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ORIGINAL RESEARCH

Vitamin D Deficiency and Insufficiency Among University Students: Prevalence, Risk Factors, and the Association Between Vitamin D Deficiency and Episodes of Respiratory Tract Infections

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Background: Vitamin D deficiency (VDD) and insufficiency (VDI) is a public health problem worldwide. Low blood levels of vitamin D have been associated with many illnesses, including respiratory tract infections (RTIs). This study aims to evaluate the prevalence of VDD and VDI among university students, assess the correlation with demographic and anthropometric factors, and determine the effect of VDD on the respiratory tract infection (RTI) incidence.

Methods: A cross-sectional and prospective design was used. Our sample consisted of 287 students aged 18–24 years from the University of Sharjah-UAE. Participants were tested for serum 25(hydroxyvitamin)D levels, Body mass index (BMI) was calculated, and the survey was completed. The association between VDD, VDI with the participant's characteristics, and the incidents of RTIs were examined.

Results: VDD and VDI were highly prevalent among 85% of the students. The median serum 25(OH) D level was 15.8 ng/dl (19.5±11.6). The mean BMI was (24.32±6.3) kg/m. The results showed a significant positive correlation between VDI and VDD with gender and students who were previously diagnosed with VDD ($P < 0.05$); however, they were not statistically significant ($P < 0.05$) with other factors. The tonsillitis incidents were significantly associated with VDD ($P = 0.027$), while no significant correlation with other incidences of RTIs was found.

Conclusion: VDD and VDI represent a significant problem across the university students specifically with the female gender. VDD is associated with tonsillitis infection incidence. Both the health and higher education authorities' attention is needed, exploring the causes of VDD and VDI, regular 25(OH)D serum level examination, and educational programs on VDD risks are required.

Keywords: Vitamin D deficiency, Vitamin D insufficiency, Respiratory tract infections, RTIs, Tonsillitis, University students, United Arab Emirates

Background

Vitamin D is a vital fat-soluble vitamin with hormonal functions. It plays an essential role in bone and muscle integrity. The serum level of 25(OH) D is the best indicator of vitamin D status in humans.[1] Vitamin D deficiency (VDD) and vitamin D insufficiency (VDI) are major worldwide public health problems, it has been estimated that 50% of the worldwide population suffers from VDD.[2] People who live in United Arab Emirates (UAE) are at greater risk of VDD across all age groups,

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as people in the UAE do not have sufficient exposure to sunlight even though the UAE is one of the sunniest countries.[3] The rate of VDD in UAE estimated at (50–90%).[4,5]

The anthropometric characteristics that may predispose Middle Eastern people to VDD and VDI are still unknown. The main factors that are associated with a lower level of 25-hydroxyvitamin D (25(OH) D) are, lower intakes of vitamin D fortified foods, reduced intakes of foods rich in calcium, decreased outside activities, increased use of sunblock, decreased exposure to sunlight, darker skin pigmentation, female sex, and obesity.[6–8]

Studies have shown that vitamin D has a protective effect against several chronic illnesses such as autoimmune diseases, cardiovascular disease, type 2 diabetes, hypertension, cancers, asthma, and it reduces the chronic obstructive pulmonary disease (COPD) exacerbation rate.[9–11] Recent studies suggest that vitamin D enhances the innate immune response via the induction of cathelicidin, an endogenous antimicrobial peptide produced by neutrophils and macrophages at the respiratory epithelium. Vitamin D metabolites synthesize reactive oxygen species and stimulate autophagy.[12–14]

Previous studies evaluated the prevalence of low vitamin D levels and the association of lower levels with different health problems; however, fewer studies have addressed university students. The study results among female students at United Arab Emirates University reported that 37% of the students were considered vitamin D insufficient and 40% of the female students residing in the dorms also had vitamin D insufficiency.[15] Another study indicated that 47.92% of female university students had suboptimal serum vitamin D levels.[16]

Respiratory tract infections (RTIs) are common global diseases that are considered a frequent reason for patients to visit primary health-care centers that can lead causes of student absenteeism,[17] *Streptococcus pneumonia* and the Influenza virus are the most common causes of RTIs.[18,19] Worldwide, most individuals have a cold at least twice a year,[20] VDD is a significant health problem among young adults.[21]

