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CHANGE OF DIRECTION SPEED UNDER TWO LOADING CONDITIONS AMONG FEMALE POLICE OFFICERS: ASSOCIATION WITH BODY MORPHOLOGY

AGILNOST V DVEH POGOJIH OBREMENITVE MED POLICISTKAMI: POVEZAVA Z TELESNIMI ZNAČILNOSTMI

ABSTRACT

Change of direction speed (CODS) is an important performance ability for police officers. This is even more emphasized when officers perform tasks while carrying their occupational load (e.g., protective vest, weapon, radio, cuffs, etc.). The absolute weight of the equipment remains the same regardless of officer's body size and weight, which is of importance for female police officers whose morphology is different than in males. This study investigated the associations between selected measures of body morphology and CODS among female police officers under two loading conditions. The sample consisted of 29 female police officers (age = 32.00±5.09 yrs, body height = 162.92±5.01 cm, and body mass = 70.88±13.42 kg). Anthropometric variables included height, weight, and body mass index (BMI), while body composition characteristics included percent body fat, (PBF), percentage of skeletal muscle mass (PSMM), and index of hypokinesia (IH). CODS was assessed using the Illinois agility tests under loaded (LIAT) (10 kg vest) and unloaded (IAT) conditions. Participants' CODS times were significantly slower in the LIAT condition ($p < 0.001$). IAT correlated to BMI ($r=0.479$, $p<0.05$), PBF ($r=0.647$, $p<0.001$), PSMM ($r=-0.655$, $p\leq0.001$), and IH ($r=0.462$, $p<0.05$). Similarly, LIAT was associated with BMI ($r=0.446$, $p<0.05$), PBF ($r=0.651$, $p<0.001$), PSMM ($r=-0.672$, $p<0.001$), and IH ($r= 0.503$, $p<0.01$). These findings highlight the need for developing specific physical training programs aimed at improving and maintaining healthy body composition levels among female officers if improved CODS is the goal.

Keywords: agility, tactical athletes, law enforcement, body composition, physical performance

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IZVLEČEK

Agilnost (CODS) je pomembna zmogljivost policistov. Ta je še bolj poudarjena, kadar policisti opravljajo naloge, medtem ko nosijo svoje poklicno breme (npr. zaščitni jopič, orožje, radio, manšete itd.). Absolutna teža opreme ostaja enaka, ne glede na spol, telesno višino in maso policista, kar je pomembno za policistke, katerih morfologija je drugačna kot pri moških. Ta študija je preučevala povezave med izbranimi merami telesnih značilnosti in CODS med policistkami v dveh pogojih obremenitve. Vzorec je sestavljalo 29 policistk (starost = 32.00±5.09 let, telesna višina = 162.92±5.01 cm in telesna masa = 70.88±13.42 kg). Antropometrične spremenljivke so vključevale telesno višino, telesno težo in indeks telesne mase (ITM). Značilnosti telesne sestave pa odstotek telesne maščobe (PBF), odstotek mase skeletnih mišic (PSMM) in indeks hipokinezije (IH). CODS je bil ocenjen s testom agilnosti Illinois, z obremenitvijo (LIAT) (10-kilogramski jopič) in brez obremenitve (IAT). Čas CODS policistk je bil v stanju LIAT bistveno počasnejši ($p < 0.001$). IAT je bil povezan z indeksom telesne mase ($r = 0.479$, $p < 0.05$), PBF ($r = 0.647$, $p < 0.001$), PSMM ($r = 0.655$, $p \leq 0.001$) in IH ($r = 0.462$, $p < 0.05$). Podobno je bil LIAT povezan z indeksom telesne mase ($r=0.446$, $p<0.05$), PBF ($r=0.651$, $p<0.001$), PSMM ($r=-0.672$, $p<0.001$) in IH ($r= 0.503$, $p<0.01$). Te ugotovitve poudarjajo potrebo po razvoju posebnih programov telesne vadbe, namenjenih izboljšanju in ohranjanju zdravih ravni telesne sestave med policistkami, če je cilj izboljšanje CODS.

