

The NFL Combine: A Scientific-Based Analysis and Critical Review

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Abstract

The NFL combine has been created with the intent of assessing American football players' physical, cognitive and psychological qualities, in order to understand their future value and on-field performance. The literature showed that American football players' playing ability is highly correlated with maximal strength and power (both upper and lower body), agility, reactive strength and sprinting performance. Due to abundant literature regarding physical tests, the NFL combine, in author's opinion, should slightly modify the actual testing battery, implementing new tests such as an isometric mid-tight pull, medicine ball put and drop jump; in the interest of creating a more complete and valid assessment. An upgrade in technology, regarding the jump tests, is also advised to increase tests' validity and reliability, replacing the Vertec device with an electronic jump mat. However, has been shown that past on-field performance can better detect players' future NFL performance, while physical tests can only partially predict it. These findings suggest an analysis on how much a single physical assessment event can detect about future NFL career.

Introduction

American football is one of the most popular and competitive team sports in the United States of America and probably in the world. The National Football League (NFL) is the American most important league and being a player in this league requires extraordinary physical and playing capabilities [1]. Every year, a week-long event is held in Indianapolis (IN), which is known worldwide as the NFL combine. During this week, a battery of off-field and on-field tests are the core of this event, coupled with other activities. Coaches and scouts from all the 32 NFL franchises use this event to evaluate the aspirant prospects, who wish to be selected to play in the NFL. The combine is an invitation only event where only around 330 players are invited from almost 10,000 National Collegiate Athletic Association (NCAA)'s players [2,3]. The NFL combine evaluation procedure is composed of anthropometric measurements, cognitive tests, physical tests, injury and drug screening and finally extensive interviews [3]. Mental, off-field and positional tests are an essential part of this evaluation process and have a high impact on on-field performance. However, they are not the focus of this paper, which will only analyse the physical characteristics. The physical tests performed by the college players are the 40-yard dash, 225-lb bench press test, vertical jump, broad jump, pro-agility shuttle, 3-cone drill [1].

The purpose of this article is to provide an evidence-based needs analysis of the sport of American football from the physical performance characteristics standpoint. Once highlighted the most important physical characteristics that correlate with a better performance on the field, a critical analysis of the NFL combine testing battery will be realized using the first part of the article as a guideline, with the goal to suggest implementation and/or changes to the actual assessment procedure. The final objective is to propose a better screening system, more scientific based, which can detect better, the most important characteristics of an American football player.

Strength

Strength is the maximal force that can be generated by a muscle; or, the neuromuscular system's capacity to create force facing an opposing resistance [4]. High level of strength is a discriminant factor of successful performance, in various sports [5]. There is also a high correlation between the ability to attain a high level of maximum force and the better

performance of power related activities like counter movement jump, broad jump and sprinting action [6-10]. Various studies showed significantly higher strength measures, both in upper and lower body, in American football players from higher divisions or levels, when compared to lower categories ones [11-13]. Iguchi et al. [13] and Schmidt [14] also found that starters players have better strength performances if compared to non-starters, in the same team. Sawyer et al. [15] only found similar results in defensive players; while Fry & Kraemer [11] found starters significantly better in the performance of both bench press and back squat exercises' 1-Repetition Maximum (1-RM), in all positions, excluded the quarterback and running back ones. It is therefore important to assess American football players' strength, through the implementation of upper and lower body tests, because of its high correlation with playing status and supposedly on-field performance.

Power

Force and velocity are the two underpinning variables of power, which can be described as the application of the highest force, in the shortest amount of time [4,16,17]. Power is relevant in a sport because of the limited amount of time to apply force, typical of most sport's movements and skills [16]. The vertical jump, more precisely, the counter movement jump (CMJ), has been utilised commonly in the strength and conditioning field to evaluate lower limbs power and explosive qualities [18-21]. However, Verkoshansky [22] differentiates areas of the force-velocity curve, into speed-strength and strength-speed. The CMJ assesses the speed-strength portion, while the strength-speed assessment could be completed utilising an Olympic weightlifting exercise, as suggested by Turner et al. [23].

