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Original Research

Relationships between Playing Time and Selected NBA Combine Test Performance in Division I Mid-Major Basketball Players

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ABSTRACT

International Journal of Exercise Science 13(4): 583-596, 2020. There has been limited analyses of DI mid-major male basketball players, and no analyses of relationships between athletic abilities and playing time in this population. The purpose of this study was to (1) describe and compare backcourt and frontcourt players from one mid-major team and (2) determine if there were relationships between playing time (total minutes, total games played, minutes per game) and select tests from the NBA Combine (height, body mass, standing reach, and wingspan; countermovement [VJ] and approach [AppVJ vertical jump], lane agility drill, ¾ court sprint, and 83.91-kg bench press). A retrospective analysis of data from the 2018 season for a men's DI team (n = 10) was conducted. Performance testing was completed in the pre-season, and playing time metrics were collated by the team's staff over the season. Players were split into backcourt (n = 6) and frontcourt (n = 4) groups and compared via independent samples t-tests ($p < 0.05$) and effect sizes (d). Pearson's correlations calculated relationships between playing time metrics and the NBA combine test data ($p < 0.05$). When compared to the backcourt group, the frontcourt group were significantly taller, heavier, had a greater standing reach and wingspan, and performed poorer in the VJ, AppVJ, and ¾ court sprint (d = 1.49-3.45). There were no significant relationships between playing time and any NBA Combine test (r = -0.363-0.511). Basketball-specific skill may have a larger impact on playing time in this mid-major team. However, the mid-major players in this study may have had above-average athletic abilities as measured by NBA combine testing, limiting correlations with playing time.

KEY WORDS: Change-of-direction speed, college athletes, minutes per game, linear speed, lower-body power, standing reach, upper-body strength, wingspan

INTRODUCTION

Basketball is a physically demanding, intermittent team sport, which involves predominantly low-intensity activity (e.g. walking, jogging) intermixed with high-intensity actions (e.g. sprinting, jumping) (2, 3, 44). Players can complete between 40-60 short sprints, over 40 jumps, and approximately 100 high-intensity basketball-specific movements that commonly involve

direction changes during a game (3). As a result of these demands, strength and conditioning coaches will often use tests to measure the physical qualities important for the sport. Testing data can be very useful, as this information can be used to profile an athlete's strengths and weaknesses, determine training progress, and assess an individual's athletic talent and potential in a sport (35).

Specific to elite basketball, prior to entering the draft for the National Basketball Association (NBA), certain players will participate in the NBA Combine. The NBA Combine consists of a series of test measurements and drills, including anthropometrics (e.g. height, body mass, standing reach, and wingspan), athletic abilities (e.g. countermovement and approach vertical jump [VJ and AppVJ, respectively], lane agility drill [LAD], ¾ court sprint, reactive shuttle run, and 83.91-kg [185-lb] bench press completed for repetitions), shooting skills, and scrimmages between prospective players (37, 46). Players are invited to participate based on their previous performance during collegiate or international basketball play (36). There may be potential limitations with these tests; for example, the ¾ court sprint exceeds sprint distances typically covered during a basketball match (3, 44). Nonetheless, these are still standard tests used to assess collegiate basketball players before they transition to the professional ranks (46). In addition to this, Teramoto et al. (46) noted the value of NBA Combine testing, with certain variables predicting future on-court performance, such as length-size (anthropometrics), power-quickness (jumps, sprints), and upper-body strength (bench press). Due to its importance and potential value (34, 36, 43, 46), collegiate coaches may use NBA Combine tests to assess the athletic abilities of their own players during a season. Although there is no available data stating how many programs use the NBA Combine performance tests, anecdotally players are aware that these tests are used in the lead-up to the NBA Draft. As a result, the use of NBA Combine tests (regardless of their potential limitations) can assist with buy-in from the players, as it provides feedback as to how comparable they are to players drafted in previous years.

Nonetheless, a player's on-court performance is still the most important factor in determining the quality of a basketball player (36). The simplest metric of a player's value to their team is playing time; better players should spend more time on the court than players of lower abilities players. There has been some analysis of the relationships between fitness testing data and playing time at the collegiate level of play (8, 13, 34). Dawes et al. (8) found that estimated one-repetition maximum (1-RM) bench press (r = 0.71) and back squat (r = 0.74) measured during pre-season significantly correlated with total minutes played in a season for Division II (DII) male basketball players. In a major Division I (DI) basketball program, Hoffman et al. (13) found that lower-body strength (1-RM back squat), lower-body power (VJ), and aerobic fitness (2.4-km run) correlated with playing time (r = 0.52-0.64) across four years of analysis. Specific to selected NBA combine tests, McGill et al. (34) found that the LAD significantly correlated with playing time (minutes per game; MPG) in players from a major collegiate basketball program (r = -0.594), although the VJ (r = 0.39) and ¾ court sprint (r = -0.06) did not.

There have been limited analyses of relationships between playing time and NBA Combine tests for DI mid-major programs. Mid-major schools tend to have less available finances compared to major conference schools (41), and this can influence the type of athletes recruited (4).

