location and then scales ranging from 0 to 100, with a higher score indicating more relative search volume (RSV) [15]. The data could be exported as comma-separated values (CSV) files [15]. Two search terms can be combined with a plus sign (+) that denotes "OR," and results include searches containing either term [15]. To eliminate selection bias, Google Trends excludes duplicate queries by the same person in a short time frame [15].

In May 26, 2018, we searched Google Trends and downloaded the CSV files for the following query terms: [teeth grinding], [teeth clenching], [teeth grinding + teeth clenching], and [bruxism]. These queries were searched within the USA, the UK, Canada, and Australia from January 2004 to December 2017 using the "health" category. We selected the health category because we wish to evaluate interest in the health area. The main symptoms of

bruxism (teeth grinding, teeth clenching) were chosen as the primary search because it was reasoned that using the symptom rather than the disease as the search query might catch more persons with bruxism who may not have sought health care or have not yet been diagnosed. Observing of that a symptom (i.e., teeth grinding) had a ≈ 2-fold more RSV than bruxism (Supplementary file 1) corroborates our presumption. Furthermore, although symptoms of bruxism (i.e., [teeth grinding], [teeth clenching]) were individually searched, these symptoms were not separately analyzed for the seasonality. Because it was reasoned that the combined approach [teeth grinding + teeth clenching], in which the results included searches of either teeth grinding or teeth clenching, would provide a more comprehensive and valid representation of the symptoms of bruxism rather than a separate approach for each symptom. We selected the USA, the UK, Canada, and Australia because these countries reflect native English-speaking countries in both hemispheres. With an inclusion of countries of both hemispheres, we can assess the seasonal pattern, which is expected as reversed by about 6 months among the hemispheres, similarly emphasized in previous studies [16–32]. New Zealand and Ireland could not be included because Google Trends did not provide any data for our study's primary search query (teeth grinding + teeth clenching); probably, the data were too sparse to generate trend (Supplementary file 2).

The exported CSV files are included as supplementary for providing reproducibility of our findings (Supplementary files 3–6).

Statistical analysis

We used the cosinor analysis to test the seasonal variation, similar to earlier researches examining the seasonal variation in health problems using Google Trends [18, 20, 24, 27, 29, 31], The cosinor analysis and the program used to perform the cosinor analysis are presented in detail [34, 35]. In short, the cosinor analyses are based on the sinusoidal patterns with the formula of

$$\mathrm{St} = A\cos\left(\frac{2\pi t}{c} - P\right), \qquad t = 1, \ldots, n,$$

wherein A indicates a size, P indicates a phase, c indicates a length, t indicates a time, and n indicates the number of observations. The cosinor analysis has a sine p value and cosine p value, and significance level is set $p < 0.025$ for controlling the type I error in multiple comparisons [34, 35]. We presented one of them ((i.e., cosine p value), as suggested [34, 35]. We used the Poisson model and offset in the cosinor analysis. Cosinor analysis and time series plot were performed using "season" package in the R [35, 36].

Table 1 The seasonal variation in the relative search volume of the [teeth grinding + teeth clenching] and [bruxism] (cosinor test was used to examine the seasonality)

Country	Amplitude	Phase month‡	Low point month‡	p value§
[teeth grinding + teeth clenching]				
USA	5.54	12.9	6.9	$p < 0.001$
UK	4.36	12.2	6.2	$p < 0.001$
Canada	1.53	12.4	6.4	$p = 0.034$
Australia	3.11	6.1	12.1	$p < 0.001$
[bruxism]				
USA	1.91	1.6	7.6	$p = 0.003$
UK	1.11	1.5	7.5	$p = 0.032$
Canada	1.91	2.1	8.1	$p < 0.001$
Australia	2.25	7.6	1.6	$p < 0.001$

‡ Numeric values correspond to months as follows: January = 1, February = 2, March = 3, April = 4, May = 5, June = 6, July = 7, August = 8, September = 9, October = 10, November = 11, and December = 12

§ The threshold of significance is adjusted at $p < 0.025$ to control the false discovery rate due to multiple testing in the cosinor analysis. The cosine p value is presented

