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Physiology of Pe'a and Malu: Biocultural Case Studies of Endocrine and Immune Responses to Samoan Tatau

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Abstract

Tattooing has become a prominent form of body modification worldwide since the 20th century, leading to a revival of traditional hand-tap techniques, especially those from Samoa. The Samoan traditional *pe'a* (male tattoo) and *malu* (female) are distinctive, as they are administered by hand-tap tools in open-air bungalows and are to be completed in a short period of time, usually 1-2 days for the *malu* and a week to a month for the *pe'a*. This study involved systematically collecting saliva samples from participants undergoing traditional Samoan tattooing practices facilitated by Sulu'ape Tatau in Apia, Samoa. The Sulu'ape Tatau lineage is recognized as a prominent representative of the Su'a Guild, which holds significant cultural and historical importance within the realm of Samoan *tatau*. This study characterizes the physiological responses to tatau by analyzing biomarkers such as cortisol, secretory immunoglobulin A, and C-reactive protein. Given the constraints on healthcare resources in Samoa, understanding these physiological responses provides insight into how cultural practices like *tatau* may enhance biological resilience against health challenges.

Keywords

allostasis, malu, pe'a, tatau, tattoo, traditional handtap tattooing

Introduction

During the Age of Exploration, Indigenous tattoo traditions significantly declined due to missionary prohibitions that undermined their cultural importance within various communities. Samoa successfully preserved and sustained its tattoo culture during that era, primarily due to the inability of colonizers to unify the islands under a single government and the permissive stance of Catholic missionaries who allowed the continuation of this cultural practice [Su'a Alaiva'a Sulu'ape, personal communication, July 15, 2019; 1]. Today, traditional *tatau* are administered by members of three Samoan guilds—Su'a, Tulou'ena, and Lai'afaiva. There is a debate within the Samoan community regarding the historical legitimacy of these guilds; however, this article cannot accommodate an exploration of that local issue.

Tattooing has undergone significant transformation and growth throughout the 20th century, particularly in Western regions such as the United States and Europe [2]. This marked a notable shift in societal perceptions of tattoos, transitioning from stigmatized body art associated with rebellion or deviance to a widely accepted form of personal expression and artistry [3, 4]. Tattooing emerged as one of the most rapidly expanding sectors during this time, reflecting broader cultural changes that embrace individuality and self-expression [3, 5]. The rise of tattoo parlors, increased visibility in popular culture through celebrities and media, and the advent of social media platforms have all contributed to this expansion. As more individuals sought to adorn their bodies with tattoos, the industry experienced a surge in demand for skilled artists capable of creating intricate designs. This growth was not merely quantitative; It also led to qualitative advancements in tattoo artistry, including innovations and techniques, equipment, and ink quality [4].

Alongside the modern evolution of tattooing, there has been a noteworthy resurgence in traditional hand-tap techniques. These methods are deeply rooted in various cultural contexts, with

particular emphasis on practices originating from regions such as Samoa. Hand-tap tattooing is characterized by its manual application process using tools like sticks or bones rather than electronic machines. This technique is often imbued with cultural significance and spiritual meaning, reflecting the identity and heritage of the communities from which they originate [5].

The Samoan traditional *pe'a* (male tattoo) and *malu* (female) are unique in that they are administered by hand-tap tools in open-air *fales* (bungalows) and are to be completed in a short period of time, usually 1-2 days for the *malu* and a week to a month for the *pe'a*. In Samoa, efforts are made to faithfully preserve and emulate traditional cultural practices to the greatest extent possible. Sulu'ape Tatau (representing the Su'a guild) occupies a *fale* in the Samoan Cultural Village administered by the Samoan Tourist Authority. Individuals originating from Samoa, American Samoa, and the broader diaspora participate in this significant rite of passage. These participants contribute to the ceremony by bringing their families, providing daily sustenance for all attendees, and supplying mats for seating arrangements. Furthermore, they offer monetary contributions for the ceremonial (*sama*) aspects that honor *tufuga tā tatau* (master handtap tattooist in the Samoan style), who is recognized as a master practitioner of hand-tapped tattooing in the Samoan tradition. The *tufuga tā tatau* holds a distinguished position within this context, serving not only as an artisan but also as *matai* (chief) within the framework of Samoan *tatau*. This dual role underscores the importance of both artistry and leadership in maintaining cultural heritage. Through these collective efforts and contributions, individuals reaffirm their cultural identity and communal bonds during this important ceremonial event.

