ORIGINAL ARTICLE

Comparing the maximal horizontal deceleration demands between a novel acceleration to deceleration assessment and the 505 change of direction test

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ABSTRACT

The importance of quantifying maximal horizontal deceleration performance in athlete populations has received a considerable increase in interest over recent years. However, research is still scarce investigating movement characteristics of maximal horizontal decelerations outside of measures derived from instantaneous horizontal velocity of the centre of mass, using technologies such as radar or laser-based devices. Therefore, this study aimed to explore the biomechanical differences for measures of deceleration ability between a novel deceleration task, and the 505 change of direction test, using an inertial measurement unit-based technology. Primary findings suggested differences across several biomechanical characteristics quantified during the deceleration phase, with moderate to large between-test effect sizes. Specifically, subjects were found to exhibit significantly greater reductions in velocity and horizontal braking forces in the 505. Further, subjects showed significantly shorter stopping times and distances in the acceleration-deceleration assessment, however, these displayed insufficient levels of reliability across both assessments, which should be interpreted as a limitation. Therefore, it may be speculated that based on our data, the 505 test, which possesses a predetermined stopping/turning point, presents a greater or different biomechanical challenge to individuals, which must be met with the appropriate neuromuscular and skill-related qualities to efficiently reduce whole-body momentum. These findings may be relevant to practitioners interested in choosing the right assessment to quantify athletes' maximal horizontal deceleration performance, which can have implications for both health and performance.

Keywords: Biomechanics, Deceleration, Change of direction, Assessment.

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INTRODUCTION

Across different multidirectional sports, athletes must show proficiency in motor tasks such as sagittal plane sprinting and high-intensity running, lateral shuffling and cutting, as well as jumping (Taylor et al. 2017). Especially when performing high-intensity cuts and changes in direction, athletes are exposed to large decelerative demands, which require sufficient braking strategies. Recently, sports science literature investigating athletes' horizontal deceleration ability has gained increasing attention (Harper et al. 2020; Harper et al.2022; Harper et al. 2018; Harper et al. 2022; Philipp et al. 2023; Philipp et al. 2023). Researchers have proposed that the development of reliable deceleration metrics, and the design of corresponding training interventions, are capable of enhancing braking performance capabilities, facilitating game-specific speed abilities, and reducing predisposition to fatigue and injury, which could ultimately reflect positively on athletes' health and performance (Harper et al. 2021). What may have in part contributed to the recent interest in studying athletes' deceleration performance was a previous lack of methods, tests, and technologies to effectively quantify horizontal deceleration. Using radar technology, Harper et al. have recently proposed the use of the acceleration to deceleration assessment (ADA) to quantify athletes' maximal horizontal deceleration ability (Harper et al. 2020). This test requires athletes to sprint over a predetermined distance, followed by a rapid deceleration coming to a stop (Harper et al. 2020). The distance and therefore velocity over which athletes accelerate prior to initiating the deceleration plays a key role in the outcome of the test, and the metrics that are being calculated (Philipp et al. 2023). Philipp et al. have shown that when performing the ADA test over 20 yards (18.3 meters), compared to 10 yards (9.2 meters), athletes exhibited significantly greater magnitudes of maximal approach velocity and momentum, as well as average deceleration, braking impulse, and stopping time, therefore presenting athletes with significantly greater braking demands (Philipp et al. 2023). In a further investigation, researchers found moderate effect sizes for comparisons in deceleration metrics between the ADA test over 10 meters, and the 505 change of direction test, suggesting that different deceleration assessments may pose different biomechanical challenges to athletes, which should be acknowledged by practitioners implementing assessments (Philipp et al. 2023). Further, Graham-Smith et al. developed a method evaluating athletes' horizontal deceleration ability in relation to their self-determined limit to accelerate within a prescribed distance, which may be used by practitioners to aid in their understanding and application of appropriate stopping distances based on the distances of acceleration drills and the typical speed a player is likely to attain (Graham-Smith et al. 2018).

Considering the previously highlighted studies, it seems that when selecting deceleration assessments, practitioners may choose between tests during which athletes initiate the deceleration phase at a pre-set distance (i.e., ADA), or tests during which they stop or change direction at a pre-set distance or point (e.g., 505). However, research is scarce in describing biomechanical differences between said assessments, which ultimately limits partitioners in their understanding and selection process. Further, research is limited to investigating movement characteristics of maximal horizontal decelerations outside of measures derived from instantaneous horizontal velocity of the centre of mass (COM), using technologies such as radar or laser-based devices.