Results

We presented the results of cosinor analysis in Table 1, and presented the plots of cosinor analysis in Fig. 1. The cosinor analysis showed statistically significant seasonal patterns in RSV of [teeth grinding + teeth clenching] in the USA (amplitude $\{A\} = 5.54$, phase month$\{p\} = 12.9$, low point month $\{L\} = 6.9$, $p < 0.001$), the UK ($A = 4.36$, $p = 12.2$, $L = 6.2$, $p < 0.001$), and Australia ($A = 3.11$, $p = 6.1$, $L = 12.1$, $p < 0.001$), and a trend towards a seasonal variation in Canada ($A = 1.53$, $p = 12.4$, $L = 6.4$, $p = 0.034$). Peaks were found in winter months (in countries of northern hemisphere December; in Australia June) and trough the summer (in countries of northern hemisphere countries June; in Australia December). The peaks in winter and troughs in summer were reversed by 6 months in countries of northern hemisphere compared to Australia (Table 1) (Fig. 1).

The cosinor analysis showed statistically significant seasonal patterns in RSV of [bruxism] in the USA ($A = 1.91$, $p = 1.6$, $L = 7.6$, $p = 0.003$), Canada ($A = 1.91$, $p = 2.1$, $L = 8.1$, $p < 0.001$), and Australia ($A = 2.25$, $p = 7.6$, $L = 1.6$, $p < 0.001$), and a trend towards a seasonal variation in the UK ($A = 1.11$, $p = 1.5$, $L = 7.5$, $p = 0.032$). Peaks were observed in the winter months (January for the USA and the UK, February for Canada; July for Australia) and trough in the summer months (July for the USA and the UK, August for Canada; January for Australia). Again, the peaks in winter, and troughs in summer were reversed by about 6 months in countries of northern hemisphere compared to Australia (Table 1) (Fig. 1).

Time series plots emphasized the consistency of seasonal trend that was ascertained in the cosinor analysis, by repeating in nearly all years (Figs. 2 and 3). However, the magnitude of seasonal change has been reduced in recent years in RSV for [teeth grinding + teeth clenching] (Fig. 2). Time series plots showed slight upward trend throughout the years for RSV of [teeth grinding + teeth clenching] (Fig. 2).

Discussion

To our knowledge, our study was the first of its kind aimed at examining the seasonality of bruxism and its symptoms. Although the magnitude was decreased in recent years, a statistically significant seasonal pattern was identified in the symptoms of bruxism (teeth grinding + teeth clenching) in the USA, the UK, and Australia, and a trend towards a seasonal variation in Canada. In fact, peaks tooth grinding and clenching appeared to occur in the winter months, and trough, the summer months. Similarly, a seasonal variation was found for bruxism, peaking in winter and declining in the summer.

As our research involved data of the USA, the UK, Canada, and Australia, the research sample represents both hemispheres. Thus, the seasonal patterns could be compared between these hemispheres, where the seasons are reversed. When comparing the seasonal patterns of RSV of the countries of northern hemisphere with Australia, the seasonal trend was found to be reversed by 6 months. This observation implied that the pattern was seasonal—rather than calendar-driven.

It could be commented the observed seasonality might be due to increments in the internet use in winter, but that presumption was not corroborated since several earlier examinations showed seasonality in searches of restless leg syndrome [18], leg cramps [22], foot and ankle pain [25], ankle swelling [26], gout [29], and cellulitis [32] with a peak in summer.

To the best of our knowledge, no epidemiological study has yet investigated the seasonality of bruxism or its symptoms. Therefore, the theoretical development regarding seasonality in bruxism is somewhat limited. However, our study provides preliminary evidence for seasonality in bruxism and its symptoms. Some mechanisms might be responsible for the seasonality of bruxism and its symptoms. First, several lines of evidence suggested that the central dopaminergic system may have a major role in the causes of bruxism; an increase in dopamine or hypersensitivity of dopamine receptors induce bruxism and worsen the symptoms [6, 37–40]. Interestingly, previous studies have shown seasonal fluctuations of dopamine levels in the human brain.

