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ORIGINAL ARTICLE

Ratio of accelerations to decelerations in Women's division I lacrosse

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ABSTRACT

This study analyzed the differences by position in acceleration, deceleration, and the ratio of accelerations to decelerations in drills and quarters of games (Q1-Q4). Data were collected in 23 female collegiate lacrosse athletes (20.8 ± 1.5 years, 168.3 ± 6.1 cm), consisting of ten midfielders, five defenders, and eight attackers. Drills were categorized as: stickwork (SW), small-sided games (SSG), warm-up (WU), active recovery (AR), individual skills (IS), scrimmage, and conditioning. AR (0.31 ± 0.09 accelerations/min) and WU (0.47 ± 0.07 accelerations/min) showed the lowest number of accelerations, and conditioning and SW were the highest (>1.0 accelerations/min). Conditioning showed the highest demand for decelerations (0.37 ± 0.14 decelerations/min) and AR and WU had the fewest (0.10 ± 0.04 decelerations/min). AR, IS, SW, and WU all had higher acceleration/deceleration ratios (4:1 to 5.7:1) than the remaining drill types (p = .000 - .050, 3:1-4:1). Q1 had a higher acceleration demand (0.72 ± 0.52 accelerations/minute) than the remaining three quarters (0.57 - 0.67 accelerations/min). The game demand in decelerations was approximately 0.20 decelerations/minute across all quarters and the acceleration/deceleration ratio was approximately 4:1, with the exception of defenders in Q1 who had 6:1 ratio. There is a large demand for accelerations in field lacrosse with no positional differences, and training should be devoted towards this skill.
Keywords: Performance analysis, Team sport, Change of direction, Speed.

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INTRODUCTION

Lacrosse is a mentally, physically, and emotionally demanding sport that consists of accelerations, decelerations, agility, and high-speed sprints (Rosenberg et al., 2021). There are three primary positions: defence, attack, and midfield. Defensive players are responsible for performing quick bursts of energy to stop an attacking player from going to the goal; attackers utilize deceptive changes in direction to beat their defender to generate offense and try to score; midfielders perform offensive and defensive manoeuvres in addition to transitioning between the offensive and defensive zones of the field. While each position performs different tasks, research has found modest positional differences in traditional measures of external training workload (e.g., total distance moved, high-intensity efforts) (Robinson et al., 2022). Previous literature surrounding women's field lacrosse analysed high-speed running density, the ratio of high-speed efforts and distance covered, and found low inverse correlations with accelerations and decelerations to high-speed running density (Hamlet et al., 2021). The data indicated that defenders had several high-speed efforts, with less high-speed distance compared to the other positions and the authors concluded this was likely due to the reactionary nature of the position. Robinson et al. found that each drill type produces a different high-intensity distance covered with conditioning (508 ± 329 m) producing the highest among the different types of training (e.g., stickwork, small-sided, games, scrimmages) (Robinson et al., 2022). In comparison to training, conference game play produces a larger high-intensity distance covered (10.85 ± 2.9 m/min of play time, PT) and high-intensity sprints (0.12 ± 0.5 num/min PT) than non-conference game play (7.82 ± 2.8 m/min PT; 0.09 ± 0.6 num/min PT) (Thornton et al., 2021). The importance of high-intensity efforts in both training, especially in relation to drill type, and game competition cannot be understated in women's field lacrosse. Accelerations and decelerations are two critical elements of high-intensity movements.

Accelerations and decelerations represent important variables for assessing external load in field lacrosse (Bunn et al., 2021, 2022); monitoring the frequency at which an athlete initiates and terminates high-intensity efforts is important because of the mechanical load placed on the muscles and joints used in these motions because these variables are associated with greater injury risk. Poor deceleration has been associated with non-contact anterior cruciate ligament (ACL) injuries, a common injury in the sport of women's field lacrosse, due to the high eccentric force applied to the muscle and connective tissue (Wolfe et al., 2023). Poor deceleration can be attributed to several factors: fatigue, previous injury, or playing style. Typically, small-sided games tend to put the most deceleration load on the muscles due to the limited space they are played in paired with a greater number of stop and start (Robinson et al., 2022). Similarly, Devine et al. (2020)stated that injuries in women's field lacrosse may also be caused by the demands of the game. It was found that players performed an average of 51 ± 34 high-intensity accelerations (≥ 3 m·s^{-2}) and 38 ± 25 high-intensity decelerations (≥ -3 m·s^{-2}) per game with defenders exhibiting lower decelerations than attackers and midfielders. It is not often that an ACL injury is recorded in defenders suggesting that their low number of decelerations experienced in games may play a role. Therefore, a greater comprehension of quantification of accelerations and decelerations can potentially help ~~to~~ decrease injury risk in athletes.

