VALIDITY OF A 5-METER MULTIPLE SHUTTLE RUN TEST FOR ASSESSING FITNESS OF WOMEN FIELD HOCKEY PLAYERS

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ABSTRACT: Boddington, M.K., M.I. Lambert, and M.R. Waldeck. Validity of a 5-meter multiple shuttle run test for assessing fitness of women field hockey players. J. Strength Cond. Res. 18(1): 97-100. 2004.—The aim of this study was to establish validity of a 5-m multiple shuttle test (5-m MST) using indirect (criterion and construct) and direct measures of performance. For criterion validity, comparisons were made between data from established fitness tests and a 5-m MST. Construct validity was determined by comparing results from a 5-m MST with subjects of different playing abilities. Direct validity was determined by comparing values attained from a 5-m MST with data from a time-motion study of field hockey. For criterion validity, the strongest relationship existed between the 20-m MST (42.7 ± 7.1 m·kg·min⁻¹) and total distance from the 5-m MST (650.9 ± 59.2 m; r = 0.92). For construct validity, regional representative players covered more distance than club-level players (689.9 ± 46.6 m vs. 661.1 ± 31.0 m; p < 0.01). For direct validity, the highest correlation was found between total distance from the 5-m MST (706.0 ± 37.5 m) and mean displacement during matches (61.0 ± 6.0 m; r = 0.74). It was concluded that the 5-m MST had both indirect and direct validity for the fitness assessment of field hockey players. The data obtained from the 5-m MST directly relates to the physical fitness of the players during competition.

KEY WORDS: field tests, indirect validity, direct validity

INTRODUCTION

There is a trend for athletes from a variety of sports to consult with sports scientists about having their fitness evaluated at various stages of the season (off-season, preseason, and mid-season) or as part of their preparation toward a major competition (10). The coaches and players expect sports scientists to provide them with a comprehensive assessment of their squad's present fitness level, how it compared with previous occasions, and how it can be improved. However, the assessment can only be useful if the tests have a certain level of scientific integrity and are reliable, sport specific, and valid.

There is a tendency for fitness testing to move away from the less sports-specific laboratory tests toward the more representative field tests (12). However, these field fitness tests need to be valid for the sports scientist to give players and coaches accurate and relevant feedback after the assessment. Validity is defined as "the extent to which a test, measurement, or other method of investigation possesses the property of actually doing what it has been designed to do" (5). In accordance with this, a fitness test is described as valid if the results of the test allow conclusions to be made about the fitness status of the individual.

Validity can be determined in several ways according to the National Coaching Foundation (NCF; 6); logical (face), criterion, or construct validity are indirect forms of validity. Logical validity is determined if the primary fitness components responsible for performance are known and there is a high level of confidence that the test in question measures those components. Logically this would lead to the conclusion that the test possesses some form of validity. If assumptions from logical validity were evaluated against an established testing procedure and there was a strong relationship between the data from the new test and the established one, then the new test would have criterion validity. Construct validity is ascertained if the test is able to discriminate different fitness levels between different levels of groups of performers. Another category of validation important for interpreting the results of a fitness test is direct validity. Direct validity is determined when direct comparisons can be made between the results obtained during a fitness test and the actual physical attributes (distances covered, speeds attained, etc.) of players during competitive matches.

A test that is frequently performed during training sessions and fitness assessments of field hockey and other sport players is a 5-m multiple shuttle test (5-m MST; 2). On initial inspection, this test appears to have logical validity because the physical demands of field hockey include a variation in sprint distances accompanied by periods of acceleration, deceleration, and a change in direction with the body in a low position. All of these characteristics are measured by the 5-m MST. However, the criterion, construct, and direct validity of the test have not been established. This can be attributed to (a) the limited time-motion analysis studies on field hockey, and (b) that these were all conducted before the 1998 rule changes, which altered the demands of the game. Therefore, direct comparisons between fitness test results and physical match requirements are not possible as there are no time-motion analysis studies on the 'modern' game of field hockey. It is therefore important to validate the 5-m MST more scientifically for an accurate interpretation of the data.