Fig. 1 The plots of cosinor models fitting generalized linear models based on data from January 2004 to December 2017 for the seasonal variation in the relative search volume of [teeth grinding + teeth clenching] and [bruxism] in **a** the USA, **b** the UK, **c** Canada, and **d** Australia. Relative search volume is a proportion to all searches on a range of 0 to 100. The blue line represents relative search volume of [teeth grinding + teeth clenching]; the green line represents relative search volume of [bruxism]. The months are as follows: January, February, March, April, May, June, July, August, September, October, November, and December
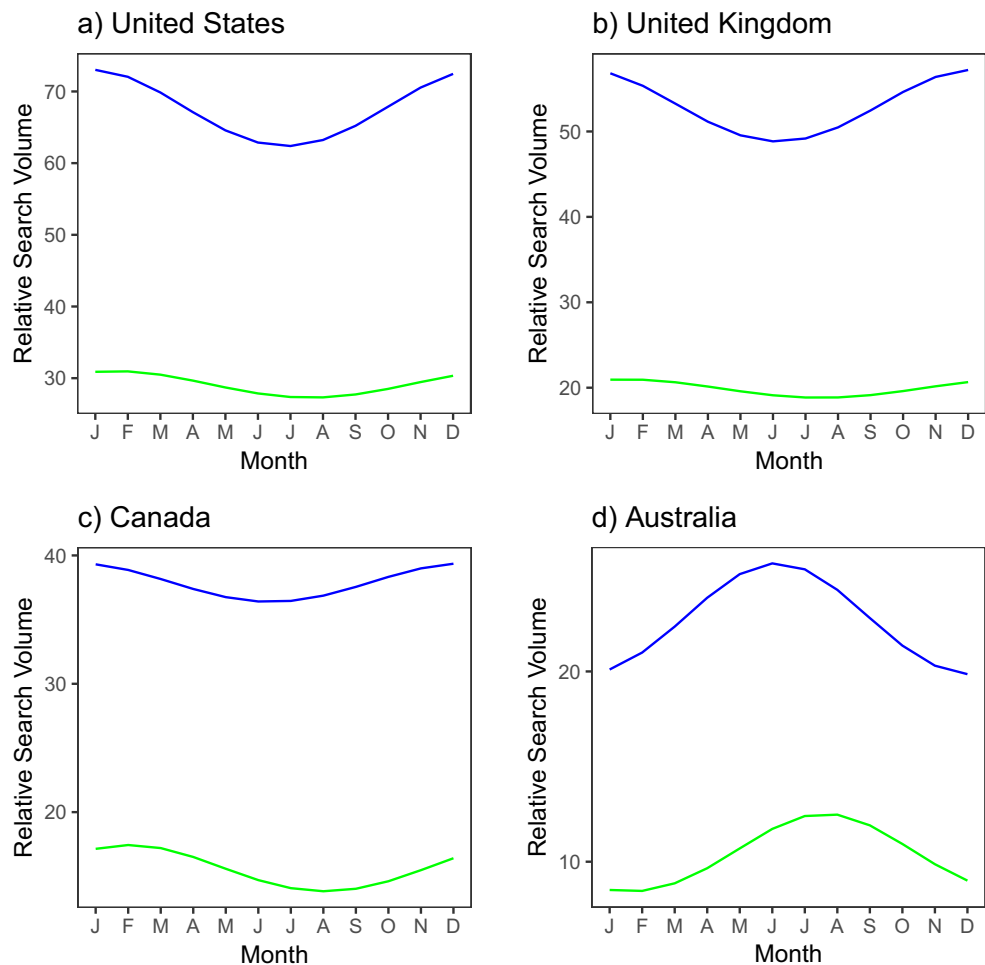
Increasing concentrations of hypothalamus dopamine and higher striatal presynaptic dopamine synthesis and storage were found in winter in healthy adults [41, 42]. In this context, seasonal fluctuations in dopamine may be associated with the intensity of bruxism symptoms; the increases in dopamine in winter worsen the symptoms in patients with bruxism. Second, seasonal weather parameters (e.g., temperature, relative humidity, air pressure, precipitation, and extreme events) might be the main causes of the observed seasonal variation in internet searches of bruxism in our research. For instance, the body's immediate response during exposure to cold environments is shivering, which is defined as an involuntary muscular activity to produce heat. As the exposure to cold is the highest in winter, shivering-related teeth chattering may worsen the bruxism symptoms and might contribute to the increases in bruxism search in winter. Third, the main risk factors for bruxism that may be influenced by seasons include sleep problems, smoking, and anxiety. The sleep quality and time spent in the deeper stages of sleep are lower in winter, and sleep problems (e.g., sleep-disordered breathing) are higher in

