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Impact of Ramadan fasting on metabolic profile, biochemical and hematological parameters in healthy adults among the Muslim community in Ogbomoso, Nigeria

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Abstract

Background and Objective: Research on the subject of religious fasting has seen a marked increase over the last two decades, with a particular emphasis on the Ramadan fast. The present study examined its impact on metabolic, hematological, and biochemical parameters in healthy adult Muslims in Ogbomoso, Nigeria, despite conflicting global findings and scant West African data.

Materials and Methods: Fifty healthy adult volunteers, aged between 25 and 56 years, and with no evidence of chronic illness, diabetes mellitus, or hypertension, were enrolled in the study. The participants were non-smokers, non-obese, and observed the fast during the month of Ramadan, from sunrise to sunset for a period of 29 days. A semi-quantitative food questionnaire was utilized to document the dietary patterns of the subjects on days 0 and 29. Blood samples were collected prior to and during the fast at various intervals, and anthropometric measurements were recorded. Comprehensive arrays of hematological and biochemical parameters were meticulously analyzed from the collected blood samples.

Results and Conclusion: The results demonstrated a substantial decrease in weight, waist-height ratio, body fat percentage, and plasma glucose levels during the practice of Ramadan fasting. A decline in cholesterol and low-density lipoprotein cholesterol, accompanied by an increase in high-density lipoprotein cholesterol levels was also observed. Furthermore, significant alterations in hematocrit, hemoglobin, and white blood cells were observed during the fasting period. However, no significant changes ($p > 0.05$) were observed in the levels of albumin, total protein, aspartate amino transferase, and alanine amino transferase.

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The anthropometric and metabolic characteristics of healthy adults residing in Ogbomoso, Nigeria, are significantly influenced by the Ramadan fast. The results obtained are consistent with those of earlier research, which described hematological alterations, and point to possible advantages for the management of diabetes and cardiovascular disease. This study underscores the necessity for further research on the health implications of Ramadan fasting and provides valuable insights.

Keywords: Ramadan fasting; Metabolic parameters; Anthropometric changes; Hematological parameters

1. Introduction

Ramadan fasting constitutes a religious obligation and an act of worship that is recognized as the fourth pillar of Islam. It is practiced annually by Muslims worldwide [1,2]. Ramadan fasting is observed during the ninth month of the lunar calendar, and this month is regarded as a sacred period [3]. During this month, healthy adult Muslims of both genders abstain from eating, drinking, smoking, and taking oral drugs from sunrise (Suhoor) until sunset (Iftar). The duration of this fast typically exceeds 12 hours, depending on the season and geographical location [4,5]. The day breakfast is usually consumed with dates and fruits after sunset, and the principal meal is consumed prior to fasting before the prayer time [6]. The timing of meals and the overall nutritional pattern during Ramadan deviates considerably from typical dietary habits [7].

From a biomedical perspective, fasting during Ramadan can be categorized as an intermittent fasting regime, a regimen that has gained popularity over the last few decades as a non-pharmacological intervention for weight management and improvement of metabolic health [8]. Intermittent fasting encompasses a variety of approaches, including time-restricted eating, alternate-day fasting, twice-a-week fasting, and 24-hour fasting [9]. Ramadan fasting constitutes a form of time-restricted feeding, whereby individuals abstain from food, fluid, and smoking for periods ranging from 12 to 22 hours, depending on season and geographical location [10-12]. Therefore, the lunar month of Ramadan, which varies between 29 and 30 days, provides a distinctive and substantial natural model for the examination of the physiological, nutritional, and health consequences of intermittent fasting [8].

Ramadan fasting has been shown to induce a range of metabolic effects, resulting from alterations in the lifestyle of the individual [6,7]. These alterations are characterized by the practice of fasting for a period of one lunar month. It has been documented that Ramadan fasting is linked to a substantial decline in body mass, low-density lipoprotein (LDL), and total cholesterol (TC). Conversely, there was an increase in high-density lipoprotein (HDL) during Ramadan [13]. The findings of one study conducted on the effects of Ramadan fasting on both healthy and obese individuals have demonstrated its beneficial role in improving both anthropometric and metabolic profiles [14]. Other studies have examined the impact of physical exercise and Ramadan fasting on individuals' hematological and biochemical responses throughout the sacred month [15-17]. As indicated, the healthy individuals who engage in fasting during Ramadan do not experience any adverse consequences [18,19]. Nonetheless, there are insufficient and contradictory results about the metabolic effects of Ramadan fasting in the individuals. Therefore, the present study examines the effect of Ramadan fasting on metabolic profiles and specific hematological and biochemical indicators in both male and female healthy subjects in Ogbomoso, Nigeria.

