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Influence of maximal linear deceleration on lateral deceleration and shuffle performance in NCAA Power 4 basketball athletes

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Keywords:	Basketball Performance, Change of Direction, Lateral Shuffle, Braking, Multidirectional Deceleration
Abstract:	<p>The sport of basketball requires players to have high-level multidirectional deceleration performance to excel in training and match-play. Therefore, the aim of this present study was to investigate multidirectional deceleration performance to determine if maximal deceleration following linear running can differentiate performance in a lateral shuffle movement. One hundred and twenty-four male basketball athletes (age = 20.9 ± 1.2 years, height = 195 ± 14.3 cm, body mass = 89.9 ± 10.2 kg) from 10 different NCAA Power 4 basketball programs participated in this study. Deceleration ability was evaluated based on maximal deceleration (Decel Max) following a linear acceleration using a 10 m acceleration-deceleration ability (ADA) test and lateral deceleration using a 5-5 lateral shuffle test. The cohort was split by position (Guards and Bigs) and dichotomized into high and low deceleration capabilities (High Dec Bigs, High Dec Guards, Low Dec Bigs, Low Dec Guards) based on results from the 10m ADA. In the 5-5 lateral shuffle test, High Dec Bigs had significantly lower total time (3.68 ± 0.24 s) compared to the Low Dec Bigs (3.90 ± 0.32 s; ES = 0.78; $p < 0.001$), and High Dec Guards significantly lower total time (3.62 ± 0.23 s) than Low Dec Guards (3.76 ± 0.26 s; ES = 0.57; $p = 0.01$), as well as significantly higher Decel Max (Bigs ES = 0.93; Guards ES = 0.87). These findings highlight the relevance of linear deceleration capacity as a potential determinant of lateral movement performance in elite basketball.</p>

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3 **1 Influence of maximal linear deceleration on lateral deceleration and shuffle performance in**
4 **2 NCAA Power 4 basketball athletes**

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53 **24** **Keywords:** Basketball Performance, Change of Direction, Lateral Shuffle, Braking,
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55 **25** Multidirectional Deceleration

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5 27 **NCAA Power 4 basketball athletes**
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7 28

9 29 **Abstract**

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12 30 **The sport of basketball requires players to have high-level multidirectional** deceleration
13 31 performance to excel in training and match-play. Therefore, the aim of this present study was to
14 32 investigate multidirectional deceleration performance to determine if maximal deceleration
15 33 following linear running can differentiate performance in a lateral shuffle movement. One
16 34 hundred and twenty-four male basketball athletes (age = 20.9 ± 1.2 years, height = 195 ± 14.3
17 35 cm, **body mass** = 89.9 ± 10.2 kg) from 10 different *NCAA* Power 4 basketball programs
18 36 participated in this study. Deceleration ability was evaluated based on maximal deceleration
19 37 (Decel Max) following a linear acceleration using a 10 m acceleration-deceleration ability
20 38 (ADA) test and lateral deceleration using a 5-5 lateral shuffle test. The cohort was split by
21 39 position (Guards and Bigs) and dichotomized into **high and low deceleration capabilities** (High
22 40 Dec Bigs, High Dec Guards, Low Dec Bigs, Low Dec Guards) based on results from the 10m
23 41 ADA. In the 5-5 lateral shuffle test, High Dec Bigs had significantly lower total time (3.68 ±
24 42 0.24 s) compared to the Low Dec Bigs (3.90 ± 0.32 s; ES = 0.78; p < 0.001), and High Dec
25 43 Guards significantly lower total time (3.62 ± 0.23 s) than Low Dec Guards (3.76 ± 0.26 s; ES =
26 44 0.57; p = 0.01), as well as significantly higher Decel Max (Bigs ES = 0.93; Guards ES = 0.87).
27 45 **These findings highlight the relevance of linear deceleration capacity as a potential determinant**
28 46 **of lateral movement performance in elite basketball.**
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58 Introduction

59 The **sport** of basketball imposes high-intensity intermittent actions of cuts and changes of direction,
60 which require high acceleration and deceleration capacities in different locomotive patterns (e.g.
61 side shuffle and running)¹⁻⁵. As it pertains to shuffling, particularly on defense, the ability of the
62 athlete to rapidly reposition their center of mass in the frontal plane becomes a tactical advantage
63 when defending actions such as ball-screens, dribble handoffs, cuts, as well as preventing dribble
64 penetration to the basket. Therefore, the ability to occupy space defensively to force a low
65 percentage contested shot is a principal component to defensive success in basketball. In fact,
66 previous time motion analysis research in basketball from McInnes et al.⁶ observed that 31% of
67 basketball competition was spent in shuffling movement, with 20% being high-intensity shuffling
68 actions. Furthermore, previous literature has shown that the majority of acute lower extremity
69 injuries occur during maneuvers involving rapid multidirectional deceleration⁷⁻⁸. Thus, the ability
70 to perform high-intensity shuffling actions during match-play is a vital aspect of basketball
71 performance.