Therefore, the primary aim of this study was to investigate the biomechanical differences for measures of deceleration ability between the ADA test over 10 meters, and the 505 change of direction test, using an inertial measurement unit (IMU)-based technology. A secondary aim was to describe the intra-session reliability of respective horizontal deceleration metrics for both tests, using IMU technology.

Researchers hypothesized that tests would display differing biomechanical characteristics, which may aid practitioners in their understanding of each test, and ultimately enhance decision making with regards to which assessment to implemented when measuring horizontal deceleration performance.

MATERIAL AND METHODS

Participants

Nineteen recreationally trained, college-aged individuals (n = 14 male, age = 21.1 ± 1.8 years, height = 1.80 ± 0.05 m; body mass = 80.1 ± 9.8 kg; n = 5 female; age = 20.1 ± 2.8 years, height = 1.70 ± 0.02 m; body mass = 63.8 ± 2.3 kg) with at least four years of recent, organized playing experience in a multidirectional sport (e.g., basketball, soccer) volunteered to participate in the present study. All subjects provided their written consent as approved by the University's Institutional Review Board.

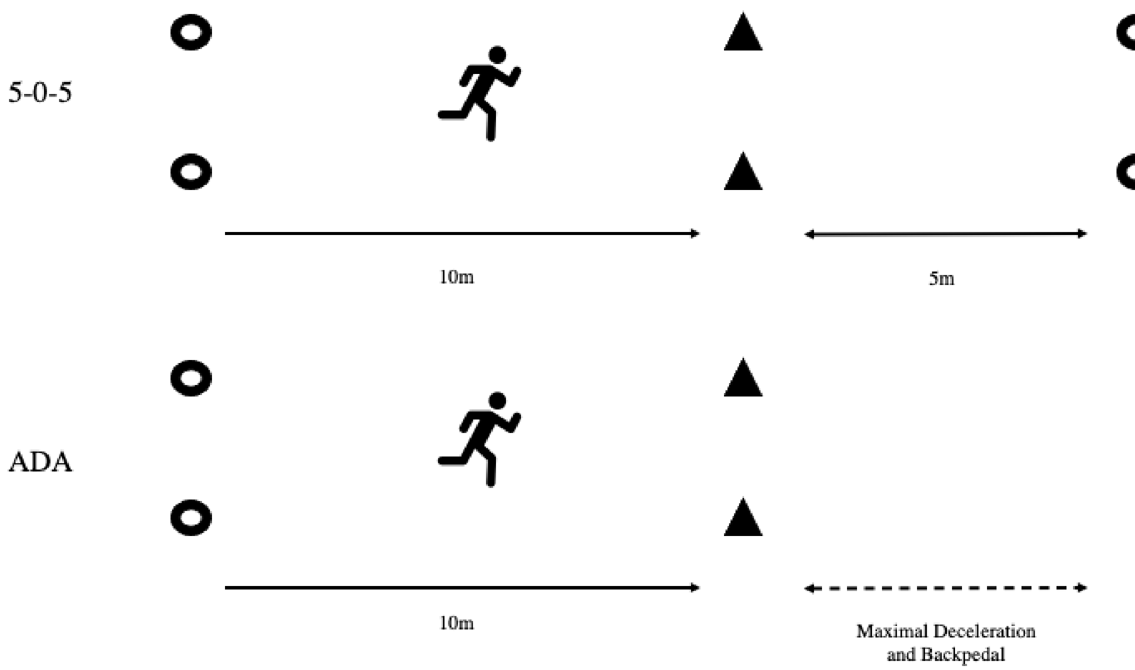
Protocol

Upon arriving to the testing facility, the participants' anthropometric data was collected (i.e., height and weight), including measurements specific to the inertial measurement unit (IMU) (Xsens MVN Awinda, Enschede, Netherlands) calibration and sensor placement process performed in line with manufacturer guidelines (Nijmeijer et al. 2023; Schepers et al. 2018). From there, the IMU-based system was calibrated according to manufacturer guidelines (Nijmeijer et al. 2023). Before the start of data collection, all subjects performed a dynamic warm-up that was led by a Certified Strength and Conditioning Specialist. Each subject performed three trials in the ADA test and four repetitions (two to each side) in the 505 change of direction test. During the warm-up, all athletes were given three to four practice attempts in each test to familiarize them with the procedures.