Superior athletes, especially in major sports such as football and basketball, will tend to be recruited to major schools from Power 5 conferences that have superior finances (and thus scholarships), facilities, and a history of success (4, 16, 17). Thus, the physical qualities of these mid-major players relative to playing time should be specifically analyzed. The strength and conditioning coach at the mid-major level could have greater influence on enhancing physical abilities that relate to playing time, especially if the athletes at this level are anecdotally perceived as being lesser than those in major programs. Indeed, one of the goals of the strength and conditioning coach is to physically prepare all players such that they have the requisite athletic abilities and can play at an optimal level during a game, irrespective of the head coaches' final decision about playing time.

Therefore, the purpose of this study was to initially describe a DI mid-major men's collegiate basketball team As previous research has indicated anthropometric and physiological differences between backcourt (guards) and frontcourt (forwards and centers) players (11, 42, 45), this was also assessed in the current study. The second and primary goal of this study was to provide a preliminary analysis of the relationships between playing time (total minutes from the season [MIN], total games played [GP], and MPG) (8, 34) and selected NBA Combine tests (height, body mass, standing reach, and wingspan; VJ and AppVJ; LAD and ¾ court sprint; and the 83.91-kg bench press) (34, 46). The coaching staff from this school did not include the reactive shuttle run as they did not have the equipment to truly induce reactive conditions required for this test (37). Additionally, there was a significant correlation (r=0.45) between the LAD and shuttle run when considering data from players between 2010-2017 (37), which provides some indication of crossover between the tests. Firstly, it was hypothesized that the frontcourt players would be larger in stature and complete more bench press repetition than the backcourt players, but the backcourt players would perform better in the jump and running tests (11, 42, 45). Secondly, and as previous research has shown inconsistent relationships between select fitness tests and playing time (8, 13, 34), it was hypothesized that the NBA Combine tests would not significantly correlate with the playing time metrics for the mid-major DI players.

METHODS

Participants

A retrospective analysis of existing data was conducted on one men's DI collegiate basketball team, which encompassed 10 players. Only players with full data sets were considered for analysis in this study. Descriptive data for the sample is shown in Table 1 in the Results section. The approach and sample for this study was similar to that undertaken by Dawes et al. (8). All players were required to be actively competing and training with the team, and as stated, only those players with full data sets from pre-season testing were included in this study. The data arose as a condition of monitoring conducted by the team's coaching staff. All staff members were Certified Strength and Conditioning Specialists, and followed standard procedures and guidelines to ensure accurate testing data collection (35, 39). Although data was not collected for the express purpose of research, the strict procedures adhered to by the staff ensured the data that was collected was as accurate as possible. The institutional ethics committee approved the use of pre-existing data (HSR-18-19-121). The study still conformed to the recommendations

of the Declaration of Helsinki (48). Additionally, this study adhered to the ethical guidelines set forth by the editorial board for the International Journal of Exercise Science (40). Each player had also completed the university-mandated physical examination, and read and signed the university consent and medical forms for participation in collegiate athletics.

Protocol

The team's coaching staff tested all players, which was conducted during the pre-season period in the summer of 2018. The tests used by this coaching staff were drawn from the NBA Combine (43, 46), following procedures that will be detailed. All athletes were familiar with the tests in this study, as they were performed as part of standard physical monitoring practices by the team's coaching staff. The data analyzed in this study came from the start of the pre-season period. Testing was completed in one session, and the order of tests followed the National Strength and Conditioning Association recommended guidelines (35). Following anthropometric measurements, all players completed a standard, full-body dynamic warm-up that was performed prior to all training sessions for this mid-major team. The dynamic warm-up consisted of: lunge and twist, inchworm and frog, up dog, down dog, scorpion kicks, knee hugs, overhead squat, pigeon plus twist, and band shoulder rotations. Additionally, there was a jump rope warm-up consisting of 100 repetitions, followed by a jump warm-up, and then a jump and stick completed five times (1). The warm-up was led by a member of the strength and conditioning staff, and lasted for approximately 15-20 minutes.

Anthropometrics: Firstly, players had their body height and mass recorded. Height was measured barefoot using a portable stadiometer (Detecto, Webb City, MO, USA), while mass was recorded by electronic digital scales (Ohaus, Parsippany, NJ, USA). The player's height and body mass was given in inches and pounds, respectively, and converted to metric units. Wingspan was measured with a handheld tape measure (Lufkin, Sparks, Maryland), and was the distance between the middle fingers of each hand while the arms are outstretched (8, 21, 46). Standing reach was measured with the player standing and reaching straight up (46), and was recorded by the Brower Vertical Jump system (BVJ; Brower Timing System, UT, USA) as part of the methods to measure the VJ. The measurements for both wingspan and standing reach were also provided in inches and converted to metric units.