METHODS

Experimental Approach to the Problem

The aims of this study are threefold. The first is to determine whether the 5-m MST has criterion validity by comparing performance in this test with performance in the 40-m timed sprint (which determines the subject's sprint ability) and the 20-m multiple shuttle test (which
determines the subject’s endurance ability (9). These fitness components are demanded by the sport (field hockey) and also by the 5-m MST. The second aim is to determine whether the 5-m MST has construct validity by comparing performance in this test of players from a regional representative team with that of club-level field hockey players. The third aim is to determine whether the 5-m MST has validity by comparing performance during competitive field hockey matches, from a time-motion study, to performance in the 5-m MST.

The subjects for the criterion validity phase of the study included women hockey players (n = 14) and women rugby players (n = 17) who volunteered to participate in this study. All subjects were tested during their playing season. Two field hockey and nine rugby players withdrew from the study because of injury, illness, or work commitments. The remaining subjects (n = 20, aged 26.6 ± 4.0 years, height 165.3 ± 8.8 cm, weight 61.7 ± 8.1 kg, and body fat 24.3% ± 2.9%) completed a 40-m timed sprint and the 20-m multiple shuttle test (20-m MST) on their first visit to the laboratory, and the 5-m MST on their second visit within a 2-week period. All testing occurred on rubberized indoor surfaces. Before testing, all subjects completed an informed consent form and a medical screening questionnaire. The study was approved by the Ethics and Research Committee of the Faculty of Health Sciences of the University of Cape Town.

**Experimental Design**

All tests were administered at the same time of day (within ±30 minutes), and the subjects attended the laboratory with instructions to abstain from caffeine intake for 3 hours prior to testing and to control their training the day before and on the day of testing in an attempt to standardize the physical preparation before each test. Body mass, stature, and body fat (sum of 4 skinfolds: triceps, biceps, subscapula, and supra-iliac as described by Dubin and Womersley [4]) were measured at the first session.

Each subject was allowed 10 minutes to complete her own specific warm-up for both visits. Before the 40-m timed sprints, each subject ran maximally along the sprint track 3 times for each trial separated by 1 minute. No additional warm-up was required for the 20-m MST. Preparation for the 5-m MST was the same as described in Boddington et al. (2). In this study, the intraclass coefficient ranged from R = 0.98 to R = 0.74 for the outcomes measures.

The 40-m sprint was performed on a special rubber sprint track with photocells placed at the start and then every 10 m, so that split times at 10, 20, and 30 m could also be recorded. The 20-m MST (9) required the subjects to run between 2 lines spaced 20 m apart in time with an audio cassette. The test was conducted about 20 minutes after the sprint test. The 5-m MST (2) was conducted within 2 weeks of this testing. The 5-m MST required the subjects to sprint between a series of 6 beacons spaced 5 m apart in a straight line to cover a total distance of 25 m. Subjects were instructed to perform maximally throughout the whole test. Each subject started the test in line with the first beacon (A), and upon an auditory signal sprinted 5 m to beacon B, touched the ground adjacent to the beacon with their hand, and returned back to beacon A, touching down on the ground adjacent to the beacon with the hand again. The subject then sprinted 10 m to the third beacon C, and back to beacon A, etc., until an exercise period of 30 seconds had elapsed. The distance covered by each subject was recorded to the nearest 2.5 m during each 30-second shuttle. Thereafter there was a 35-second recovery, during which the subjects walked back to beacon A.

Construct validity was determined using data from Boddington et al. (2) and subdividing the data into regional representative and club-level players.

Direct validity was determined from a comparison with time-motion data (3) and the data from the 5-m MST (criterion validity subjects, field hockey players, n = 9). The time-motion study recorded the displacement of women field hockey players (n = 11) during league matches (n = 3) using video analysis (3).

**Statistical Analyses**

Data are expressed as mean ± standard deviation. Maximal oxygen consumption was estimated from the results of the 20-m MST (9).

Pearson’s product moment correlation was used to determine the relationships between variables. The criterion validity of the 5-m MST was determined by the strength of the relationship between the 5-m MST data and either the VO\textsubscript{max} estimated from the 20-m MST or the 40-m sprint test. A correlation coefficient of \( r = 0.5 \) and \( r = 0.7 \) was considered low, \( r = 0.7–0.8 \) moderate, and \( r = 0.9 \) or higher was good for defining relationships between variables (11).

