

ORIGINAL ARTICLE



Which Postural Control and Functional Movement Screen Values Related to Change of Direction Runs?

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ABSTRACT

Background. To examine the relationships between soccer players static, dynamic postural control (PC) and Functional movement screen (FMS) scores and 3 different change of direction (COD) running. Seventeen male soccer players aged 18-30 and playing soccer in the regional amateur league participated in the study. **Methods.** PC measurements were performed as static and dynamic (dynamic measurements at 40-30-20 difficulty levels). The Deep Squat (Ds), hurdle step (Hs), in-line lunges (I-LL), trunk stability (Ts) and rotary stability (Rs) tests were used in the FMS measurements, and T-Running, Illinois running and 505-running measurements were used in the COD measurements of the athletes. The significance levels between the data were accepted as $P \leq 0.05$, and correlation analysis was used for statistical analysis. **Results.** Significant relationships were found between PC and FMS scores ($P \leq 0.05$). However, the relationships between PC and COD skills have controversial results. Among the FMS scores, significant relationships were found between Hs-left and T-run ($r = -0.049$), I-LL-left and Illinois-run ($r = -0.053$), while no statistically significant correlations were found between other FMS scores and COD. **Conclusion.** According to the results of this research; while athletes with good PC scores had higher FMS scores, complex movement tests Hs and I-LL scores obtained from FMS measurements revealed that the athletes had results on their COD performance.

KEYWORDS: *Change of Direction, Postural Control, Functional Movement Screen*

INTRODUCTION

In order to exhibit an effective performance in soccer competitions, athletes must run with high intensity (1). In soccer competition, players practice high-intensity movements that require a change of direction between 1200 and 1400 (2). In such high intensity and directional movements, it is very important that soccer players show higher performance than their opponents in terms of gaining superiority over the opponents. Because in soccer competition, soccer players have to move quickly by changing direction runs according to the positions of the opponent players. Elite soccer players have been shown to perform COD skills in a shorter time than semi-professional and amateur soccer players suggesting it is a characteristic that discriminates

between standards of soccer players? (3). For movement skills such as COD to be executed very quickly and accurately, movement patterns must emerge correctively. Studies show that the basic movement skills performed correctly in training and competition reveal effective performance values (4). However, in order to demonstrate appropriate performance skills, athletes' postural control at an appropriate level with correct movement patterns (Sheppard & Young, 2006), they must have strength and explosive strength (5). It is stated that athletes have these abilities and their postural control abilities positively affect joint stabilization in high-intensity movements, and as a result, they perform quality movement patterns at high speeds. (5, 6). These

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structures are also part of the neural system (7). Considering the neural system, it is emphasized that postural control ability has positive and important effects on athletes' high-intensity activities such as COD (6). Postural control ability helps the athlete who moves rapidly to maintain the position of the body during the phases of a sudden stop, change of direction, and acceleration (1, 8, 9). Also, studies investigating the relationship between strength and COD abilities indicate that leg muscle strength levels are associated with athletes' COD abilities (10). The eccentric strength phase enables athletes to achieve a more positive result during stop phase and that more positive COD times are obtained with horizontal ground force in the concentric muscle contraction phase about strength levels and mechanical components (11). If athletes have weaknesses in any of these abilities, there are both injury risks and performance losses. Studies have also shown that athletes with an inappropriate neuromuscular structure will have low performance in COD (12). In this case, many physical fitness levels of the athletes should be at the appropriate level for a appropriate COD performance. Finally, instead of different measurements of physical performances such as postural control, strength, and flexibility, studies investigating many abilities such as the harmony between these abilities and body segments simultaneously with the test FMS results and different physical relationships were performed. Meaningful results and other relationships between COD, FMS, and PC have previously been reported. (7, 13-17). The common point of different results in studies is the number of subjects, ages, sports backgrounds, and differences in measurement methods. This studies investigating the relationship between FMS and postural control abilities, and research on postural control abilities, and based on the lack of research that examines the types of dynamic postural control (3 difficulty levels), FMS, and different change of directions runs.

MATERIALS AND METHODS

Subjects. Soccer players from regional amateur league teams, who train regularly 5 days a week and participate in 1 official competition, were included in the study. Before starting the study, approval was obtained from the Medical Faculty Ethics Committee. A total of 17 football players were included in the study (age: $22.05 \pm$

4.54 , stature: 178.94 ± 6.74 , body mass: 72.29 ± 4.16 kg).