2. Materials and Methods

2.1. Study design and subjects

This study was conducted in the month of Ramadan among the Muslim community of Ladoke Akintola University of Technology Teaching Hospital (LTH), Ogbomoso, Nigeria. It comprised fifty healthy adult volunteers who did not have a history of diabetes mellitus, hypertension, or any other chronic illness. All

volunteers were non-smokers, non-obese, and observed fasting during Ramadan. Volunteers were between the ages of 25 and 56, had similar dietary patterns and levels of physical activity, and fasted every day from sunrise to sunset for 29 days. The subjects gave their informed consent, and dietary patterns were evaluated using a semi-quantitative food questionnaire given on day 0 and day 29 of the study.

2.2. Ethical consideration

The Institutional Ethical Review Committee (Protocol number LTH/EC/2022/03/112) provided ethical approval for this study. In accordance with the Helsinki Declaration on research bioethics, written consent was obtained from the participants, who were also given the option to exclude themselves from participating in the study.

2.3. Collecting the blood samples

Blood samples were collected 2 to 5 days before the commencement of Ramadan, and also on days 10, 20, and 29 of fasting. Pre-Ramadan blood samples were collected in the morning following an overnight fast of a minimum of 12 hours (i.e. no food or drink from the previous night), whereas the post-Ramadan samples were collected before sunset. All the samples were analyzed in a single batch to avoid day-to-day laboratory variation, and anthropometric measures were recorded concurrently. On day 29, anthropometric measurements and eating habits were recorded again. Blood was collected into lithium heparin tubes (for plasma), fluoride oxalate tubes (for glucose), plain tubes (for serum), and EDTA tubes (for hematology). Serum was obtained by low-speed centrifugation at 3000 rpm for 5 min, the samples were separated immediately, and stored at -20 ºC until analysis.

2.4. Anthropometric measurements

The subjects' weight (in kilograms), height (in centimeters), waist circumference (in centimeters), and hip circumference (in centimeters) were recorded. Then, the body mass index (BMI) was calculated by dividing the patient's weight in kilograms by their height in square meters. Furthermore, the waist-to-hip ratio, percentage of body fat, and waist-to-height ratio were calculated as indices of abdominal adiposity.

2.5. Hematological and biochemical parameters

In order to determine the hematological parameters including lymphocyte, hemoglobin, white blood cells, hematocrit, and platelets, fresh EDTA blood was analyzed using a Sysmex Hematology Auto-analyzer. The serum lipid profile, encompassing total cholesterol, triglycerides (TG), HDL, and LDL was measured by means of an enzymatic colorimetric method, utilizing commercially available kits provided by Randox Laboratories Ltd. UK. The serum LDL was calculated by Friedwalds formula [LDL (mmol/L) = TC- (HDL+TG/2.2)]. The biochemical parameters of fasting blood glucose, sodium, potassium, chloride, urea, creatinine, bicarbonate, serum albumin, serum globulin, total serum protein, serum aspartate amino transferase (AST), and serum alanine amino transferase (ALT) were measured by an enzymatic colorimetric method using commercially provided kits by Randox Laboratories Ltd UK.

2.6. Statistical analysis

Statistical analysis was performed using the SPSS data analysis system version 20. The demographic and biochemical data is expressed as mean ±standard deviation (SD). The analysis of variance (ANOVA) was used to compare the means. P-values lower than 0.05 were considered as significant difference.