72 Previous literature has examined lateral shuffling in basketball players^{9-10,26}. For example,
73 Shimokochi et al.⁹ studied the kinetic and kinematic factors associated with lateral shuffling and
74 cutting in collegiate women's basketball and found that performance indicators were determined
75 by the athlete's ability to rapidly lower their center of mass in the lateral direction at the point of
76 zero velocity, and the capacity to quickly produce force and thereby change momentum and
77 accelerate in the opposite direction. Recently, Leidersdorf et al.¹⁰ examined lateral movement
78 within an elite basketball population, comparing a 5-5 lateral shuffle test to a lateral
79 countermovement jump on force platforms and found that faster shufflers generated significantly
80 more relative lateral force than the slower shuffling group. These findings suggest that there are
81 distinct characteristics for basketball athletes when translating laterally in frontal plane movement.

82 Deceleration performed following rapid linear acceleration is also another important physical
83 quality in basketball that is pertinent to both performance and potential risk of injury^{17-20,23}.
84 Previous literature has demonstrated that basketball athletes are exposed to larger volumes of high-
85 intensity decelerations than accelerations in competitions^{1-2,5,17}. Furthermore, the mechanical
86 demands imposed by high-intensity decelerations have been shown to be greater than that of high-
87 intensity accelerations²¹⁻²². These findings suggest that the ability to control high braking forces

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3 88 following rapid linear acceleration may have performance and prophylactic impacts within the
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5 89 sport of basketball. Harper et al.²⁷ investigated if athletes with high deceleration following linear
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7 90 acceleration could discriminate those with low deceleration in various vertical countermovement
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9 91 jump metrics. The key findings from this study were that the group with high deceleration also had
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11 92 moderate and large differences in vertical countermovement jump eccentric (ES = 0.72) and
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13 93 concentric peak forces (ES = 0.95), respectively. Deceleration following rapid acceleration,
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15 94 however, only quantifies the ability to brake in a posterior direction. In basketball, decelerations
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17 95 are performed in multiple directions based on the direction of locomotion such as **forwards,**
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19 96 **backwards, lateral and combinations of these.**

19 97 While it is evident that deceleration from rapid linear acceleration and lateral movements is
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21 98 important in the sport, there is a need to create standardized and repeatable tests and generate
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23 99 normative values in both lateral shuffling and following linear running movement patterns in elite
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25 100 basketball athletes. While previous biomechanical literature has advanced the field and
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27 101 understanding of lateral shuffling⁹⁻¹⁴, most practitioners do not have access to marker-based
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29 102 motion capture and embedded tri-axial force platforms in a lab-based setting. It is proposed that
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31 103 having ecologically valid means of measuring deceleration within lateral movement and following
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33 104 linear acceleration in basketball may also provide valuable means to evaluate and generate insights
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35 105 on these specific movement patterns that are relevant to training or rehabilitation. Motorized
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37 106 resistance devices (MRD) obtain reliable and valid continuous (i.e. time, distance, velocity, force)
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39 107 and phase-specific outcome measurements (i.e., acceleration, deceleration, re-acceleration)
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41 108 provide such a means for in-situ evaluations¹⁵⁻¹⁶. To the authors' knowledge no study has
42
43 109 investigated both deceleration following rapid linear acceleration and side shuffling (right and left
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45 110 lateral), movements in an elite basketball athletes. **Consequently, the purpose of this study was to**
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47 111 **investigate if maximal deceleration following linear acceleration can differentiate performance in**
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49 112 **a lateral shuffle movement measured using MRD technology.**

113 **Materials and Methods**

114 *Participants*

115 One-hundred and twenty-four players across 10 different NCAA Power 4 basketball teams
116 participated within this study. **Participants were categorized by position (Biggs and Guards). Biggs**
117 **were comprised of the positions of Forwards and Centers, whereas Guards were the composite of**

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3 118 Point Guards and Shooting Guards. Hybrid wings were vetted by the performance staff of each
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5 119 team to determine if the athlete were used tactical closer to the basket or on the perimeter and
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7 120 then grouped accordingly. Within this cohort there were fifty-four Bigs (age = 20.5 ± 1.4 years,
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9 121 height = 204.4 ± 7.6 cm, body mass = 102.1 ± 7.9 kg) and seventy Guards (age = 21.2 ± 1.1
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11 122 years, height = 190.5 ± 5.1 cm, body mass = 86.2 ± 4.5 kg). Given the achieved sample size, a
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13 123 sensitivity analysis indicates sufficient power (80% , $p \leq 0.05$) to detect moderate between-group
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15 124 effects (Cohen's $d = 0.50$). Each participant had an injury-free status and was cleared to
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17 125 participate by the team's health and performance staffs. All able roster athletes for each team
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19 126 participated within this study. Written consent was obtained from each athlete prior to
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21 127 participation and institutional review approval was attained via Mississippi State University
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23 128 (IRB-24-390).