Procedures. Acute performances of the athletes were evaluated using the single measurement method for the study. The tests were designed as two as laboratory and field tests and a total of 5 tests were carried out in the same period for 2 weeks. In the first stage, PC tests and then FMS tests of the athletes were performed with 2 days intervals. One week after these tests, T-run, 505-run, and finally Illinois-run tests were performed with a 1-day interval. The measurements that the athletes will perform before all tests were shown in detail by a trainer and demos were performed. During the tests performed for these two weeks, only technical and tactical training was performed to the athletes. Before all tests, the "HarmoKnee" warming procedure was applied, which prevents injury, provides a planned warming program, and causes less strain on the knee joint (18).

Dynamic and Static Postural Control Tests.

Static and dynamic PC tests were measured using the Tecnobody (Prokin System ProKin 212 N Bergamo, Italy) postural control tests device. The measurements were carried out on a stabilometric platform consisting of three measuring systems placed in an area of 40 cm^2 and an angle of 120° . The data obtained were processed with a measurement frequency of 20 Hz per second. From the calculations made according to the center pressure point; sway in anterior-posterior (ap), medial-lateral (ml) axes, standard deviation (ss), duration of sway (sn), sway total circle area (el), perimeters (prmtr), central pressure x-axis (CoPx) and y (CoPy) is calculated by the device in a type of distance to the axis. In the first stage of static postural control measurements, athletes' feet were placed naked on the postural control platform in the previously determined area. Later, the test was performed by focusing on a fixed point positioned 1 meter away at eye level for 30 seconds on the fixed surface of the athletes and maintaining their balance.

During the tests, the measurements were performed by positioning the hands on the waist. Static postural control tests were performed with bipedal open and closed eyes and unipedal with eyes open. In the dynamic postural control measurements, the feet of the athletes were carried out on the moving floor for 30 seconds, including bipedal and unipedal measurements with eyes open. Dynamic postural control tests

were performed at the difficulty levels including 40-30 and 20 (the lower the number, the more difficulty), which are among the features of the device. When the results of the test were obtained, the decrease in the numerical data in the evaluations was calculated by the device as the postural control levels were better (maintaining the postural control status in the areas close to the pressure center), the increase in the numerical data as a move away from the swing area, that is, the deterioration of the postural control. This information should be taken into consideration when interpreting the correlation results. Data are recorded: static bipedal eyes open (Sbeo), static bipedal eyes close (Sbec), static dominant leg (Sd), static non-dominant leg (Sn), dynamic bipedal (Db), dynamic dominant leg (Dd), dynamic non-dominant leg (Dn) in this research data.

Functional Movement Screen Test. This test is usually used to determine the limitations of motion profiles, postural control, coordination, mobility, flexibility, appropriate muscle strength, and asymmetries between body parts. 5 basic motion practices were determined for the test. Deep squat (Ds), hurdle step (Hs) (Hs-left and Hs-right total score), in-line lunge (I-LL) (ILL-left and ILL-right total score), trunk stability (Ts), and rotary stability (Rs) (total Rs- left and Rs-right score) movements. These movements were scored between 0 and 3 using a scoring system. The points given to the athletes in the test were performed according to the criteria determined by Cook G., et al. (19), the test was administered by a trainer with at least 3 years of practice experience, and FMS tests were administered to all athletes by the same trainer. Higher FMS scores mean that athletes perform more correctively, while low scores mean worse performance scores. This information is important for the interpretation of correlation analysis.

Change of Directions Tests. All change of direction tests were performed on the synthetic ground that athletes are used to. For the test, 3 different COD tests were performed, which are the most common and preferred in the literature. A special timer device was used to ensure that all tests were done correctly (Newtest Oy, Oulu, Finland, Power timer 300-series). COD tests were performed at intervals of one day after the

recovery training of the athletes and were carried out during the competition season after the preparation season.

