New Position-Specific Movement Ability Test (PoSMAT) Protocol Suite and Norms for Talent Identification, Selection, and Personalized Training for Soccer Players

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ABSTRACT

Jubbitt P, Tingsabhat J, Chaiwatcharaporn C. New Position-Specific Movement Ability Test (PoSMAT) Protocol Suite and Norms for Talent Identification, Selection, and Personalized Training for Soccer Players. JEPonline 2017;20(1):59-82. The purpose of this study was to develop a soccer position-specific movement ability test (PoSMAT) Protocol Suite and establish their norms. Subjects consisted of six different position soccer players per team from six Thai Premier League 2013 teams. The first step was to identify position-specific high speed running/sprint speed with corresponding distances covered by TRAK PERFORMANCE software. The second step was to develop the PoSMAT Protocol Suite by incorporating position-specific movement patterns and speed-distance analyses from the first step into three test protocols for ATTK - Attacker, CMCD - Central Midfielder and Central Defender, and WMFB - Wide Midfielder and Full Back with respect to the soccer players’ abilities in speed, agility, and cardiovascular endurance. The findings indicate that the PoSMAT Protocol Suite was statistically valid, objective, reliable, and discriminating. Also, PoSMAT norms from 360 Thai elite soccer players were established. Thus, the PoSMAT Protocol Suite and norms can be used for position-specific talent identification, selection for proper playing position placement, and individualized training to enhance the players' soccer career.

Key Words: Position-Specific Movement Ability Test Protocol Suite, Soccer Player Norms, Talent Identification, Individualized Training
INTRODUCTION

Soccer is a popular global sport with a multi-million market all around the world. Any club or national team that can recruit and develop talented players to their fullest potential has a lot of advantages and economic benefits. But, in most clubs, the players are selected through scouts and recommendation by coaches with the player’s predictive success based mostly on intuition rather than objective data. In addition, it is known that talent identification and development are a multifactorial process involves many characteristics (51). While soccer is not a science, it is believed that science may help improve soccer performance that is linked to a myriad of factors including technical, biomechanical, tactical, mental, and physiological considerations. The best teams continue to increase their physical capacities, while the less well ranked have similar values as reported 30 yrs ago (83). A multidisciplinary approach to talent identification in soccer has concluded that the physiological measures were generally more discriminating than anthropometry (68). Acceleration, maximum speed, and agility are specific qualities and relatively unrelated to one another. Specific testing and training procedures for each speed component should be used when working with elite players (49).

Bloomfield et al. (10) provided an indication of the different physical demands of different playing positions in the English Football Association (FA) Premier League match-play through assessment of movements performed by players. They found that position had a significant influence on the purposeful movement time spent, for example, in sprinting, skipping and standing still. Similarly, Sporis et al. (77) concluded that players in different positions had different physical and physiologic profiles. The findings are in agreement with Oliver et al. (64) who used the soccer-specific intermittent-exercise test (SSIET) to provide a reliable method of assessing prolonged repeated-sprint ability (RSA) in the laboratory. The distance covered and the physiological responses during the SSIET successfully recreated the demands of competing in a soccer match (64). There were significant differences in the running repeated sprint ability (rRSA) performance between goalkeepers and outfield-positions. Forwards had better rRSA performance compared to defenders and midfielders. Aziz and colleagues (2) reported that performance in the rRSA was superior in teams with a higher level of competitiveness and/or adaptation to resistance training. The repeated-shuttle-sprint ability (RSSA) test showed adequate construct validity while only RSSA mean time showed sufficient reliability to detect large training-induced changes but not small important differences (40). Game-specific repeated-sprint ability test can discriminate elite women's soccer players of higher and lesser skill levels, and it offers a reliable method of assessing repeated-sprint ability in elite women's soccer players when results are expressed as the total sprint time (30).

The RSA refers to an individual's ability to perform maximal sprints of short duration in succession with little recovery between sprints. The running-based anaerobic sprint test (RAST) was adapted from the Wingate anaerobic test (WAnT) protocol as a tool to assess RSA and anaerobic power (44). Ruscello et al. (72) evaluated the testing of young soccer players’ RSA and concluded that the initial 90% HR reflects more realistically the metabolic responses in which a soccer player operates during a real match (72). The Loughborough Intermittent Shuttle Test (LIST) was determined to be reproducible and closely simulates the physiologic and metabolic responses during a soccer match (61). The LIST as a match simulation training method in sub-elite soccer players may be a useful tool given its superior physiological requirements and training load (37). Also, Di Mascio et al. (26) concluded that
the Reactive repeated-sprint test (RRST) is both a reliable and valid test that distinguishes between performance across standards, positions, and seasonal periods (26).