Recent literature has evaluated the ratio of accelerations to decelerations during game play to assess the balance of starting to stop and evaluate if the ratio is a key factor in relation to injuries. A study performed on elite male basketball players (age ranging from 19-36 years of age) concluded that point guards (1:3.94 ± 1.3), shooting guards (1:4.87 ± 1.8), and small forwards (1:4.26 ± 0.8) had higher acceleration/deceleration ratio (>3 m·s^{-2}) compared to power forwards (1:2.67 ± 0.4) and centres (1:2.57 ± 0.5) (Vázquez-Guerrero et al., 2018). These data indicate that in men's basketball, the number of decelerations is much greater than accelerations at >3 m·s^{-2}. These findings correlate to the actions performed by these players as maximal decelerations were necessary for high intensity offensive movements such as change of direction as well as defensive reactions to the opposing team. A similar study performed on female U18 basketball players focused on acceleration and deceleration during matches by position and quarter (Reina et al., 2019). The number of accelerations and decelerations (<1 m·s^{-2}) implemented decreased from the first and third quarter to the second and fourth quarter. These findings illustrate the importance of acquiring a deeper understanding of the impact that accelerations and decelerations have on high-intensity efforts within team sports. Like basketball, which shares many similarities with field lacrosse, a winning outcome in field lacrosse is often determined by a team's ability to win the greatest number of high-intensity encounters.

To date, literature investigating women's field lacrosse has focused on general counts of acceleration and deceleration within games (Calder et al., 2021; Devine et al., 2020; Killian et al., 2022; A. Thornton et al., 2021; A. R. Thornton et al., 2023). and training (Robinson et al., 2022). However, the concept of assessing the ratio of accelerations to decelerations has not been applied to this sport. The aim of this study was to analyse differences by position in accelerations, decelerations, and the ratio of accelerations to decelerations in categorized practice drills and by quarter of games. It was hypothesized that defenders would have the lowest acceleration/deceleration ratio followed by attackers and midfielders in games and midfielders would have the highest acceleration/deceleration ratio in practice drills.

MATERIALS AND METHODS

Study design and participants

This observational study included 71 training sessions and 19 games during the 2023 competitive season. The participants included 23 members from a Division I women's lacrosse team (20.8 ± 1.5 years, 168.3 ± 6.1 cm) consisting of ten midfielders, five defenders, and eight attackers. Participants were excluded if they were not eligible for play as determined by a healthcare professional, were determined ineligible by the National College Athletic Association (NCAA) or were removed from the team. This study was approved by the institutional review board and participants completed an informed consent prior to study participation.

Data collection

Data were collected using VX Sport Microtechnology (Wellington, New Zealand) devices. Units were numbered and assigned to a player for the year where they wore the same unit every practice, game, and conditioning session. Units were turned on and established satellite connection prior to each session and distributed accordingly. Following practice, games, and conditioning sessions, the data were uploaded into the VX Sport Training Software and trimmed and split based on drill types and game quarters to remove inactivity, drill changes, timeouts, and water breaks. Acceleration and deceleration were used as metrics during data collection and were determined by a change in acceleration more than ± 3 m·s^{-2}.

Drills were categorized into seven types: stickwork (SW), small-sided games (SSG), warm up (WU), active recovery (AR), individual skills (IS), scrimmage, and conditioning. SW focused on refining mechanics vital to the sport of women's lacrosse such as passing, catching, ground balls, and cradling. SSG involved drills with five or less players including even play, man down or man up. WU was performed to create blood flow through the body and reduce the risk of injury. AR was a low-intensity exercise done at the conclusion of practice to assist in athlete recovery. IS prioritized skills that may not be used by every position such as shooting, draw controls, defensive footwork, and dodging. Scrimmages served to mimic live gameplay incorporating the intensity of full field games. Conditioning consisted of quick bursts of acceleration at the level that was determined for the athlete prior to in season training. All drills (n = 31) were categorized accordingly, and means were calculated for each athlete per minute of play within each category. The drill categories also align with previous literature in field lacrosse (Alphin et al., 2019; Bunn et al., 2021; Robinson et al., 2022).