Furthermore, multiple observational studies indicate a clear association between low levels of 25(OH)D and increased risk of an acute respiratory tract infection (ARTI).[22,23] Other studies stated that vitamin D supplementation reduces the risk of ARTI through their effects on both adaptive and innate immune systems.[24] A recent meta-analysis and systematic review showed that vitamin D supplementation reduces the risk of RTIs in children but not in adults,[25] However, published randomized controlled trials (RCTs) addressing the hypothesis that vitamin D could reduce the risk of RTIs did not include young adults. Many young adults skip breakfast meal, prefer carbonated beverages to milk, and did not consume vitamin D fortified foods, thereby decreasing the intake of both calcium and vitamin D.[26–28]

In the UAE, data on the prevalence of VDD and VDI, association factors, and the incidence of RTIs associated with the serum 25(OH)D levels among university students are limited. Therefore, this study aimed to evaluate the prevalence of VDD and VDI among university students, to assess the correlation with demographic and anthropometric factors, and to determine the effect of VDD on the incidence of RTIs.

Methodology

Participants and Sampling

A questionnaire-based prospective and cross-sectional study was conducted at the medical campus of the University of Sharjah-UAE, from 23\February-2\March 2020. Participation in the study was voluntary and anonymous; Informed consent was sought from all the participants prior to fill out the questionnaire and take a blood sample. All the participants signed a consent form, the participants who declined consent were not permitted to participate in this study, and participants were informed that could withdraw at any time in line with stipulations of the World Medical Association Declaration of Helsinki Ethical principles.[29] Students were recruited to participate in the study by sending an email invitation, inclusion criteria were undergraduate students aged 18–26 years from College of Medicine, Dentistry College, College of Pharmacy, and Health Sciences college who agreed to participate in this study, provide the serum 25(OH)D test, and complete the survey. The exclusion criteria were the students who are taking vitamin D supplements. The students have been informed that all responses will be confidential and anonymous. Measured outcomes included serum 25(OH)D level and body mass index (BMI).

Serum 25(OH)D level was measured by collecting blood samples. A single blood sample was obtained from each participant, analyzed in the laboratories of Thumbay hospital, Ajman-UAE. The results were classified into four categories, based on vitamin D 25-hydroxyvitamin level: deficiency (<10 ng/dl), insufficiency (10–29 ng/dl), sufficiency (30–100 ng/dl), and potential intoxication (>150 ng/dl).

Body mass index (BMI) was computed as the weight in kilograms divided by height in meters squared (kg/m2). BMI was categorized into underweight (≤18.5 kg/m2), normal or healthy (18.5 to <24.9 kg/m2), overweight (25.0 to <30 kg/m2), and Obese (≥30 kg/m2), based on the World Health Organization classification.[30]

The Survey and Data Collection

A total of 287 out of 306 students completed the survey and provided serum 25(OH)D test result included in this study. Our survey was created depending on the different literature, which was published previously.[16,31,32]

The questionnaire was designed in the English language, and it was pilot tested by 15 medical volunteer students through face-to-face interviews to clarify and ascertain whether the questionnaire was appropriate for the students, resulting in minor modifications.

The survey consisted of an interface page and two parts: The first includes demographic and anthropometric characteristics questions of each participant such as (gender, age, college, year of study, nationality, skin complexion, smoking status, residential area, history of VDD, and information on VDD), the second part includes the question of how often is it that you had the following diseases over the last six months: common cold, seasonal influenza, nasal obstruction, tonsillitis, sinusitis, laryngitis, and bronchitis.

Statistical Analysis

Data analysis was conducted using SPSS version 23. The qualitative variables were summarized using frequencies and percentages, the quantitative variable was summarized using means and Standard Deviation (±SD). A Chi-square test was used to investigate the difference in the proportions of the serum 25(OH)D levels and the incidence of respiratory tract infection (RTI). A simple binary logistic regression was used to investigate the associations between vitamin D insufficiency/deficiency and other significant risk factors. A p-value <0.05 was considered significant.

Results

Demographic and Anthropometric Characteristics of Participants

The demographic characteristics of participants are shown in Table 1. A total of 287 participants in this study completed the survey and provided serum 25(OH)D test results. The average age was 19.9±1.6, most of the participants were females 65.9% (n=189), and 34.1% (n=98) were males.