As agility patterns may vary per playing position, different tests are suggested for different positions (76). The test of reactive strength (i.e., the bilateral side jumps - BSJ) was found to be the most significant predictor of agility performances in children, and training-induced changes in different motor qualities and their influence on agility (75). The Canadian Agility and Movement Skill Assessment (CAMSA) was developed to measure selected fundamental, complex, and combined movement skills for childhood physical literacy (50). Quality movement is a fundamental aspect of performance in the majority of field sports. As a basic motor skill, sport movement should be subject to a systematic development program in which quality practice and quality coaching play a lead role (42). The Illinois change of direction speed test (ICDST) found differences in change of direction speed (CODS) performance among soccer players of different age categories (U-10, U-12, U-13, and U-18), and the test also demonstrated that developing allometric exponents are effective in the control of the players’ anthropometric measures (60). In fact, changes in body mass of young soccer players have the largest effect on changes in accelerative ability and on drive and transition phases, while changes in leg muscle power have impact only on the drive phase of the acceleration (62).

Linear sprint speed has the potential to be a useful talent identification index for youth soccer players. On the other hand, muscular power and COD ability is changeable during the growth period that suggests these parameters are not useful for talent identification index (36). The study of match activity profile of U9 and U10 elite soccer players found that both squads covered approximately 4,000 m in total, U10 squad covered a greater distance at moderate and high speeds than the U9 squad, and those players who are retained by academies cover a greater distance in total and at low speeds (32). A wide range of psychological characteristics for soccer performance should be included in talent identification and development process (38). The improvement in power capacities will probably result in an improvement in agility in basketball athletes, while anthropometric indices should be used in order to identify those athletes who can achieve superior agility performance (74). In junior water polo, fitness capacities were found to be more important as determinants of quality among perimeters than among centers (39).

Physiological responses to repeated bouts of short duration maximal-intensity exercise on mean plasma concentrations of hypoxanthine (HX) and uric acid (UA) and time of last sprint increased during 30-m and 40-m sprints (3). In elite outfield players, the average work rate during a soccer match, as estimated from variables such as heart rate, is approximately 70% of maximal oxygen uptake (VO₂ max). Furthermore, the adenosine diphosphate degradation products—ammonia/ammonium, hypoxanthine and uric acid are elevated in the blood during soccer matches. Thus, the anaerobic energy system is heavily taxed during periods of match-play. Although glycogen in the working muscle seems to be the most important substrate for energy production during soccer matches, muscle triglycerides, blood free fatty acids and glucose are also used as substrates for oxidative metabolism in the muscles (5). A top-class soccer player covers an average distance of approximately 11 km during a match. The distance differs highly between players and is partly related to the position in a team. In addition to running, a player is engaged in many other energy demanding activities, such as tackling, jumping, accelerating, and turning (6). Motion characteristics of professional youth
soccer players were quantified and a soccer-specific exercise protocol was developed to induce a similar physiological load to soccer match play to study the physiological demands of soccer [79]. The physiological response to the Copenhagen Soccer Test (CST) was reproducible and comparable to that of high-level competitive games. The CST allowed for rapid muscle sampling and revealed high creatine phosphate degradation throughout the test and a lowered glycogen utilization toward the end of the simulated game [48].

Update on information about physiology of soccer players and referees, and relevant physiological tests that have important implications for the safety and success of soccer players have been compiled (78). The Wingate Anaerobic Test (WAnT) has been established as an effective tool in measuring both muscular power and anaerobic capacity in a 30-sec time period for men and women of the National Collegiate Athletic Association (NCAA) Division I college athletes. One-half standard deviations were used to set up a 7-tier classification system (poor to elite) for the assessments of absolute and relative peak power and anaerobic capacity (89). The Bangsbo test and 30 m sprint test correlated with VO$_2$ max and vertical jump force and velocity, respectively, while Bangsbo test did not give a good estimate of VO$_2$ max in the young soccer players (17). The Copenhagen Soccer Test for Women was comparable to competitive match-play (8). The Yo-Yo Intermittent Endurance Level 2 (Yo-Yo IE2) test is reproducible and can be used to determine the capacity of elite soccer players to perform intense intermittent exercise as well as differentiate intermittent exercise performance of players in various stages of the season and playing positions (11,13). Match performance and physical capacity of players in the top three competitive standards of English soccer could be associated with technical characteristics inherent to lower standards that require players to tax their physical capacity to a greater extent (12). Players reporting lowest performance decrements in the repeated-sprint ability test performed more high-intensity actions interspersed by short recovery times compared with those with higher decrements. Across positional roles, central-midfielders performed more high-intensity actions separated by short recovery times (< = 20 sec) and spent a larger proportion of time running at higher intensities during recovery periods, while fullbacks performed the most repeated high-intensity bouts (15). Soccer at the elite level, such as the French First League, requires the players to have a high aerobic capacity, and they must be able to perform many high-intensity actions, especially the capacity for repeated sprints. (25). It is important to understand the technical and physical demands of small versus large sided games in relation to playing position in elite soccer (24). Goalkeepers were found to be able to perform better on explosive power tests (squat jump and countermovement jump) than players in the field (77).