Ključne besede: agilnost, taktični športniki, kazenski pregon, telesna sestava, telesna zmogljivost

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INTRODUCTION

Law enforcement is a physically demanding occupation (Drain & Reilly, 2019; Lentine et al., 2021). In general, police officers are expected to possess the ability to regularly perform tasks requiring lower and upper body power, speed, strength, agility, flexibility, and endurance (Marins et al., 2019; Maupin et al., 2018). These tasks may include, but are not limited to: foot pursuits of varying distances, changing directions to avoid obstacles or apprehend a suspect, and seeking cover (Anderson, Plecas, & Segger, 2001; Marins et al., 2019; Thomas et al. 2018). In addition to performing these tasks under chaotic and rapidly changing conditions, police officers also need to possess the ability to perform these tasks while wearing duty loads weighing approximately 10 kg (Baran et al. 2018). This duty load is typically comprised of body armor and other essential equipment such as a baton, radio, handcuffs, sidearm, and flashlight (Baran et al., 2018). Although the purpose and significance of officer's wearing their occupational load is well understood, current research suggests that these loads have a negative impact on specific measures of physical performance, such as speed and agility (Kukić et al., 2020; Lyons et al., 2005; Na et al., 2016). Thus, it is of utmost importance to understand the impact physical fitness has on performing occupational tasks and how to enhance performance through physical training.

Numerous studies have reported the deleterious effects of duty load on sprint ability and change of direction speed (CODS) performance among male and female tactical operators (Carlton et al. 2014; Schram et al. 2019; Thomas et al., 2018). Carlton et al. (2014) found significant increases in time to complete a tactical movement and 80 kg dummy drag task when specialist tactical officers were loaded with a 22 kg occupational load compared to an unloaded condition. Additionally, Dempsey et al. (2013) reported that time to complete a simulated vehicle exit and sprint (mean time = 1.95 s loaded, 1.67 s unloaded, $p < 0.001$) and time to complete a mobility battery (mean time = 18.16 s loaded, 15.85 s unloaded, $p < 0.001$) were significantly increased when subjects were wearing stab-resistant body armor weighing 7.65 ± 0.73 kg. However, little evidence exists regarding the impacts of duty load on physical performance within female law enforcement populations specifically.

Although previous research has highlighted the negative effects of duty load on occupational performance, the individual's body mass can also impact sprint ability and CODS (Kukić et al., 2020; Pihlainen et al. 2018; Schram et al., 2019). For instance, Pihlainen et al. (2018) reported that successful completion of an occupationally relevant military simulation test was strongly

related to body fat percentage ($rs = 0.53$, $p < 0.001$) and skeletal muscle mass ($rs = -0.47$, $p < 0.001$). The investigators concluded that as the percent of body fat (PBF) increased, task completion times also increased. In contrast, as skeletal muscle mass increased, completion time on these tasks decreased. Similar findings have been reported within law enforcement populations (Kukić et al., 2020; Lockie et al., 2018). A recent study by Lockie et al. (2018) provided evidence that law enforcement recruits with a greater waist circumference, irrespective of sex, tend to have poorer fitness test performance, while Kukić et al. (2020) found that body composition was a significant predictor of performance in the Illinois agility test (IAT).

Female police officers may have to pursue offenders on foot, while wearing duty loads that are relatively heavier than those carried by male officers (Kukić et al., 2020). These duty loads reduce mobility and are associated with physical performance (Loverro et al. 2015; Na et al., 2016). Also, due to the propensity of females, in general, to possess greater body fat and lower levels of skeletal muscle compared to their male counterparts (Dopsaj et al., 2020), the ability to change direction may be further impacted (Kukić et al., 2020). Therefore, understanding the relationships between fitness measures and load carriage during a CODS task among female officers may help inform physical conditioning requirements to improve occupational performance (e.g., ability to pursue offenders on foot while wearing occupational loads). On this basis, the aims of this research were to investigate the effects of occupational load on a short explosive CODS task among female police officers and determine if body composition measures were related to occupational load carriage requirements during a change of direction task. The authors hypothesized that there would be a strong relationship between body composition and CODS performance in both loaded and unloaded conditions.

METHODS

An applied non-experimental cross-sectional research design was conducted on a random sample of female police officers from the Abu Dhabi Police to investigate the association of lower-body power, and anthropometrics to change of direction speed under two loading conditions. The IAT was performed without load and with a 10-kg loaded vest and correlated with lower-body power. Additionally, five main body characteristics were assessed, height, body mass, body mass index (BMI), PBF, and percent skeletal muscle mass (PSMM) to provide insight into the relationship between these anthropometric measures and performance.