Table 1 Demographic and Anthropometric Characteristics of Participants, UOS Students (n=287)

Demographic	Groups	Frequency (n)	Percentage (%)
Gender	Male	98	34.1
	Female	189	65.9
College	Medicine	239	83.3
	Dentistry	18	6.3
	Pharmacy	14	4.9
	Health sciences	16	5.6
Year of study	Foundation	51	17.8
	1st	72	25.1
	2nd	74	25.8
	3rd	47	16.4
	4th	32	11.1
	5th	11	3.8
Nationality	Emirati	28	9.8
	Arabic non-Emirati	235	81.9
	Other Nationalities	24	8.4
Skin complexion	Dark color	17	5.9
	Medium color	157	54.7
	Fair color	113	39.4
Smoking status	Smokers	29	10.1
	Non-smokers	258	89.9
History of vitamin D deficiency	Yes	131	45.6
	No	156	54.4
Information on vitamin D	Have Information	244	85
	Do not have Information	43	15
Residence area	Villa	77	26.8
	Apartment	177	61.7
	University dorm	33	11.5
	Underweight ≤ 18.5	29	10.1
BMI	Normal 18.5 to <25	158	55.1
	Overweight 25.0 to <30	62	21.6
	Obese 30.0 or higher	38	13.2

Almost 83.3% (n=239) of participants were from the College of Medicine, while 6.3% (n=18), 5.6% (n=16), and 4.9% (n=14) were from Dentistry College, Health Sciences and Pharmacy Colleges, respectively. Regarding the study year, around 17.8% (n=51) were in the foundation year, while 25.1%, 25.8%, 16.4%, 11.1%, 3.8% were from 1st, 2nd, 3rd, 4th, and 5th year, respectively. The

majority of respondents were Arab non-Emirati's students 81.9% (n=235) followed by the Emiratis participants were 9.8% (n=28), and 8.4% (n=24) were non-Arab nationalities. As for the skin complexion of the participants, more than half had a medium skin color 54.7% (n=157), while 5.9% (n=17) had dark skin, and 39.4% (n=113) had fair skin color. The vast majority of respondents were non-smokers 89.9% (n=258), and 10.1% (n=29) only were smokers. More than half of participants 61.7% (n=177) live in apartments, 26.8% (n=77) in villas, and 11.5% (n=33) live in university dorm. Less than half of students 45.6% (n=131) have been diagnosed with VDD previously, while 85% (n=244) of respondents had previous information on vitamin D.

The respondents' mean height and weight were (167.5 ± 12) cm and (68.2 ±17.6) Kg. The mean BMI of the respondents was (24.3 2±6.3) kg/m. Our results show that 10.1% (n=29) of the participants were underweight, 55.1% (n=158) were normal, 21.6% (n=62) were overweight, and 13.3% (n=38) were obese, as shown in Table 1.

Distribution of Serum 25(OH)D Levels Among Participants Students (UOS)

The distribution of different serum 25(OH)D levels among the participants is presented in Table 2 The median serum 25(OH) D level of the participants was 15.8 ng/mL (19.5 ±11.6). Almost 16.7% (95% CI: 12.4–21.1) of respondents had VDD level, 68.3% (95% CI: 61.4–72.4) had VDI level, and 15% (95% CI: 10.8–19.1) of the participant had a normal level of vitamin D. Among the participants, a higher proportion of females (15.3%) were VDD and (40%) were VDI compared to the male students (1.39%) and (28.2%), respectively.

Table 2 Distribution of Serum 25(OH)D Levels Among Participants, UOS Students (n=287)

Vitamin D Status	Frequency	Proportions	95% CI*	
Vitamin D deficiency (<10 ng/dl**)	48	16.70%	12.4	21.1
Vitamin D insufficiency (10–29 ng/dl**)	196	68.30%	61.4	72.4
Normal (30–100 ng/dl**)	43	15%	10.8	19.1

Note: **Nanograms per decilitre.
Abbreviation: *CI, confidence interval.