3. Results and Discussion

3.1. Anthropometric changes during Ramadan

Table 1 presents the changes in participants' anthropometric indices before and during the Ramadan fast. Body weight was significantly lower on days 10 and 29 compared to pre-Ramadan baseline measurements. Conversely, BMI exhibited only a marginal, transient increase

on days 10 and 20 before returning to baseline by day 29. This temporary fluctuation in BMI—despite concurrent weight loss—potentially reflects measurement variability, highlighting why waist-to-height ratio (WHtR) and body fat percentage are generally considered more sensitive indicators of body composition. While the waist-to-hip ratio (WHR) remained constant at 0.9 across all time points, WHtR increased significantly from baseline through days 10, 20, and 29. Additionally, PBF showed marginal increases on days 10 and 20, followed by a decline by day 29 relative to pre-Ramadan values.

Table 1- Anthropometric measures in healthy adults (n=50) during Ramadan fasting

Index	Before Ramadan	Day 10 of fasting	Day 20 of fasting	Day 29 of fasting
Weight (Kg)	68.8 ±1.3	68.1 ±1.35	68.9 ±1.3	67.1 ±1.25
BMI (Kg/m^2)	24.3 ±0.6	25.0 ±0.6	25.0 ±0.6	24.3 ±0.6
WHR	0.9 ±0.01	0.9 ±0.01	0.9 ±0.01	0.9 ±0.1
WHtR	46.3 ±2.2	49.7 ±1.5	52.7 ±1.1	52.7 ±1.1
BF (%)	26.9 ±1.4	27.1 ±1.2	27.6 ±1.3	26.7 ±1.3

*Kg=Kilogram; BMI=Body mass index, Kg/m^2=Kilogram per square meter; WHR= Waist to hip ratio; WHtR=Waist to height ratio; BF=Body fat

3.2. Changes in metabolic profile during Ramadan fasting

Participants' metabolic profiles exhibited significant alterations throughout the Ramadan fast (Table 2). Fasting blood glucose was within normal physiological limits pre-Ramadan and decreased progressively on days 10, 20, and 29 relative to baseline. Total cholesterol dropped significantly by day 10 followed by increasing until the end, while downward trend relative to the baseline was maintained through days 20 and 29. Similarly, fasting TG level showed a decline on day 10, and returned back to baseline further. Conversely, HDL increased markedly by day 20, while LDL demonstrated a steady, concurrent decline.

Table 2- Changes in metabolic profile in healthy adults (n=50) during Ramadan fasting

Index (mmol/l)	Before Ramadan	Day 10 of fasting	Day 20 of fasting	Day 29 of fasting
FBS	4.9 ±0.07	4.7 ±0.07	4.5 ±0.07	4.5 ±0.05
CHOL	3.7 ±1.1	3.2 ±0.07	3.4 ±0.07	3.4 ±0.07
TG	0.9 ±0.1	0.8 ±0.03	0.9 ±0.05	0.9 ±0.05
HDL	1.3 ±0.17	1.4 ±0.1	1.7 ±0.1	1.7 ±0.1
LDL	2.0 ±0.1	1.3 ±0.1	1.2 ±0.1	1.2 ±0.1

*FBS= Fasting blood sugar; CHOL= Cholesterol; TG= Triglyceride; HDL= High-density lipoprotein; LDL= Low-density lipoprotein; mmol/L= Milimol per liter

3.3. Hematological changes during Ramadan fasting

During the Ramadan fast, participants' hematological markers exhibited significant changes (Table 3). Before Ramadan, the total white blood cell (WBC) was counted. On day 10, it dropped, then increased somewhat on day 20, and then dropped once more to on day 29. After initially declining from a baseline on day 10, the lymphocyte percentage returned to near pre-Ramadan levels on day 20 and then increased significantly by day 29. Hemoglobin (HGB) concentration remained stable on day 10, exhibited a minor, non-significant decline on day 20, and decreased significantly by day 29 relative to baseline. Conversely, hematocrit (HCT) rose significantly on day 10 before progressively declining on days 20 and 29. Platelet counts (PLT) dropped significantly by day 10, rebounded by day 20, and subsequently stabilized by day 29.