Vertical Jump (VJ): The VJ was used to indirectly measure lower-body power in the vertical plane, and conducted according to standard procedures (1, 23, 25-29). The BVJ was used to measure the jumps. The player initially stood with their dominant side toward the BVJ, and while facing forwards and keeping their heels on the ground, reached upward as high as possible. This allowed the coaching staff to record their highest reach in order to calculate displacement once the athletes' completed their jumps, by subtracting the reach height from the jump height. Players then performed a countermovement jump as explosively as possible and extended their dominant hand (along the BVJ) as high as they could. Each player completed three trials, and the highest jump was recorded in inches and converted to cm.

Approach Jump (AppVJ): The AppVJ was another indirect measure of lower-body power, and was conducted using previously established parameters (1, 42). The BVJ again used to record

jump height. The athletes used an individually determined running approach (maximum 5 m distance from start to take-off, which would encompass two steps) and performed a quick countermovement jump with an arm swing, accompanied with one-arm maximal reach. Players were instructed to perform the jumping procedure in a manner that mimicked the technique they would use in a game or practice situation (1, 42). As for the VJ, the jump height score was calculated by subtracting reach height from the jump height, three trials were completed, and the best trial was converted from inches to cm and used for analysis.

Lane Agility Drill (LAD): The structure of the LAD is shown in Figure 1. As described by Teramoto et al. (46), a cone was placed at each corner of the lane on the basketball court. Players started from the left corner of the free-throw line, ran forward to the baseline, side-shuffled to the right corner of the lane, back pedaled to the right corner of the free-throw line, and side-shuffled to the left to return to the starting point. Then, the player changed direction, side-shuffled to the right corner of the free-throw line, ran forward to the baseline, side-shuffled to the left corner of the lane, and back pedaled to finally return to the starting point. Time was recorded in seconds via stopwatch. Although timing via stopwatch is not ideal, testers trained in the use of stopwatch timing procedures for fitness tests can still record reliable data (12, 31). Two trials were completed, and the fastest trial was analyzed.

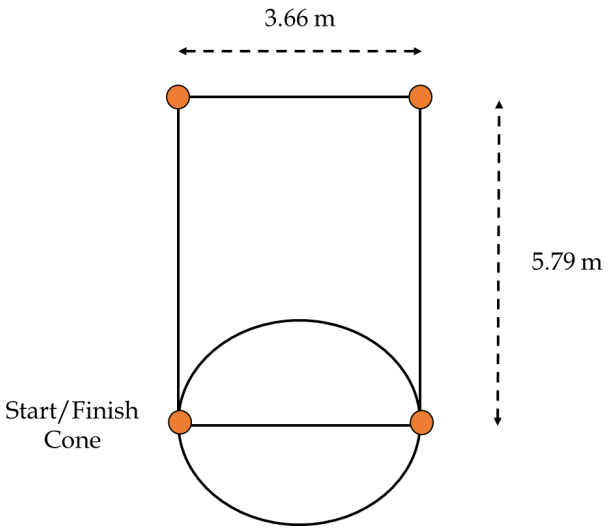

Figure 1. Structure of the LAD.

¾ Court Sprint: The ¾ court sprint was used to measure linear speed over a 22.86-m distance (1, 37, 46). Sprint time was recorded by timing gates (PowerMax TC Gates; Brower Timing System, UT, USA), with the gates positioned at 0 m and 22.86 m. Players began from 50 cm behind the first gate in order to initiate timing, and were also instructed to run maximally from the beginning through the last gate. Two trials were completed, and the fastest trial was used for analysis.

83.91-kg (185-lb) Bench Press: The bench press test required players to complete as many repetitions as possible with an 83.91-kg load with correct form (46). A standard Olympic bar and weight plates were used, and players were instructed to grip the bar in their 'strongest' position

(19-21, 49). The technique required for the bench press has been described in previous literature (19-21). The player unracked the bar with assistance from a spotter, if required, and began the lift with the arms extended and elbows locked. The 'touch-and-go' procedure was adopted, in that the bar was required to touch the chest before being pressed to full arm extension. A repetition was deemed to be successful when the bar was moved from the chest to a position of full elbow extension. Failure to do this, or bouncing the bar on the chest, disqualified a repetition. During the bench press, the player's back and feet were to remain in contact with the bench and ground, respectively, throughout each repetition. A spotter was positioned behind the bar for assistance with lift-off if required and for safety, but did not touch the bar except in the event of a failed lift. Only one attempt was completed by the players, in which they completed as many repetitions as possible.