23 129 *Procedures*

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25 130 The same researcher performed on-site data collection at the team's practice facility or arena court
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27 131 for all 10 teams. All data was collected within the same 2-week period of the NCAA Collegiate
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29 132 Basketball preseason. For familiarization, every team's performance staff was sent a protocol of
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31 133 each of these tests a month prior to on-site data collection to have multiple exposures for the
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33 134 athletes. The participants wore the same footwear and performed the tests on the same hardwood
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35 135 surface as training or competitions. Each athlete performed a standardized warm-up prior that
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37 136 included dynamic stretching, skipping patterns, acceleration and deceleration, as well basketball
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39 137 specific locomotor patterns prior to participating.

40 138 Following the warm-up, maximal deceleration ability was assessed using a 10-meter acceleration-
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42 139 deceleration ability (10 m ADA) test²⁴. Upon the initiation of the test the athletes were positioned
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44 140 at the starting position (0 m mark). Three 5 m segments were demarcated with orange traffic cones
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46 141 (45 cm height) and blue painters' tape. The athletes started in a self-selected two-point staggered
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48 142 position. The athletes were instructed to accelerate as hard and as fast as possible passing the 10m
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50 143 mark before performing a maximal deceleration. After the maximal deceleration, the players
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52 144 backpedaled to the 10 m mark to clearly delineate the end of the deceleration phase.

53 145 After the 10 m ADA, modified 5-5 shuffle tests were performed with both left and right foot turns
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55 146 to assess lateral change of direction (COD) ability and lateral deceleration performance⁹⁻¹⁰. The
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57 147 athletes were positioned parallel to the sideline and perpendicular to the baseline of the basketball

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3 148 court. The athlete starting positions (0 m mark) were in a two-point athletic stance with a self-
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5 149 selected vertical position (i.e., magnitude of hip-, knee- and ankle dorsiflexion). The athletes were
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7 150 instructed to shuffle as fast as possible to a 5 m mark, which was marked by an orange traffic cone
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9 151 (45 cm height) and blue painters' tape, laterally change direction with the foot touching the blue
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11 152 tape, before re-accelerating and shuffle back to the start mark. The athletes were instructed to
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13 153 shuffle through the finish line (0 m mark) and not cross their feet while shuffling. Each athlete
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15 154 performed two repetitions: one facing the sideline with the right foot leading, and one facing the
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17 155 opposite sideline with the left foot leading. For standardization, each athlete performed the first
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19 156 trial with the right foot leading, followed by a trial with the left foot leading. The mean value of
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21 157 the 5-5 shuffle test for both left and right foot turns was used for analysis. While only one trial per
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23 158 direction was used for analysis, previous work using the same MRD under comparable conditions
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25 159 demonstrate good reliability for phase-specific deceleration and COD metrics^{15,16}.

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27 160 During both the 10 m ADA and the 5-5 shuffle test, a portable MRD (1080 Sprint; 1080 Motion,
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29 161 Lidingö, Sweden) was attached to that athlete's waist and used to measure instantaneous velocity,
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31 162 distance, time and pulling force. Data was recorded at 333 Hz with a 1.3 Hz fourth order
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33 163 Butterworth lowpass filter applied prior to extraction of all outcome measurements. Resisted and
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35 164 assisted load and speed settings were set to 3 kg and 14 m/s (maximum speed allowed),
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37 165 respectively. This was done to allow for comparison to previous research³⁰. The effects of the 3 kg
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39 166 load are expected to be minimal, and it was the same load used in both validation¹⁵ and reliability
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41 167 analysis¹⁶ of deceleration and change of direction testing. Both the ADA and 5-5 Shuffle Test were
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43 168 performed with an assisted start, which is the athlete initiating the movement toward the MRD,
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45 169 with the MRD positioned 3 m behind the baseline and 18 m away from the starting position for
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47 170 the ADA test. During the 5-5 shuffle test the MRD was also positioned 3 m behind the baseline of
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49 171 the court and 8 m away from the starting position. A diagram of set-up for both the 10 m ADA and
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51 172 5-5 Shuffle Test is presented in Figure 1. Definitions of all outcome variables have been presented
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53 173 previously³⁰ and summarized in Table 1 for clarity of the 5-5 Shuffle Test.

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****Insert Table 1****

*****Insert Figure 1*****

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178 Statistical Analysis

179 All participants were classified into two positions (Guards and Bigs) and dichotomized into **High**
180 **Deceleration (High Dec)** and **Low Deceleration (Low Dec)** groups based on a median split analysis
181 of maximal deceleration measured during the 10 m ADA test. Consequently, the categories were
182 listed as High Dec Big, Low Dec Big, High Dec Guard, and Low Dec Guard.