Sports scientists require a thorough understanding of the energy demands of sports and physical activities so that optimal training strategies and game simulations can be constructed. A range of techniques has been used to both directly assess and estimate the physiological and biochemical changes during competition. A fundamental approach to understanding the contribution of the energy systems in physical activity has involved the use of time-motion studies. A number of tools have been used from simple pen and paper methods, the use of video recordings, to sophisticated electronic tracking devices. Depending on the sport, there may be difficulties in using electronic tracking devices because of concerns of player safety. The results indicate distances measured using computer-based tracking (CBT) overestimated the actual values (measured with a calibrated trundle wheel) by an average of about 5.8%. The global positioning technology (GPS) overestimated the actual
values by about 4.18%. Both systems showed relatively small errors in true distances (29). The distances covered by Brazilian soccer players analyzed and compared to the European players by automatic tracking system capable of tracking simultaneous trajectories of all soccer players revealed 7% reduction in mean distance covered in the second half. After 8 min of the second half, player performance was decreased but maintained throughout the second half (7). The total distance covered and motion pattern characteristics of young Brazilian soccer players during competitive matches show differences in running volume and intensity between the age groups during match play (22).

Motion-based recognition which deals with the recognition of an object or its motion based on motion in a sequence of images (16), which can be applied to track soccer motion. Two descriptors were developed to index video sequences according to their dynamic content to broadcast sports and video surveillance (41). Object-based video analysis and interpretation based on automatic video object extraction, video object abstraction, and semantic event modelling can provide a detailed description of the characteristics of video objects that can be readily interfaced to MPEG-7 application (52). Feature-based motion cues (a motion-based frequency-domain scheme for human periodic motion recognition) avoids a time-consuming recovery of underlying kinematic structures in visual analysis and largely reduces the parameter domain in the presence of human motion irregularities (54). The hierarchical durational-state dynamic Bayesian network (HDS-DBN) was developed for activity recognition by decomposing states in terms of multi-scale motion details, and each kind of state indicates legible meaning (28). Color-independent visual model based on the target's local motion resolves situations when the target is occluded by or moves in front of a visually similar object (47), frequently occurred in soccer video analysis. Computer vision techniques have been adapted to be applicable in the challenging soccer context for real time soccer video analysis (27). Time-stamped ball-related event descriptions and coordinates from Prozone Sports were used to build a summary of the football's motion. The data could potentially be used to quantify what happens during a kick and in some situations provide medical researchers with a better idea of what cranial accelerations are present in a header (33). Tactic analysis using efficient real-world trajectory extraction method based on field line detection and definition and recognition of typical soccer patterns for tactic video analysis were introduced to improve the tactic analysis in terms of the conciseness, clarity, and usability (63).

The score measuring system, mobiXeyes, developed by Mobics SA calculates the 3D position and the speed of a fast moving object for scoring Beach-Racket game and could be used also in a wide range of relevant sports with none or minor modifications (73). Incremental Discriminative Colour Object Tracking was introduced to track entities on a sports ground by modifying certain elements of the original Mean Shift algorithm so as to track entities in video streams with changing colour, shape, and direction. The trajectory formed from this method enables the calculation of the distance covered by an entity in the field (85). A new methodology using neural network-based classifier, the k-Nearest Neighbour, the Support Vector Machine, and the Random Forest classifiers were able to perform the team activity recognition task with high accuracy when classifying three Football actions: Ball Possession, Quick Attack, and Set Piece (57). An approach for exploiting structural relations to track multiple objects that may undergo long-term occlusion and abrupt motion by initializing a probabilistic Attributed Relational Graph (ARG) from the first frame, which is incrementally updated along the video, to generate new tracking hypotheses to
improve or recover the track of lost objects was proposed to analyze sports videos that present structural patterns (59). Automatic camera planning for soccer games using pan, tilt and zoom (PTZ) cameras by the Overlapped Hidden Markov Model (OHMM) method to effectively optimize the camera trajectory in the temporal space, results in much more natural camera movements present in real broadcasts, and CalibMe to automatically calibrate cameras for soccer games was introduced for soccer video recording and analysis (19). In tennis, a fully automatic annotation of tennis game was developed using broadcast video integrating computer vision, machine listening, and machine learning to improve state-of-the-art tennis ball tracking algorithm, audio signal processing techniques to detect key events and construct features for classifying the events (88).

Typical field test protocols used in soccer are specific for a particular physiological purpose. That is why there are many combinational (battery) tests needed to serve collective purposes such as talent identification, selection, and personalized training position-specific soccer players to meet their salient characteristic nature and demand. Thus, the purpose of this study was to develop a position-specific test protocol suite with corresponding norms to help discriminate specific characteristics and capability of a soccer player in favor of a particular position in a soccer team with level of suitability and matching. This means the team manager will find it much easier to place one player into a particular slot and have more choices in exchangeability of team squads and future planning. Also, given that the protocols will have been validated and verified for all criteria as an accurate and reliable tool, at least for Thai professional soccer players, they serve as benchmark for other levels of professionalism from grassroots up.