Participants

The sample utilized in this investigation consisted of 27 female police officer (age = 32.2 ± 5.1 yrs, height = 162.8 ± 5 cm, and body mass = 71.31 ± 13.42 kg). It should be noted that the descriptive data for this sample of officers has been reported elsewhere (Orr et al., 2019) but this data was utilized for a different purpose. The mean length of service was 8.3 ± 3.2 years. The assessments of physical abilities were conducted as part of the regular physical conditioning for this agency. Prior to testing, all subjects signed an informed consent, granting permission to utilize the collected data for research and publishing purposes. As such, this research was carried out in accordance with the conditions set forth by the Declaration of Helsinki (Williams, 2008), and with the ethical approval number 440-2 of the ethical board of the University of Criminal Investigation and Police Studies, Serbia.

Protocol

The assessments were conducted over two days, 24-48 hours apart. Anthropometrics and body composition measures were collected on the first day, while power and CODS tests were assessed on the second day. Physical ability testing was preceded by a standard 15-minute warm-up (e.g., low aerobic intensity jogging and calisthenics, bodyweight squats, lunges, and jumps). Following a detailed explanation and demonstration of each test. All subjects performed one practice trial followed by two consecutive experimental trials with the best test trial being recorded as their final score and used for further analysis. The rest periods between consecutive trials were 2 minutes, and between two consecutive tests were 5 minutes, respectively. The subjects first performed the IAT and then Loaded IAT (LIAT) after 5 minutes of rest.

Anthropometrics and body composition

Body characteristics such as height and body mass were assessed using a Seca 769 digital scale with a measuring rod (Hamburg, Germany). BMI, PBF and PSMM were assessed using an 8-channel multi-frequency bioelectric impedance (InBody 720: Biospace Co. Ltd, Seoul, Korea) following previously reported procedures (Dopsaj et al., 2020; Kukić et al., 2020). This device was shown to be valid (r = 0.93), and reliable (ICC = 0.98) (Aandstad et al. 2014). It was also used to track age-related changes in body composition of general public (Dopsaj et al., 2020, 2021) and to differentiate elite athletes by morphological characteristics (Dopsaj et al., 2021). The official InBody service provider (Borf d.o.o, Belgrade, Serbia) calibrated the machine twice a year (once each six months). In short, all measurements were conducted before breakfast

between 08:00 and 10:00 h by experienced examiners and subjects were instructed to fast for 12 hours prior to testing and to refrain from strenuous exercise 48 hours prior testing. Subjects were wearing sports shorts and T-shirt, were barefoot, and had all metal, plastic, and magnetic accessories removed, stood on the device and on the metal spots designated for their feet. In their hands, they held the device's handles with electrodes. Hands were positioned next to the body in slight abduction so the hands do not touch the body. The outcome measures from this device were printed out, but only PBF and PSMM were used for the analyses.

Change of direction speed (CODS)

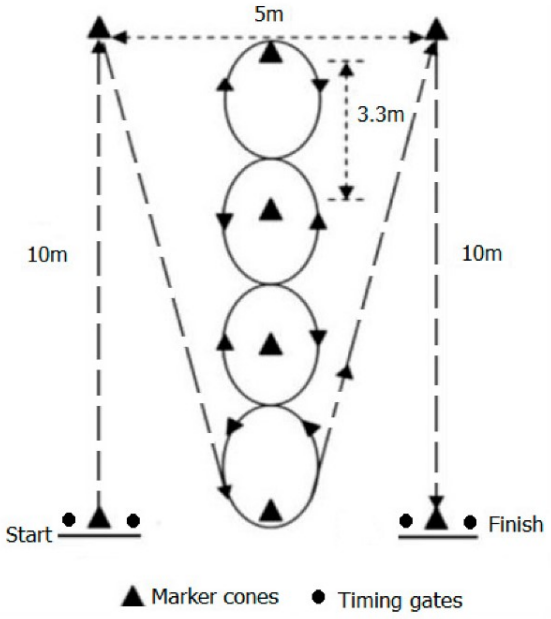
The IAT provides information about the ability to accelerate, decelerate, turn in different directions, as well as run at different angles, and has been used to establish criterion data for males and females (Miller et al., 2006). Hachana et al. (2013) reported a high intra-trial reliability of this test (ICC = 0.96). The IAT was performed in loaded and unloaded conditions. For the loaded condition, the subjects wore an adjustable 10 kg vest (Figure 1). A 400-g vest was loaded with additional 24 small 400-g pouches filled with lead grain that absorbed the impacts of the vest on the body in acceleration, deceleration, and when changing direction. In addition, the vest was tightened to the body by the strap around the waist. The 400-g pouches were equally distributed at the front and back of the upper body. Only one weight of the west was used, without normalizing to participants' body weight because it mimicked the work load an officer needs to carry regardless of their body size and weight.