183 Differences in 5-5 lateral shuffle variables between high- and low- deceleration ability for both
184 positional groups, as defined from ADA deceleration performance, were assessed using an
185 independent sample *t-test*. Descriptive data were calculated using Microsoft Excel (Microsoft
186 Corp., Redmond, WA, USA) and presented for mean and standard deviation. All data were
187 assessed using the Shapiro-Wilk test and Q-Q plots for normality. The statistical analysis was
188 performed using Jamovi (**version 2.3.6**), statistical inferences were made by using an alpha level
189 of $p < 0.05$. The magnitude of differences was calculated using Cohen's *d* effect sizes, which were
190 interpreted as trivial ($d \leq 0.19$) small ($d = 0.2-0.49$), moderate ($d = 0.50-0.79$), or large ($d \geq 0.80$)²⁵.

191 Results

192 Descriptive data of the 10m ADA test for High and Low Dec groups split by positions is presented
193 in Table 2. A large significant difference was observed between high and low Decel Max for both
194 Bigs (**High = 7.74 ± 0.49 m/s² vs. Low = 5.74 ± 1.38 m/s²; ES = 1.93; $p < 0.001$) and Guards (High**
195 **8.04 ± 0.42 vs. Low 6.77 ± 0.50 m/s²; ES = 2.71; $p < 0.001$). Furthermore, we observed a large**
196 **significant difference for Decel Time between High and Low Dec Bigs (High 1.23 ± 0.06 s vs.**
197 **Low 1.40 ± 0.22 s; ES = -1.07; $p < 0.001$) and Guards (High 1.19 ± 0.06 s vs. Low 1.29 ± 0.08 s;**
198 **ES = -1.39; $p < 0.001$).**

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Insert Table 2

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202 There were significant positional differences in 5-5 Lateral Shuffle test performance. High Dec
203 Bigs had lower Total Time (3.68 ± 0.24) than Low Dec Bigs (3.90 ± 0.32 ; ES = 0.78; $p < 0.001$)
204 for the 5-5 Lateral Shuffle test. Similarly, High Dec Guards had lower Total Time (3.62 ± 0.23)

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3 205 than Low Dec Guards (3.76 ± 0.26 ; ES = 0.57; $p = 0.01$). Top speed for phase 1a and 1b displayed
4 206 moderate effect size differences between High and Low Dec for Bigs (phase 1a = -0.62; phase 1b
5 207 = -0.63) and Guards (phase 1a = -0.75; phase 1b = -0.90). Decel Max displayed large effect size
6 208 differences in both positions (Bigs ES = -0.93; Guards ES = -0.87). Re-acceleration (Max Accel
7 209 1b) displayed moderate differences between High and Low Dec for Bigs (-0.61) and Guards (-
8 210 0.50), while small (-0.33) and trivial (-0.04) effects were observed for acceleration (Max Accel
9 211 1a) for Bigs and Guards, respectively. All outcome measurements with between group comparison
10 212 for the 5-5 Lateral Shuffle is presented in Table 3.
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20 214 *** Insert Table 3***

21 215 Discussion

22 216 The aim of this study was to describe multidirectional deceleration performance according to
23 217 **global** position in elite collegiate basketball athletes to determine if maximal deceleration
24 218 following rapid linear acceleration can differentiate performance in a lateral shuffle movement.
25 219 Our findings indicate that Decel Max following linear acceleration can differentiate lateral
26 220 deceleration performance, the High Dec group (based on Decel Max in a 10 m ADA test)
27 221 significantly outperforming their Low Dec counterparts in 5-5 lateral shuffle Total Time and Max
28 222 Decel. In particular, the Decel Max metric, derived from the 5-5 lateral shuffle displayed a large
29 223 and significant difference when comparing the **High and Low Dec** groups in the 10m ADA, a
30 224 **pattern** observed for both Guards and Bigs.
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41 225 In the present sample, Decel Max values ranged between $5.74 - 8.04 \text{ m}\cdot\text{s}^{-2}$ in the ADA test and
42 226 between $6.23 - 7.57 \text{ m}\cdot\text{s}^{-2}$ in the lateral shuffle. These values indicate a need for basketball athletes
43 227 to possess the ability to generate and tolerate rapid **braking** forces when decelerating in multi-
44 228 directional movements. In both Bigs and Guards, High Decel Max performance in the ADA test
45 229 was associated with High Decel Max in the 5-5 lateral shuffle test. Furthermore, deceleration times
46 230 were also lower, with large effect sizes, for both High Dec groups. This is logical considering that
47 231 a greater deceleration capacity will allow a player to slow down in a shorter amount of time and
48 232 distance. Differences in deceleration times between groups (Bigs: 0.17 s; Guards: 0.10 s) did not
49 233 only have large effect sizes but were also greater than the moderate worthwhile change values
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3 234 (0.04 to 0.05 s) of the 10-0-5 CoD test, which is the test most comparable to the ADA, based on
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5 235 observed top speed (5.95 to 5.96 m·s⁻¹)³¹. In addition, we observed large effect size differences in
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7 236 Top Speed 1a (Bigs: 0.35 m·s⁻¹; Guards: 0.25 m·s⁻¹) with values greater than moderate worthwhile
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9 237 change (0.21 to 0.22 m·s⁻¹) from a 10-0-5 CoD test³¹. **These differences in Top Speed 1a highlight**
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11 238 **the importance of the ability to achieve high max velocities to generate large Decel Max values**
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13 239 **and decreases in total time to completion.** In summary, it appears that the players with greater
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15 240 deceleration ability in the ADA also have that in the 5-5 lateral shuffle test, both achieving a greater
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17 241 top speed and decelerating in a shorter time frame.