Different lower-limbs power tests (CMJ, standing long jump and standing triple jump) showed a positive correlation with acceleration performance at 9.1-m; while scores from 1-RM power clean, relative to body mass, were positively correlated with acceleration, velocity and sprint time at 9.1-m and 36.6-m [10]. CMJ height and peak power output along with standing long jump distance seems to be very highly related to muscular strength, agility and sprinting performance [8]. Robbins and Young [24] found similar correlations comparing both vertical and horizontal jumping performance with sprints; however, the study highlighted a stronger correlation with maximum speed rather than with acceleration. Jumping height, measured through the CMJ test, has been shown to be correlated with American football level of play since players from higher divisions have significantly better scores [11-13]. It is also positively correlated with the player status on the team, with starters having significantly better performance compared with reserve players [11,15]. Teramoto et al. [25] found the CMJ test the best predictor of NFL future success for the wide receiver position. Regarding the strength-speed portion of the force-velocity curve, similar results have been found using the power clean exercise, with starters and player from higher division performing significantly better than non-starters and lower divisions' players [11,12].

Unfortunately, to our knowledge, the literature investigating

power in the upper body is lacking; only Schmidt [14] assessed and compared American football players using a seated medicine ball put test. Results showed a significantly better performance by the starters when compared to reserve players [14]. In a similar sport like rugby, Baker [5] found higher power scores in the bench throw exercise, by professional players, in comparison to college and high-school athletes. Thus, a better ability to produce a high level of force, in a short amount of time, can be safely correlated with athlete's playing ability and therefore, must be assessed in both upper and lower body.

Speed

Sprinting speed can be described as the capacity to cover a determined distance, in a specific time [26]. Straight-line sprinting is determined by acceleration, attainment of maximal speed and maintenance of maximal speed [23]. In team sports, like American football, only a few positions cover long distances at high speed [27], and it is rare that sprints are in a straight line, while the majority, are multi-directional, with the athlete responding to an ever-changing scenario, utilising changes of direction combined with re-accelerations and maximal velocity reaching [28]. The 40-yard sprint test is the most implemented to assess speed in American football players, with both acceleration and attainment of maximal speed tested [29]. These are probably the two most important characteristics for team sports player, while maintenance of maximal speed is more related to track and field events [28]. Between different divisions of NCAA football, the sprint times in the 40-yard dash test were significantly better for higher divisions athletes, with the only exception for the tight end position [11,12]. The 40-yard dash test has been also a pretty common indicator of playing ability in American football players comparing starters and non-starters; Fry & Kraemer [11] found that all defensive starters, combined with wide receiver and tight end starters, were significantly superior than reserves. Similarly, Black & Roundy [30] detected better sprinting performance for starters, in 10 out of 20 positions. Sawyer et al. [15] utilising a 20-yard sprint test, found significant differences only in the wide receiver, corner back, running back, tight end and line backer positions. Due to all the positive correlations between 40-yard sprint time and playing ability, assessing both acceleration and attainment of maximal speed appears of significant importance in American football players.

Agility

Agility has been described as a rapid, whole-body movement, with a change of direction or velocity in response to a stimulus [31]. As a matter of fact, field and court sports combine both pre-planned and reactive changes of direction [28]. So, it appears that agility is composed of two elements. The physical component relies on the ability to change direction through technique, lower body strength, reactive strength and power [31,32]. While the cognitive element depends on anticipation and visual-scanning techniques and speed [31]. The physical ability to change direction has been investigated through the years utilising change-of-direction speed (CODS) tests, while recently, a few tests have been implemented