Statistical Analysis

Descriptive statistics (mean±standard deviation [SD]) were used to provide the profile for each measured parameter. Data regarding playing time (MIN, GP, and MPG) was provided by the team's coaching staff to the researchers in an Excel file (Microsoft Corporation™, Redmond, Washington, USA). Statistical analyses were processed using the Statistics Package for Social Sciences Version 25.0 (IBM Corporation, New York, USA). The sample was divided into backcourt (n = 6) and frontcourt (n = 4) groups, and independent samples t-tests ($p < 0.05$) calculated any between-group differences. Effect sizes (d) were also calculated for the between-position comparison, where the difference between the means was divided by the pooled SD (7). In accordance with Hopkins (15), a d less than 0.2 was considered a trivial effect; 0.2 to 0.6 a small effect; 0.6 to 1.2 a moderate effect; 1.2 to 2.0 a large effect; 2.0 to 4.0 a very large effect; and 4.0 and above an extremely large effect. Similar to Lockie et al. (22), effect sizes were included in this study to ascertain how much difference existed between the position groups irrespective of the p value, and to potentially provide additional information for the practitioner. Pearson's correlations were used to determine relationships between MIN, GP, and MPG with the NBA Combine tests ($p < 0.05$). Correlation strength was defined as an: r between 0 to 0.3, or 0 to -0.3, was considered small; 0.31 to 0.49, or -0.31 to -0.49, moderate; 0.5 to 0.69, or -0.5 to -0.69, large; 0.7 to 0.89, or -0.7 to -0.89, very large; and 0.9 to 1, or -0.9 to -1, near perfect for relationship prediction (14).

RESULTS

The descriptive data for the mid-major team for all players combined, and the backcourt and frontcourt groups, is shown in Table 1. For the between-group comparisons, equal variances were assumed for all variables except wingspan and AppVJ. When compared to the backcourt group, the frontcourt group were significantly taller, heavier, had a greater standing reach and wingspan, and performed poorer in the VJ, AppVJ, and ¾ court sprint. All of these differences had large effects. The correlation data is shown in Table 2. There were no significant relationships between any of the NBA Combine tests with any of the playing time metrics.

Table 1. Descriptive data (mean ± SD) for age, height, body mass, standing reach, wingspan, VJ, AppVJ, LAD, ¾ court sprint, 83.91-kg bench press, and playing time (MIN, GP, MPG).

	Team (n = 10)	Backcourt (n = 6)	Frontcourt (n = 4)	p	d	d strength
Age (years)	20.20 ± 0.79	20.00 ± 0.63	20.50 ± 1.00	0.356	0.60	Small
Height (m)	1.93 ± 0.08	1.88 ± 0.06	2.01 ± 0.06*	0.008	2.17	Large
Body Mass (kg)	93.21 ± 15.09	83.27 ± 8.08	108.13 ± 9.92*	0.002	2.75	Large
Standing Reach (m)	2.50 ± 0.12	2.41 ± 0.07	2.62 ± 0.05*	0.001	3.45	Large
Wingspan (m)	1.99 ± 0.10	1.94 ± 0.10	2.05 ± 0.03*	0.041	1.49	Large
VJ (cm)	77.98 ± 9.86	83.40 ± 8.41	69.85 ± 5.18*	0.022	2.25	Large
AppVJ (cm)	91.69 ± 12.64	99.06 ± 11.13	80.65 ± 1.27*	0.009	2.32	Large
LAD (s)	10.42 ± 0.61	10.16 ± 0.33	10.95 ± 0.78	0.060	1.32	Large
¾ court sprint (s)	3.19 ± 0.16	3.11 ± 0.11	3.35 ± 0.11*	0.016	2.18	Large
83.91-kg bench press (reps)	7.60 ± 6.13	5.00 ± 4.00	11.50 ± 7.23	0.101	1.11	Moderate
MIN	486.20 ± 403.80	639.83 ± 438.742	255.75±224.35	0.149	1.10	Moderate
GP	25.90 ± 8.13	27.17 ± 8.54	24.00±8.29	0.577	0.38	Small
MPG	16.16 ± 11.58	20.73 ± 12.56	9.30±5.87	0.132	1.17	Moderate

Note: *Significantly (p < 0.05) different from the frontcourt group.

Table 2. Pearson's correlations for relationships between playing time (MIN, GP, and MPG) with the NBA Combine tests (age, height, body mass, standing reach, wingspan, VJ, AppVJ, LAD, ¾ court sprint, and 83.91-kg bench press).

		MIN	GP	MPG
Age	r	0.174	0.281	0.163
	p	0.631	0.432	0.653
Height	r	-0.306	-0.342	-0.299
	p	0.390	0.334	0.402
Body Mass	r	-0.337	-0.222	-0.341
	p	0.341	0.538	0.335
Standing Reach	r	-0.343	-0.273	-0.346
	p	0.332	0.446	0.328
Wingspan	r	-0.005	-0.038	-0.002
	p	0.990	0.917	0.995
VJ	r	0.215	0.032	0.228
	p	0.552	0.929	0.527
AppVJ	r	-0.074	-0.305	-0.052
	p	0.838	0.392	0.886
LAD	r	-0.311	-0.090	-0.320
	p	0.416	0.817	0.401
¾ court sprint	r	0.113	0.511	0.078
	p	0.772	0.160	0.842
83.91-kg bench press	r	-0.363	-0.248	-0.363
	p	0.302	0.489	0.303

DISCUSSION

This study firstly provided a description of a mid-major basketball team. Typical of previous research (11, 42, 45), there were clear differences in the stature and physical performance between the backcourt and frontcourt players. Frontcourt players were taller and heavier, had a greater wingspan, and were stronger as measured by completed repetitions in the 83.91-kg

bench press. Backcourt players were significantly superior in lower-body power as measured by the VJ and AppVJ, and were faster in the ¾ court sprint. The difference in the LAD was not significant, but there was a large effect for the faster time recorded by the backcourt group. These data relate to established positional differences inherent to the positions of guards, forwards, and centers in basketball (e.g. guards spend more time on the perimeter and can initiate fast breaks, forwards and centers will play in the key more and will experience greater physical contact) (11). These data also provide descriptive data for a successful DI mid-major team, as this team qualified for the NCAA Division I Men's Basketball Tournament in 2018. Practitioners involved in men's collegiate basketball could use this information as comparative data for their teams.