Procedures for the ADA were adapted from previous research (Harper et al. 2020; Philipp et al. 2023). Subjects were instructed to sprint maximally over a distance of 10 meters, following a start in a staggered stance. Upon crossing the 10-meter marker, subjects performed a maximal deceleration coming to a stop, which was followed by a backpedal to the 10-meter marker. A set of timing gates (Brower Timing Systems, Draper, UT, USA) was placed at the 10-meter marker, which made a distinct sound upon crossing, which subjects were instructed to use as a signal to initiate the deceleration phase. Subjects performed three trials with three minutes of passive rest in between each trial. If athletes were visually observed to slow down prior to the 10-meter mark, or significantly after it, the trial was repeated following three minutes of passive rest.

Similar to the ADA, procedures for the 505 tests were adapted from previous research (Draper and Lancaster, 1985), in which subjects maximally sprinted over 10 meters, with a 180-degree turn complete at the 15-meter marker, which was marked on the floor with cones and tape. Subjects crossed a single set of timing gates at the 10-meter marker, decelerated, turned at the 15-meter marker, and rapidly reaccelerated back through the set of timing gates placed at the 10-meter marker. Participants performed two trials of turning with their right leg, and two trials of turning with their left leg.

For this study, an IMU-based motion capture system (Xsens, MVN Awinda, Netherlands) was used to capture the biomechanical differences between the ADA and 505 tests. Recent research has documented that this technology displayed excellent levels of agreement with a Vicon optoelectronic motion capture system in capturing kinematics in the sagittal plane of movement (Schepers et al. 2018). Other research utilizing the Xsens IMU-based system has shown acceptable validity in assessing temporal-spatial parameters during the ADA test (Jordan et al. 2021). The individual IMUs' consisted of a three-dimensional linear accelerometer, magnetometer, gyroscope, as well as a barometer, and sampled at a rate of 100 Hz. Following manufacturer guidelines, researchers placed IMUs at strategic locations around the subject's body (secured by straps). Within the Xsens MVN software (MVN Record 2023) researchers chose the suit configuration "*lower body with sternum*", which required units to be placed around the anterior superior part of the foot, the tibia close to the knee, the middle of the lateral thigh, the posterior pelvis at a height of the anterior superior iliac spine, as well as the sternum. Raw IMU-derived data were uploaded to the Athlete Analytics software platform (Athlete Analytics, Atlanta, GA, USA) where metrics of interest were calculated based on proprietary algorithms. In this analysis, the start of the deceleration phase was identified as the point in time where the greatest change in acceleration of the centre of mass in the opposite direction (i.e., negative acceleration) occurred. Ground contact accelerations were derived from the accelerometers attached to the lower limbs of the participants, while their foot was in contact with the ground (x, y, and z directions combined), and were converted from meters per second to gravitational acceleration (g's), by dividing values by 9.81. In line with previous research (Harper et al. 2020; Morin et al. 2019), average horizontal braking force was calculated using fundamental laws of dynamics in the horizontal direction.



**Notes: Circles represent cones, and triangles represent timing gates.*

Figure 1. Visual representation of the two assessments compared in this study.

Analysis

Researchers downloaded metrics of interest for the two assessments from the Athlete Analytics software platform (Athlete Analytics, Atlanta, GA, USA), and entered data into a spread sheet (Excel), prior to importing the excel file to RStudio (Version 1.4.1106), where further data treatment and statistical analyses were performed. All data was checked for normality using a Shapiro-Wilks test. For all metrics of interest, intraclass correlation coefficients (ICC), standard errors of measurement (SEM), and minimal differences needed to be considered real (MD) were calculated. ICCs were calculated using the $ICC_{2,k}$(consistency) model, and were interpreted where <0.50 was deemed poor reliability, 0.50-0.74 was deemed moderate reliability, 0.75-0.90 was deemed good reliability, and >0.90 was deemed excellent reliability (Koo and Li, 2016). The SEM was calculated as the square-root of the mean square error (MS_E), which was gathered from a repeated measures ANOVA performed between the three trials performed for each metric (Cleary et al. 2022; Weir, 2005). The