Figure 1. Representation of the loaded west.

The IAT and LIAT outcomes were recorded using the electronic timing gates (Fitro Lighteight Gates, Fitronic, Bratislava, Slovakia). Precision of the measurement was 0.01 s. The LIAT and

IAT course was marked by cones as previously explained in detail in research on police (Koropanovski et al., 2022; Orr et al., 2019) and as presented in Figure 2. Two cones were used to mark the turning points, while four center cones were placed down the center and spaced 3.3 m apart. The subjects began the test lying prone on the floor behind the starting line. On command, the subjects ascended and ran forward to the first turning cone. The subjects were required to turn around the first turning cone and moved back to the first center cone, where they weaved up and back through the four center cones. The subjects then ran to the second turning cone. After turning around the second turning cone, the subjects were required to run across the finish line. Subjects were instructed to complete the test as quickly as possible. Participants performed the IAT first, rested for 5 minutes and then they performed the LIAT.

Figure 2. Schematic presentation of Illinois Agility Test.



Statistical Analysis

Descriptive statistics were calculated for mean, standard deviation, minimum, and maximum values. A Shapiro-Wilk test was used to assess the normality of data distribution. Paired sample t-test was used to determine the differences between the IAT performance in unloaded and loaded conditions. The IAT, LIAT, and the obtained differences between the conditions were correlated with participants' body composition characteristics. The significance level was set at $p < 0.05$. The magnitude of correlations were defined as small (r = 0.2 - 0.5), medium (r = 0.5 - 0.8), and large (r > 0.8) (Sullivan & Feinn, 2012). All statistical procedures were

conducted in Statistical Package for Social Sciences (IBM, SPSS Statistics 20, Chicago, IL) and JASP (version 0.16.1).

RESULTS

Descriptive statistics for mean, standard deviation, minimum, and maximum values and the Shapiro-Wilk analysis are shown in Table 1. All variables were normally distributed. Six participants could be classified as normal weight (i.e., BMI ≤ 25kg/m^2) and 21 could be classified as overweight or obese (i.e., BMI > 25 kg/m^2) based on classifications by American College of Sports Medicine (Riebe et al., 2018). Accordingly, parametric statistical analyses were conducted for further analysis.

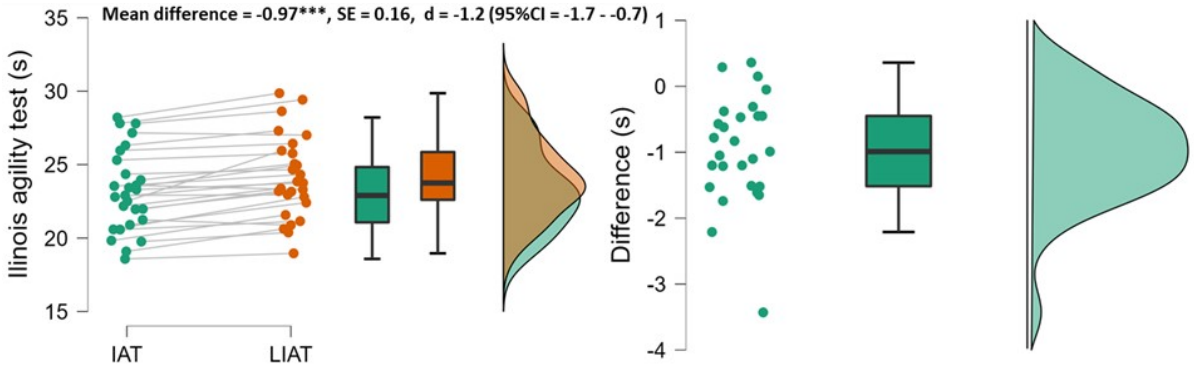
Table 1. Descriptive data for police officers.