18 242 The ability to decelerate in a running locomotive pattern (ADA) was consistently greater than in
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20 243 the 5-5 lateral shuffle test for both High Dec Big and Guards. Specifically, the ADA mean Decel
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22 244 Max for High Dec Bigs (7.74 m·s⁻²) was greater than during the 5-5 lateral shuffle test (6.92 m·s⁻²).
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24 245 Interestingly, this trend was reversed for Low Dec Big with a greater Decel Max observed
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26 246 during the 5-5 lateral shuffle test (6.32 m·s⁻²) than in the ADA test (5.74 m·s⁻²), a pattern also
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28 247 observed in the guards. Specifically, the ADA (8.04 m·s⁻²) Decel Max for High Dec Guard was
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30 248 greater than during the 5-5 lateral shuffle test (7.57 m·s⁻²), while Low Dec Guard had a greater
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32 249 Decel Max in the 5-5 lateral shuffle (6.93 m·s⁻²) than in the ADA test (6.77 m·s⁻²). We also noted
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34 250 a wider distribution of deceleration performances on the ADA as compared to the 5-5 lateral
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36 251 shuffle test.

37 252 Deceleration performance during the ADA test differentiated deceleration performance during the
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39 253 5-5 lateral shuffle test. Specifically, Decel Max was the only outcome measurement with large
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41 254 effect sizes for both Bigs and Guards. The observed differences (Bigs: 0.60 m·s⁻²; Guards: 0.64
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43 255 m·s⁻²) were greater than the moderate worthwhile change (0.45 to 0.48 m·s⁻²) of a m505 CoD test
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45 256 values in previous literature³¹. Furthermore, a similar pattern to the ADA was observed for both
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47 257 Decel Time and Top Speed, with moderate effect sizes and group differences greater than moderate
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49 258 worthwhile changes of the m505 CoD test³¹. Based on these observations one might expect Phase
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51 259 1a times to be shorter, but this was only observed for the Bigs (0.22 s), with a moderate effect and
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53 260 a group difference greater than the moderate worthwhile change for both m505 and 10-0-5 CoD
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55 261 tests (0.08 to 0.10 s). In contrast, a trivial effect was observed for Phase 1a time for Guards, with
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57 262 an observed group difference of 0.06 s. This suggests that if deceleration capacity is an important

263 variable to target or profile in lateral shuffle, Phase 1a time may not be a good variable to group
264 players, except possibly for Bigs.

265 Notably, all outcome measurements (time, Max Accel and Top Speed) associated with phase 1b
266 had moderate to large effect size differences between groups. In addition, shorter times were
267 observed in phase 1b (Bigs: 1.64 s; Guards: 1.65 s) as compared to phase 1a (Bigs: 2.03 s; Guards:
268 1.97 s). **This could be due to the stretch-shortening components associate with phase 1b be after
269 the point of zero velocity opposed to the static initiation of phase 1a.** One variable of particular
270 interest during both phases is Max Accel. Specifically, small and trivial effects between groups
271 were observed for Max Accel during Phase 1a, while moderate effects were observed in Phase 1b
272 for both Bigs and Guards. Furthermore, the differences in magnitude of Max Accel between phases
273 is also of interest. Specifically, Max Accel during Phase 1a (Bigs and Guards: $3.81 \text{ m}\cdot\text{s}^{-2}$) is lower
274 than Max Accel during the re-acceleration in Phase 1b (Bigs: $5.28 \text{ m}\cdot\text{s}^{-2}$; Guards: $5.36 \text{ m}\cdot\text{s}^{-2}$). Of a
275 number of possible explanations for this finding, we speculate that the 5 m distance may be too
276 long for a lateral shuffle test for basketball athletes since in practice and game situations players
277 will use lateral shuffles for two to three steps ($< 5 \text{ m}$) and change locomotive pattern if increased
278 speed is required. Thus, the players tested may recognize this and pace themselves with a lower
279 initial Max Accel during Phase 1a, since they will easily be able to achieve a Top Speed that they
280 are comfortable decelerating from. However, Top Speed during Phase 1a is similar to Phase 1b.
281 Specifically, Top Speed for Bigs (Phase 1a: $3.76 \text{ m}\cdot\text{s}^{-1}$; Phase 1b: $3.68 \text{ m}\cdot\text{s}^{-1}$) and Guards (Phase
282 1a: $4.00 \text{ m}\cdot\text{s}^{-1}$; Phase 1b: $3.83 \text{ m}\cdot\text{s}^{-1}$) are not different based on moderate worthwhile change from
283 reliability statistics³¹. Thus, phase-specific Top Speed does not explain why Max Accel was greater
284 in Phase 1b. The Max Accel differences may be due to the players wanting to change direction
285 faster, and that change of direction laterally does not happen from a static position in game
286 situations, but rather from entry velocities in different directions. When examining the sports-
287 specific context, the primary actions during basketball match-play are cuts, shuffles and CODs. In
288 fact, basketball players have a high frequency of lateral movement in competition, of up to 450
289 exposures per game²⁹. Therefore, it is plausible that practitioners working in basketball should
290 emphasize phase-specific training to enhance both deceleration and re-acceleration capabilities,
291 particularly in defensive scenarios.