to assess the cognitive ability, or also named reactive agility [32]. In American football both qualities are important because of the wide variety of roles; wide receivers, for example, run following pre-planned routes, so CODS test appears to be a valid assessment, while defensive players, need to react and respond to visual stimulus through the whole game, so they rely more on reactive agility [28,32,33]. Unfortunately, in American football, agility has been generally confined to tests of CODS and only one study by Sawyer et al. [15] analysed differences in CODS, between coaches' high and low ranked players, found that only for the running back, tight end and line backer positions, higher ranked players performed significantly better in the pro agility shuttle. Different studies investigated both CODS and reactive agility, in Australian football and rugby players [34-49]. The findings were interesting because reactive strength tests could discriminate between higher and lower level players, while CODS tests did not [32,34-39]. These findings could be questioning the validity of pre-planned CODS tests, for assessing players' skill level [32,35-39]. They also highlight the importance of perceptual skills in a high level of sports performance [32,36,40]. It would be interesting having data about American football players' reactive agility to compare the different positions and levels of play.

Reactive Strength

It has been demonstrated that body's musculoskeletal elements like muscles, tendons, and ligaments work together as a "spring" system, which function is fundamental during physical activities that require initial eccentric action and a subsequent concentric contraction [41-43]. This basic human locomotion complex is known as the stretch-shortening cycle (SSC) [41-43]. The functionality of the SSC can be measured during rebound jumping, though the reactive strength index (RSI) and leg stiffness [44]. The RSI is calculated dividing jump height with ground contact time and it reveals the rebound efficiency of the musculotendinous unit during activities that require the use of the SSC [44-47]. The assessment of the RSI provides an indicator of the ability to generate force through the SSC by an athlete [17,48,49]. Various studies found that an augmented reactive strength ability translated to better jumping and hopping height [41,50] coupled with quicker ground contact time during sprinting [50,51] and boosted rate of force development [52,53]. Reactive strength also seems to be highly correlated with the change of direction ability [40,54,55] and straight sprinting speed [54]. Lockie et al. [51] found a significantly greater RSI in faster athletes compared to slower in short distance sprints (0-10m). To the author's knowledge there is no literature investigating reactive strength in American football players, however, considering the above-cited studies, it appears to be a relevant factor in athletic performance.

What should be tested?

In the first part, a need analysis of the sport of American football has been completed, highlighting the main biomotor abilities which, in accordance with the actual literature, appears to be more correlated with great physical performance in broad terms and, on-field American football playing ability. In the following part,

a scientific-based critical analysis of the NFL Combine will evaluate the various testing procedures utilised and modifications or implementations will be suggested if necessary, in author's opinion.

Strength tests

During the NFL combine the only strength assessment is the NFL 225-lb bench press test, which requires the performance of as many repetitions as possible, without any rest, with 225-lb (102.3-kg) [56]. Every position at the NFL combine performs this test [56]. Literature investigated the validity and accuracy of this test in the past years with multiple studies finding a high correlation between the estimated 1-RM from the NFL 225-lb bench press test, and the actual bench press 1-RM [56-64]. It should be highlighted that the performance of more than 10 repetitions increases the prediction bias [57,59,60,62,65]. Regarding the reliability of this sub-maximal test, Mann et al. [56] found a reliable consistency over multiple trials, with a variation of ± 2 repetitions between test-retest. It can be safely considered a reliable test because the smallest worthwhile difference (SWD) is three repetitions [56]. To author's opinion, the NFL 225-lb bench press test, utilised at the NFL combine, can be considered adequate for the circumstances, due to the high reliability and satisfactory validity to assess upper body maximal strength, which appears to have a good correlation with American football on-field performance [11-15]. The employment of a 1-RM bench press test would be impractical, given the extensive time-consuming procedure [66], so the NFL 225-lb bench press test is an excellent alternative considering the high number of athletes to be tested at the NFL combine.