SEM is also presented as a percentage of the grand mean by dividing the SEM by the mean and multiplying it by 100. The MD was calculated based on the SEM as suggested in earlier research (Weir, 2005). Finally, paired sample t-tests between metrics of interest for the ADA and 505 were performed. Means and standard deviations for each test and metric, in addition to mean differences with 95% confidence intervals (CI), and Hedge's g effects sizes (ES) with 95% confidence intervals were reported in the results. Effect sizes were classified as either negligible (<0.20), small (0.21-0.50), moderate (0.51-0.80), and large (>0.80) (Cohen, 2013). To highlight the differences between tests for selected metrics, between-group mean values and mean differences for each respective team were visualized using Gardner-Altman plots (Ho et al. 2019). Gardner-Altman plots were generated in RStudio using the 'dabestr' package. Statistical inferences were made using an α level of $p \leq .05$.

RESULTS

Reliability statistics are presented in Table 2. and suggest poor to excellent levels of consistency, as well as SEM's ranging from 2.3 to 21% of the mean. Between-test comparisons revealed statistically significant differences for six of the twelve measures of deceleration ability investigated in this study. More specifically, subjects exhibited significantly greater magnitudes of average deceleration (ES = -2.46) and average horizontal braking force (ES = -1.61) in the 505, compared to the ADA. Further, subjects showed significantly longer stopping times (ES = -0.90) and further braking distances (ES = -2.06) in the 505, compared to the ADA. Lastly, in the 505, subjects exhibited significantly shorter brake step ground contact times (ES = 0.65), as well as shorter brake steps, relative to the centre of mass (ES = 0.91). Between-test comparison statistics may be found in Table 3. Figure 1 shows a visual representation of between-test comparisons for metrics displaying significant differences.

Table 1. Names and definitions for deceleration metrics of interest.

Metric (Unit)	**Definition | Calculation**
Avg. Approach Velocity (m/s)	Average horizontal approach velocity of the COM
Avg. Approach Momentum (kg*m/s)	Average horizontal approach momentum of the COM
DEC Phase Avg. Deceleration (m/s^2)	Average horizontal deceleration of the CIOM
DEC Phase Avg. Horizontal Braking Force (N)	Horizontal antero-posterior ground reaction force applied to the body COM
Stopping Time (s)	Time from the start of the deceleration phase to the end of the deceleration phase
Stopping Distance (m)	Distance from the start of the deceleration phase to the end of the deceleration phase
COM Drop During DEC (cm)	Downward movement of the COM during the deceleration phase
Avg. Brake Step Ground Contact DEC (g)	Average ground contact deceleration during all steps of the deceleration phase
Avg. Brake Step Ground Contact Time (s)	Average foot ground contact time during all steps of the deceleration phase
Avg. Brake Step Hip Flexion at GC (deg)	Average brake step hip flexion during the deceleration phase
Avg. Brake Step Knee Flexion at GC (deg)	Average brake step knee flexion during the deceleration phase
Avg. Brake Step Position Relative to COM (cm)	Foot position relative to the COM for all brake steps in the deceleration phase

**Notes: "Avg." = Average, "DEC" = Deceleration, "N" = Newton, "deg" = degrees, "COM" = Centre of mass, "GC" = Ground contact.*

Table 2. Reliability statistics for all metrics of interest.

Metric	Test	ICC (CI)	SEM	MD
Avg Approach Velocity (m/s)	ADA	0.79 (0.60; 0.91)	0.10 (2.3%)	0.28
	505	0.82 (0.68; 0.92)	0.14 (3.2%)	0.39
Avg Approach Momentum (kg*m/s)	ADA	0.98 (0.95; 0.99)	8.91 (2.6%)	24.8
	505	0.97 (0.93; 0.99)	9.90 (2.9%)	27.4
Avg DEC (m/s²)	ADA	0.34 (0.04; 0.65)	0.41 (12.1%)	1.10
	505	0.47 (0.23; 0.71)	0.28 (6.9%)	0.77
Avg Horizontal Braking Force (N)	ADA	0.80 (0.62; 0.91)	32.1 (12.8%)	88.9
	505	0.83 (0.69; 0.92)	21.3 (6.82%)	59.1
Stopping time (s)	ADA	0.51 (0.21; 0.76)	0.11 (11.9%)	0.39
	505	0.56 (0.34; 0.78)	0.22 (15.8%)	0.62
Stopping distance (m)	ADA	0.13 (-0.14; 0.47)	0.89 (21.0%)	2.48
	505	0.26 (0.04; 0.54)	0.69 (12.9%)	1.92
DEC COM Drop (cm)	ADA	0.66 (0.40; 0.84)	2.12 (16.7%)	5.83
	505	0.82 (0.67; 0.92)	2.57 (19.8%)	7.11
Avg Brake Step GCD (g)	ADA	0.81 (0.63; 0.92)	0.94 (8.4%)	2.60
	505	0.62 (0.40; 0.81)	1.09 (9.9%)	3.01
Avg Brake Step GCT (s)	ADA	0.59 (0.32; 0.81)	0.02 (9.9%)	0.06
	505	0.46 (0.22; 0.71)	0.02 (10.7%)	0.06
Avg Brake Step Hip Flexion at GC (deg)	ADA	0.96 (0.92; 0.99)	2.68 (8.2%)	7.40
	505	0.95 (0.91; 0.98)	2.39 (7.3%)	6.63
Avg Brake Step Knee Flexion at GC (deg)	ADA	0.84 (0.69; 0.94)	3.65 (10.6%)	10.1
	505	0.59 (0.37; 0.79)	4.58 (13.8%)	12.70
Avg Brake Step Position Relative to COM (cm)	ADA	0.70 (0.46; 0.87)	1.03 (6.4%)	7.20
	505	0.45 (0.21; 0.70)	3.65 (10.1%)	10.1