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3 292 Our analysis highlights specific positional differences in performance in these tests. Max Decel is
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5 293 greater in both High and Low Dec Guard as compared to High and Low Dec Big, differences likely
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7 294 to be due to differences in limb lengths and body mass between positions, and in positional
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9 295 demands within the tactical context of basketball. For example, guards are typically on the
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11 296 perimeter and tasked with defending the primary ball handler defensively. In contrast, the Bigs are
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13 297 typically taller and longer based on anthropometrics and more than likely going to protect the shots
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15 298 at the rim defensively. Recent literature investigated positional differences in match-play demands
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17 299 within basketball and found that guards complete more high-intensity shuffles and changes of
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19 300 direction than Bigs²⁸. These differing positional demands align with our findings with respect to
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21 301 greater Max Decel values of Guards in the 5-5 Lateral Shuffle test when compared to the Bigs.

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23 302 While our key finding indicates that within elite college basketball better maximal horizontal
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25 303 deceleration was associated with better lateral shuffling performance is pertinent to practitioners
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27 304 working in basketball, and potentially other sports, there are some limitations that must be
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29 305 addressed. While MRD has been validated for COD assessment using tethered resistance and
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31 306 assistance could influence changes in kinematic strategies based on body mass and limb length.
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33 307 The use of a fixed 3 kg resistive load across athletes introduces relative loading differences
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35 308 between lighter and heavier players, which may partially influence absolute deceleration values.
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37 309 Future work should examine mass-normalized loading strategies. Also, the cross-sectional nature
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39 310 of the study means that despite the observed association we cannot conclude that training
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41 311 interventions leading to improvement in horizontal deceleration would also enhance lateral
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43 312 performance or vice versa. This would need to be examined in further research examining
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45 313 training interventions. In addition, data collection was conducted during the collegiate basketball
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47 314 pre-season and the analysis based on a single testing session, factors such as training load,
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49 315 match-play congestion, injury, and residual or accumulated fatigue may also cause these
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51 316 posterior and lateral deceleration outputs to fluctuate throughout the competitive season.
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53 317 Furthermore, tactical methodologies from the head coach combined with the general physical
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55 318 preparation prescribed by performance staff will dictate the amount of exposure to high-
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57 319 threshold decelerations in training. How tactical coaches determine best practice to defend ball-
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59 320 screens, cuts, and dribble handoffs; as well as their principles on spacing offensively and
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321 defensively will also have an impact on an athletes' most effective strategy to decelerate
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posterior and laterally. Potentially, teams with low exposure due to tactical methodologies may

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3 323 need to provide this stimulus in a controlled manner to ensure adequate capacity and injury risk
4 324 mitigation. Future research is needed to determine how these global inputs may influence
5 325 deceleration outputs.
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8 9 326 **Conclusion**

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11 327 In a large cohort of elite collegiate basketball athletes, we found a transfer of capacity between
12 328 horizontal deceleration and lateral shuffling performance when players were grouped by position.
13 329 This provides novel evidence of a significant association between better maximum deceleration in
14 330 the ADA and proficiency in the lateral shuffle, highlighting shared neuromuscular qualities. The
15 331 findings from this present study support the evaluation and benchmarking of the 10 m ADA and
16 332 5-5 lateral shuffle test in elite team sports. In basketball, having a greater ability to rapidly
17 333 decelerate and translate their center of mass within the frontal plane is advantageous in contesting
18 334 shots defensively and for creating uncontested shots offensively. A greater understanding of the
19 335 factors underpinning the association between horizontal deceleration and lateral movements may
20 336 therefore increase performance outputs, as well as contribute to efforts to minimize risk of injury
21 337 within elite basketball.
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30 31 338 **Statements and Declarations**

32 33 34 339 **Ethical consideration**

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37 340 This study received institutional review approval via Mississippi State University (IRB-24-390).
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39 341 **Consent to participate**