The second and major part of this study was to provide an initial analysis of relationships between playing time over the course of a season and performance in selected NBA Combine tests in DI mid-major players. Most notably, and somewhat similar to previous research (8, 13, 34), there were no significant relationships between playing time and the NBA Combine tests. This does not discount the value of the physical qualities measured by the NBA Combine tests, although there may be limitations with using these tests to reflect the actual ability of an athlete to play basketball. Indeed, these data may indicate that specific to this mid-major team, there may be other characteristics that impact playing time. As will be discussed, this is important to recognize, especially given the differences in recruits that may join a mid-major collegiate program versus that of a major school (4).

None of the anthropometric measures, most notably height, standing reach, and wingspan, correlated with playing time metrics (MIN, GP, MPG). Interestingly, Teramoto et al. (46) found that height, body mass, standing reach, and wingspan measured during the combine had positive relationships with defensive metrics in NBA players (r = 0.229-0.268). This could be a specific issue at the mid-major level. When compared to prospects from the 2018-2019 NBA combine (43), collectively as a team, the mid-major players were shorter (1.93 ± 0.08 m vs. 1.96 ± 0.08 m), lighter (93.21 ± 15.09 kg vs. 95.41 ± 10.77 kg), had a lower standing reach (2.50 ± 0.12 m vs. 2.61 ± 0.13 m), and shorter wingspan (1.99 ± 0.10 vs. 2.10 ± 0.10 m). Further, elite NBA players are likely to be taller and have a wider wingspan (38). It could be expected that players recruited to major collegiate programs, as opposed to mid-majors, would be taller and longer, as they have greater potential for future success (38, 46). Further analysis of differences in the anthropometrics of DI players from major programs with mid-major basketball players is required. This would be particularly impactful for strength and conditioning coaches. If a player is lacking in height, reach, or wingspan for a particular position, then they would need to ensure some other quality stands out (e.g. playing status or physical performance) for NBA coaches to notice them.

Jumping is clearly a necessary trait for basketball (1-3, 44), which can influence specific skills such as shooting, blocking, and rebounding. Additionally, better jump performance has been related to faster linear and change-of-direction speed in athletic populations (1, 5, 6, 9, 10, 18, 30, 33). Hoffman et al. (13) found that VJ related to playing time in DI male basketball players, although McGill et al. (34) did not. The results of this study supported McGill et al. (34), in that

neither the VJ or AppVJ significantly correlated with playing time metrics. Interesting, the mid-major players in this study had mean values that were superior (although no statistical comparisons were made) to participants from the 2018-2019 NBA Combine in the VJ (77.98 ± 9.86 cm vs. 74.85 ± 6.55 cm), and similar in the AppVJ (91.69 ± 12.64 vs. 91.39 ± 8.46 cm) (43). It could be that the players from this mid-major team collectively had above-average jump performance, and as a result, most players had effective lower-body power for their position. This would be a positive for the strength and conditioning coach, as the development of lower-body power and jump performance is a controllable aspect of training, regardless of each player's basketball-specific skills.

The ¾ court sprint also did not significantly relate to MIN, GP, or MPG in this mid-major team. This was despite previous research indicating the value of sprinting speed for basketball (46), although it did support the findings of McGill et al. (34). However, most maximal linear sprints in basketball are of a very short duration and distance (3, 44). This is because the nature of the game and dimensions of the court limit the distances players can sprint in a straight line. For instance, Scanlan et al. (44) found a mean sprint distance of ~3-4 m in elite male basketball players, and 9-10 m for sub-elite players. Both of these distances are below that of the 22.86-m distance measured in the ¾ court sprint. This may highlight a limitation of the sprint testing used in the NBA Combine, and its applicability to basketball players. Additionally, the ¾ court sprint time of the mid-major players from this study (3.19 ± 0.16 s) was similar to that of NBA Combine prospects (3.20 ± 0.09 s) (43). Similar to the jump data, the strength and conditioning coaches for this mid-major team could have developed linear speed to the extent that most players have the requisite qualities to be effective within a game, notwithstanding their basketball skill level.