Literature has also found a positive correlation between lower body strength and player's performance level within the sport of American football [11-14]. Author's suggestion is the addition of a strength assessment for the lower body, in future NFL players. As for the upper body, maximal testing, in terms of a 1-RM test, is too problematic [66]. A possible solution is the utilisation of the isometric mid-thigh pull (IMTPf) test. This test, commonly used to quantify maximal strength [6,65-68], replicate the position held during the second pull phase of a clean, with the athlete in an upright position with a slight hip and knee flexion [69]. The IMTPf test records the peak isometric force while the athlete exerts its maximal force from that position to an immovable barbell [70]. The peak isometric force has shown perfect correlations with multiple athletic performances such as weightlifting [6,67,70,71], change of direction [72] and jumping [6,67,70,71]. Most importantly, isometric peak force showed a positive correlation with 1-RM back squat performance in American football players [73], rugby union players [74] and in college level wrestler [75]. Due to its proven test-retest reliability [70,71] and easy administration and minimal skill requirement [76], the isometric mid-thigh pull test could be a practical solution to generate a complete strength assessment of both upper and lower body, during the NFL combine.

Power tests

Lower limbs power assessment, both vertically and horizontally, is important due to its high correlation with American football playing ability [11-15]. During the NFL combine this assessment

is accomplished utilising a counter movement jump (CMJ) and a broad jump [1]. Both tests are easy to administer and non-fatiguing [59]. The CMJ height is recorded utilising a Vertec device, which measures the difference between the fully extended standing reach height, arms comprised, of the athlete and its maximal vertical jump-and-reach height, recorded on plastic swivel vanes [15,60]. The athlete uses its hand to displace the vanes during the overhead swinging motion at the top of the vertical jump [15,60]. Nuzzo et al. [21] recommend a separate familiarization session and the completion of more than three trials using the Vertec device because of its not high test-retest reliability. Comparing the scores obtained using Vertec with others devices like the 3-camera motion analysis system, considered the “gold standard” method [61] and a jump mat with micro switches embedded [62], showed a good correlation between the 3-camera motion analysis system and the jump mat, while the Vertec had significant differences [63]. This could encourage the NFL to utilise a jump mat with micro switches embedded, due to its better accuracy in recording jumping height and quicker administration time, without the possibility of a human error, due to the computer system jump height calculation [63]. The Vertec device appears to rely on individual skills like shoulders range of motion and ability to hit the vanes at the maximum height by the athlete, combined with the test administrator accuracy on the count of the vanes displaced and the determination of the starting position [63]. It should be highlighted, that literature employed only physically active individuals, so it would be interesting testing validity e reliability of the various measuring devices utilising elite athletes. Regarding the broad jump utilised during the NFL combine, in the author’s opinion, it appears to be a valid test of horizontal lower body power, frequently used in the strength and conditioning practice [64]. Unfortunately, to author’s knowledge, no studies investigated its reliability with athletic population or elite athletes, but only with youth individuals, finding good reliability in adolescents [65]. The strength-speed portion of the force-velocity curve can be assessed utilising the isometric mid-thigh pull test, described in the previous paragraph, because of its perfect correlation with weightlifting maximal efforts tests [6,66-68].

Even with limited literature to support the utilisation of upper body power assessments, significant differences have been reported in upper body power in players from higher ranks compared to lower [14,77]. The NFL combine does not implement any test in this regard. It could be argued that literature regarding upper body power relationship to on-field performance is lacking, however, NFL personnel could consider the addition of a medicine ball put (MBP) test, which it is considered easy to administer and also specific to functional movement typical of various sports [78]. The test detailed procedure is described by the NSCA [64], and Clemons et al. [79] confirmed its validity and reliability.

Speed tests

Examined the high importance of sprinting speed in the sport of American football and its value on differentiating players’ rank [11,15,31], the 40-yard dash test occurs to be a valid and reliable assessment [80]. The NFL utilises electronic timing to record the

data, which can be considered the “gold standard” method [81]. However, the author would like to suggest the addition of the 10-yard split time, because of peculiar American football positions such as offensive and defensive line, which rarely exceed this distance during games [24]. These data on shorter and more specific distances would be a better insight into pure acceleration for players who merely rely on these short bouts of sprinting performance [24].