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41 342 Written informed consent was obtained from all participants prior to participation in the study.
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44 343 **Consent for publication**

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46 344 All data presented in the current study is deidentified. Therefore, consent for publication is not
47 345 applicable.
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50 51 346 **Declaration of conflicting interest**

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54 347 The author(s) declared no potential conflicts of interest with respect to the research, authorship,
55 348 and/or publication of this article.
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3 **349 Funding statement**
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6 **350 The author(s) reported that there is no funding associated with the work featured in this article.**
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9 **351 Data availability**
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11 **352 The data that support the findings of this study are available on request from the corresponding**
12 **353 author, [AJP]. The data are not publicly available due to privacy issues.**
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19 **355 References**
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24 446 **Table 1:** Description and definitions of 5-5 Lateral Shuffle outcome variables

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Phase	Variable	Abbreviation	Definitions or calculations
Full			From the start of the measurement ($0.2 \text{ m}\cdot\text{s}^{-1}$ trigger in MRD) back to the start/finish line. Note. phase 1a + phase 1b as defined below
1a			Phase 1a was defined as the phase from the start of the measurement ($0.2 \text{ m}\cdot\text{s}^{-1}$ trigger in MRD) to when velocity changed direction (V_0).
1b			Phase 1b was defined as the phase from V_0 until the same distance as measured in phase 1a was covered.
Full	Total time (s)	Total time	Time to complete full test
	Total distance (m)	Total dist	Total distance covered in full test
1a	Time (s)	Time 1a	Time to complete phase 1a
	Distance (m)	Dist 1a	Distance covered during phase 1a
	Top speed ($\text{m}\cdot\text{s}^{-1}$)	Top Speed 1a	Maximum speed during phase 1a
	Maximum acceleration (m/s^2)	Accel Max 1a	The 0.5 second time-interval with the greatest average acceleration during phase 1a.
	Maximum deceleration ($\text{m}\cdot\text{s}^{-2}$)	Decel Max	The 0.5 second time-interval with the greatest average deceleration during phase 1a.
	Deceleration time (s)	Decel time	Time from Top Speed 1a to V_0
1b	Time (s)	Time 1b	Time to complete phase 1b
	Distance (m)	Dist 1b	Distance covered during phase 1b
	Top speed (m/s)	Top Speed 1b	Maximum speed during phase 1b
	Maximum acceleration (m/s^2)	Accel Max 1b	The 0.5 second time-interval with the greatest average maximum acceleration during phase 1b.

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473 **Table 2.** Descriptive statistics of the ADA test showing differences between high- and
 474 low- deceleration groups based on position.

Metric	High Dec Big		Low Dec Big		ES	Descriptor	p	High Dec Guard		Low Dec Guard		ES	Descriptor	p
	Mean ± SD	CI (95%)	Mean ± SD	CI (95%)				Mean ± SD	CI (95%)	Mean ± SD	CI (95%)			
Decel Max	7.74 ± 0.49	7.54; 7.93	5.74 ± 1.38	5.17; 6.31	1.93	Large	<.001	8.04 ± 0.42	7.89; 8.19	6.77 ± 0.50	6.58; 6.95	2.71	Large	<.001
Decel Time	1.23 ± 0.06	1.20; 1.25	1.40 ± 0.22	1.31; 1.49	-1.07	Large	<.001	1.19 ± 0.06	1.16; 1.21	1.29 ± 0.08	1.26; 1.32	-1.39	Large	<.001
Accel Max	5.72 ± 0.20	5.80; 5.94	4.90 ± 0.17	4.83; 4.97	0.35	Small	0.316	5.81 ± 0.23	5.73; 5.98	5.83 ± 0.26	5.74; 5.92	0.09	Trivial	0.969
Top Speed	6.07 ± 0.20	5.98; 6.17	5.72 ± 0.24	5.60; 5.84	1.33	Large	<.001	6.27 ± 0.44	6.18; 6.36	6.03 ± 0.22	5.93; 6.12	0.93	Large	<.001

475 Definition and description of all outcome variables are presented in Table 2. Abbreviations: SD = Standard Deviation; 95% CI =
 476 95% confidence interval; ES = Effect Size; p = p-value

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Table 3. 5-5 Lateral Shuffle outcome measurements for High- and Low Dec Bigs and Guards

