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Research Article

A Comparative Analysis of the 2021 NFL Combine Data: The Relationship Between Linear Sprint, Momentum, Vertical and Horizontal Jumps and Change of Direction Deficit

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Abstract

The majority of COD execution assessments employ the use of total time as the metric by which COD performance is judged. This study investigated the relationships between CODD time, sprint time, 5-10-5 and jump performance. Performance data of 328 participants of the 2021 NFL Combine (age: 22.35 ± 1.00 years; height: 1.87 ± 0.07m; weight: 108.51 ± 21.61kg) was collected and used for the analysis. CODD correlated to the 5- 10-5 pro-agility (r= 0.69 - 0.71) test but not sprint time (r= 0.15 - 0.27) for both the drafted and undrafted groups. Meanwhile, there was a large to very large association between 5-10-5 proagility time and the sprint variables (r = 0.62 - 0.82) for both drafted and undrafted groups. The correlation between CODD time and momentum was minor (r= 0.26 – 0.28) for both drafted and undrafted groups, but the 5-10-5 pro-agility reported a strong to a very strong association with momentum (r= 0.57 – 0.75). There was an inversely small correlation between CODD time and VJh (r= – 0.27) and BJ (r= -0.25– -0.28) for both drafted and undrafted groups whereas the 5-10-5 pro-agility time reported an inversely large to very large correlation with VJH (r= -0.51 – -0.68) and BJ (r= -0.57 – -0.71) on both groups. The magnitude and impact of the momentum, horizontal jump, and vertical jump of participants on their CODD time indicate that coaches and fitness experts should focus on improving the technical aspects of the COD execution when attempting to improve their CODS.

Keywords

Anthropometric, Quarterbacks, Technique, Playing Position, Sprint, Relationship

1. Introduction

The NFL is one of North America's four major professional sports leagues, with 32 teams evenly split between the National Football Conference (NFC) and the American Football Conference (AFC). It is a 17-week regular season competition with each club playing 16 games with one bye week [1]. Annually the NFL Combine is organized for players who are eligible to be drafted into the NFL. At the combine, each team evaluates the players on their physical abilities, and the players are subjected

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to a medical examination, including a review of their health records and imaging studies. Using this information, the NFL uses a medical rating system to determine a player's perceived ability to play in the league [2]. The National Collegiate Athletic Association (NCAA) Division I football combine invites about 330 athletes from those schools. Prospects are evaluated during the combine. As part of the evaluation process, there are a variety of regular physical examinations [3]. The 40-yard dash, 225-pound bench press, vertical jump, broad jump, pro-agility shuttle test, and 3-cone drill are some of the physical tests evaluated at the NFL Combine [4]. Although data from the NFL Combine provides some level of guidance for NFL teams to reduce selection risks [2-4] the Combine aims to make assumptions of possible future success in the NFL [2].

A review of data from the 2004-2005 Combine, on the efficacy of Combine performance data to influence draft order indicated that outcomes in the physical battery of a Combine have little to do with draft success. When using results from the [8] tests that made up the Combine's physical tests to predict draft order, normalized data did not outperform raw data. Straight sprint time and jump appear as the most important indicator of NFL personnel responsible for selection decisions out of the eight performance measurements evaluated [10]. This finding reveals that the NFL Combine is missing the evaluation of the most important test variables necessary for playing success. To investigate the connections between the various indicators of performance at the NFL combine, Robbins [11] collected data from draftees who took the tests each year from 2005 to 2009. The 9.1-meter, 18.3-meter, and 36.6-meter sprint times, as well as the COD ability test all, had a very high correlation with one another (r-value ranges from 0.900 to 0.967). Longer sprint distances have a stronger correlation with performance in both jumping tests. These findings suggest that mechanisms like the stretch-shortening cycle may be more significant at high speeds. The bench press performance is favorably connected with results in all sprints and inversely correlated with jumps, suggesting that above the waist strength may not be helpful to these activities in the observed cohort, despite the very small correlation coefficients [11].