Illinois-Running Test. The athletes were ready for the test in a comfortable standing position 1 meter in front of the line where the entrance photocell is located. Acceleration, turning and running performance values of the athletes were tested with this test. The test was performed as a total of 3 repetitions and repetitions were performed by applying 3-minute rest intervals between each repetition. The best measurement time among 3 repetitions was evaluated (20)

505-Running Test. It was aimed to measure the ability of the athletes to accelerate, stop suddenly, change direction by 180 degrees and accelerate (21). The athletes started the exam by standing 1 meter behind the starting line where they felt comfortable. The test was performed in 3 sets, resting for at least 3 minutes between sets. The best test time was evaluated in the test performed as 3 replicates in total.

T-Running Test. This test, which has a high level of validity and reliability, was carried out to evaluate the running performance of the athletes by performing acceleration and side stepping (22). The athletes started the test in a stance that they felt comfortable 1 meter in front of the start line. The test was performed for a total of 3 repetitions, with at least 3 minutes rest from each repetition. The best running time was evaluated in the test performed as 3 repetitions in total.

Statistical Analysis. The data obtained were expressed as \pm mean standard deviation ($\bar{X} \pm Ss$). The appropriateness of the variables to the normal distribution was evaluated using the Shapiro-Wilk Test and correlation analysis was performed to determine the relationship between variables. The relationships between postural control, COD and FMS performance were analyzed using the Correlation Analysis (r), with the level of statistical significance set at $P < 0.05$ in SPSS for Windows, version 21.0 (SPSS, Inc., Chicago, IL).

RESULTS

Descriptive statistics of the athletes are given in Table 1. FMS total scores (FMS) were calculated over 5 tests. All descriptive statistics for other data are included in the Table except PC.

Table 1. Descriptive Statistics for FMS and COD Data.

	Minimum	Maximum	Mean	Std. Deviation
505-right (second)	22.24	25.18	23.4400	0.85174
505-left (second)	22.29	25.98	24.4629	1.03323
Illinois-run (second)	14.48	16.40	15.6012	0.49480
T-run (second)	9.12	11.27	9.8759	0.54253
Deep squat	0.00	3.00	2.2353	0.83137
Hurde step left	1.00	3.00	2.4118	0.79521
Hurde step right	1.00	3.00	1.9412	0.89935
Hurde step total	1.00	3.00	2.0000	0.70711
In-line lunge left	1.00	3.00	2.5294	0.87447
In-line lunge right	1.00	3.00	2.7647	0.56230
In-line lunge total	1.00	3.00	2.5294	0.79982
Trunk stability	1.00	3.00	2.2941	0.77174
Rotary stability left	1.00	3.00	1.9412	0.55572
Rotary stability right	1.00	3.00	1.9412	0.55572
Rotary stability	1.00	3.00	1.8824	0.60025
Functional movement screen total	6.00	14.00	10.9412	2.24918

Table 2. Relationships between COD Data and PC Data

	505-run		Illinois-Run	T-Run
	Right	Left		
$Sbec_{aps}$	-0.157	-0.134	-0.116	-0.164
$Sbec_{apsn}$	-0.018	0.069	-0.197	0.441
$Sbec_{mlss}$	-0.521*	-0.191	-0.564*	-0.222
$Sbec_{mlsn}$	-0.331	-0.382	-0.417	-0.247
$Sbec_p$	-0.299	-0.218	-0.531*	0.028
$Sbec_{el}$	-0.433	-0.250	-0.476	-0.304
$Sbec_{copy}$	0.061	0.180	-0.206	0.104
$Sbec_{copy}$	0.054	0.036	-0.125	-0.526*
$^{20}Db_{aps}$	-0.446	-0.256	-0.387	-0.556*
$^{20}Db_{apsn}$	-0.462	-0.627**	0.083	0.153
$^{20}Db_{mlss}$	-0.091	-0.119	-0.179	-0.274
$^{20}Db_{mlsn}$	-0.150	-0.311	0.038	0.236
$^{20}Db_p$	-0.434	-0.600*	0.108	0.206
$^{20}Db_{el}$	-0.169	-0.169	-0.408	-0.460
$^{20}Db_{copy}$	-0.251	-0.478	0.029	-0.049
$^{20}Db_{copy}$	0.072	0.101	0.222	0.022