METHODS

Subjects

For PoSMAT Protocol Suite Establishment
A total of 36 subjects were used for the establishment of a position-specific movement ability test (PoSMAT) Protocol Suite. All subjects were Thai professional soccer players from the six leading teams of the 18 “Thai Premier League 2013” teams (namely, Buriram United FC, SCG Muangthong United FC, Chonburi FC, Suphanburi FC, Bangkok Glass FC, and Army United FC). Six different playing position players were purposively selected from each team.

For PoSMAT Protocol Suite Validation
A total of 101 subjects were used for validation of PoSMAT Protocol Suite. They were Thai Division II soccer players of which 36 were attackers, 32 were central midfielders and central defenders and 33 were wide midfielders and full backs from Nakornnayok FC, Rangsit University, Pathumthani United FC, and Chonburi FC.

For PoSMAT Protocol Suite Norms Establishment
A total of 360 subjects were used for the establishment of PoSMAT Protocol Suite norms. They were subjects who were not involved in protocol establishment or the validation from 5 Thai professional league teams, 6 Division I teams, and 18 Division II teams.

Instrumentation
Typical digital video cameras were used to capture movement of the soccer players during competition and tests instead of the hand-held stopwatches (35,53). TRAK PERFORMANCE
software was used for motion analysis of video clips from real competition. Polar heart rate monitors were used (21,79) to monitor proper intensity during testing of all the subjects to ensure reliable and accurate test results.

**Procedures**
The following steps were taken to establish the PoSMAT Protocol Suite and norms.

**PoSMAT Protocol Suite Establishment**
Video analysis of position-specific high speed running and sprinting speed with corresponding distances covered in combination with position-specific movement patterns of soccer players constituted the PoSMAT Protocol Suite for differentiating position-specific demands in terms of speed, agility, and cardiovascular endurance.

**Video Analysis of Speed versus Distance Covered**
Video capturing movement of the 36 subjects selected for Protocol Suite establishment were made during real Thai Premier League 2013 competition, which was analyzed for position-specific high speed running and sprinting speed with corresponding distances covered (7,29) using the TRAK PERFORMANCE software. By specifying speed greater than 25 km·h\(^{-1}\) as sprinting speed and speed greater than 19.8 km·h\(^{-1}\) as high speed running (15,26), average distances covered by high speed running of attacker, central midfielder, full back, and wide midfielder were 640, 490, 429, and 677 m per match, respectively, while average distances covered by sprinting were 210, 180, 108, and 218 m per match respectively, as compared to those of English professional soccer players (12) whose average distances covered by high speed running of attacker, central midfielder, full back, and wide midfielder were 714, 736, 459, and 883 m per match, respectively, and average distances covered by sprinting were 312, 217, 115, and 331 m per match, respectively.

**Position-Specific Movement Patterns**
Reviewing the literature about movement training for field sports (42), movement patterns in the elite Brazilian youth soccer players (22), the physical demands of different positions in the FA Premier League soccer (10), the match performance and physical capacity of players in the top three competitive standards of English professional soccer (12) including the Periodization Training for Sports (9) in combination with the speed-distance video analysis can be consolidated into three different field test protocols. They are the position-specific movement ability test, the PoSMAT Protocol Suite as shown in Figures 2, 3, and 4 in terms of salient characteristics of movement patterns of different playing positions, and the position-specific physiological demands on speed, agility, and cardiovascular endurance.

**PoSMAT Protocol Suite for Attacker: PoSMAT-ATTK**
Upon hearing the start signal, the test subject ran from the 1st cone to and around the 2nd cone, to and around the 3rd cone back to the 2nd cone, then to and around the 4th cone to the 5th cone and back to the 1st cone to complete one round. The subject could choose to finish 4 rounds on the right and then 4 rounds on the left or vice versa in the fastest continuous manner in every round. Video recording for subsequent scouting and speed analysis was used instead of a stop watch to eliminate reaction time errors by the test administrators. An important point is that timing accumulation for each round was only from the 1st cone to the 5th cone. Duration from the 5th cone back to the 1st cone in each round
was disregarded. Then, the elapsed time of 8 segments were summed up to be PoSMAT-ATTK time for the test subject.

**PoSMAT Protocol Suite for Central Midfielder and Central Defender: PoSMAT-CMCD**

Upon hearing the start signal, the test subject ran backwards as fast as possible from the 1st cone to the 2nd cone and then forwards normally to and around the 3rd cone towards the 4th cone to the 5th cone to and around the 6th cone and back to the 1st cone to complete one round. The subject could choose to finish 4 rounds on the right and then 4 rounds on the left or vice versa in the fastest continuous manner in every round. The video recording for subsequent scouting and speed analysis was used instead of the stop watch to eliminate reaction time errors by the test administrators. The important point is that timing accumulation for each round was only from the 1st cone to the 6th cone. The duration from the 6th cone back to the 1st cone in each round was disregarded. Then, the elapsed time of 8 segments was summed up to be PoSMAT-CMCD time for the test subject.

**Figure 1.** Digital video cameras were used to capture movement of soccer players during tests under PoSMAT Protocol Suite, 50-m Run Test Protocol, agility T-Test Protocol and RAST Protocol instead of stop watches.