Statistical analysis

Data for each athlete were averaged for accelerations, decelerations, and acceleration/deceleration per minute of playing time for each drill category and section of a game. All data were analysed using SPSS (IBM, Chicago, IL) and an alpha level of 0.05 was used to determine differences. Data were determined to be normally distributed via a Shapiro-Wilks test of normality. A three (position) by seven (drill type) repeated measures multivariate analysis of variance of variance (RM-MANOVA) was used to determine differences in accelerations and deceleration demands by drill type and position. A second three (position) by four (quarter) RM-MANOVA was used to determine differences in acceleration and deceleration demands by game quarter. If the RM-MANOVAs indicated a main effect difference, univariate tests were evaluated to determine which variable showed the difference. Paired samples t-tests were then used to determine specific drill, or quarter differences. Partial eta-squared effect sizes (η_p) were used to determine the magnitude of the effect and interpreted as small (0.01), moderate (0.06), and large (0.14) (Cohen, 1988).

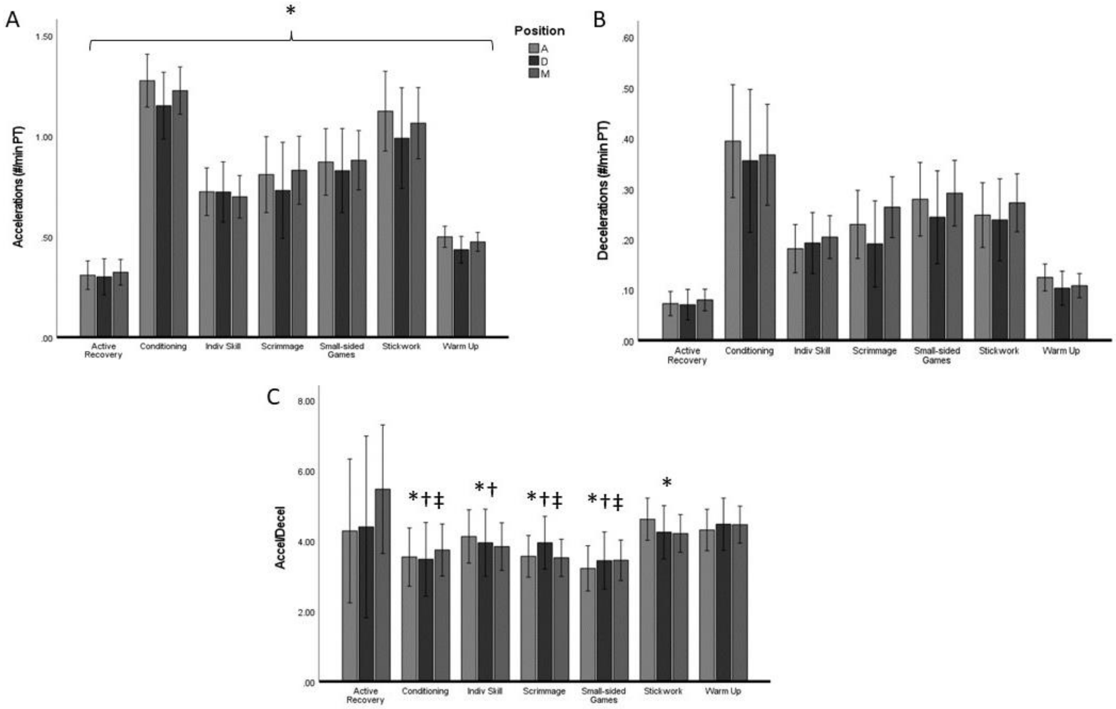
RESULTS

Drill comparisons

The RM-MANOVA indicated a difference in accelerations and deceleration demands by drill type (F(18,334) = 21.735, p < .001, η_p = 0.518 large), but no difference by position (F(6,36) = 0.696, p = .654, η_p = 0.104 moderate) or an interaction between drill type and position F(36, 349) = 0.508, p = .992, η_p = 0.049 moderate). Univariate tests by drill type showed differences across accelerations (F = 104.50, p < .001, η_p = 0.839 large), decelerations (F = 52.96, p < .001, η_p = 0.726 large) and acceleration/deceleration (F = 4.75, p = .020, η_p = 0.192 large). Figure 1 shows the results of the pairwise analyses for accelerations, decelerations, and acceleration/deceleration, respectively. For accelerations (Figure 1A), each drill was different from one another (p = .000 - .017). AR (0.31 ± 0.09 accelerations/min) and WU (0.47 ± 0.07 accelerations/min) showed the lowest number of accelerations and conditioning (1.23 ± 0.18 accelerations/min) and SW (1.07 ± 0.26 accelerations/min) were the highest, with more than 1.0 accelerations per minute of play. For decelerations (Figure 1B), each drill was different from one another (p = .000 - .045), except there was no difference between scrimmage and SW (p = .089). Conditioning showed the highest number for decelerations with 0.37 ± 0.15 decelerations/min and AR (0.08 ± 0.03 decelerations/min) and WU (0.11 ± 0.04 decelerations/min) had the lowest number of decelerations. For acceleration/deceleration (Figure 1C), AR, IS, SW, and WU all had higher ratios than the remaining drill types (p = .000 - .050). These four drills ranged from 4:1 to 5.7:1 accelerations/decelerations, and the remaining three drills were all between 3:1 and 4:1 accelerations/decelerations.