$Sbec_{aps}$: Static bipedal eyes close anterior-posterior standard deviations, $Sbec_{apsn}$: static bipedal eyes close anterior-posterior duration of sway, $Sbec_{mlss}$: Static bipedal eyes close anterior-posterior standard deviations, $Sbec_p$: Static bipedal eyes close perimeter, $Sbec_{el}$: Static bipedal eyes close circle area, $Sbec_{copy}$: Static bipedal eyes close center of pressure x, $Sbec_{copy}$: Static bipedal eyes close center of pressure y, $^{20}Db_{aps}$: dynamic bipedal 20 difficulty level anterior-posterior standard deviations, $^{20}Db_{apsn}$: dynamic bipedal 20 difficulty level anterior-posterior duration of sway, $^{20}Db_{mlss}$: dynamic bipedal 20 difficulty level medial-lateral standard deviations, $^{20}Db_{mlsn}$: dynamic bipedal 20 difficulty level medial-lateral duration of sway, $^{20}Db_p$: dynamic bipedal 20 difficulty level perimeter, $^{20}Db_{el}$: dynamic bipedal 20 difficulty level circle area, $^{20}Db_{copy}$: dynamic bipedal 20 difficulty level center of pressure x, $^{20}Db_{copy}$: dynamic bipedal 20 difficulty level center of pressure y. $P < 0.05^*$

Table 3. Relations between FMS Scores and COD Data

COD&FMS	Hurdle Step			In-Line Lunge			Rotary Stability			Trunk Stability	Deep Squat	Fms Total Score
	Left	Right	Total	Left	Right	Total	Left	Right	Total			
505- run												
Right	0.087	-0.213	-0.228	-0.057	0.118	0.121	-0.064	-0.156	-0.078	-0.157	-0.362	-0.186
Left	-0.155	0.192	-0.018	0.340	0.177	0.460	0.115	0.046	0.217	0.053	-0.069	0.237
Illinois-Run	0.175	-0.098	-0.193	-0.538*	-0.065	-0.377	-0.089	-0.112	-0.211	-0.033	-0.141	-0.278
T-Run	-0.495*	-0.340	-0.543*	-0.028	0.242	0.081	0.012	-0.125	-0.107	0.195	0.140	-0.010

$P < 0.05^*$

FMS scores were related to PC data; Ts total score ($r = -0.634^{**}$), Snd_{apsn} ($r = -0.676^{**}$) Hs left, $40Db_{el}$ with inline lunge total scores ($r = -0.608^{**}$), in-line lunge left with sbecopy ($r = -0.632^{**}$), and in-line lunge total score ($r = -$

0.683^{**}), $30D_{cadel}$ ($r = -0.664^{**}$) and $30Db_{mlss}$ ($r = -0.679^{**}$) with FMS total score. Statistically negative correlations were found between other Pc data and FMS data ($P < 0.05$).

Table 2 shows the statistical relationships between postural control and COD data. In the analysis results not included in the Table, Sb_{eocopy} with T-run ($r = -0.553^*$), $40Dd_{mlss}$ with illinois-run ($r = -0.630^{**}$) and T-run ($r = -0.544^*$), $30Dd_{apss}$ and illinois-run and Sb_{eocopy} ($r = -0.553^*$), $20Dnd_{copx}$ with 505-run right leg turn ($r = -0.501^*$) and between $20Dnd_{mlsn}$ and 505-run left leg turn ($r = -0.711^{**}$). In positive relationships, 505-run left leg turn ($r = 0.502^*$) with $30Dd_{copy}$, 505-run right leg turn ($r = 0.522^*$) with $20Dd_{copy}$, T-run with $40Dnd_{apss}$ ($r = 0.495^*$), and $30Dnd_{mlsn}$ ($r = 0.484^*$). In the study, no significant relationship was found between the PC tests $Sbeo$ (40, 30, 20 difficulty levels), Sd , Snd , Db data (40 and 30 difficulty stages) and COD times.

Table 3 shows the correlation relationships between athletes; FMS scores and COD skills. In the correlation analysis of 17 footballer participating in the study, there are negative correlations between FMS measurements Hs left and I-LL left scores and Illinois-running and T-running tests.