Table 3- Hematological changes in healthy adults (n=50) during Ramadan fasting

Index	Before Ramadan	Day 10 of fasting	Day 20 of fasting	Day 29 of fasting
WBC (10^9/L)	6.1 ±1.3	4.9 ±0.18	5.7 ±0.92	4.9 ±0.17
Lymph (%)	43.4 ±1.17	40.5 ±0.91	45.2 ±1.03	48.3 ±0.91
HGB (g/dL)	12.5 ±0.18	12.5 ±0.20	12.1 ±0.2	12.01 ±0.13
HCT (%)	37.0 ±0.51	42.5 ±0.68	36.1 ±0.43	35.6 ±0.36
PLT (10^9/L)	226.2 ±8.07	206.1 ±7.53	220.9 ±6.68	226.1 ±6.82

*WBC= White blood cell; Lymph= Lymphocyte; HGB= Hemoglobin; HCT= Hematocrit; PLT=Platelet

3.4. Electrolyte and renal function changes during Ramadan fasting

During the Ramadan fast, electrolyte levels showed no statistically significant changes (Table 4). The concentrations of serum sodium (Na^+) on day 29 were with no significant change prior to Ramadan. Similarly, at all-time points, potassium (K^+) levels stayed constant. The levels of bicarbonate (HCO_2^-) and chloride (Cl^-) were stable, with no significant changes from the baseline. Renal function indicators, however, showed significant alterations. Before Ramadan, blood urea levels were normal but slightly rose on day 10. However, on days 20 and 29, they decreased; these changes were not statistically significant. Prior to Ramadan to day 10 and then to days 20 and 29, serum creatinine levels demonstrated steady increase.

Table 4- Electrolyte and renal function changes in healthy adults (n=50) during Ramadan fasting

Index (mmol/l)	Before Ramadan	Day 10 of fasting	Day 20 of fasting	Day 29 of fasting
Na^+	137.7 ± 0.5	137.68 ± 0.46	137 ± 0.46	137 ± 0.7
K^+	3.5 ± 0.5	3.5 ± 0.5	3.5 ± 0.5	3.5 ± 0.5
Cl^-	98.4 ± 0.5	98.4 ± 0.5	98.4 ± 0.5	98.4 ± 0.5
HCO_2	25.0±0.4	25.0±0.4	25.0±0.4	25.0±0.4
Urea	3.5 ± 0.2	4.7 ± 0.2	3.9 ± 0.2	3.9 ± 0.2
Creatinine	76.3 ± 1.7	77.9 ± 1.5*	78.7 ± 1.5*	78.7 ± 1.5*

* Na^+= Sodium; K^+= Potassium; Cl^-= Chloride; HCO_2= Bicarbonate; *= Statistically significant

3.5. Effects of Ramadan fasting on serum proteins and liver enzymes

Serum proteins and liver function metrics exhibited divergent responses to the Ramadan fast (Table 5). On day 10 of Ramadan, total protein levels dropped significantly and remained consistently lower on days 20 and 29 relative to pre-Ramadan baseline concentrations. While serum albumin levels demonstrated no appreciable changes throughout the fasting period, serum globulin concentrations decreased significantly from baseline on day 10 and remained suppressed through days 20 and 29, mathematically driving the reduction observed in total protein. Throughout the fasting period, serum activities of the liver enzymes ALT and AST exhibited minor baseline fluctuations but showed no statistically significant differences at any time point compared to pre-Ramadan values (Table 5).

Table 5- Serum protein and liver enzymes in healthy adults (n=50) during Ramadan fasting

Index	Before Ramadan	Day 10 of fasting	Day 20 of fasting	Day 29 of fasting
Total protein (g/L)	73.4 ±0.82	72.1 ±0.75*	72.2 ±0.75*	72.3 ±0.73*
Albumin (g/L)	42.4 ±0.75	42.4 ±0.74	42.4 ±0.71	42.8 ±0.75
Globulin (g/L)	31.4 ±0.8	30.0 ±0.73*	30.2 ±0.71*	30.1 ±0.72*
AST (IU/L)	16.2 ±0.63	16.0 ±0.60	16.2 ±0.62	16.1 ±0.61
ALT (IU/L)	9.2 ±0.51	9.0 ±0.50	9.1 ±0.52	9.2 ±0.50

*AST= Aspartate amino transferase; ALT= Alanine amino transferase; *= Statistically significant

Fasting is increasingly recognized as a potent non-pharmacological intervention for metabolic optimization, with accumulating evidence supporting its role in promoting longevity and preventing chronic diseases. Ramadan fasting, practiced annually by hundreds of millions of

Muslims worldwide, serves as a unique epidemiological model for intermittent fasting. However, the health-related outcomes of Ramadan fasting exhibit substantial heterogeneity due to various confounding variables. These factors include pronounced geographic variations in daily fasting duration—typically exceeding 12 hours and extending up to 20 hours in high-latitude regions (e.g., Scandinavia) during summer months—alongside lifestyle and clinical determinants such as smoking status, medication adherence, dietary composition, and cultural eating patterns, all of which distinctively modulate metabolic responses [20].