Direction changes are very common and decisive acts in team sports, leading to tries, goals, and game momentum shifts. Expects in athlete development together with researchers in team- sport disciplines are of much interest in the COD development and studies since it is believed that athletes need to possess the skill to change movement direction effectively [12]. COD has been described by scholars as a must-have ability for successful sports performance currently. COD is the most vital performance variable that scouts in the NFL teams focus on during the talent hunt. The NFL combine considers COD as a prerequisite for drafting wide receivers, running backs, defensive backs, and quarterbacks in addition to distinguishing between elite and non-elite football athletes. As an important variable for effective sports performance, strength, and condition professionals must develop valid and very reliable training methods that may improve COD performance [13]. However, currently, most agility and COD test may be inaccurate and unreliable due to the over-reliance on linear sprint speed without focusing on the technical execution of COD movement [14, 15]. The concept of Change of Direction Deficit (CODD) is a measure that is assumed can better indicate an athlete's ability in Change of Direction (COD) compared to simple time completion tests for the speed of COD [16, 17]. There is evidence in studies conducted on CODD time and linear sprint time with several investigations reporting that athletes with faster sprint time showed to have a larger CODD indicating no significant influence of speed on the CODD time [18, 19]. Others have also suggested that sprint momentum can be a valuable indicator of CODD and needs further examination [20]. CODD has been classified as an absolute measure of COD since it has proven to provide accuracy when used [16]. Henceforth findings from other studies have all demonstrated a substantial relationship between the CODD and the COD test used but small relation with the sprint speed performance. As a proponent and a strong advocate of the CODD, Nimphius et al. [21] described CODD as a unique measure of physical performance overlooking linear sprint speed that can mask a player's actual COD time [22]. Little studies have been conducted on the association between physical ability factors, such as jump quality (vertical and horizontal) and momentum, as the current studies reveal contrary findings. In examining elite athletes Emmond et al. [23] and Loturco et al. [24] discovered a highly significant link between the CODD and performance characteristics such as speed measures that contradict previous findings that have reported a non-significant relationship between the CODD time and linear sprint speed. The relationship between bilateral jumping, unilateral jumping, and CODD has been investigated with findings in this area showing inconsistencies. Whereas some studies have, reported no significant relation between bilateral jump and CODD and even concluded that athletes must improve jump unilaterally while attempting to enhance COD performance [25, 26]. Others have also indicated an absence of a relationship between unilateral jumping and CODD [27, 28]. However, some studies have suggested that unilateral jumping performance can be associated with a small CODD value [29].

Agility and speed are two of the most important physical attributes in AF since they help players on both sides of the ball avoid being tackled or covered [30]. COD speed is the basis of agility, often tested in football players and other athletes who play team sports since most of the direction change in the game is pre-planned [31]. Every year, the NFL conducts the NFL Combine to give collegiate players who qualify to play in the NFL the opportunity to prove why they are ready to play in the NFL [5]. The 5-10-5 pro-agility test and the three-cone drill (L-run) are performed at the annual NFL Combine this signifies the importance of the COD ability to the participation of the sports [32]. Although Change of Direction Speed (CODS) is vital in football, the ultimate aim is career success prediction for each athlete in the NFL [33]. Comparisons between drafted and undrafted players have also produced finding which shows drafted players are better than undrafted players in all the performance batteries. To our knowledge, it seems no studies on the NFL draft data about the relationship between the NFL combine test variables exist. We believe if there is clear scientific evidence on how these variables relate to each other, coaches can find a better way to create a training program that will suit a desirable outcome for future NFL players. The inconsistencies in the findings regarding CODD, the performance indicators that influence the CODD time, and the scarcity of knowledge in the area of performance variables in the NFL Combine triggered this study.

The study's primary purpose was to investigate the association between momentum, Vertical Jump height (VJh) and Broad Jump (BJ), and CODD: an analysis of the 2021 NFL combine data.

Research Question

In light of the above-defined research aim, the study's research question is:

What is the correlation between the momentum, vertical and horizontal jumps, and the CODD time of the 2021 NFL Combine subject?