Variables	Mean	Std. Deviation	Minimum	Maximum	Shapiro-Wilk
IAT (s)	23.2	2.7	18.6	28.2	0.4
LIAT (s)	24.1	2.8	19.0	29.9	0.8
IATdiff (s)	0.97	0.82	-0.37	3.43	0.2
BM (kg)	71.3	13.4	50.5	109.5	0.3
BMI (kg/m2)	26.9	4.6	20.8	36.6	0.1
PBF (%)	36.2	8.4	15.6	49.8	0.2
PSMM (%)	34.8	4.6	27.4	46.5	0.2
IH (no)	1.3	0.2	0.7	1.8	0.3

Note: IAT – Illinois agility test, LIAT – Loaded Illinois agility test, IADdiff – Difference attained between the IAT and LIAT, BM – Body mass, BMI – Body mass index, PBF – Percent of body fat, PSMM – Percent of skeletal muscle mass, IH – Index of Hypokinesia.

Paired sample t-test showed that the load carried significantly affected the IAT performance as participants performed slower while carrying the load (Figure 3). Only 3 participants performed lower without the load than with the load.

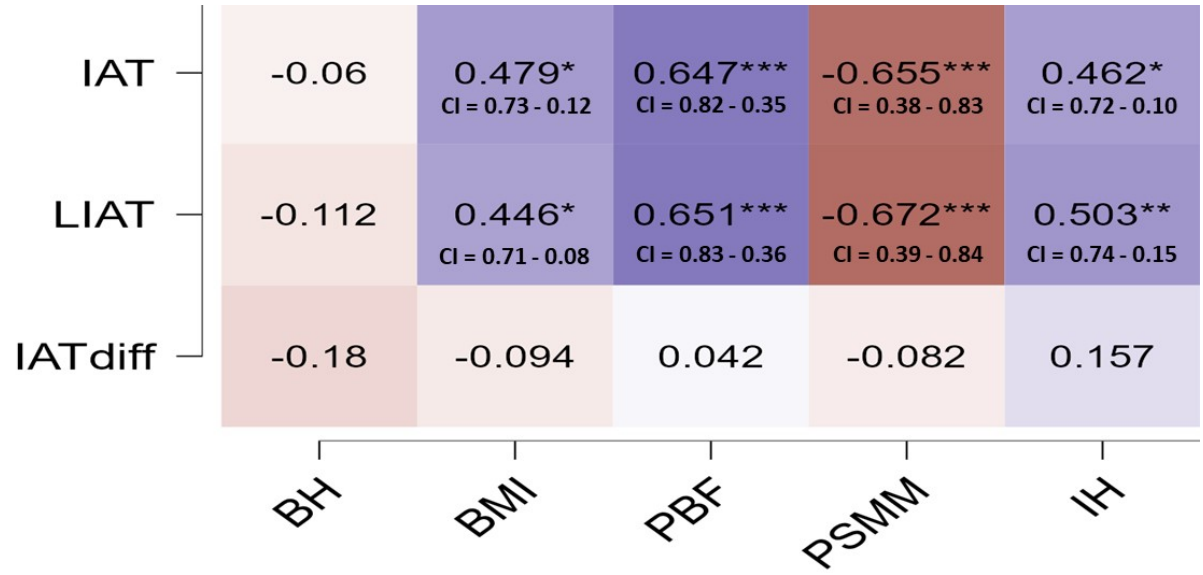
Figure 3. The difference in IAT performance produced by the load carried.



Note: ***Significant at $p < 0.001$. SE – standard error of the difference. IAT – Illinois agility test, LIAT – loaded Illinois agility test.

The correlation analysis revealed that IAT and LIAT performance was significantly correlated to anthropometrics and body composition. Similarities in correlations between anthropometrics and body composition and performance with (LIAT) and without (IAT) load suggests that load carried did not significantly further correlate to anthropometrics and body composition (Figure 3). The IAT and LIAT inversely correlated with PSMM whereby lower PSMM led to slower IAT and LIAT times.