The *pe'a* is administered over multiple days due to its extensive nature, which encompasses a significant area of the body. This intricate design extends from the mid-back down to below the knees and encircles the torso, creating a visual effect that early European explorers likened to

woven silk [6]. People from the diaspora often receive the *pe'a* in less than two weeks because of their shorter stays on the islands. In contrast, individuals residing in Samoa may experience a longer duration for this process, as the *tufuga* often advises allowing sufficient time for healing between tattooing sessions Individuals undergoing the *pe'a* process are advised to always maintain sobriety, carry an umbrella to protect against sun damage, sleep on a mat, abstain from sexual activity, avoid going out without a companion, and ensure regular bathing while having someone massage the *tatau* to prevent scabbing. During tattooing, the person is in a *fale* with the *tufuga* and multiple *toso* (pullers or stretchers) holding the skin, wiping down the ink and blood, and fanning the flies and mosquitos away. Families also gather around in the *fale* to support and fan the person receiving *tatau*. Daily sessions last 4-6 hours, and the *pe'a* is usually completed with the *puke* (belly button tattoo) after 30-35 hours. The *malu* has similar guidelines but consists of multiple patterns on the thighs rather than the solid blackwork of the *pe'a* that takes so much time. A *malu* is often completed in one sitting, though a local Samoan might choose to do it over two days.

Samoa adopted hygiene standards for traditional handtap tattooing in 2017 [Samoa Ministry of 7]. The Samoan *tufuga* make their traditional tools with synthetic materials that can be autoclaved, and needles are now disposable stainless-steel combs specially made for the Sulu'ape. Similarly, their traditional ink is no longer made by hand but is now specially manufactured by a tattoo ink company. All materials used in the *tatau* process including pillows and pads are wrapped in disposable plastic between each session. Nevertheless, there remains risk of infection throughout the process, including from flies and mosquitos.

Saliva samples were collected from participants undergoing *pe'a* and *malu* in Samoa via Sulu'ape Tatau in Apia, Samoa. This study investigates the physiological responses to *tatau* by exploring cortisol, secretory immunoglobulin A (sIgA), and C-reactive protein (CRP).

Methods

Previous studies have explored the physiology of electric tattooing [8-13], but only one other study has yet explored the physiological response to hand-tapped *tatau* [14]. Samoan *tatau* are standardized in style and present a rare opportunity to explore this intensive traditional body modification practice.

Participants

Saliva samples were collected from 5 men receiving *pe'a* and 10 women (ages 18-50, mean ± SD = 30 ± 9.5) receiving *malu*. Samples were collected immediately prior to daily sessions and again an hour into each session. The field season lasted six weeks; however, we were unable to obtain samples from any *pe'a* throughout its entire duration of administration. In contrast, multiple daily samples were successfully gathered from 4 male individuals. Participants provided saliva via passive drool into 1mL cryovials, with collection times recorded to determine salivary flow rates and to account for tattooing duration.

Procedures

A questionnaire assessing prior tattoo experience was administered. Height was measured with a stadiometer, weight was recorded using a medical scale, and body mass index (BMI) was calculated. Bioelectrical impedance analysis for fat mass estimation was unavailable.