Based on the research questions, we hypothesized that:

There is a significant association between the participants in the NFL Combine 2021 CODD time and their momentum, vertical jump height, and horizontal jump

2. Materials and Methods

2.1. Subjects

Data from test results of three hundred and twenty-eight (n=328) subjects who participated in the 2021 NFL combine were retrieved and analyzed. This subject qualified for the combine and was free of injuries and fully ready to be drafted into the NFL for the following season. The average age among all players was 22.35±1.00yrs, the average weight was 108.51±21.61kg and the average height was 1.87±0.07m. Out of the 328 players who took part in the combine 130 (39.3%) participants were drafted, and 198 (60.7%) participants were not drafted. These players were categorized according to their draft status after the combine i. e., drafted players, and undrafted players. Since the NFL is recognized worldwide as the top football league in North America the standard of the combine is highly regarded since it's the gateway for most players to enter the NFL. Therefore, questions of test reliability and validity were already answered and the data retrieved was believed to be precise and accurate. Table 1 shows the subjects demographic data.

Table 1. *Mean±SD results for subject's demographic features.*

Demography	Combined (n = 328)	Drafted (n = 130)	Undrafted (n =198)
Age (yrs.)	22.35±1.00	22.05±0.94	22.54±1.00
Height (m)	1.87±0.07	1.87±0.08	1.87±0.07
Weight (kg)	108.51±21.61	110.01±22.47	107.53±21.03

2.2. Research Design

The cross-sectional research design was adopted for the study. This cross-sectional study analyzed data from performance tests of participants of the 2021 NFL Combine to investigate the influence momentum, vertical jump, and horizontal jump had on the CODD.

2.3. Statistical Analysis

SPSS software was used for statistical analysis (Version 27.0; IBM Corporation, NY, USA). The mean and standard deviation of test results values are shown as Mean ± SD. The Shapiro- Wilk proved the assumption that data were normally distributed. The demographics of the participants were estimated using descriptive statistics. The correlation (association) between CODS and CODD timings and all the performance measures was calculated for both the drafted and undrafted groups using Pearson's correlation (r) analysis. Hopkins [16] quantified the degree of the correlation coefficient as Between 0 and 0.30, or 0 and -0.30, the r value was considered small; between 0.31 and 0.49, or -0.31 to -0.49, it was considered moderate; between 0.50 and 0.69, or -0.50 to -0.69, it was considered large; between 0.70 and 0.89, or -0.70 to -0.89, it was considered very large; and between 0.90 and 1, or -0.90 to -1, it was almost perfect.

2.4. Methodology

The 2021 NFL combine testing camp was conducted in the First Energy Stadium (FES) in Cleveland, Ohio, from

April 29 to May 1, 2021. This investigation utilized data collected by the combine after testing was completed. Because the combined results may be available in multiple public access domains and individual participant identities will not be released, using data through an institutional review board is deemed unimportant. The data were analyzed using the results from the following Combine tests:

2.4.1. 40yards (36.6m) Sprint

A timing lighting system was used to record the subject's linear speed in the three domains. At 0 m, 9.14 m, 18.29 m, and 36.58 m, gates were placed. To activate the first gate, subjects started the sprint from a stance 30 cm behind the start mark. From the starting line, the subjects were told to run through each set of timing lights while picking up speed. The trial was ignored and replayed if the individuals moved before it began. For each distance, the time was recorded to the closest estimate of 0.001 seconds. Three trials were done by each subject, and the fastest one was recorded for the analysis [34]. Momentum was derived using the 40 yards Sprint test, a test of acceleration and the maximum speed of the player. Moreover, in this test, a player may be required to take a 180° turn at 9.1m and carry on which can provide a change of direction perspective. Thus, overall, this test provides three different types of measure, the overall 40yards time, 20yards split, and 10yards split times, and split with a direction change time.

2.4.2. Momentum

Sprint momentum was a product of players' weight and average velocity for each measured interval in the 10 yards sprint [35]. The velocity is the player's 10-yard dash distance in meters (9.1m) divided by the time individual players spent covering the 10-yard sprint in seconds (s). Therefore, the unit for velocity will be (m/s). The weight of players during the combine is the same as the players' body mass in kilograms (kg). In that case, the momentum is the product of the mass of players' weight in kilograms (kg) and velocity in the 10 yards sprint (kgm/s-1).