The LAD provides a measure of change-of-direction speed, incorporating movements specific to basketball (i.e. short accelerations, side shuffling, and back pedaling) (46). Although McGill et al. (34) found the LAD correlated with playing time in their DI major collegiate players, that was not the case for the mid-major players in this study. The duration of this test may provide more of a challenge to an athlete's metabolic capacities, as opposed to purely their change-of-direction ability (47), which could have influenced the results. It would have been beneficial to include the reactive shuttle run in this study, and it is a limitation that it was not featured in the testing battery used by this school. Nonetheless, the players from this mid-major team completed the LAD in 10.42 ± 0.61 s, which was faster than the mean for prospects tested at the NBA Combine from 2018-2019 (11.34 ± 0.56 s) (43). As for the VJ, AppVJ, and ¾ court sprint, the mid-major players may all have above-average athletic abilities (in this instance change-of-direction speed) as measured by the LAD, which may limit correlations with playing time. What is also worth noting is that the LAD involves planned movements, and accordingly may limit some of the skills that could more greatly influence playing time, such as agility and the ability to react to basketball-specific stimuli. As an example, in a comparison between semi-professional and amateur basketball players, Lockie et al. (24) suggested that the higher level players had superior visual scanning abilities. Basketball-specific skill performance was not analyzed in this study, although it is very clear that this influences playing time in basketball

players. Future research should attempt to analyze basketball-specific skills and the influence this has on playing time in collegiate basketball players, and the trainability of these skills.

Dawes et al. (8) illustrated that estimated 1-RM bench press and back squat correlated with total minutes for DII male basketball players, while Hoffman et al. (13) found the 1-RM back squat related to playing time in DI players from a major school. In this study, the 83.91-kg bench press provided some measure of strength, although as it is completed for repetitions to failure, it could be more of a muscular endurance test (32). However, for relatively weaker players, this bench press test could be more of a maximal strength test (4/10 players completed 3 repetitions or less). Regardless, the results from this study indicated that the number of completed repetitions from the 83.91-kg bench press did not relate to MIN, GP, or MPG. Further, when considering the mean for the team, the data was similar to that of 2018-2019 NBA Combine participants (7.60 ± 6.13 repetitions vs. 7.92 ± 4.87 repetitions) (43). This is not to discount the value of strength, but rather to suggest that there are other qualities that could more greatly influence playing time from this mid-major team. Indeed, future research on mid-major basketball players should incorporate 1-RM testing of the exercises such as the bench press and back squat to provide descriptive data, in addition to documenting whether there are relationships with playing time (8, 13).

There are some study limitations that should be acknowledged. Only one DI mid-major collegiate men's basketball team was analyzed in this study, with only six frontcourt and four backcourt players. This limits the generalizability of the current results, and indeed the data may reflect the training practices of this team (30). Ideally, future research could integrate multiple mid-major collegiate squads in the analysis of relationships between positions, playing time, and NBA Combine performance. There were no aerobic fitness assessments used by the coaching staff from this mid-major team. It is possible aerobic fitness could influence playing time, and this has been shown by Hoffman et al. (13) in DI basketball players from a major program. No lower-body strength tests are featured within the NBA Combine test battery, and were thus not included in this study. As Hoffman et al. (13) and Dawes et al. (8) found relationships between the 1-RM back squat and playing time in DI and DII male basketball players, respectively, this should also be investigated in DI mid-major players. There were also no skill tests included (e.g. shooting and dribbling tests), and this could have a greater impact on playing time for a mid-major program. Future research should investigate the skills of mid-major players specific to playing time, as well as drawing comparisons to players from other collegiate levels of play.

In conclusion, this study firstly showed clear differences in anthropometrics and NBA Combine test performance between backcourt and frontcourt players from one DI mid-major collegiate basketball team. This is to be expected, given the different game demands for guards, forwards, and centers. Notably, this study also found no significant relationships between playing time (MIN, GP, and MPG) and NBA Combine test performance in male collegiate basketball players from the mid-major level. This might indicate that skill and the ability to play the game of basketball may have a larger impact on the number of minutes played in this mid-major team. What was also notable was that the mid-major players were comparable athletic abilities to NBA

Combine participants, but were smaller in stature and had a lesser wingspan (43). The differences in anthropometry may be reflective of the type of players recruited to a mid-major school versus that of a larger program, given the value for height and wingspan in basketball (38, 46). The data may also suggest that the strength and conditioning staff for this team may have prepared all players such that their physical fitness was appropriate for their respective positions, limiting the relationships with playing time. Lastly, from a practical standpoint, the data from this research suggest collegiate (and potentially NBA team personnel) may consider reevaluating the usefulness of the combine's physical performance tests as predictors of playing time. Furthermore, the results from this study should encourage college and professional team personnel to consider the importance of the various NBA Combine metrics, and the potential benefits of overhauling this process, with the goal of creating a more valid system for predicting player outcomes.

REFERENCES

1. Banda DS, Beitzel MM, Kammerer JD, Salazar I, Lockie RG. Lower-body power relationships to linear speed, change-of-direction speed, and high-intensity running performance in DI collegiate women's basketball players. J Hum Kinet 68:223-232, 2019.

2. Ben Abdelkrim N, Castagna C, Jabri I, Battikh T, El Fazaa S, El Ati J. Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. J Strength Cond Res 24(9): 2330-2342, 2010.