DISCUSSION

In the main findings of this study, it was revealed that dynamic and static postural control data were correlated with FMS scores and FMS could be a good test that includes postural control levels the result is determined. Also hurdle step and in-line lunge scores were correlated with COD skills and then FMS tests could be use predicted test for COD skills. However, statistical relationships between other FMS scores and PC data and COD performances were not revealed. It was found that athletes with poor PC data had shorter COD times. Although these similar results to those in the literature, no results parallel to the literature could be obtained between PC and COD. Although there are studies investigating the relationship between FMS and PC levels and change of directions running performance, it is seen that studies examining the relationship between different PC and FMS scores and different running levels are inadequate. Studies have determined that there are relationships between FMS total scores and stork balance test and trunk stability push-up test results (23). The inherent demonstration of postural control and trunk strength performance of the FMS test enables the detection of associated correlations between them. However, some studies have

contrasting results. Hartigan, Lawrence, Bisson, Torgerson & Knight (14) found no correlation between FMS in-line lunge scores and postural control data in comparisons between FMS, postural control, and jump performances. However, this study revealed that unlike other studies, athletes with lower numerical values in postural control (those with better postural control) had higher FMS test scores than other athletes. In this study, it is thought that athletes who provide better postural control perform in the FMS test and that athletes need centre of pressure (CoP) levels in order to stay in postural control while moving at maximum angles in dynamic movement measurements. Unlike the literature, the population results in this study consisted of soccer players who train regularly, while Hartigan, Lawrence, Bisson, Torgerson & Knight (14) the population of the tested who is both male and female and 18-40 ages. It stated that the inclusion of individuals between the ages may have different results across studies.

The FMS test has been proposed to determine the postural control, coordination, mobility, appropriate muscle strength level and flexibility problems as well as to reveal asymmetric conditions as well as to investigate the possible injury risks of athletes right and left sides of the body (24). These tests were recently included in study subjects to reveal relationships between athletes and physical abilities. Hartigan, Lawrence, Bisson, Torgerson & Knight (14) investigated the relationship between the strength, sprint and postural control between the ages of 18 and 40 male and female athletes. Results showed that there was no relationship between strength and postural control skills. In a different study on this subject, Zalai et al. (25) could not find a relationship between FMS tests and motor skills of elite soccer players aged 16.7 ± 2.3 . Similarly, Zou (23) found that T-run test results and FMS test result in a study on 48 men, and 8 women from different branches revealed no relationship. Zalai and others. (25) and Hartigan, Lawrence, Bisson, Torgerson & Knight (14) investigated the relationships between athletes; sprint abilities and FMS scores, and it is seen taking into account the tests performed here. The relationships between FMS test results, especially complex movement applications, and uncomplicated and straight line sprint tests. The absence of a relationship is thought to be due to the tests applied. Because, while FMS tests

measure for complex movement patterns, the researcher investigated in this study that there may be results related to straight sprinting performance performed instead of complex performance tests such as COD. In Zou study (23), the application of the measured group in different branches and to both men and women suggests that the results of the studies may be different. However Lockie et al. (7) found positive correlations between in-line lunge, hurdle step and active straight leg raise scores and COD performances among the FMS test scores performed on 9 women, and they stated that the athletes with well FMS scores had worse COD times. However, the limitation of the study was that the group consisted of both female athletes and subject number was only 9. Again, the same researcher found that FMS total score and hurdle step scores were associated with the T-run test in their study on men. Similarly, Okada, Huxel, and Nesser (16) showed that there was a relationship between Hurdle step FMS scores and in-line lunge right scores and the T-run test of the male and female group (age 24.4 ± 3.9). They explained that the COD skill requires coordination and the step skill requires coordination, stabilization, and mobilization in the changing plane between the upper and lower body, and similarly, in-line lunge skill the cause of the relationship stability, mobilization and coordination skills. Also, Atalay, Tarakçı, and Algun (13) stated that the FMS total scores were related to the illinois running test results as a result of the protocols performed by handball athletes. They stated that the result is that the COD performance requires the ability to change of direction with sudden stopping and sudden acceleration, which may be due to the need for the joints to move within the kinetic chain at the appropriate level and painlessly. Also, Lee, Kim & Kim (15) found a statistical relationship between the FMS test of 20 elite male athletes and their sprint and overhead agility times of 10, 30 meters. The biggest difference in the study is due to the statistical method. Athletes with a total FMS score of 14 and above were divided into two and their level of association was determined. Athletes with a low FMS total score were shorter than those with a high FMS total score and those with a high FMS total score. It has been determined that they realize the strength power parameters. In the results of this study, relationships between hurdle step left and T-