2.4.3. Vertical Jump

A vertical jump measure can indicate the ability of vertical jumping in NFL players. For the vertical jump calculations, the device, known as the Vertec was used. The individual initially stood sideways to the device and reached as high as they could while still having ground contact and facing ahead. This was done to move the maximum number of vanes. The last vane that moved was used as the zero point. In this test during the NFL combine, the players are instructed to take a standing 2-footed position in an erect body form and jump as high as they can by use of a swing of the arm, this jump is also referred to as a bilateral jump since the take-off is from both feet. At the highest point, the players move the horizontal vanes, and the height reached is then calculated as a difference between the player's reach height from standing and the height of the jump height.

2.4.4. Horizontal Jump (Broad Jump)

Horizontal jumps or standing broad jumps are a test of the ability of a player to jump for a linear distance. In this test during the NFL combine, the players are instructed to take a standing position and ground their feet in a fixed 2-footed position standing on their toes. Then, by using an arm swing, the subject is required to take a jump in the forward direction and cover as much distance as possible, and land on both feet simultaneously. The standing broad jump result is the distance between the start line and the nearest point to the start line where the subject made contact with the ground.

2.4.5. 20-Yd Shuttle Run (5-10-5 Pro-agility Test)

The 5-10-5 pro-agility test, assesses anaerobic power, the capacity to quickly and swiftly raise and reduce speed in a new movement direction. In a three-point posture, subjects straddled the center between digital time gates. A start-sensitive device was utilized, which starts automatically when the subject is well positioned to perform within the laser device. Subjects sprint from the start position 5m to one end and touch the line sprint back to the 10m to the other end through the start gage and finish 5m back to the start line. The test was done twice by the athletes, once in each direction. For each direction, the average time was written down. The 5-10-5 pro-agility test is always done on both legs (dominant and non-dominant, but for this study, the focus is on the dominant leg. The CODD was calculated by subtracting the 20-yard shuttle time from the (5-10-5 pro-agility test) i. e. (20-yard shuttle run – 20-yard split sprint= CODD).

3. Results

The results of the data collected from the 328 subjects of the 2021 NFL Combine. The data was analyzed to find if an association exists between the CODD time and the various performance variables during the Combine.

Table 2. *Descriptive data mean ± SD of subject's performance results (n = 328).*

Test Variables	Drafted (n = 130)	Undrafted (n=198)	p-value
Momentum (kgm/s^{-1})	607.91 ±91.58	583.39 ±85.41	<0.01

Test Variables	Drafted (n = 130)	Undrafted (n=198)	p-value
VJh (cm)	34.41 ±3.59	32.84 ±4.16	<0.01
BJ (cm)	118.52 ±8.99	115.68 ±9.29	<0.01
Pro-agility Test (s)	4.39 ±0.24	4.50 ±0.32	<0.01
20Yardsplit (s)	2.72 ±0.17	2.76 ±0.18	<0.05
CODD (s)	1.67 ±0.14	1.71±0.14	<0.01
40YardSprint (s)	4.72 ±0.31	4.80 ±0.32	<0.05
10Yardsplit (s)	1.64 ±0.11	1.67 ±0.10	<0.01

The participants who were drafted performed significantly better than the undrafted players in all the performance batteries as compared in Table 2.

The correlation analysis between CODD time and the test variables (momentum, vertical and horizontal jumps, 5-10-5 pro-agility test, 20-yard Split, 40-yard sprint, and 10- yard split).

Pearson correlation analysis was used to analyze the level of association between CODD and the performance variables. The result revealed a significant association between CODD time and the performance variables in both the Drafted and Undrafted groups. The results for the Drafted group reported the following in Table 2. (Momentum, r = 0.28, p = <0.01, VJh, r = - 0.27, p = <0.01, BJ, r = -0.25, p = <0.01, pro-agility test, r = 0.71, p = <0.01, 20YardSplit, r = 0.15, p =.025, 40YardDash, r = 0.23, p = <0.01 and 10YardSplit, r = 0.25, p = <0.01). Whereas the results for the Undrafted group reported the following in Table 2. (Momentum, r = 0.26, p = <0.01, VJh, r = -0.27, p = <0.01, BJ, r = -0.28, p = <0.01, pro-agility test, r = 0.69, p = <0.01, 20YardSplit, r = 0.16, p =.025, 40YardDash, r = 0.26, p = <0.01 and 10YardSplit, r = 0.27, p = <0.01). There was a positive correlation between the variables CODD and Momentum, 20YardSplit, 40YardDash, and 10YardSplit within the Drafted and Undrafted groups except for VHh, and BJ which showed a significantly small negative correlation. Momentum, the 20-yard split, the 40-yard dash, and the 10-yard dash all had positive correlations with CODD, while VHh and BJ had slight negative correlations.