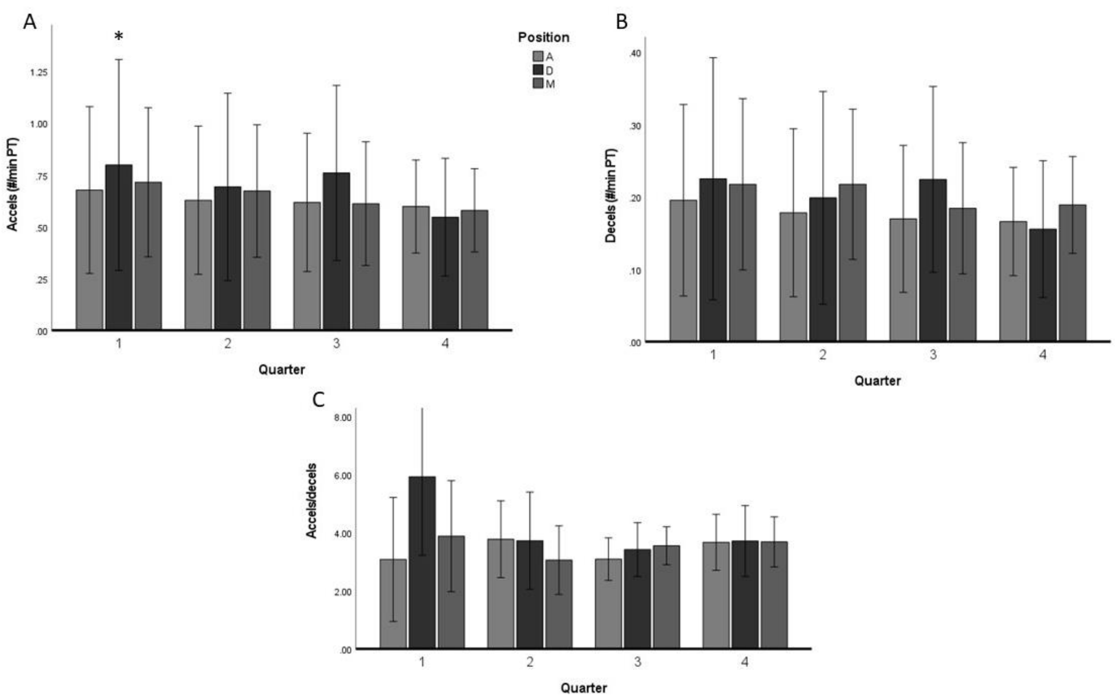
Game comparisons

The 3x4 RM-MANOVA showed a difference in acceleration and deceleration demands by quarter (F(9,141) = 2.310, p = .022, η_p = 0.103 moderate), but not by position (F(6,36) = 0.719, p = .637, η_p = 0.107 moderate) or an interaction between position and quarter (F(18,164) = 0.958, p = .511, η_p = 0.090 moderate). Univariate tests indicated a difference by quarter for accelerations (F = 4.861, p = .022, η_p = 0.196 large), but not for decelerations (F = 3.193, p = .066, η_p = 0.138 large), or acceleration/deceleration (F = 1.543, p = .220, η_p = 0.072 moderate). Figure 2A shows that the first quarter had a higher acceleration demand (0.72 ± 0.52 accelerations/minute) than the remaining three quarters (0.0.57 – 0.67 accelerations/minute, p = .011 - .027). Figures 2B and 2C show that the deceleration demand and acceleration/deceleration were fairly even across all quarters. The game demand in decelerations was approximately 0.20 decelerations/minute for each quarter and the acceleration/deceleration ratio was generally around or below 4:1, except defenders in Q1 who had 6:1 ratio.



*Note. * Indicates different from warm up, p < .05. † Indicates difference from stickwork, p < .05. ‡ Indicates different from active recovery. A: attackers, D: defenders, M: midfielders.*

Figure 1. Means and standard deviations during drills per minute of training for A) accelerations, B) decelerations, and C) acceleration/deceleration.



*Note. * Indicates a difference from second, third, and fourth quarters, p < .05. A: attackers, D: defenders, M: midfielders.*

Figure 2. Means and standard deviations during games per minute of played for A) accelerations, B) decelerations, and C) acceleration/deceleration.

DISCUSSION

This study aimed to evaluate acceleration and deceleration demands of Division I collegiate women's field lacrosse training and games. The results demonstrated differences in acceleration, deceleration, and acceleration/deceleration by drill type and acceleration by game quarters. There was no positional difference for any variable between drill types. Overall, conditioning appeared to have the highest load indicated by its high number of decelerations and accelerations compared to all other drills. Active recovery and warm up then had the lowest acceleration/deceleration ratio among the other drills. Game analysis revealed that the first quarter of play produced more accelerations than the remaining quarters, possibly due to players' excitement at the start of the game.