The findings of this study demonstrate that body weight decreased significantly on days 10 and 29 of the Ramadan fast compared to pre-Ramadan baseline values. This observation aligns with previous literature, including the work of Turkestani et al. [21], who reported a substantial reduction in body weight among healthy adults during Ramadan. This weight loss is primarily attributable to a net reduction in total daily caloric intake due to the restricted eating window, alongside altered dietary habits and potential compensatory elevations in non-exercise activity thermogenesis.

Notably, WHR remained unaffected throughout the fasting period. This finding contrasts with the study by Abdulrahman et al. [22], which reported a significant reduction in WHR among healthy adult women during the Ramadan fast. The stability of the WHR in the present study suggests it may be less sensitive to short-term changes in body mass compared to metrics such as WHtR and percentage body fat. This lack of sensitivity is underscored by the significant increases observed in WHtR on days 10, 20, and 29 of Ramadan relative to baseline values. These findings align with those of Turkoglu et al. [23], who also observed significant shifts in body composition parameters, including WHtR and body fat percentage, among healthy male and female adults.

Concurrently, BMI exhibited a marginal, transient reduction on days 10 and 20 of the Ramadan fast. This minor fluctuation contrasts with the findings of Khafaji et al. [24], who reported sustained BMI declines in healthy men. The minimal variations in BMI observed here—especially when contrasted with the significant shifts in WHtR—suggest that fasting-induced alterations in body composition are more pronounced in peripheral fat distribution and adiposity percentage than in total body mass indices. Ultimately, the anthropometric outcomes of the present study align with accumulating evidence that Ramadan fasting facilitates weight loss and modulates fat patterning, even if certain conventional metrics, such as the WHR, remain uninfluenced.

The metabolic profiles of the participants demonstrated significant improvements during the Ramadan fast. Fasting plasma glucose levels decreased progressively throughout the fasting month. This downward trajectory aligns with the findings of Al-Hamad et al. [25], who reported parallel reductions in plasma glucose concentrations among healthy adults. Mechanistically, this progressive decline is primarily attributable to a net reduction in caloric intake and the subsequent down-regulation of hepatic gluconeogenesis, reflecting enhanced systemic glucose homeostasis.

Evaluation of the lipid profiles revealed highly favorable changes throughout the fasting period. The lipid-lowering trends align with the findings of Turkestani et al. [20], who reported significant reductions in fasting total cholesterol levels during Ramadan. Mechanistically, these collective decreases are primarily attributable to reduced dietary fat and carbohydrate consumption, which down-regulates hepatic lipid synthesis and suppresses lipoprotein secretion into circulation. Conversely, HDL concentrations rose significantly by day 20, aligning with findings by Norouzy et al. [26]. This fasting-induced elevation may reflect enhanced lipid

clearance secondary to dietary restriction and physical activity, which is highly relevant given the athero-protective role of HDL. Collectively, these metabolic adaptations suggest that Ramadan fasting improves cardiometabolic health by suppressing glucose, total cholesterol, LDL, and TG while concurrently elevating HDL. Our hematological findings closely mirror those of Faris et al. [27], who observed an initial decline in hemoglobin and hematocrit followed by a steady rebound in subsequent weeks. This early reduction likely reflects transient hemodilution from compensatory fluid intake during non-fasting hours. Conversely, the subsequent stabilization and recovery signify a physiological adaptation to prolonged intermittent fasting, potentially mediated by erythropoietin-stimulated erythropoiesis [5,14]. WBC count exhibited significant variability, fluctuating at various intervals. These findings partially align with Ozkan et al. [28], who documented elevated WBC counts potentially linked to altered immune function and increased physical activity under fasting conditions. Conversely, lymphocyte values declined during Ramadan, mirroring the results of Ziaee et al. [19], who observed lower lymphocyte counts in fasting adults. This reduction may reflect suppressed immune activity stemming from lower caloric intake. Similarly, platelet counts followed a declining pattern during Ramadan fasting, consistent with the trends reported by Turk et al. [29]. This decline may stem from reduced nutrient intake impacting platelet production. Although a reduction in platelets theoretically predisposes individuals to bleeding risks, the observed decreases remained within the reference range, presenting no clinically significant adverse effects in healthy subjects.