Table 3. *Correlation Results for CODD against performance variables.*

	Drafted		Undrafted	
	r	p-value	r	p-value
Momentum (kgm/s^{-1})	0.28	0.01	0.26	0.01
Vertical Jump (cm)	-0.27	0.01	-0.27	0.01
Broad Jump (cm)	-0.25	0.01	-0.28	0.01
Pro-agility test (s)	0.71	0.01	0.69	0.01
20Yardsplit (s)	0.15	0.01	0.16	0.03
40YardSprint (s)	0.23	0.01	0.26	0.01
10Yardsplit (s)	0.25	0.01	0.27	0.01

The correlation analysis between the 5-10-5 pro-agility test (COD) and the test variables (momentum, vertical and horizontal jumps, CODD time, 20-yard Split, 40-yard sprint, and 10-yard split).

Pearson correlation analysis was used to analyze the level of association between the 5-10-5 pro-agility test and the performance variables. The result revealed a significant association between the 5-10-5 pro-agility test and the performance variables in both the Drafted and Undrafted groups. The results for the Drafted group reported the following in Table 3 (Momentum, r = 0.75, p = <.001, Vertical Jump, r = -0.68, p = <.001, Horizontal Jump, r = - 0.71, p = <.001, CODD, r = 0.71, p = <.001, 20YardSplit, r = 0.81, p =.025, 40YardDash, r= 0.82, p = <.001 and 10YardSplit, r = 0.77, p = <.001). The results for the Undrafted group reported the following in Table 3. (Momentum, r = 0.57, p = <.001, Vertical Jump, r = - 0.51, p = <.001, Horizontal Jump, r = -0.57, p = <.001, CODD, r = 0.69, p = <.001, 20YardSplit, r = 0.66, p =.025, 40YardDash, r = 0.69, p = <.001 and 10YardSplit, r = 0.62, p = <.001). There is a moderate to a very high, positive correlation between the variables 5-10-5 pro-agility and Momentum, CODD, 20YardSplit, 40YardDash, and 10YardSplitwith in the Drafted and Undrafted groups except for VJh, BJ which showed a significantly moderate negative correlation for the VJh and a large correlation for the BJ. Thus, there is a large to very large, positive association between 5-10-5 pro-agility and Momentum, pro-agility test, 20YardSplit, 40YardDash, and 10YardSplit, and a moderate to a large negative correlation between CODD and VJh and BJ.

Table 4. *Correlation Results for 5-10-5 pro-agility test (COD) against performance variables.*

	Drafted		**Undrafted**	
	r	**p-value**	**r**	**p-value**
Momentum (kgm/s^{-1})	0.75	0.01	0.57	0.01
Vertical Jump (cm)	-0.68	0.01	-0.51	0.01
Broad Jump (cm)	-0.71	0.01	-0.57	0.01
CODD (sec)	0.71	0.01	0.69	0.01
20Yardsplit (sec)	0.81	0.01	0.66	0.01
40YardSprint (sec)	0.82	0.01	0.69	0.01
10Yardsplit (sec)	0.77	0.01	0.62	0.01

4. Discussion

The study aimed at assessing the correlation between CODD time, momentum, and vertical and horizontal jumps, of the 2021 NFL Combine participants.