**Notes: "Avg." = Average, "DEC" = Deceleration, "N" = Newton, "deg" = degrees, "COM" = Centre of mass, "GC" = Ground contact, "ICC" = Intraclass correlation coefficient, "CI" = 95% Confidence interval, "SEM" = Standard error of measurement, "MD" = Minimal difference needed to be considered real.*

Table 3. Between-test comparison statistics for all metrics of interest.

Metric	ADA	505	Mean Diff (CI)	ES (CI)
Avg Approach Velocity (m/s)	4.43 ± 0.24	4.46 ± 0.28	-0.03 (-0.09; 0.03)	-0.11 (-0.34; 0.10)
Avg Approach Momentum (kg*m/s)	339 ± 52.6	341 ± 52.1	-2.05 (-6.53; 2.44)	-0.04 (-0.12; 0.04)
Avg DEC (m/s²) *	3.32 ± 0.33	4.10 ± 0.29	-0.78 (-0.91; 0.78)	-2.46 (-3.33; 1.88)
Avg Horizontal Braking Force (N) *	252.4 ± 26.1	313.6 ± 45.8	-61.2 (-76.1; -46.4)	-1.61 (-2.21; -1.20)
Stopping time (s) *	1.20 ± 0.18	1.41 ± 0.28	-0.22 (-0.34; -0.09)	-0.90 (-1.51; -0.39)
Stopping distance (m) *	4.17 ± 0.61	5.38 ± 0.54	-1.21 (-1.44; -0.97)	-2.06 (-2.82; -1.55)
DEC COM Drop (cm)	12.6 ± 3.36	13.0 ± 5.85	-0.39 (-3.13; 2.36)	-0.08 (-0.62; 0.45)
Avg Brake Step GCD (g)	11.2 ± 2.02	11.0 ± 1.52	0.23 (-0.29; 0.75)	0.13 (-0.12; 0.39)
Avg Brake Step GCT (s) *	0.20 ± 0.03	0.18 ± 0.02	0.02 (0.01; 0.03)	0.65 (0.26; 1.12)
Avg Brake Step Hip Flexion at GC (deg)	33.3 ± 11.9	32.3 ± 10.6	1.00 (-1.43; 3.42)	0.09 (-0.11; 0.29)
Avg Brake Step Knee Flexion at GC (deg)	34.2 ± 7.02	33.1 ± 5.83	1.13 (-0.87; 3.14)	0.17 (-0.11; 0.48)
Avg Brake Step Position Relative to COM (cm) *	41.0 ± 4.28	36.1 ± 6.04	4.86 (3.19; 6.53)	0.91 (0.61; 1.31)

**Notes: "Avg." = Average, "DEC" = Deceleration, "N" = Newton, "deg" = degrees, "COM" = Centre of mass, "GC" = Ground contact, "CI" = 95% Confidence interval, "ES" = Effect size, Bold text indicated a statistically significant between-test difference.*