**Figure 2.** PoSMAT Protocol Suite For Attacker: PoSMAT-ATTK.

**Figure 3.** PoSMAT Protocol Suite for Central Midfielder and Central Defender: PoSMAT-CMCD.

**Figure 4.** PoSMAT Protocol Suite for Wide Midfielder and Full Back: PoSMAT-WMFB.
PoSMAT Protocol Suite for Wide Midfielder and Full Back: PoSMAT-WMFB

Upon hearing the signal, the test subject ran as fast as possible from the 1st cone to and around the 2nd cone to the 3rd cone to and around the 4th cone to the 5th and 6th cone to and around the 7th cone and back to the 1st cone to complete one round. The subject could choose to finish 4 rounds on the right and then 4 rounds on the left or vice versa in the fastest continuous manner in every round. The video recording for subsequent scouting and speed analysis was used instead of a stop watch to eliminate reaction time errors by the test administrators. The important point is that timing accumulation for each round was only from the 1st cone to the 7th cone. The duration from the 7th cone back to the 1st cone in each round was disregarded. Then, the elapsed time of 8 segments was summed up to be the PoSMAT-WMFB time for the test subject.

PoSMAT Protocol Suite Validation

All 101 subjects for the Protocol Suite validation were subjected to testing under PoSMAT Protocol Suite for validity, objectivity, and reliability.

PoSMAT Protocol Suite for Talent Identification

After the PoSMAT Protocol Suite passed the tests, they were used to test 101 subjects for their discriminating power for talent identification.

PoSMAT Protocol Suite Norms Establishment

All 360 subjects for norms establishment group were subjected to testing by the PoSMAT Protocol Suite to establish PoSMAT norms.

Statistical Analyses

Content Validity of PoSMAT Protocol Suite

Five experts who were A Coaching Certificate Course coaches went through all the testing protocols for attackers, central midfielders, central defenders, wide midfielders, and full backs covering distances between cones, total test distances, testing directions, video recording instead of stop watch for time segment measurement and recording, heart rate monitor usage for testing quality and accuracy, warm-up procedure before testing, cool-down procedure after testing, running speed measurement, agility measurement, reaction time measurement, balance, co-ordination, muscle strength, muscle endurance, flexibility, cardiovascular endurance, and position-specific performance assessment capabilities. Items with Index of Item-Objective Congruence (IOC) more than 0.75 were included in final the PoSMAT Protocol Suite.

Concurrent Validity of PoSMAT Protocol Suite

Pearson’s Correlation Coefficients were used to determine the validity (45,46) of the PoSMAT Protocol Suite against standard field testing protocols in terms of speed, agility, and cardiovascular endurance for attacker in the PoSMAT-ATTK Protocol, for central midfielder and central defender in the PoSMAT-CMCD, and for wide midfielder and full back in the PoSMAT-WMFB.

Regarding running speed validity, the PoSMAT Protocol Suite was tested against the 50-m running field test protocol. Pearson’s r indicated a correlation with ATTK, CMCD, and WMFB of 0.829, 0.740, and 0.841, respectively.
Regarding agility validity, the PoSMAT Protocol Suite was tested against the agility T-Test protocol and found that Pearson’s r in correlation with ATTK, CMCD and WMFB were 0.863, 0.913, and 0.893, respectively.

Regarding special cardiovascular endurance validity, the PoSMAT Protocol Suite was tested against the RAST testing protocol and found that Pearson’s r in correlation with ATTK, CMCD and WMFB Protocols were 0.701, 0.700, and 0.733, respectively.

**Objectivity test of PoSMAT Protocol Suite**

Pearson’s Correlation Coefficients were used to determine the objectivity (45,46) of the PoSMAT Protocol Suite with respect to the testing of speed, agility, and cardiovascular endurance for attacker in the PoSMAT-ATTK Protocol, for central midfielder and central defender in the PoSMAT-CMCD Protocol, and for wide midfielder and full back in the PoSMAT-WMFB Protocol.

Regarding objectivity in testing attacker, Pearson’s r in correlation with speed, agility, and special cardiovascular endurance in the PoSMAT-ATTK Protocol were 0.850, 0.795, and 0.781, respectively.

Regarding objectivity in testing central midfielder and central defender, Pearson’s r in correlation with speed, agility, and special cardiovascular endurance in the PoSMAT-CMCD Protocol were 0.737, 0.803, and 0.873, respectively.

Regarding objectivity in testing wide midfielder and full back, Pearson’s r in correlation with speed, agility, and special cardiovascular endurance in the PoSMAT-WMFB Protocol were 0.795, 0.737, and 0.780, respectively.

**Reliability test of PoSMAT Protocol Suite**

Pearson’s Correlation Coefficients were used to determine test-retest reliability (45,46) of the PoSMAT Protocol Suite by testing 36 attackers, 32 central midfielders and central defenders, and 33 wide midfielders and full backs twice one week apart for speed, agility, and special cardiovascular endurance for reliability correlation and differences between mean values of corresponding test results.