Participants provided a saliva sample before laying down to begin their *tatau* session. One hour later, the *tufuga* paused to allow for a second saliva collection. The saliva collection process, excluding the questionnaire, was conducted daily throughout each *pe'a* session until the conclusion of the field season or the *tatau*. Some participants were already engaged in this process upon our arrival, while others commenced during data collection but did not complete it before the end of the season. Samples were stored in a -20ºC commercial refrigerator and transported on frozen cold

packs in carry-on luggage to the University of Alabama. There, samples were packed in dry ice and shipped to the Laboratory for Evolutionary Medicine and One Health at Baylor University for biomarker analyses. Samples were stored in -80Cº freezers until assayed.

Materials

The questionnaire gathered fundamental demographic data, including gender, age, education level, marital status, and social status (1 = low status, 10 = high status) [15]. It also assessed perceived stress [16] and pain levels during the tattooing process period prior tattoo experience was quantified in terms of total hours spent and the percentage of body surface area that was tattooed. To evaluate the extent and duration of participants' tattoos, a structured body grid system was utilized, enabling individuals to accurately denote the locations of their existing tattoos. Following this marking process, we documented the duration (in hours and minutes) dedicated to each tattoo, the commutative time invested across all tattoos, and the overall percentage of body surface area covered by tattoos [9].

Saliva samples were assayed for cortisol, sIgA, and CRP. Cortisol is generally viewed as a stress hormone, corresponding with changes in physical and mental health [17]. sIgA is a frontline antibody of mucosal defense, lining the gastrointestinal and respiratory tract, and can be a useful biomarker of immune function [18]. CRP is general marker of inflammation and can be used to assess baseline health [19].

Biomarker analysis

Saliva samples were thawed and centrifuged for 15 minutes at 1500 g at room temperature. Commercially available assay kits from Salimetrics, LLC (State College, PA) were used to measure levels of cortisol, sIgA, and CRP (catalog numbers #3002, #1602, #2102, respectively). Sensitivities of kits were < 0.007 µg/dL, 2.5 µg/mL, and 9.72 pg/mL, respectively. Correlation

coefficients for each standard curve were better than 0.999. Inter-assay coefficients of variation (CVs) were 8.23%, 10.04%, and 3.96%, and intra-assay CVs were 5.64%, 8.19%, and 0.97%, respectively.

Statistical analysis

Descriptive statistics were produced for all study variables, and biomarker changes from pre-*tatau* to 1 hour later were compared using Wilcoxon signed ranks test due to non-normal distribution and small sample size. Scatter plots with interpolation lines were used to visualize data. Analysis was conducted using SPSS Version 27 (IBM Corp., Armonk, NY) and statistics considered significant if $p < .05$.

Results

Table 1 reports data on perceived stress, BMI, self-reported social status, and previous tattoo experience. Previous tattoo experience included age at first tattoo, number of tattoos, total hours being tattooed, and percentage of body tattooed.

Table 1. Demographic and previous tattoo experience statistics.

	Mean	SD	Min-Max
Perceived stress (n = 12)	7.92	3.29	4-13
BMI (kg/m^2, n = 13)	34.08	5.85	26.53-46.72
Social status (n = 12)	6.08	1.26	4-8
Age at first tattoo (n = 14)	21.07	9.23	11-40
Number of tattoos (n = 12)	2.77	2.39	0-8
Total hours tattooed (n = 12)	5.49.92	5.92	0-19.50
Percent body tattooed (n = 11)	.02	.02	0-.07

Table 2 outlines biomarker results with means and Wilcoxon signed ranks test comparisons. sIgA on day 1 ($p = .001$) showed significant change between pre-tattoo and after one hour of tattooing. The comparison of pre-tattoo measurements on Day 1 with those taken one hour into tattooing on Day 5 for all three biomarkers revealed no significant differences.

Table 2. Biomarker means and paired-samples Wilcoxon signed ranks test comparisons of measures pre-tattoo session and 1 hour into each session.