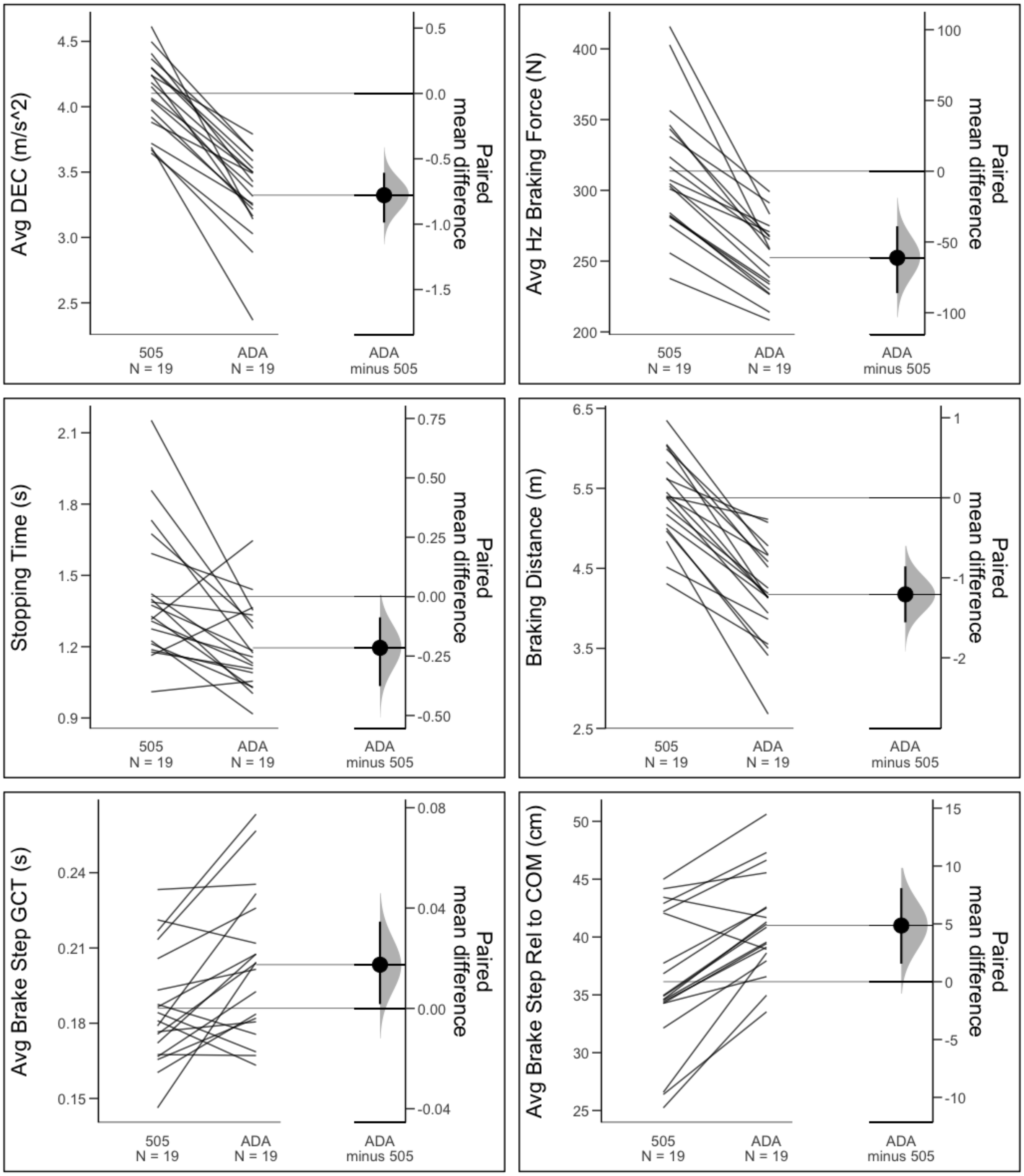


Figure 2. Gardner-Altman plots displaying between-test comparisons for metrics displaying significant differences.