running and in-line lunge left scores and illinois-running skills were found. We interpret the relationships that emerged in this study as the COD skill, which requires complex movement patterns, and the FMS scores that require complex skills. However, the score examining the relationship between them is only in-line lunge and hurdle step tests. In these two tests (especially in-line lunges), the need for athletes to stay in balance during concentric and eccentric contractions in full squatting and restart position angles, as in the COD skill, and the requirement to perform a certain coordination and mobility characteristics within the appropriate muscle strength may have led to results related to COD skill. In the literature, it supports this conclusion that unilateral studies should be performed to improve the COD skills of athletes (26). In other FMS tests, the only rotary-stability movement seems to be such a complex measurement, while deep squat and trunk-stability do not require a complex movement pattern. The fact that the rotary stability test is not related to the COD skill is thought to be due to the different planes on which the tests are performed. In the relationship between FMS total scores and COD, in the study conducted on this subject, Parchmann & Bride (17) examined the relationships between FMS, strength, sprint, and T-running skills of athletes, consisting of 15 male and 10 female athletes with an average age of 20 years. They found that FMS scores did not correlate with sprint and T-running skills. The study examined in terms of FMS total scores and this study has the same results. The reason for this situation is thought to be due to the presence of both non-complex and complex FMS tests in the total scores. In a study that supports this situation, it is mentioned that FMS test total scores do not produce a consistent result and FMS tests should be evaluated separately (27).

Although few studies are examining the relationship between postural control and COD, it is emphasized that the postural control ability has positive effects on COD (9, 28). Sekulic, Spasic, Mirkov, Cavar & Sattler (28) found that the relationship between the static and dynamic postural control measurement results applied to male and female athletes and their COD skills was determined only by the T-Run and COD. They stated that there was a correlation with the COD running test, and the dynamic postural control data had a negative correlation. In the study performed by Sekulic, Spasic, Mirkov, Cavar &

Sattler (28), it was found that postural control levels was different in women compared to men, and the static postural control levels of women was better than men. It is mentioned that muscle strength, especially in women, may affect COD skills rather than postural control. Hammami, Granacher, Pizzolato, Chaouachi & Chtara (29) found that the results of the Y postural control test were correlated with the COD performances of soccer players in the prepubescent period. However, he also mentions the scarcity of studies investigating the relationship between postural control and COD. In this study, the postural control tests were performed in more detail with the difficult stages and both bipedal and unipedal, both eyes open and eyes closed. As the difficulty levels of the postural control levels increase, it is seen that there are relationships between the 505-run data of the athletes who have good postural control data in the y-axis, which are only reached on the dominant leg, and that the nondominant leg anterior-posterior and right-left sway are associated with the T-run running times. In the results of postural control, it is thought that better postural control of the athletes in the anterior-posterior planes on the y-axis reveals the possibility that they may have made the acceleration phases more positive with the forward and backward sudden turns in the 505-running test. Also, the relation between the T-run test and the data belonging to the nondominant leg may be that the anterior-posterior and left-right postural control are related, and the T-running test will be balanced during the forward-to-back and backward running and the test will be completed in a short time. However, the results of this study indicate that there is no statistical relationship

between postural control and COD performance, and even athletes with poor postural control complete the COD tests in a shorter time. Therefore, we think that different studies should be applied between PC and COD performances.

CONCLUSIONS

According to the results of this study, although the level of postural control does not stand out as a structure that can be associated with COD skills alone, the relationship between dominant leg postural control levels and nondominant left-right and anterior-posterior postural control with COD. Also, it has been found that athletes with good postural control levels have better FMS scores. However, it gives the conclusion that for a good COD performance, not only postural control scores, but also FMS scores that require more complex measurements, skills such as in-line lunge and hurdle step, which require postural control, coordination, strength and appropriate posture structure, will be with the COD skill. These results may suggest that trainers should organize more complex training programs. To get more performance output from the athletes, more positive COD can be used to eliminate the deficiencies in the training programs, especially in the FMS tests at the beginning of the season. Also, performing FMS tests instead of high-intensity COD skill tests of athletes who are not ready at the beginning of the season may provide risks and writing healthier training programs. Also, due to the high relationship between FMS tests and PC data, it may be more appropriate to perform FMS tests instead of tests that measure a single skill such as athletes postural control measurements.

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