	Day 1		**Day 2**		**Day 3**		**Day 4**		**Day 5**	
	n = 10-15		n = 4		n = 4		n = 4		n = 4	
	Pre	1 Hr	Pre	1 Hr	Pre	1 Hr	Pre	1 Hr	Pre	1 Hr
Cort	.3678	.5823	.2743	.9132	.5678	.9730	.5440	.6255	.3540	.4310
sIgA	310.13	553.98[a]	189.23	326.80	213.15	427.79	225.77	294.56	274.42	411.75
CRP	511.98	614.74	1566.13	2019.61	1123.82	912.67	2577.36	1739.42	2657.75	3256.37
	Day 6		**Day 7**		**Day 8**		**Day 9**		**Day 10**	
	n = 1-2		n = 0-3		n = 1-3		n = 1-3		n = 0-2	
	Pre	1 Hr	Pre	1 Hr	Pre	1 Hr	Pre	1 Hr	Pre	1 Hr
Cort	.4160	.7115	.3883	.6233	.2905	.6300	.5667	.4467	.7085	.5060
sIgA	313.45	438.38	314.81	609.53	184.80	525.32	120.51	443.06	342.78	60.21
CRP	1675.82[b]	728.43 [b]	[b]	[b]	801.37 [b]	2392.43 [b]	1154.3 [b]	523.93 [b]	[b]	[b]

Note: Sample sizes varied for biomarkers so are represented by the range. Volumes of saliva remaining for BKA analysis was minimal, so sample sizes of BKA are much smaller than other biomarkers.

[a] $p < .05$

[b] $n \leq 1$

Fig. 3 illustrates biomarker changes on days 1-5. Days 6-10 had too few data points to graph.