winter compared to the summer [43, 44]. It is interesting to note that the exposure to environmental tobacco smoke is higher in winter compared to summer in both smokers and nonsmokers, as indoor-smoking is more common [45]. Nicotine affects the cholinergic nervous system, which contributed to a great extent in alertness and brain arousal system in the pathogenesis of bruxism [37]. Thus, an increase in the exposure to tobacco smoke may account for increasing the severity of bruxism symptoms during winter months. Regarding anxiety, previous investigations have clearly demonstrated seasonal variation in the mood and anxiety, with a lower mood and increased anxiety during winter compared with the summer [46, 47]. An increment in the severity of these risk factors during winter may be related to the observed seasonal variation in bruxism, and its symptoms in our study.

The strengths of our research involve a big size of data used, a comprehensive time frame of observations, and inclusion of countries from both hemispheres. But, our research has a couple of limitations. The design of our study using internet searches as proxy precludes
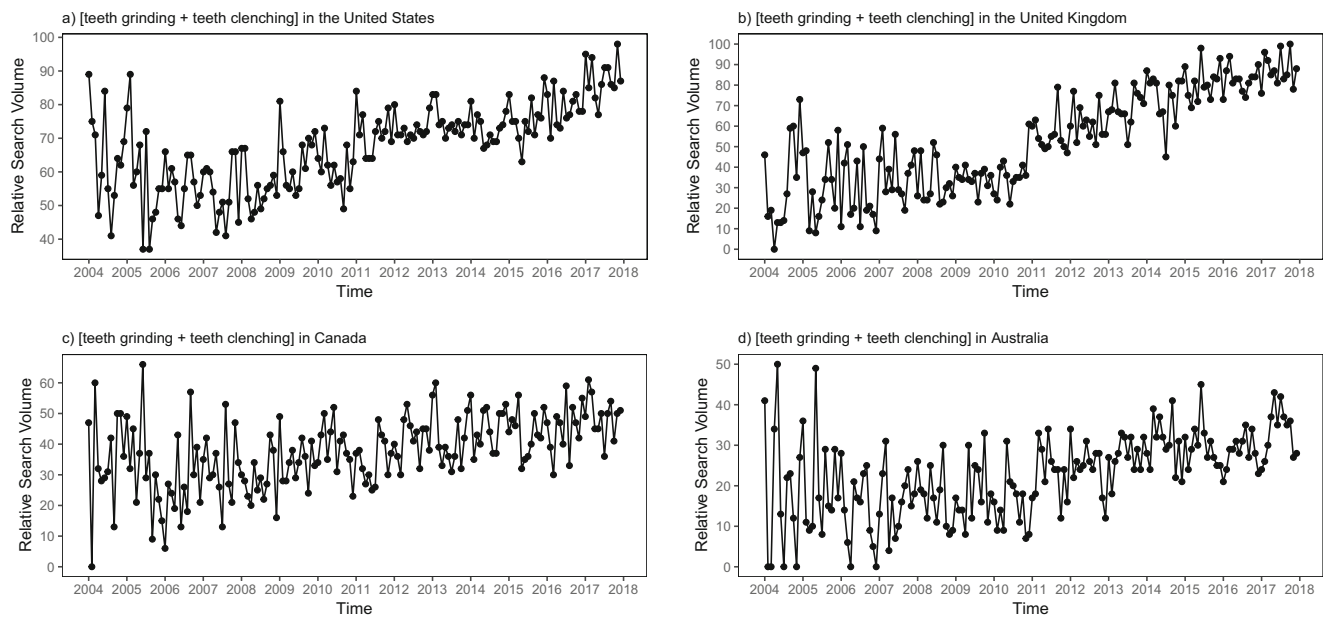
Fig. 2 Time series plots for the relative search volume of [teeth grinding + teeth clenching] in **a** the USA, **b** the UK, **c** Canada, and **d** Australia from January 2004 to December 2017. Relative search volume is a proportion to all searches on a range of 0 to 100

establishing causal relationships; thus, clinical studies are required to test whether the season has any causal association with bruxism. In addition, our study provided no information on possible mechanisms that might be responsible for the observed seasonal variation of internet searches for bruxism. Therefore, further studies testing the possible factors and causes, particularly weather variables, on worsening of bruxism symptoms are warranted to explore and explain our preliminary finding. Furthermore,