Figure 4. Correlation heat map for body composition and Illinois agility test in unloaded and loaded conditions.



Note: *Significant at $p < 0.05$, **Significant at $p < 0.01$, and ***Significant at $p < 0.001$. CI = 95% confidence interval (upper limit – lower limit). IAT – Illinois agility test, LIAT – loaded Illinois agility test. BH – body height, BMI – body mass index, PBF – percent of body fat, PSMM – percent of skeletal muscle mass, IH – index of hypokinesia.

DISCUSSION

The purpose of this study was to determine if there were significant associations between select anthropometric measures and body composition with IAT and LIAT performance among female police officer. The results from the present study indicate body composition was significantly correlated to CODS ability as measured by IAT and LIAT performance. Specifically, as PBF decreased IAT and LIAT performance improved. Additionally, as PSMM increased IAT and LIAT performance improved. IAT performance was significantly faster than the LIAT performance, whereby performance differences were associated with BMI, PBF, PSMM, and IH. The results of this study may be utilized by Tactical Strength and Conditioning Facilitators to successfully identify demographic-specific exercise modalities and develop conditioning programs to enhance occupational performance within this population. Additionally, the outcomes of this research show the necessity for a focused approach for healthy body composition if improved CODS is the goal.

The ability to perform essential job-related tasks can be the difference between life and death for a law enforcement officer. Furthermore, previous research indicates that tactical personnel with healthy body compositions, and adequate muscular power, strength, and endurance capabilities perform tasks faster (Carlton et al., 2014; Dawes et al. 2016; Kukić et al., 2020; Lockie et al., 2018). These findings agree with previous research conducted by Sekulic et al. (2013) who investigated the sex-specific influence of body composition, speed, power, and balance, on different agility tests within a population of collegiate athletes. To that end, optimal body composition is a recurring theme within many tactical based manuscripts as they are often significantly related to physical ability (Dawes et al., 2016; Kukic et al., 2018; Kukić et al., 2020; Orr et al. , 2018). PBF, PSMM, and IH were related to IAT and LIAT performance which signifies that achieving and maintaining a healthy body composition can have a positive impact on CODS. Practically, higher skeletal muscle mass and lower body fatness provide better contractile potential of skeletal muscles and lower impacts of ballast mass, thus resulting in better performance of CODS tasks. Note that the correlations were somewhat higher when officers carried the load, which further emphasizes the importance of good body composition. The non-existence of correlations between body composition and obtained differences suggests that the effects of load carried were similar regardless of body composition. Therefore, while improvement and maintenance of body composition are of great importance they should be attained through multidisciplinary strength and conditioning programs as nutrition and diet

management alone may not be sufficient to improve muscular strength with the latter known to be of importance in police officers required to wear and carry load (Orr et al., 2022).

A notable limitation associated with this study is that the reported findings only apply to IAT and LIAT performance. This is primarily due to the fact that other CODS tests were not conducted in the organization from which this data were drawn and as such not investigated. With CODS tests being unique (i.e., IAT requires an individual to start in a prone position whereas a 5-0-5 test requires an individual to start in a standing position) the transferability, while generally applicable, may have some limitations. An additional limitation associated with this study is that nutrition was not controlled and that the samples' body composition could include wider range of body fatness and body muscularity.

CONCLUSION

The results of this study highlight the relationships between CODS and body composition in a female, general duties, law enforcement cadet population. Furthermore, these relationships are significantly influenced by BMI, PBF, and PSMM. In the future, these findings can be used by law enforcement agency administration and staff to develop an evidence-based strength and conditioning program to enhance both the preparedness and performance of female general duties law enforcement officers. The presented analysis identified significant correlations between anthropometric and body composition measures and CODS performance under loaded and unloaded conditions. Understanding how to adequately assess physiological contributors to performance, prepare multidisciplinary strength and conditioning programs for female police officers, and effectively implement those programs are of high importance for future job task performance and the reduction of injury. Altogether, the findings from this analysis should provide support to tactical organizations to implement physical training programs aimed at attaining and maintaining healthy body composition ranges, as well as improving fitness and performance.

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Declaration of Conflicting Interests

None of the authors have any conflict of interest. This research project received no external financial assistance.

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