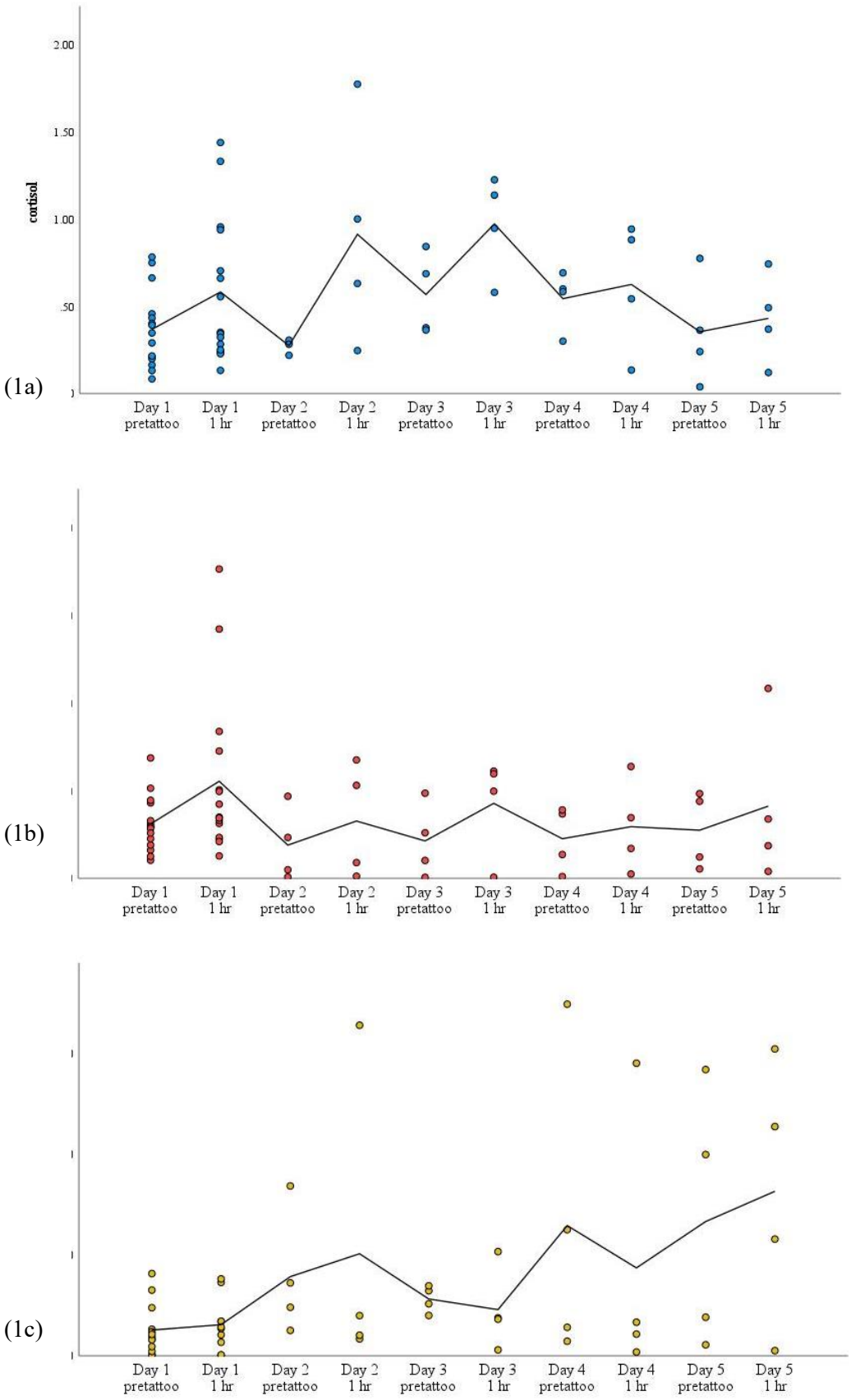

Fig. 1. Scatter plots of (1a) cortisol, (1b) secretory immunoglobulin A (sIgA), and (1c) C-reactive protein.

Discussion

This study aimed to characterize the physiological responses associated with traditional hand-tap *tatau*. Data were collected to assess changes in biomarkers from pre-tattoo measurements to one-hour into the tattooing process. The analysis revealed minimal significant alterations in these biomarkers, both during the procedure and over a 5-day observation period. These results are unexpected, given anecdotal accounts suggesting that hand-tapped *tatau* is perceived as more painful than electric tattooing. Conversations with individuals who have experienced both methods indicate a consensus on the greater discomfort associated with hand tapping, which involves repetitive striking of the ‘*au* (the tattooing instrument equipped with a comb). One participant in this study with no previous tattoo experience had purple bruising surrounded his entire tattoo at one point (**Fig. 2**). Another reported the daily pain as off the scale and was clearly nervous on each day. It is noteworthy that, despite the limited sample size, the potential outliers exerted minimal influence. Conversely, *tatau* holds significant importance for all participants, who traveled internationally and had mentally prepared for this experience for several months or longer.

Fig. 2. Bruising from administration of handtap tattooing.

These findings align with those of Landgraf et al. [14] from the same field season, where significant changes were noted post-awakening. In the present study, cortisol and CRP levels exhibited notable increases from baseline to one-hour post tattooing in certain participants; however, these changes did not yield statistically significant differences when analyzed collectively. In the case study, the greatest changes appear to have occurred after waking [14]. In the current study, there was clearly elevations from pretattoo to 1 hour later in cortisol and CRP for some participants, but when examined collectively, these did not result in significant differences. These findings are also similar to those from a study of electric and handtap tattooing in Puyallup, WA [11]. Changes from pre-tattoo to one hour into the tattoo experience were not

statistically significant, except when considering prior tattoo experience, which was excluded as a variable in this study due to the limited sample size.

The influence of mental preparation and positive cultural perceptions on the experience of *tatau* may play a significant role in the observed calmness and reduce physiological responses in some individuals during the procedure. The individual's mental state and their assessment of the situation as either stressful or non-stressful appeared to be critical determinants of their physiological reactions to *tatau.* Perhaps since tattooing is so highly valued, the pain and stress commonly associated with tattooing do not contribute to allostatic load [20]. Although Samoa is a dominantly Christian country, Samoan *tufuga* and clients receiving *pe'a* and *malu* describe the *tatau* process as spiritual in the pre-Christian manner. They describe it as connecting them to their heritage and ancestors, as well as bonding them more strongly to their families, Samoan villages, and the elders who support the experience. Men with complete *pe'a* are called *sogamiti* and ascend into a new status in Samoan culture [1]. The *malu* is more complicated, as it has become more commercialized than the *pe'a* [21]. The psychocultural importance of these tattoos make it difficult to assess the impact of the *'au* and *sausau* (the *tatau* tools) alone. It is possible that the deeply meaningful nature of receiving a tattoo in this culture has positive effects on the overall stress and immune response to the tattoo.