DISCUSSION

The primary aim of the present study was to investigate biomechanical differences for measures of deceleration ability between the ADA test over 10 meters, and the 505 change of direction test. These tests are distinguished by the fact that the ADA possesses a predetermined point at which subjects initiate the deceleration phase, with no predetermined stopping point. On the other hand, during the 505 subjects are given a predetermined stopping/turning point. The findings suggest that six out of the twelve metrics of interest displayed significant between-test differences. Interestingly, all of these metrics came from the deceleration phase of the respective tests, while average approach velocity and momentum showed no significant differences and presenting with very small between-test effect sizes (ES = -0.04 to -0.11). This suggests that subjects initiated the deceleration phase under similar conditions. During the actual deceleration phase, between-test comparisons suggested that subjects exhibited significantly greater reductions in velocity during the 505 tests, compared to the ADA, exposing them to significantly greater magnitudes of horizontal braking force. Intriguingly, previous research comparing the ADA to the 505 suggested moderately higher magnitudes of average deceleration in the ADA, while maximal deceleration was found to be moderately larger in the 505 (Philipp et al. 2023). In our study, maximal deceleration was not analysed, however, it seems logical that the absence of a pre-determined stopping or turning point as seen within the ADA could influence the rate at which individuals reduce their running velocity. Furthermore, both stopping time and stopping distance were found to be significantly greater in the 505, compared to the ADA. With a mean stopping distance of 5.38 m, this suggests that subjects in the 505 likely initiated the deceleration phase at an earlier point in time. However, what must be acknowledged by readers is the lack of stability for both of the previously highlighted measures. Both metrics across respective tests presented with ICCs ranging from 0.13 to 0.56, and SEM values of 11.9 to 21% of the grand mean. While using a different technology to quantify these metrics, this agrees with earlier literature suggesting questionable degrees of reliability for stopping distance and stopping time (Ashton and Jones, 2019; Harper et al. 2020; Philipp et al. 2023). Readers are encouraged to refer to the MD values presented in Table 2, to conceptualize what kind of change in the said metrics of interest would be needed to be considered "*real*" or meaningful. For a decrease in braking distance performance to be considered "*real*" or meaningful, subjects would need to display reductions over 2.48 m in the ADA, and 1.92 min the 505, which in our opinion appears as high.

Furthermore, in the 505, subjects exhibited significantly shorter brake step ground contact times, as well as brake steps that were positioned significantly closer to the COM, when compared to the ADA. Previous research has shown that faster change of direction performers within the 505-test present with significantly shorter ground contact times, compared to their slower counterparts (Dos'Santos et al. 2017). However, in the aforementioned study, ground contact times were measured during the penultimate and final foot contact of the assessment, while in our study ground contact times were averaged across all brake steps during the deceleration phase. Both the previously mentioned study and the current investigation found similar findings of shorter ground contact times through different measurements. However, further research is warranted to determine if these results can be replicated. This may present as a useful addition to the body of evidence in the deceleration and change of direction space, given that most research is less concerned with the early braking steps during decelerations and change of direction manoeuvres. Nedergaard et al. proposed that investigations of lower limb loading during turning should include the sudden deceleration phase prior to turning, and not focus solely on the pivot foot-ground contact (Nedergaard et al. 2014). Previous research has investigated biomechanics of the antepenultimate, penultimate, as well as final foot contacts; however, little is known about what happens prior to that (Dos'Santos et al. 2021). Dos'Santos et al. found significantly greater peak braking forces over shorter ground contact times in the antepenultimate steps, compared to the penultimate step and final foot contact (Dos'Santos et al. 2021). This highlights the potential importance of analysing individual brake steps, in addition to calculating averages across the entire deceleration phase, which may give direction to future research questions. The shorter brake step ground contact times and brake steps that were positioned closer to the centre of mass may be due in part to the biomechanical and technical nature of the declaration phase within each respective assessment. It is probable that during the ADA, subjects exhibit a more "*traditional*" horizontal deceleration profile, which is characterized by a heel strike upon ground contact, a more posteriorly oriented torso, and a slightly flexed knee and hip, in order to efficiently reduce whole-body momentum (Hewit et al. 2011). On the other hand, during the 505, and in preparation for a 180-degree turn, subjects are likely going through additional postural adjustments in the deceleration phase, which are reflected in our results. More specifically, during the 505, subjects likely went through degrees of lateral trunk flexion, and greater internal foot progression angles, with the latter being related to significantly faster 505 completion times, and shorter final foot contact times (Dos'Santos et al. 2021). Ground contact decelerations did not reflect any significant differences between tests. However, a methodological limitation that should be taken into consideration here is that in our investigation, ground contact decelerations were calculated as the sum across the y-, x-, and z-direction, as derived from the IMU-units attached to the lower limbs, which makes it difficult to partial out further biomechanical strategies implemented by the subjects. For instance, in the work by Dos'Santos et al., in addition to shorter ground contact time, authors also suggested that greater horizontal braking and propulsive ground reaction forces during the penultimate step were found in subjects performing faster 180-degree turns (Dos'Santos et al. 2021). Similarly, as touched upon earlier, the same team of authors highlighted the importance of horizontal force production and braking strategies during the antepenultimate step, to facilitate faster change of direction performance (Dos'Santos et al. 2021). Future investigations should therefore aim to replicate methodologies, partialling out the direction of ground contact acceleration/deceleration using IMU technology or use force-plates to gather ground reaction force characteristics of the earlier brake steps. However, the latter may present as challenging, especially when trying to analyse the entire deceleration phase, in which between 4 and 6 meters of three-dimensional force plates would be needed.