Drill comparisons

The present study showed that AR and WU had lower accelerations than conditioning, IS, scrimmage, SSG, and SW. Furthermore, conditioning and SW displayed higher acceleration counts than IS, scrimmage, and SSG. This agrees with the previous research as acceleration is an essential component of conditioning drills (Alphin et al., 2019; Bunn et al., 2021). SW drills can vary from stationary to dynamic work that requires a burst of speed to catch the ball as it is passed, thereby creating a high acceleration. In comparison, SSG typically require defenders to perform numerous directional changes, while offensive players accelerate towards the goal. This contributed to SSG yielding the third highest acceleration counts. The results of this study agree with previous work by Robinson et al. that classified the training workload and mechanical demands of various drills performed by collegiate women's lacrosse players (Robinson et al., 2022). Small-sided drills (SSD) showed the lowest acceleration counts followed by SW, SSG, and simulated game play (SGP). Moreover, Bunn et al. found that the number of accelerations performed from highest to lowest was conditioning, team drills, SSG, SW, and IS (Bunn et al., 2021).

AR and WU yielded the lowest number of decelerations compared to all other drills, whereas conditioning yielded the highest number of decelerations. Bunn et al. proposed that the number of decelerations during conditioning could be higher because decelerations (i.e., eccentric muscle load) are intentionally incorporated into drills to promote injury prevention (Bunn et al., 2021). Moreover, it is believed that very few decelerations were observed during AR because work performed during AR is low-intensity and continuous in nature. Further, deceleration is an eccentric load placed on the muscle to slow one down, which is not a desired movement of an active recovery. A scrimmage serves to mimic live game play, minus the presence of substitutions, and often consists of running at a constant speed for most of the scrimmage with some quick bursts or breakdowns interspersed. Thus, scrimmages are somewhat comparable to SW. Robinson et al, (2022) found fewer decelerations ~~in~~ during SW than all other drill type followed by SSD and then SSG. Similarly, Bunn et al. (2021) found that the number of decelerations performed during each training mode decreased in the following order: conditioning, team drills, SSG, SW, and IS.