CODD was positively correlated with the 40yard dash (r=0.23, p<0.01), 20yard split (r=0.15, p<0.03), and the 10yard split (r=0.25, p<0.01) in the drafted group and positively correlated with the 40yard dash (r=0.26, p<0.01), 20yard split (r=0.16, p<0.01) and the 10yard split (r=0.27, p<0.01) in the undrafted group (Tables 2 and 3). Whilst the association between the pro-agility test and the linear sprint was a very large significant positive correlation 40yard dash (r=0.82, p<0.01), 20yard split (r=0.81, p<0.01), and the 10yard split (r=0.77, p<0.01) in the drafted group and a large significant positive correlation 40yard dash (r=0.69, p<0.01), 20yard split (r=0.66, p<0.01) and the 10yard split (r=0.62, p<0.01) in the undrafted group (Table 4). The association between the pro-agility test and CODD time was a significantly very large positive correlation (r=0.71, p<0.01) in the drafted group and a significantly large positive correlation (r=0.69, p<0.01) in the undrafted group. This association is not unique since Nimphius, et al. [21] reported a very large association between the 5-10-5 pro- agility test and CODD time (r=0.89) when the sprint time variable was controlled and an association of large significant correlation when the sprint time variables were not controlled. Thomas, et al. [36] observed a large correlation between 505 agility time and CODD (r = 0.500- 0.593, p ≤ 0.002). The current findings and the previous findings explain why CODD is significantly related to COD.

Our findings indicate a significant association between the 5-10-5 pro- agility time and the straight sprint speed variables (40 yards dash, 20-yard split, and 10-yard split). These results seem to be in line with other research which found an association between linear speed and COD time. Gabbett, et al. [37] reported a large significant association between three separate sprint times with performances on the 505 tests, L -run, and modified 505 tests. Nimphius et al. [4] found that COD and sprint speed have very strong and significant relationships (r = 0.73–0.98). However, Thomas, et al. [36] reported an inversely moderate to strong correlation with speed and COD time (r = –.41 to –.66). This finding contradicts the findings of the current study although this result was recorded between the 10m sprint time and the 505-agility test not the 5-10-5 pro-agility test in this study.

The pro-agility test may be influenced by straight sprint speed, and CODD may provide a better alternative. CODD time and straight sprint speed reported a significant small positive association which seems to conform with the idea behind the CODD concept. Fernandes, et al [25] reported large associations between CODD time and 505 agility test on both limbs but CODD was not associated with straight sprint speed. The result in the current study is in line with Nimphius, et al. [21] and Fernandes, et al [25]. Thomas, et al. [36] observed a large correlation between 505 times and CODD ($r = 0.500$-0.593, $p \leq 0.002$). Although the 505-agility test is not the same as the pro-agility test Thomas, et al. simply explain as the better the sprint time the poorer the CODD time, and the poorer the sprint time the better the CODD time.

The association between CODD time and momentum was significantly positive small in both the drafted group ($r=0.28$, $p<0.01$) and undrafted group ($r=0.26$, $p<0.01$) whereas, pro-agility test and momentum reported large to very large association significant correlation in the drafted group ($r=0.75$, $p<0.01$) and undrafted group ($r=0.57$, $p<0.01$). Fernandes, et al. reported no significant association between momentum and CODD whereas Freitas et al. [12] in their comparison of male and female rugby players did report that male athletes who had good sprint time also reported better momentum. Freitas et al. also reported greater momentum in forwards compared to backs when players were grouped into backs and forwards and assessed on their performance variables to determine if CODD influence player position but this did not impact their CODD performance. The very large association between momentum and the 5-10-5 pro- agility test seems not surprising since momentum is classified as a speed quantity.