Agility Tests

Testing agility in American football players should include both change of direction speed (CODS) and reactive agility drills because literature showed that both can differentiate playing ability, especially reactive agility tests, when high-level athletes are tested [29,32,34,36-41]. However, the NFL combine only employs two CODS tests: pro-agility shuttle test and 3-cone drill. Both tests have been widely investigated, finding great test-retest reliability and validity [29,73-75]. However at least two trials are necessary in order to record valid data [82]. In various sports, agility tests that require the athlete to change direction in reaction to a not pre-planned stimulus, in sport-specific movement patterns, have been created [34,83-86]. It would be interesting, if the NFL would invest, with the intent to create a reactive agility test specific to the sport of American football. However, even considering the high validity of these type of tests in differentiating between skilled and less skilled athletes [29,33-40,87,88], a lot of issues arise with these open-skills assessments, such as standardization, familiarization, and reliability [23]. It could also be argued that players’ reactive agility in a sport-specific scenario is already evaluated during the positional drills, performed after the physical tests at the NFL combine. In author’s opinion, the agility assessment implemented at the NFL combine utilising CODS tests, summated with positional drills, allows an exhaustive evaluation of athlete’s agility. The creation of a specific reactive agility test for American football and its various positions would be time and resources consuming.

Reactive Strength Tests

NFL combine does not contemplate the implementation of a reactive strength evaluation. As analysed previously, an enhanced reactive strength is correlated with the superior performance of various physical abilities such as jumping, sprinting and change of direction [41,32,50-54]. A simple test that could be added is the drop jump (DJ). It only requires a contact mat which provides a recording of height jumped and ground contact time, that will be utilised to calculate the reactive strength index (RSI) [48]. DJ test can be implemented with different heights (30, 45, 60 and 75cm) [46]. Due to time constraint and a high number of subjects participating at the NFL combine venue, the utilisation of a 30-cm DJ test could be optimal, mostly because of its high reliability from trial-to-trial [46].

Sequence of testing

To guarantee tests reliability, the order in which tests are implemented and the duration of rest periods in-between are of fundamental importance [89]. The principle behind sequencing of testing is that one test should not affect, in any manner, the

execution of the subsequent ones, guaranteeing valid and reliable results [89]. Considering the National Strength and Conditioning Association (NSCA) guidelines [89], the NFL combine assessment procedure, including the suggested modifications in this article, will test the athletes in the 225-lb bench press test, the first testing day, separated from the other tests, as commonly implemented during the NFL combine (see NFL combine website at

www.nflcombine.net/players/schedule/). The second day of testing will start with “not-fatiguing tests” (counter movement jump, broad jump, drop jump), followed by “agility/CODS tests” (pro-agility shuttle, 3-cones drill), “maximum power tests” (medicine ball put, isometric mid-thigh pull) and finally “sprint tests” (40-yd dash) [89]. Rest periods should also be accurately determined, following the key metabolic substrates’ restoration time course [23]. The phosphagen energy system fully restores in around 3-5 minutes [90-92]. All the NFL combine tests require energy bouts of around 5-6 seconds, so three to five minutes rest periods are required through the various testing exercises [23].

Conclusion

Testing physical qualities, in a large number of National Football League’s prospects, with the intent to evaluate and detect future playing ability, could be a really hard duty. This article outlined the various biomotor abilities, that accordingly to the present literature, can discriminate playing ability in American football players. With these guidelines, the NFL combine testing procedure has been evaluated for its validity and reliability and some modifications or additions have been suggested following the literature findings, with the intent to create a more useful and precise assessment of American football players’ playing ability, utilising only physical tests. However, has been demonstrated that past on-field performance can better detect future NFL performance, compared to physical tests [93]. It also appears that only 50% of American football on-field performance can be predicted through lower body power, change of direction and sprinting speed tests’ data [94]. These findings should invite the American football scouts and strength and conditioning coaches to reflect on how much a single physical assessment event can detect the future American football player’s on-field performance [95-103].

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