This is the first study to highlight acceleration/deceleration ratio in collegiate women's lacrosse drills. AR, IS, SW, and WU all had higher ratios than conditioning, SSG, and scrimmaging. These drills likely have a high acceleration/deceleration ratio due to so few decelerations being performed, with the exception of IS. Individual skill drills incorporate very specific movements, such as dodging, shooting, and draw work, which do not require a high number of accelerations or decelerations, resulting in a high ratio. AR had a high ratio because an intention of AR is to reduce the eccentric load on the muscle. AR, IS, SW, and WU had acceleration/deceleration ratios ranging from 4:1 to 5.7:1 and the remaining three drills, SSG, conditioning, and scrimmage, were all between 3:1 and 4:1. Thus, 3-5 accelerations were performed for every 1 deceleration. The high acceleration/deceleration ratio found for AR, IS, SW, and WU is likely due to these four drills having a low deceleration load as they are less dynamic in nature.

Game comparisons

The number of accelerations per quarter was highest in Q1 compared to the other three quarters. This is likely due to the onset of fatigue as the game progresses. A recent analysis evaluating acceleration and deceleration in U-18 Women's basketball players found that the number of accelerations and decelerations decreased from the first quarter and third quarter to the second quarter and fourth quarter (Reina et al., 2019). Regarding player position, Calder et al (2021) found that midfielders and defenders displayed a greater number of accelerations than attackers in both periods of play. However, this study was done when lacrosse games were two 30-minute halves and not four 15-minute quarters.

The current study found no difference in acceleration-to-deceleration ratio throughout the four quarters of a women's collegiate lacrosse game. The acceleration/deceleration ratio recorded across player position was around or below 4:1, with the exception of defenders who had 6:1 ratio in Q1. These results disagree with our hypothesis that defenders would have the lowest acceleration/deceleration ratio. However, the high frequency of accelerations displayed in the current study by defenders agrees with previous literature by Hamlet et al. (2021) who showed that field lacrosse defenders engage in a high volume of accelerations. Acceleration/deceleration ratio data from field lacrosse differs from basketball show there are many more accelerations and decelerations at >3 $m \cdot s^{-2}$ in women's collegiate field lacrosse; basketball athletes perform more decelerations than accelerations (Vázquez-Guerrero et al., 2018). This is likely due to the smaller playing surface in basketball compared to field lacrosse and thus requiring shorter stopping distances. However, even within the small-sided games performed in the current study, there were still more accelerations than decelerations. The present study did not assess decelerations that were conducted at <3 $m \cdot s^{-2}$, so it may be that the rate of decelerations used are slower in lacrosse compared to basketball. Future research should consider assessing the accelerations and decelerations within different running speed zones during training and game play.

Limitations

Limitations for the present study include a small sample size and player variability. The number of participants for this study was limited to one collegiate women's lacrosse team but was comparable to past studies (Bunn et al., 2021; Reina et al., 2019; Robinson et al., 2022; Vázquez-Guerrero et al., 2018). It is important to recognize that athletes may exhibit variability in their data due to factors such as previous experience, training, and injury history. Therefore, there is not a set way to train but rather, coaches and sports specialists should consider individual differences and tailor training based on the individual athlete's specific needs and characteristics.

CONCLUSION

Further research is needed to explore the relationship between the acceleration/deceleration ratio, performance outcomes, and injury prevention in collegiate women's field lacrosse. Additionally, examining the effectiveness of specific training drills aimed at mimicking the acceleration/deceleration ratios of game play can provide valuable insight for optimizing athlete development and performance. In summary, the acceleration/deceleration ratio is an important metric with implications for game performance and training in collegiate women's lacrosse. The results of this study expand the literature of women's field lacrosse, and help coaches, sports medicine professionals, and athletes work collaboratively to enhance player development and optimize athletic performance on the lacrosse field.

AUTHOR CONTRIBUTIONS

Shania Roehrich: conceptualization, writing- original draft preparation. Brock Symons: conceptualization, writing- reviewing and editing. Paula Parker: supervision, writing- reviewing and editing. Jennifer Bunn: conceptualization, methodology, statistical analysis, writing- reviewing and editing, data curation. All authors agree to the publication of this manuscript in SJSP.

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No potential conflict of interest was reported by the authors.

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