3. Ben Abdelkrim N, El Fazaa S, El Ati J. Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. Br J Sports Med 41(2): 69-75, 2007.

4. Bergman SA, Logan TD. The effect of recruit quality on college football team performance. J Sports Econom 17(6): 578-600, 2014.

5. Carr C, McMahon JJ, Comfort P. Relationships between jump and sprint performance in first-class county cricketers. J Trainol 4(1): 1-5, 2015.

6. Chaouachi A, Manzi V, Chaalali A, Wong del P, Chamari K, Castagna C. Determinants analysis of change-of-direction ability in elite soccer players. J Strength Cond Res 26(10): 2667-2676, 2012.

7. Cohen J. Statistical Power Analysis for the Behavioral Sciences (2nd ed.) Hillsdale, New Jersey: Lawrence Earlbaum Associates; 1988.

8. Dawes J, Marshall M, Spiteri T. Relationship between pre-season testing performance and playing time among NCAA DII basketball players. Sport Exerc Med Open J 2(2): 47-54, 2016.

9. Dawes JJ, Orr RM, Elder CL, Krall K, Stierli M, Schilling B. Relationship between selected measures of power and strength and linear running speed amongst Special Weapons and Tactics police officers. J Aust Strength Cond 23(3): 23-28, 2015.

10. Delaney JA, Scott TJ, Ballard DA, Duthie GM, Hickmans JA, Lockie RG, Dascombe BJ. Contributing factors to change-of-direction ability in professional rugby league players. J Strength Cond Res 29(10): 2688-2696, 2015.

11. Delextrat A, Cohen D. Strength, power, speed, and agility of women basketball players according to playing position. J Strength Cond Res 23(7): 1974-1981, 2009.

12. Hetzler RK, Stickley CD, Lundquist KM, Kimura IF. Reliability and accuracy of handheld stopwatches compared with electronic timing in measuring sprint performance. J Strength Cond Res 22(6): 1969-1976, 2008.

13. Hoffman JR, Tenenbaum G, Maresh CM, Kraemer WJ. Relationship between athletic performance tests and playing time in elite college basketball players. J Strength Cond Res 10(2): 67-71, 1996.

14. Hopkins WG. A scale of magnitude for effect statistics. Available from: www.sportsci.org/resource/stats/index.html. Accessed January 9, 2016.

15. Hopkins WG. How to interpret changes in an athletic performance test. Sportscience 8: 1-7, 2004.

16. Humphreys BR, Mondello M. Intercollegiate athletic success and donations at NCAA Division I institutions. J Sport Manage 21(2): 265-280, 2007.

17. Langelett G. The relationship between recruiting and team performance in Division 1A college football. J Sports Econom 4(3): 240-245, 2003.

18. Lockie RG, Callaghan SJ, Berry SP, Cooke ER, Jordan CA, Luczo TM, Jeffriess MD. Relationship between unilateral jumping ability and asymmetry on multidirectional speed in team-sport athletes. J Strength Cond Res 28(12): 3557-3566, 2014.

19. Lockie RG, Callaghan SJ, Moreno MR, Risso FG, Liu TM, Stage AA, Birmingham-Babauta SA, Stokes JJ, Giuliano DV, Lazar A, Davis DL, Orjalo AJ. An investigation of the mechanics and sticking region of a one-repetition maximum close-grip bench press versus the traditional bench press. Sports 5(3), 2017.

20. Lockie RG, Callaghan SJ, Orjalo AJ, Moreno MR. Loading range for the development of peak power in the close-grip bench press versus the traditional bench press. Sports 6(3), 2018.

21. Lockie RG, Callaghan SJ, Orjalo AJ, Moreno MR. Relationships between arm span and the mechanics of the one-repetition maximum traditional and close-grip bench press. FU Phys Ed Sport 16(2): 271-280, 2018.

22. Lockie RG, Davis DL, Birmingham-Babauta SA, Beiley MD, Hurley JM, Stage AA, Stokes JJ, Tomita TM, Torne IA, Lazar A. Physiological characteristics of incoming freshmen field players in a men's Division I collegiate soccer team. Sports 4(2), 2016.

23. Lockie RG, Dawes JJ, Orr RM, Stierli M, Dulla JM, Orjalo AJ. An analysis of the effects of sex and age on upper- and lower-body power for law enforcement agency recruits prior to academy training. J Strength Cond Res 32(7): 1968-1974, 2018.

24. Lockie RG, Jeffriess MD, McGann TS, Callaghan SJ, Schultz AB. Planned and reactive agility performance in semi-professional and amateur basketball players. Int J Sports Physiol Perform 9(5): 766-771, 2013.

25. Lockie RG, Moreno MR, Bloodgood AM, Cesario KA. Practical assessments of power for law enforcement populations. TSAC Report (49): 6-12, 2018.

26. Lockie RG, Ruvalcaba TR, Stierli M, Dulla JM, Dawes JJ, Orr RM. Waist circumference and waist-to-hip ratio in law enforcement agency recruits: Relationship to performance in physical fitness tests. J Strength Cond Res: doi:10.1519/jsc.0000000000002825, in press.