Limitations

This study, while yielding valuable insights, does have several limitations that warrant discussion. One is the small sample size comprising only 5 men and 10 women. Such a limited number of participants raises concerns regarding the statistical power of the findings. A small sample size may lead to an increased margin of error and reduce reliability while attempting to extrapolate results to a broader population. In this case, the sample does not accurately reflect the

demographics or characteristics of the larger population in Samoa. Future studies should include a larger sample and longitudinal analysis. Another limitation stems from the geographical scope of the study; the research was conducted at a single location among mostly Samoan visitors from the diaspora, which inherently restricts its representativeness. Samoa consists of multiple islands, each with its unique cultural nuances and social dynamics. For instance, traditional tattooing is practiced differently in the villages than at the Samoan Cultural Center and for locals relative to Samoans from the diaspora. To enhance the robustness and applicability of future studies in this area it is imperative to address these limitations by incorporating a larger sample size that encompasses greater diversity from across different islands in Samoa as well as the diaspora.

Future research exploring the intricate relationship between *tatau* and physiological responses could significantly enhance our understanding of cultural practices and their physiological implications. This study would particularly benefit from a focus on healing time, perceived kinship, and social status within this context of Samoan culture, where familial bonds hold profound significance.

Investigating the healing process associated with *tatau* offers a unique opportunity to analyze how spiritual beliefs intertwine with physiological responses. By comparing the duration and quality of healing in individuals who have undergone tattooing, insights can be gained into the potential connections between spirituality and bodily processes. This approach could reveal how cultural significance influences physical recovery, thereby highlighting the importance of emotional and spiritual well-being and healing. Another intriguing avenue for future studies would be to examine genetic alterations in individuals receiving *tatau*. This line of inquiry could explore whether deep spiritual connections experienced during the tattooing process manifest at a molecular level. To conduct this research effectively, it would be essential to collect blood samples

at various stages: prior to tattooing, during the tattoo application process, and after a complete healing period of approximately 6 to 8 weeks. Such a longitudinal study would provide valuable data on how spiritual experiences may influence genetic expression.

Integrating genetic analysis into this research framework opens new pathways for understanding the interactions among pain perception, spirituality, kinship ties, and stress responses at a genetic level. This multifaceted approach not only broadens our comprehension of individual experiences but also contributes to a more holistic view of health that encompasses both physiological and psychological dimensions.

Conclusion

The healthcare landscape in Samoa presents a range of challenges and limitations that necessitate a deeper understanding of the physiological response is associated with traditional practices such as *tatau*. This cultural art form not only serves as a significant expression of identity and heritage but may also confer biological advantages that enhance resilience amongst various health threats. The findings indicate that while the process of obtaining a tattoo can be associated with considerable pain and may conflict with certain religious beliefs prevalent outside of Samoan culture, it remains an integral and profoundly meaningful aspect of life for many Samoans. The practice of *tatau* embodies more than mere aesthetics; it is interwoven with social, spiritual, and communal values that reinforce individual and collective identity. Therefore, recognizing the multifaceted implications of *tatau* can provide valuable insights into how cultural practices contribute to health outcomes in specific populations, ultimately highlighting the importance of integrating cultural understanding into healthcare strategies.

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Contributions

CDL and MM conceived the study design; CDL collected the data; MM and TN conducted biomarker analyses; CDL and CM composed the manuscript; CDL, MM, TN, and CM contributed to editing and approved the final draft.

Conflict of interest

The authors have no conflicts of interest to report.

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