Association Between Demographic and Anthropometric Characteristics with Vitamin D Insufficiency/Deficiency Level of the Participants Students (UOS) by Univariate Logistic Regression

Table 3 shows the results of the univariate logistic regression model applied to participant demographic and anthropometric characteristics. This table presents the results for VDI and VDD. Accordingly, significantly increased risks of VDI were observed in male participants (OR=2.56, CI=1.45–4.54, P-value =0.001) but decreased risks of VDI were observed in participants who were previously diagnosed with vitamin D deficiency (OR=0.54, CI=0.33–0.89, P-value =<0.016). On the other hand, the prevalence of VDD decreased with the male participants (OR=0.14, CI=0.05–0.40, P-value <0.001). However, there were no statistical differences between the risk of VDI and VDD with other participant's demographic and anthropometric characteristics: College, year of study, nationality, skin complexion, smoking status, information on VDD, resident area, and BMI.

Episodes of Respiratory Tract Infections (RTIs) of the Participants Students (UOS)

Table 4 presents the episodes of RTIs for participants in the past six months of the study. The table shows that almost 7.0%,11.1%, 2.1%, 4.5%, 1.0%, 2.1%, and 1.4% of participants had frequently (always/often) infection of the common cold, seasonal influenza, nasal obstruction, tonsillitis, sinusitis, laryngitis, and bronchitis, respectively, during the past six months of the study. While 10.8%, 14.3%, 5.2%, 4.2%, 1.7%, 1.4%, and 0.3% (sometimes) had an infection of common cold, seasonal influenza, nasal obstruction, tonsillitis, sinusitis, laryngitis, and bronchitis, respectively, during the past six months of the study. Besides, 82.2%, 74.6%, 92.7%, 91.3%, 97.2%, 96.5%, and 98.3% have not been infected with the common cold, seasonal influenza, nasal obstruction, tonsillitis, sinusitis, laryngitis, and bronchitis during the past six months, respectively.

Association Between Episodes of Respiratory Tract Infections (RTIs) and Vitamin D Deficiency of the Respondents' Students by Bivariate Analysis

The bivariate analysis results about the correlation between VDD and episodes of respiratory tract

Table 3 Univariate Logistic Regression Analysis for Factors Associated with Vitamin D Insufficiency/Deficiency

Participant's Characteristics	Groups	Vitamin D Insufficiency				Vitamin D Deficiency			
		OR	95% CI*		P. Value	OR	95% CI*		P. Value
Gender	Male	2.56	1.45	4.54	**0.001**	0.14	0.05	0.4	**<0.001**
	Female	1	—	—	—	1	—	—	—
College	Dentistry	1.17	0.24	5.69	0.85	0.26	0.02	2.74	0.26
	Medicine	0.62	0.19	1.97	0.41	0.92	0.25	3.38	0.92
	Pharmacy	1.22	0.22	6.73	0.82	0.72	0.1	5.09	0.72
	Health sciences	1	—	—	—	1	—	—	—
Year of study	Junior years	0.88	0.51	1.49	0.62	1.45	0.72	2.95	0.3
	Senior year	1	—	—	—	1	—	—	—
Nationality	Emirati	0.47	0.15	1.5	0.21	2.37	0.62	8.99	0.21
	Arabic non-Emirati	0.88	0.35	2.21	0.78	0.87	0.28	2.71	0.82
	Other Nationalities	1	—	—	—	1	—	—	—
Skin Complexion	Dark color	2.76	0.75	10.2	0.13	0.58	0.12	2.75	0.49
	Medium color	1.27	0.76	2.1	0.36	0.83	0.44	1.57	0.57
	Fair color	1	—	—	—	1	—	—	—
Smoking status	Smokers	1.34	0.57	3.14	0.51	0.55	0.16	1.88	0.34
	Non-smokers	1	—	—	—	1	—	—	—
History of vitamin D	Yes	0.54	0.33	0.89	**0.016**	0.54	0.28	1.03	0.063
	No	1	—	—	—	1	—	—	—
Information on vitamin D deficiency	Have information	0.97	0.49	1.94	0.93	0.86	0.37	1.99	0.72
	Do not have information	1	—	—	—	1	—	—	—
Resident area	Villa	1.04	0.44	2.47	0.93	1	0.35	2.88	1
	Apartment	1	0.46	2.2	1	0.85	0.32	2.24	0.74
	Others	1	—	—	—	1	—	—	—
Age		0.95	0.82	1.11	0.53	1.02	0.84	1.22	0.87
BMI		1.02	0.98	1.06	0.38	0.99	0.95	1.05	0.89

Note: Significance <0.05 are bolded.
Abbreviation: *CI, confidence interval.