Regarding reliability in running speed testing ability of the ATTK, the CMCD, and the WMFB protocols, Pearson’s r in correlation with average best running times between two tests were 0.850, 0.737, and 0.795, respectively, with no statistical differences between two tests.

Regarding reliability in agility testing ability of the ATTK, the CMCD and the WMFB protocols, Pearson’s r in correlation with average best times between two tests were 0.795, 0.803, and 0.737, respectively, with no statistical differences between two tests.

Regarding reliability in cardiovascular testing ability of the ATTK, the CMCD and the WMFB protocols, Pearson’s r in correlation with average heart rates between two tests were 0.781, 0.873, and 0.780, respectively, with no statistical differences between two tests.
Discriminating power of PoSMAT Protocol Suite

Analysis of Variance (ANOVA) was used to assess pairwise differences of means in testing 36 attackers, 32 central midfielders and central defenders, and 33 wide midfielders and full backs under all test protocols in Table 1 with *post hoc* analysis using Scheffé’s method as shown in Table 2 to determine the discriminating power of the PoSMAT Protocol Suite with respect to the standard field test protocols.

Table 1. The Comparisons of Position-Specific Movement Ability Demands between Speed Testing by 50-m Run and PoSMAT, Agility Testing by T-Test and PoSMAT, and Cardiovascular Endurance Testing by RAST and PoSMAT.

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<th>Parameter</th>
<th>Position</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Std Err</th>
<th>For Mean</th>
<th>Lower Bound</th>
<th>Upper Bound</th>
<th>Max</th>
<th>Min</th>
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<td>ATTK</td>
<td>36</td>
<td>7.1439</td>
<td>.41337</td>
<td>.06890</td>
<td>7.0040</td>
<td>7.2838</td>
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<td>.33916</td>
<td>.05996</td>
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<td>6.8379</td>
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<td>.46000</td>
<td>.04577</td>
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<td>10.6128</td>
<td>1.08897</td>
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Notes:
1. **ATTK** = attacker position, **CMCD** = central midfielder and central defender position; **WMFB** = wide midfielder and full back position.
2. **PoSMAT** = Position-Specific Movement Ability Test Protocol Suite; **50-M** = 50-meter Running Test Protocol; **T-Test** = Agility T-Test Protocol; **RAST** = Running-Based Anaerobic Sprint Test Protocol
Table 2. ANOVA Multiple Comparisons with Post Hoc Analysis by Scheffé’s Method.

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<th>Position (J)</th>
<th>Mean Difference (I-J)</th>
<th>Std Err</th>
<th>Sig</th>
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*The mean difference is significant at the 0.05 level.

PoSMAT Protocol Suite Norms
The 105 attackers - ATTK, the 129 central midfielders and central defenders – CMCD, and the 126 wide midfielders and full backs - WMFB from norms establishment subject group were subject to test under the PoSMAT Protocol Suite to obtain testing values of speed, agility, and quickness in terms of running time, movement time and total time in seconds according to their playing positions and the corresponding frequency distributions were used.
to establish one standard deviation 5-tier classification system for norms as per format shown in Table 3.

Table 3. One Standard Deviation 5-tier Classification System for Norms Establishment.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Very Good (sec)</th>
<th>Good (sec)</th>
<th>Fair (sec)</th>
<th>Poor (sec)</th>
<th>Very Poor (sec)</th>
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<td>Speed</td>
<td>$&lt; \bar{x} - 2SD$</td>
<td>$\bar{x} - 2SD - \bar{x} - SD$</td>
<td>$\bar{x} - SD - \bar{x} + SD$</td>
<td>$\bar{x} + SD - \bar{x} + 2SD$</td>
<td>$&gt; \bar{x} + 2SD$</td>
</tr>
<tr>
<td>Agility</td>
<td>$&lt; \bar{x} - 2SD$</td>
<td>$\bar{x} - 2SD - \bar{x} - SD$</td>
<td>$\bar{x} - SD - \bar{x} + SD$</td>
<td>$\bar{x} + SD - \bar{x} + 2SD$</td>
<td>$&gt; \bar{x} + 2SD$</td>
</tr>
<tr>
<td>Quickness</td>
<td>$&lt; \bar{x} - 2SD$</td>
<td>$\bar{x} - 2SD - \bar{x} - SD$</td>
<td>$\bar{x} - SD - \bar{x} + SD$</td>
<td>$\bar{x} + SD - \bar{x} + 2SD$</td>
<td>$&gt; \bar{x} + 2SD$</td>
</tr>
</tbody>
</table>

Notes: $\bar{x} =$ mean, $SD =$ Standard Deviation, $2SD =$ 2 times Standard Deviation.

RESULTS

Validity, Objectivity, and Reliability
Testing of the PoSMAT Protocol Suite verified that it was statistically valid, objective, and reliable. The contents have been validated by five experts. Their concurrency have been validated against standard protocols, i.e. speed protocol against 50-m run test protocol, agility protocol against the agility T-Test protocol, and cardiovascular endurance protocol against RAST protocol.