The preserved electrolyte balance during fasting aligned with previous literature that reports minimal disruption to renal electrolyte homeostasis during the Ramadan period [30,31]. Preservation of electrolyte homeostasis is critical, as imbalances can predispose individuals to dehydration, muscle cramps, or cardiac arrhythmias. The observed stability further underscores the safety of Ramadan fasting for healthy populations. Serum creatinine demonstrated a statistically significant, progressive increase across the fasting period, although all values remained within the normal physiological reference range. This trend aligns with reports by Goktas et al. [32] and Sari et al. [33]. The modest elevation in creatinine likely reflects accelerated protein catabolism and gluconeogenesis from amino acids during caloric restriction, rather than pathological muscle wasting. Consequently, this adaptation represents a recognized physiological response to short-term fasting in healthy individuals and does not imply clinically significant muscle loss or renal impairment.

The study found that serum globulin and total protein levels were significantly lower during Ramadan compared to pre-fasting baselines, aligning with previous research [34,35]. These reductions are likely attributable to decreased dietary protein intake during the fasting period. Albumin levels remained stable, suggesting that hepatic protein synthesis was preserved despite reduced dietary intake. Similarly, AST and ALT exhibited no significant fluctuations during Ramadan. This outcome aligns with findings by Bouhlel et al. [36], who reported no significant differences in liver enzyme activity. Conversely, Brini et al. [37] observed elevations in AST and ALT among fasting subjects, attributing these increases to hepatocellular stress during prolonged caloric restriction. Such discrepancies between studies are typically driven by variations in dietary intake, physical activity, baseline liver function, and specific population characteristics, rather than an underlying pathological metabolic mechanism.

This study provides valuable insights into the physiological impacts of Ramadan fasting through a systematic assessment of Anthropometric, metabolic, biochemical, and hemato-

logical parameters within a survey of healthy Muslim adults in Ogbomoso, Nigeria. A primary strength of this work is its prospective design, which utilized repeated measures across multiple time points (pre-Ramadan, and fasting days 10, 20, and 29) to evaluate both immediate and cumulative effects. Furthermore, the inclusion of both sexes enhances the external validity of the findings within this population, while adherence to standardized laboratory protocols ensured the precision and comparability of the biochemical and hematological indices. Importantly, this research expands the limited literature on Ramadan fasting in sub-Saharan Africa, a region where distinct dietary habits, lifestyle factors, and climatic conditions may yield physiological outcomes different from those documented in Middle Eastern or Asian cohorts.

The study's limitations include a small sample size, a lack of sex-stratified data, and reliance on self-reported dietary and physical activity data. Furthermore, results are limited by potential recall bias, site-specific cultural/seasonal factors, and the lack of long-term follow-up to assess the persistence of physiological changes.

4. Conclusion

Ramadan fasting induces positive physiological adaptations by reducing body weight and improving metabolic markers like glycemic control and lipid profiles, potentially protecting against metabolic syndrome. Transient changes in hematological parameters and a slight, non-pathological rise in creatinine indicate safe physiological adaptation rather than renal impairment or pathology, within normal limits. Based on the findings of this study, Ramadan fasting should be encouraged among healthy Muslim adults, as it induces favorable metabolic, biochemical, and hematological adaptations without adverse health effects. However, to maximize these health benefits, individuals should receive dietary counseling to adopt healthy eating practices during non-fasting hours, emphasizing adequate hydration, low-fat options, and a high intake of fruits, vegetables, and lean proteins. Safe fasting practices should be integrated into community health education initiatives in Ogbomoso, particularly targeting individuals at risk for dehydration or nutritional imbalances. Finally, future research involving larger, more diverse cohorts and extended post-Ramadan follow-up is warranted to enhance the generalizability of these findings and determine the long-term persistence of these physiological changes.

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6. Conflict of Interests

The authors declare no competing interest.

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