Google Trends provides only relative-rather than actual-quantities of search volume, restricting an interpretation of the absolute magnitude in seasonal change. Additionally, Google Trends does not provide the demographical features of consumers who search in Google; so, it is not possible to assess the seasonal variation by stratification of the population. Hence, our results could merely be interpreted for a population basis. Lastly, we only searched Google search engine; but more than 65% of all
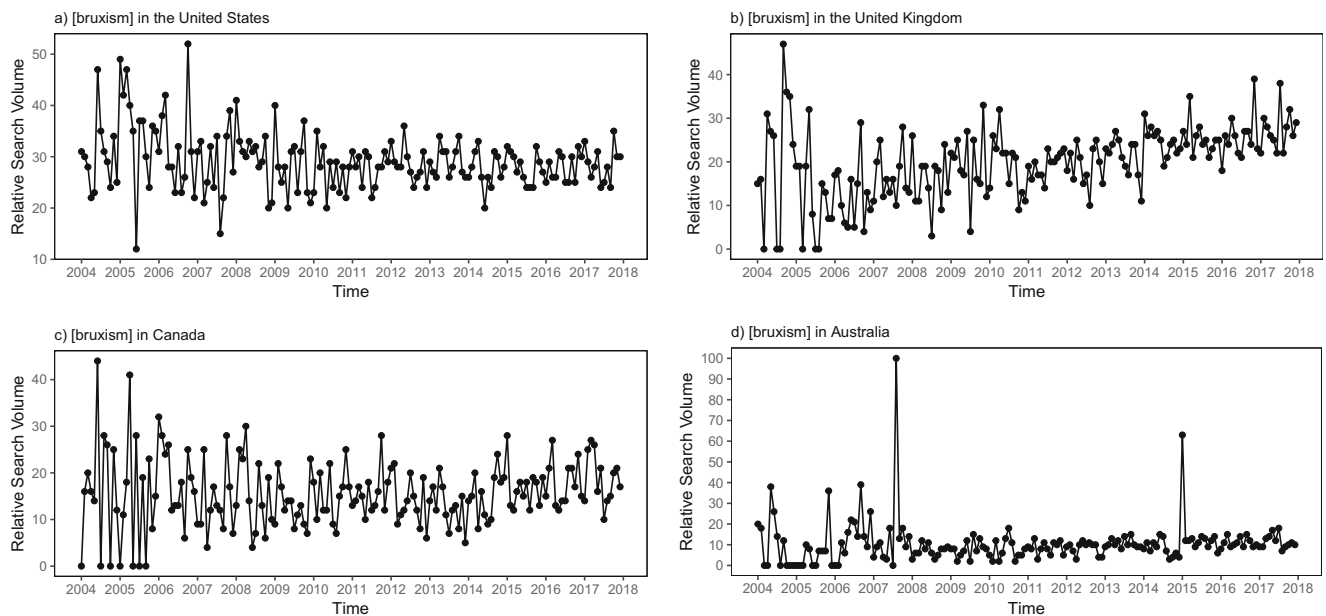

Fig. 3 Time series plots for the relative search volume of [bruxism] in **a** the USA, **b** the UK, **c** Canada, and **d** Australia from January 2004 to December 2017. Relative search volume is a proportion to all searches on a range of 0 to 100

queries are searched through the Google search engine [48]. In spite of the limitations, our study contributes to the literature with regard to the seasonal variation of bruxism and its symptoms on a population basis.

Conclusion

The preliminary evidence showed a seasonal variation in bruxism and its symptoms, with a peak in the winter months. This novel finding in bruxism epidemiology requires to be verified with clinical studies, and further researches are necessary to elucidate the potential mechanism behind seasonal variation in bruxism.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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