Phase	Metric	High Dec Big			Low Dec Big			High Dec Guard			Low Dec Guard		
		Mean \pm SD	ES (95% CI)	Descriptor	p-value	Mean \pm SD	ES (95% CI)	Descriptor	p-value	Mean \pm SD	ES (95% CI)	Descriptor	p-value
Total	Time	3.68 \pm 0.24	3.90 \pm 0.32	0.78 (0.11; 0.33)	Moderate	<.001	3.62 \pm 0.23	3.76 \pm 0.26	0.57 (-0.22; -0.05)	Moderate	0.01		
	Time	2.03 \pm 0.16	2.12 \pm 0.19	0.51 (0.02; 0.16)	Moderate	0.01	1.97 \pm 0.15	2.03 \pm 0.11	0.44 (-0.10; -0.01)	Small	0.01		
1a	Accel Max	3.81 \pm 1.12	3.43 \pm 1.17	-0.33 (-0.83; 0.07)	Small	0.09	3.81 \pm 1.33	3.76 \pm 0.70	-0.04 (-0.32; 0.42)	Trivial	0.78		
	Top Speed	3.76 \pm 0.24	3.59 \pm 0.29	-0.62 (-0.27; -0.06)	Moderate	0.02	4.00 \pm 0.29	3.79 \pm 0.25	-0.75 (0.11; 0.30)	Moderate	<.001		
	Decel Time	0.74 \pm 0.11	0.83 \pm 0.19	0.54 (0.02; 0.14)	Moderate	0.07	0.68 \pm 0.10	0.74 \pm 0.12	0.54 (-0.10; -0.02)	Moderate	0.02		
	Decel Max	6.92 \pm 0.62	6.32 \pm 0.64	-0.93 (-0.84; -0.34)	Large	<.001	7.57 \pm 0.69	6.93 \pm 0.76	-0.87 (0.38; 0.89)	Large	<.001		
1b	Time	1.64 \pm 0.13	1.77 \pm 0.18	0.81 (0.06; 0.19)	Large	<.001	1.65 \pm 0.13	1.73 \pm 0.18	0.50 (-0.13; -0.02)	Moderate	0.01		
	Accel Max	5.28 \pm 0.34	4.97 \pm 0.61	-0.61 (-0.49; -0.10)	Moderate	0.03	5.36 \pm 0.39	5.14 \pm 0.45	-0.50 (0.06; 0.36)	Moderate	0.01		
	Top Speed	3.68 \pm 0.26	3.51 \pm 0.28	-0.63 (-0.27; -0.06)	Moderate	0.02	3.83 \pm 0.27	3.58 \pm 0.25	-0.90 (0.14; 0.33)	Large	<.001		

Definition and description of all outcome variables are presented in Table 3.

Abbreviations: SD = Standard Deviation; ES = Effect Size; 95% CI = 95% confidence interval.

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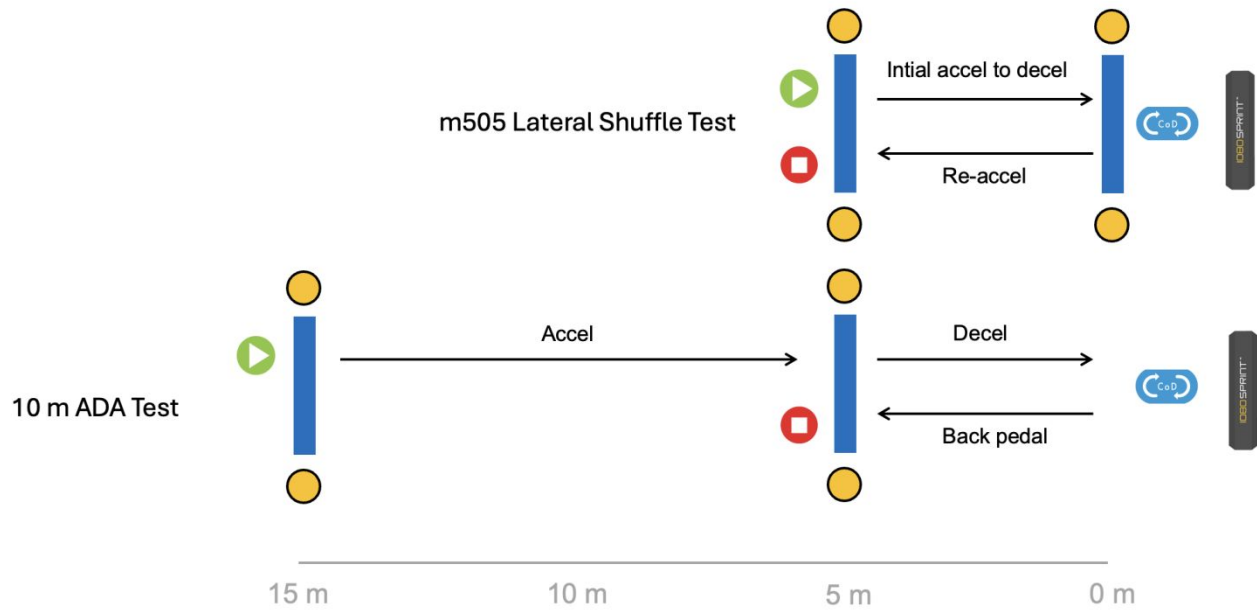
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520 **Figure 1. Visual representation of the setup for Lateral Shuffle Test and 10m ADA Test**



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