Table 4 Episodes of Respiratory Tract Infections (RTIs) of the Participants (n = 287)

RTIs Diseases	Never/ Rarely	Sometimes	Always/ Often
	n(%)	n(%)	n(%)
Common cold	236(82.20)	31(10.8)	20(7)
Seasonal Influenza	236(82.20)	31(10.8)	20(7)
Nasal obstruction	214(74.60)	41(14.3)	32(11.1)
Tonsillitis	266(92.70)	15(5.2)	6(2.1)
Sinusitis	262(91.30)	12(4.2)	13(4.5)
Laryngitis	277(96.50)	4(1.4)	6(2.1)
Bronchitis	282(98.30)	1(0.3)	4(1.4)

infections are shown in Table 5. The bivariate analysis shows that the incidence of tonsillitis was significantly associated with VDD (P = 0.027), while no significant correlation between the episodes of common cold, seasonal influenza, nasal obstruction, sinusitis, laryngitis, and bronchitis with VDD ($p < 0.05$).

Discussion

This study provided information on the prevalence of VDD and VDI among medical students in the University of Sharjah, and the association with participant characteristics. This study also provides novel information on the

Table 5 The Association Between Respiratory Tract Infections Incidents and Vitamin D Deficiency of the Participants (n = 287)

RTIs Episodes in the Past Six Months (Always/ Often)	Vitamin D Deficiency			
	All	Yes (%)	No (%)	P. Value
Common colds	48 (16.7%)	5 (25)	43 (16.1)	0.304
Seasonal Influenza	48 (16.7%)	5 (25)	43 (16.1)	0.304
Nasal obstruction	48 (16.7%)	5 (15.6)	43 (16.9)	0.86
Sinusitis	48 (16.7%)	2 (15.4)	46 (16.8)	0.895
Tonsillitis	48 (16.7%)	3 (50)	45 (16)	**0.027**
Laryngitis	48 (16.7%)	0(0)	48 (17.1)	0.267
Bronchitis	48 (16.7%)	0(0)	48 (17)	0.367

Note: Significance <0.05 are bolded.

association between lower serum 25(OH)D level and common RTIs incidents at university students.

The results reported that VDD and VDI were significantly prevalent among university students, more importantly, a substantially higher number of female students than their male counterparts.

Multiple studies in the UAE have shown similar results. A study conducted on undergraduate university students at Abu Dhabi, UAE, reported that the mean serum 25(OH)D level of female students was 20.9 ± 14.9 nmol/L, while that for male students was 27.3 ± 15.7 nmol/L.[21] Another study conducted on UAE college students revealed that 47.92% of students had suboptimal serum 25(OH)D levels.[16]

VDD and VDI are considered a major public health problem worldwide. The low serum 25(OH)D level of university students is mostly because of reduced outdoor activities and limited sun exposure.[16,33]

In the UAE, adult females observe conservative dress codes outside that covers most of their bodies and limit sunlight exposure.[34] The lower serum 25(OH)D levels have been revealed among the women wearing Niqab and Hijab in Jordan and Turkey that may interfere with the penetration of ultraviolet rays into the skin.[35,36]

In the UAE, the markets include a few vitamin D fortified foods because there is no law mandating essential foods' fortification.[37] Inadequate intake of foods fortified with vitamin D may further reduce the serum 25 (OH)D levels among adult students.

A study on dietary consumption estimates among Emirati female students in the UAE aged 19 to 23 years reported that 70% of young female students did not consume vitamin D fortified foods, which may lead to a high incidence of VDD and VDI.[27] Many adult students prefer carbonated soft drinks to milk, which contributes to low calcium and vitamin D in the body and potentially increases the risk of VDD among students.[28]

Lower 25(OH)D levels increase with other factors such as darker skin pigmentation, obesity, and smoking.[8] In our study, 21.6% were overweight, and 13.2% were obese. Our findings showed an inverse correlation between Body Mass Index (BMI) and serum 25 (OH)D levels of the participants. BMI remained an independent association with the serum 25 (OH) D level, consistent with similar studies.[16,27]