In the current study, an inverse association was recorded between the CODD time and both the VJh and BJ in the two groups. The drafted group recorded ($r=-0.27$, $p<0.01$) for vertical jump height and ($r=-0.25$, $p<0.01$) while the undrafted group ($r=-0.27$, $p<0.01$) for vertical jump height and ($r=-0.28$, $p<0.01$). Whilst the association with the pro-agility test reported an inversely significant large association between vertical jump height ($r=-0.68$, $p<0.01$) and a significantly very large association between the horizontal jump ($r=-0.71$, $p<0.01$) in the drafted group. With a significant large association between vertical jump height ($r=-0.51$, $p<0.01$) and a significantly large association between the horizontal jump ($r=-0.57$, $p<0.01$) in the undrafted group. If straight sprint speed is not associated with CODD but is a component of COD and is associated with it. Then it is expected vertical jump and horizontal jump should be associated with CODD since they are strength-related variables and as they improve the time is executing CODD and COD should reduce. The current findings are a true reflection of this association however when compared to previous studies the magnitude of the association is inconsistent. Fernandes et al. [25] reported no correlation between unilateral single-leg countermovement jump and single-leg drop jump and CODD. Lockie et al. [9] reported no correlation among academy soccer players' jump variables and CODD time and a further no relationship between countermovement jump, BJ, and CODD in either 8 female collegiate rugby players or 8 team-sport athletes [8] and further analysis of the same research group reported no relationship between CODD and countermovement jump in female soccer players [37]. The findings of Fernandes et al. [25] and Lockie et al. [8] are not in line with the current findings. Thomas [7] reported an inverse relationship between CODD and countermovement jump in the unilateral plan on both limbs; right limb ($r=-0.39$ to -0.40; $p< 0.05$) and left limb ($r=-0.26$ to -0.44 $p<0.05$) in a mixed investigation of team athletes from netball, cricket, and basketball. Thomas et al. further reported a moderate relationship between the countermovement jump and the 505 COD task which is consistent to the current findings. Lockie et al. [6] found no association between bilateral counter movement jump and CODD in a mixed study of recreational athletes on right and left legs ($r = -0.34 – -0.44$; $P < 0.05$). Thomas [7] and Lockie et al. [6] also recorded correlation between the counter movement jump and the 505 COD task which is consistent to the current findings and proves the relationship between COD and strength related variables. The negative relation is also a true reflection of the relation since an increase in jump performance will definitely reflect in a decrease in COD time.

5. Practical Applications

The CODD is the most effective tool to better assess the COD ability of athletes looking at how its relationship with the performance variables has been reported so far. However, the magnitude and impact of the momentum, horizontal jump, and vertical jump of participants on their CODD time indicate that coaches and fitness experts should focus on improving the technical aspects of the COD execution when attempting to improve their CODS. Though the participants for this study were chosen purposefully, categorizing them as elite athletes; this limits the generalization of these findings except for only elite athletes. Notwithstanding, we recommend that coaches and trainers should design training programs that focus on improving both straight-line sprint speed and agility. Incorporating drills and exercises specific to COD movements, such as the pro-agility test, can help athletes enhance their agility performance, leading to improved CODD times. Given the significant inverse correlation between CODD time and vertical/horizontal jumps, athletes should prioritize lower body strength training to improve jump performance. Exercises targeting explosive power and strength, such as squats, lunges, and plyometric drills, can contribute to better COD execution by enhancing lower body strength and power. Recognizing the variability in associations between CODD time and performance measures among athletes, training programs should be tailored to individual strengths and weaknesses. Conducting assessments to identify areas of improvement for each athlete can help in designing personalized training regimens that address specific needs.

6. Conclusions

The study provides valuable insights into the complex interplay between sprint speed, agility, momentum, and jump performance in relation to CODD time among NFL Combine participants. These findings have implications for athlete training and performance assessment, emphasizing the importance of both speed and strength-related variables in COD execution.

Abbreviations

NFL	National Football League
COD	Change of Direction
CODD	Change of Direction Deficit
AFC	American Football Conference
NFC	National Football Conference
NCAA	National Collegiate Athletic Association
VJh	Vertical Jump Height
BJ	Broad Jump
SPSS	Statistical Package for the Social Sciences
SD	Standard Deviation

Author Contributions

Issaka Seidu: Conceptualization, Preparation of draft, Writing – original draft

Eric Opoku-Antwi: Methodology, Data curation, Data analysis

Regiwan Dauda: Writing – review & editing

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Data Availability Statement

Full data of the study will be made available upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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Research Field

Issaka Seidu: Strength and Conditioning Training, Human movement Analysis

Eric Opoku-Antwi: Strength and Conditioning Training, Human movement Analysis, Exercise Science

Regiwan Dauda: Strength and Conditioning Training, Human movement Analysis