27. Lockie RG, Schultz AB, Callaghan SJ, Jeffriess MD. The effects of traditional and enforced stopping speed and agility training on multidirectional speed and athletic performance. J Strength Cond Res 28(6): 1538-1551, 2014.

28. Lockie RG, Schultz AB, Callaghan SJ, Jordan CA, Luczo TM, Jeffriess MD. A preliminary investigation into the relationship between functional movement screen scores and athletic physical performance in female team sport athletes. Biol Sport 32(1): 41-51, 2015.

29. Lockie RG, Schultz AB, Jordan CA, Callaghan SJ, Jeffriess MD, Luczo TM. Can selected functional movement screen assessments be used to identify movement deficiencies that could affect multidirectional speed and jump performance? J Strength Cond Res 29(1): 195-205, 2015.

30. Lockie RG, Stage AA, Stokes JJ, Orjalo AJ, Davis DL, Giuliano DV, Moreno MR, Risso FG, Lazar A, Birmingham-Babauta SA, Tomita TM. Relationships and predictive capabilities of jump assessments to soccer-specific field test performance in Division I collegiate players. Sports 4(4), 2016.

31. Mann JB, Ivey PJ, Brechue WF, Mayhew JL. Validity and reliability of hand and electronic timing for 40-yd sprint in college football players. J Strength Cond Res 29(6): 1509-1514, 2015.

32. Mayhew JL, Prinster JL, Ware JS, Zimmer DL, Arabas JR, Bemben MG. Muscular endurance repetitions to predict bench press strength in men of different training levels. J Sport Med Phys Fit 35(2): 108-113, 1995.

33. McFarland I, Dawes JJ, Elder CL, Lockie RG. Relationship of two vertical jumping tests to sprint and change of direction speed among male and female collegiate soccer players. Sports 4(1), 2016.

34. McGill SM, Andersen JT, Horne AD. Predicting performance and injury resilience from movement quality and fitness scores in a basketball team over 2 years. J Strength Cond Res 26(7): 1731-1739, 2012.

35. McGuigan MR. Principles of test selection and administration. In: GG Haff and NT Triplett editors. Essentials of strength training and conditioning. Champaign, IL: Human Kinetics; 2015, pp. 249-258.

36. Mehran N, Williams PN, Keller RA, Khalil LS, Lombardo SJ, Kharrazi FD. Athletic performance at the National Basketball Association Combine After anterior cruciate ligament reconstruction. Orthop J Sports Med 4(5), 2016.

37. Milan FJ, Soares ALA, Quinaud RT, Kós LD, Palheta CE, Mendes FG, Nascimento JV, Carvalho HM. Power and agility testing within the NBA pre-draft combine. Rev Bras Cineantropom Desempenho Hum 21, 2019.

38. Monson TA, Brasil MF, Hlusko LJ. Allometric variation in modern humans and the relationship between body proportions and elite athletic success. J Anthr Sport Phys Educ 2(3): 3-8, 2018.

39. National Strength and Conditioning Association. NSCA strength and conditioning professional standards and guidelines. Strength Cond J 39(6): 1-24, 2017.

40. Navalta JW, Stone WJ, Lyons S. Ethical issues relating to scientific discovery in exercise science. Int J Exerc Sci 12(1): 1-8, 2019.

41. Padgett T, Hunt CS. The influence of winning on mid-major college football attendance. JAEB 13(2): 129-132, 2012.

42. Pehar M, Sekulic D, Sisic N, Spasic M, Uljevic O, Krolo A, Milanovic Z, Sattler T. Evaluation of different jumping tests in defining position-specific and performance-level differences in high level basketball players. Biol Sport 34(3): 263-272, 2017.

43. Perrin OD, Jensen RL. A comparison of the National Basketball Association's annual National Basketball Association Draft Combine 2001 to 2018. ISBS Proceedings Archive 37(1): 216-219, 2019.

44. Scanlan A, Dascombe B, Reaburn P. A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. J Sports Sci 29(11): 1153-1160, 2011.

45. Scanlan AT, Tucker PS, Dalbo VJ. A comparison of linear speed, closed-skill agility, and open-skill agility qualities between backcourt and frontcourt adult semiprofessional male basketball players. J Strength Cond Res 28(5): 1319-1327, 2014.

46. Teramoto M, Cross CL, Rieger RH, Maak TG, Willick SE. Predictive validity of National Basketball Association draft combine on future performance. J Strength Cond Res 32(2): 396-408, 2018.

47. Vescovi JD, McGuigan MR. Relationships between sprinting, agility, and jump ability in female athletes. J Sports Sci 26(1): 97-107, 2008.

48. World Medical Association. World Medical Association declaration of Helsinki. Recommendations guiding physicians in biomedical research involving human subjects. JAMA 277(11): 925-926, 1997.

49. Young KP, Haff GG, Newton RU, Gabbett TJ, Sheppard JM. Assessment and monitoring of ballistic and maximal upper-body strength qualities in athletes. Int J Sports Physiol Perform 10(2): 232-237, 2015.