A higher BMI value of ≥30 and subcutaneous adipose tissue was associated with low 25(OH)D, this could be explained by the increased metabolic clearance of vitamin D in obesity, possibly due to enhanced absorption by adipose tissue. Obese people may need to consume larger than usual vitamin D to achieve 25(OH)D levels comparable to average weight because subcutaneous fat traps more of the vitamin D and alters its release into the blood circulation.[38]

When our study evaluated the associations between vitamin D level and participant's demographic and anthropometric characteristics, we found that the participants with a history of VDD had higher odds of VDI than others. These students may not have been exposed to enough sunlight, have fewer intakes of vitamin D fortified foods or still have not completed their VDD treatment.[39,40]

We evaluated the association between VDD and the incidences of Respiratory Tract Infections (RTIs). Our findings showed that tonsillitis infection incidence was higher in students with VDD, while there was no association between VDD and other RTIs among our participants. Similar to our results, a study conducted among healthy adults aged 45 years and older found no significant benefit of 1000 IU/day vitamin D3 supplementation on the incidence, duration, and severity of URTI symptoms in vitamin D deficient subjects.[41]

Our proposed association mechanism with RTIs is suggested by recent evidence that vitamin D enhances the innate immune response via the induction of cathelicidin, an endogenous antimicrobial peptide produced by neutrophils and macrophages at the respiratory epithelium. Vitamin D metabolites stimulate autophagy and synthesize reactive oxygen species.[12–14] Thus, it protects against many diseases, including RTIs.

Vitamin D has a significant impact on the respiratory cell's function, affecting inflammation, wound healing, repair, host defense, and other vital processes. A clinical

study showed that less airway hyperresponsiveness, improved lung function, and improved glucocorticoid response were associated with high serum 25(OH)D levels.[42]

Observational research in the British birth cohort has reported significant linear relationships between 25(OH)D serum levels and decreased risk of acute respiratory tract infection (ARTI).[43] Other observational research in the United States (US) in the Third National Health and Nutrition Examination Survey suggested that the serum 25(OH)D levels are inversely associated with upper respiratory tract infections (URTIs); this association may be more robust in those with respiratory tract diseases.[23]

The current preliminary studies remain indecisive about vitamin D's effects on preventing RTIs among the general public. Most of the studies exploring that aspect are based on small, non-diverse groups of patients; the relationship between 25(OH)D level and RTIs at a population level has not been explored.

Limitations of the Study

A potential weakness of the study is that it was conducted among the students of medical colleges at the University of Sharjah in the United Arab Emirates, and the results could not be generalized.

Although many demographic and anthropometric factors were included in this study, other factors may have been missing and may need other investigations rather than just a questionnaire and blood test.

The current study identified an association between VDD and incidents of RTIs diseases. Ideally, a more extensive study performed in one season with a higher number of students would strengthen the association between VDD and RTIs incidents.

Conclusion

VDD and VDI are both significant problems across both genders and all ages of university students in the United Arab Emirates. Females are more likely to have VDD and VDI. Moreover the students who were previously diagnosed with VDD are more likely to have low level of 25 (OH)D serum than their counterparts. VDD is associated with an increased incidence of tonsillitis infection, while there was no statistical association with other RTIs such as common cold, seasonal influenza, nasal obstruction, sinusitis, laryngitis, and bronchitis in our population study. Both the health and higher education authorities' attention is needed to explore the causes of VDD and VDI among adults, regular 25(OH)D serum level examination, awareness of effective sunlight exposure, and educational programs on VDD risks are required.

Abbreviations

VDD, vitamin D deficiency; VDI, vitamin D insufficiency; RTIs, respiratory tract infections; 25(OH)D, serum 25 (hydroxyvitamin)D; BMI, body mass index; COPD, chronic obstructive pulmonary disease; UAE, United Arab Emirates; UOS, University of Sharjah; URTI, upper respiratory tract infection; ARTI, acute respiratory tract infection.

Data Sharing Statement

All data and material are available in the manuscript.

Ethics Approval

Ethical approval for the study was obtained from the Research Ethics Committee (RIC) at Sharjah University, Sharjah UAE, with reference number: REC-19-12-18-02.

Consent for Publication

All authors agreed to publish the manuscript.

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Disclosure

The authors declare no conflicts of interest for this work.

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