The PoSMAT Protocol Suite objectively test attackers (ATTK), central midfielders and central defenders (CMCD) and wide midfielder and full back (WMFB) for their speed, agility, and cardiovascular endurance.

The PoSMAT Protocol Suite is a reliable test and retest for all player positions for speed, agility, and cardiovascular endurance.

Discriminating Power
The PoSMAT Protocol Suite discriminates player position-specific characteristics compared to standard protocols with respect to physiological demands in terms of movement abilities of speed, agility, and cardiovascular endurance (as summarized in Table 4).

In terms of speed ability, the 50-m running test protocol can discriminate position-specific speed demand statistically in the order of running time: ATTK > CMCD > WMFB, while the PoSMAT Protocol Suite can rank average running times in the same order, but average ATTK running time was not significantly longer than average CMCD running time.

In regards to agility (i.e., movement ability), the agility T-Test protocol and the PoSMAT Protocol Suite discriminate position-specific agility demand in the order of movement time: ATTK > CMCD > WMFB, but the average ATTK movement time was not significantly longer than the average CMCD movement time.

As to cardiovascular endurance demand of movement ability, both the RAST protocol and the PoSMAT Protocol Suite can discriminate position-specific cardiovascular endurance demand in the order of heart rate ATTK < CMCD < WMFB without statistical significance.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>ATTK vs CMCD</th>
<th>CMCD vs WMFB</th>
<th>ATTK vs WMFB</th>
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</thead>
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<td>&gt;&gt;</td>
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<td>Speed – PoSMAT</td>
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<td>Agility – T-Test</td>
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<td>Agility – PoSMAT</td>
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<td>Endurance – RAST</td>
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<tr>
<td>Endurance – PoSMAT</td>
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<td>&lt;</td>
<td>&lt;</td>
</tr>
</tbody>
</table>

Notes: >> = Statistically more than significantly, black background; > = Statistically more than insignificantly, grey background; < = Statistically less than insignificantly, grey background.

From Table 4, it is clear that WMFB – wide midfielder and full back position demands significantly the highest running speed and the highest agility player. CMCD – center midfielder and central defender position demands generally, but not necessarily, higher running speed and higher agility, than ATTK – attacker position. In other words, CMCD and ATTK positions are replaceable or interchangeable from the perspective of speed and agility. WMFB possesses generally, but not necessarily, more endurance than CMCD, and in turn more than ATTK. In other words, all positions are replaceable or interchangeable from the perspective of endurance.

Position-Specific Norms
PoSMAT Protocol Suite norms for attacker – ATTK, central midfield and central defender – CMCD and wide midfielder and full back – WMFB are shown in Table 5, 6, and 7, respectively.

Table 5. The Norms for Attacker: ATTK.

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<th>Characteristics</th>
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<th>Good (sec)</th>
<th>Fair (sec)</th>
<th>Poor (sec)</th>
<th>Very Poor (sec)</th>
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<tr>
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<td>&lt; 7.67</td>
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<td>9.20 – 9.70</td>
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<td>Agility</td>
<td>&lt; 7.93</td>
<td>8.45 – 8.96</td>
<td>8.97 – 9.48</td>
<td>9.49 – 10.00</td>
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<tr>
<td>Quickness</td>
<td>&lt; 75.41</td>
<td>79.65 – 83.88</td>
<td>83.89 – 88.12</td>
<td>88.13 – 92.36</td>
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</tbody>
</table>

Table 6. The Norms for Central Midfielder and Central Defender: CMCD.

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<th>Fair (sec)</th>
<th>Poor (sec)</th>
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<td>8.78 – 9.20</td>
<td>9.21 – 9.63</td>
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<tr>
<td>Quickness</td>
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<td>74.08 – 78.77</td>
<td>78.78 – 83.47</td>
<td>83.48 – 88.17</td>
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Table 7. The Norms for Wide Midfielder and Full Back: WMFB.

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<th>Poor (sec)</th>
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<td>9.41 – 10.09</td>
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<tr>
<td>Quickness</td>
<td>&lt; 64.45</td>
<td>70.99 – 77.52</td>
<td>77.53 – 84.06</td>
<td>84.07 – 90.60</td>
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</table>

Applications

Talent Identification
The PoSMAT Protocol Suite can be used to identify position-specific talent by subjecting the players to test under three protocols of the PoSMAT Protocol Suite and then compare to the norms. It identifies the position the player scores best, which is his position-specific inherent talent.

Proper Selection for Playing Position Planning and Placement
The PoSMAT Protocol Suite can be used to select an appropriate playing position that matches his position-specific talent. Since the PoSMAT Protocol Suite suggests WMFB position demands the highest speed and highest agility player, while CMCD and ATTK are interchangeable; whereas, quickness ability in terms of endurance are interchangeable, yet preferable higher from ATTK to CMCD to the highest in WMFB position. This help team management and coaches plan proper playing position placement and reserved players from movement ability perspective.

Personalized Training
The PoSMAT Protocol Suite can be used to plan personalized training and benchmark individual against the norms. It helps in goal setting for training plan, especially if one would like to change playing position to another position that demands higher speed or higher agility than current ability.