In light of our findings and given the different layouts and characteristics of the ADA and the 505, a discussion of how a predetermined stopping point affects deceleration and change of direction performance deserves recognition. The present study found six out of twelve deceleration metrics (Avg DEC, Avg Horizontal Braking Force, Stopping time, Stopping distance, Avg Brake Step GCT, Avg Brake Step Position Relative to COM to have statistically significant differences between the two tests. When making a 180-degree turn, such as that during the 505, one has to undergo multiple postural changes in order to decrease their horizontal momentum to zero by not only rotating their trunk, but by planting their foot ahead of their COM to produce horizontal braking and propulsive impulse, followed by reaccelerating after horizontal momentum briefly reaches zero (Dos'Santos et al. 2017). In addition to these movement patterns, individuals must possess faster approach COM velocities along with medial trunk lean and internal pelvic and foot rotation (Dos'Santos et al. 2020). Athletes who can effectively perform the previously identified biomechanical movement patterns have the potential to achieve reduced stopping times in the 505 change of direction test. In a study by Dos'Santos et al. (2019), authors found that using external cues for cutting technique modification, was effective in improving cutting completion times, COD deficits, and movement quality in youth soccer players (Dos'Santos et al. 2019). Having a location that is already known for an individual to plant and turn at, could potentially have a similar effect of external cueing by developing motor skill retention and developing an individual's focus distance within their external focus of attention (Winkelman et al. 2018). By having the location predetermined, this forced each participant to not react, but rather prepare by taking shorter brake step ground contact times, as well as positioning brake steps closer to the COM. Understanding the role of how external cues may affect metrics identified in the present study in both the 505 and the ADA may allow for further confirmation of the motor skills needed to increase performance in these change of direction tests.

While authors believe the present study effectively adds to the body of literature, certain limitations should also be acknowledged when interpreting the findings of our investigation. For one, while test familiarization was provided during the warmup, the sample consisted of recreationally trained athletes with little prior experience in the implemented assessments, rather than higher-level athletes, who might present with more sufficiency. While speculative, this may have influenced the variability in some measures of deceleration performance. For example, while presenting with sufficient ICCs, deceleration phase COM drop being a metric reflecting the deceleration strategy, exhibited elevated SEM values displayed as a percentage of the grand mean, which may suggest substantial variability between individual subject trials. Future investigations should aim to further investigate the biological and technological reliability of the technology and assessments used in this study.

CONCLUSION

In summary, our study found differences across several biomechanical characteristics quantified during the deceleration phase when comparing the ADA to the 505 change of direction test. These differences displayed moderate to large between-test effect sizes. More specifically, subjects were found to exhibit significantly greater reductions in velocity and horizontal braking forces in the 505. Further, subjects showed significantly shorter stopping times and distances in the ADA, however, these displayed insufficient levels of reliability across both assessments, which should be interpreted as a limitation. Lastly, subjects showed significantly shorter brake step ground contact times in the 505, which were accompanied by shorter brake step distances with regard to their position relative to the COM. Therefore, it may be speculated that based on our data, the 505, which possesses a predetermined stopping/turning point presents a greater or different biomechanical challenge to individuals, which must be met with the appropriate neuromuscular and skill-related qualities to efficiently reduce whole-body momentum. Sport science practitioners may use the results presented in our study to enhance their decision-making processes in selecting assessments that target the quantification of maximal horizontal deceleration ability.

AUTHOR CONTRIBUTIONS

NMP – Conceptualization, methodology, data curation, data analysis, data visualization, writing original draft. AAS – Writing - review & editing. BRC – Writing – review & editing. DC – Writing – review & editing. QRJ – Writing – review & editing. ACF - Conceptualization, methodology, project supervision.

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