DISCUSSION

Talent Identification
There are many field tests that have been validated to identify soccer player talent in terms of anthropometric (50,60,68,75) and physiological variables and, then, matching performance at various level of standards, including sex, age categories, and playing positions (3,5,7,8,11-13,15,17,24,25,29,40,48,77,79,89). But, none of these tests has served the purpose of position-specific talent identification with norms to benchmark against. The present study has incorporated relationships among movement patterns, physiological demand characteristics of different positions of soccer players to derive position-specific field test protocol suite that is valid, objective, and reliable. The test discriminates various specific characteristics of each playing position complete with norms. It is low cost test that is simple to conduct, yet powerful, accurate, reliable, and insightful for talent identification, selection for position placement and planning for personalized training.
PoSMAT Protocol Suite Development

Time and Distance Covered Recording
Video recording was used instead of hand-held stop watches to eliminate test administrators errors for inherent inter-tester and intra-tester reaction time response in pushing stop watch buttons (35). Electronic timing gates (53) were not used as running paths were too complicated to setup and register all time segments. With 30 frames per second video, time resolution is .033 second per frame when the video is subsequently analyzed for accurate time segment durations by video editing software like Movie Maker. The intent of the research was to develop simple, low cost, and fast setup protocols that are not complicated, thus encouraging a wide adoption and application (e.g., cones at fixed patterns with a digital video camera).

Testing Conditions
Since there were several phases of this study from protocol establishment and validation to norms establishment, the testing conditions for all phases were consistent throughout data collection by using heart rate monitors (21,79) to ensure that all subjects performed their best on grass with soccer cleats (23) without familiarization (31).

Further Development
As advanced technology in motion tracking, motion recognition, real-time video analysis, and tactic analysis (16,19,27,28,33,41,47,52,54,57,59,63,73,85,88), the PoSMAT Protocol Suite can be further developed on tablet with embedded norms so that real-time testing can be captured by a built-in camera. The test results as well as norm assessment can be available instantly for talent identification purpose, or ad hoc playing position selection and placement from available squad. Future integration with real-time video tactic analysis will help position-specific evaluation of proper assignment to meet overall technical and tactical goals.

Individualized Training
The Complete Handbook of Conditioning for Soccer (84), a complete guide to developing every aspect of conditioning for soccer players should be consulted as Europe's top soccer conditioning experts contributed the following chapters: Soccer Strength Training, Soccer Specific Endurance Training, Speed Training for Soccer, Pre-Season Conditioning, Goalkeeper Training, Fitness Testing, and Injury Prevention. Periodization Training for Sports (9) should also be consulted for detailed periodization planning and training. Training for Speed, Agility, and Quickness (SAQ) should be consulted for balanced integration of SAQ training into overall training program (14).

The complexity of the physical demands of soccer requires the completion of a multi-component training program. The development, planning, and implementation of such a program are difficult due partly to the practical constraints related to the competitive schedule at the top level. The effective planning and organization of training are therefore crucial to the effective delivery of the training stimulus for both the individual players and the team. (58). The SAQ training program appears to be an effective way of improving some segments of power performance in young soccer players during the in-season period and should be planned for (43). The SAQ training is an effective way to improve agility either with or without the ball for young soccer players, and it can be included in physical conditioning programs (55). Also, a high carbohydrate diet should be administered in preparation for intense training and competition (4).
Improvement in the players’ physical condition can be associated with reduced incidence and severity of injuries by applying “The 11” injury prevention program developed by the FIFA Medical Centers and Clinics of Excellence (F-MARC) (81). Also, a proper warm-up that integrates flexibility and speed components (20), including identification of true causes of pain from testing (65), can help reduce injuries.

Pattern recall skills should be enhanced as the more experienced players anticipate the pattern further in advance than the less experienced players and, thus demonstrated a higher search rate, a shorter fixation duration and a higher fixation order (82). Other sports psychological skill training should also be incorporated into the training program. In particular, neuroscience has provided evidence for improving and enhancing complex soccer motor skill acquisition through cerebral plasticity (87), which can help augment training in the soccer players’ physical, mental, and intellectual development.

Therefore, in sum, it should be apparent that the PoSMAT Protocol Suite can be instrumental in planning and training soccer players in holistic manner from physical to mental and intellectual development.

National and International Benchmarking
The established PoSMAT Protocol Suite norms from Thai professional and elite soccer players can be used as benchmarks for our soccer players in Thailand and potentials for international benchmarking (18). Norms for lower levels to U9 will be further developed and can be used as national guidelines in talent identification and development programs from grassroot up.

CONCLUSIONS
This study has resulted in accurate and reliable field test protocols and norms that can be used for talent identification to assess and discriminate position-specific movement ability among soccer players. It can also be used for selection to match individual salient performance characteristics to appropriate playing position, and for planning proper specific individualized training to enhance their best possible career in the future. Test protocols together with norms developed from this study can be refined for other levels of soccer players, and the norms established can be used as benchmarks for further development and comparison tools across countries.

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