To establish whether construct validity existed, a 2-way (shuttle × level of play) analysis of variance (ANOVA) with repeated measure was used. ANOVA was used to analyze the total and peak distances covered during the shuttles. The interaction between the “level of play” and “shuttle” was analyzed with an ANOVA.

To determine the direct validity, Pearson’s product moment correlation coefficients were calculated between the total and peak distances collected during the 5-m MST and the mean displacement per minute playing time, mean displacement, and mean speeds recorded during the field hockey time-motion study (3). The strength of the relationship between these factors was used to determine whether the 5-m MST was valid for determining the fitness of field hockey players. The relationship between the 5-m MST data and the total displacement was not calculated because playing time varied between the players.

**RESULTS**

**Criterion Validity**

The mean estimated maximal oxygen uptake value was 42.7 ± 7.1 ml·kg\(^{-1}\)·min\(^{-1}\). The mean time for the 40-m sprint was 6.37 ± 0.27 seconds. The mean total and peak distances calculated posttest from the 5-m MST were 650.9 ± 59.2 m and 114.8 ± 8.6 m, respectively.

The correlation coefficients between the estimated VO\textsubscript{max} from the 20-m MST and the performance in the 5-m MST and the 40-m sprint test are summarized in Table 1.

**Construct Validity**

The characteristics of the subjects were the following: regional representative, \( n = 12 \), aged 22.8 ± 4.3 years, stature 164.6 ± 3.9 cm, body mass 59.4 ± 5.9 kg, and body...
The purpose of this study was to determine the validity of the 5-m MST field test that is used for the physical assessment of team sport athletes. For a test to be valid it must directly measure an aspect, or aspects, of actual sporting performance (13).

Two techniques for determining validity were used in this study. First, indirect methodology was used to determine logical, criterion, and construct validity. Second, using direct methodology, the fitness test data and data from a time-motion study on field hockey were compared. In determining the relationship between the 5-m MST, 20-m MST, and the 40-m sprint test, it was found that the strongest relationships occurred between the $V_{\text{O}_2\text{max}}$ data estimated from the 20-m MST and the total distance covered during the 5-m MST ($r = 0.92$), and the $V_{\text{O}_2\text{max}}$ and the peak distance from the 5-m MST ($r = 0.83$). This indicates that players with a higher estimated $V_{\text{O}_2\text{max}}$ would cover a greater distance on their first sprint and maintain that greater work throughout the 5-m MST than those with a lower $V_{\text{O}_2\text{max}}$. Although Pendleton (8) also found a relationship between $V_{\text{O}_2\text{max}}$ and total distance covered during the 5-m MST ($r = 0.72$), which was lower than the relationship reported in this study ($r = 0.92$).

The 5-m MST was able to differentiate between the 2 different standards of players in this study. In particular, the regional representative players achieved greater distances in the 5-m MST than the club-level players. This result confirms the observation that as the level of expertise of the players increase, so also should their fitness levels (7). Pendleton (8) found that a similar fitness test to that used in this study was able to discern performance differences between endurance-trained athletes and those with a sprint training background. The ability of the test to distinguish between playing abilities and training backgrounds increases the usefulness of the 5-m MST for assessing fitness of field hockey players. However, a study needs to evaluate whether the 5-m MST has sufficient precision to track changes in fitness in the same players throughout a season.

When the direct validity was analyzed, this study found significant relationships between the displacement covered per minute playing time (meters) and the total

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**Table 1.** Correlation coefficients ($R$) for the comparison of data obtained from the 5-m MST, 20-m MST, and the 40-m sprints ($n = 20$).\(^a\)

<table>
<thead>
<tr>
<th>5-m MST</th>
<th>$V_{\text{O}_2\text{max}}$ (ml·kg$^{-1}$·min$^{-1}$)</th>
<th>40-m sprint (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total distance (m)</td>
<td>0.92</td>
<td>-0.73</td>
</tr>
<tr>
<td>Peak distance (m)</td>
<td>0.83</td>
<td>-0.77</td>
</tr>
</tbody>
</table>

\(^a\) MST = multiple shuttle test.

**Figure 1.** Mean group data for the distance covered (meters) during testing for the regional representative and club-level players. The asterisk (*) represents significant differences between the Regional representative ($n = 12$) and club-level ($n = 11$) players ($p < 0.01$).

**Table 2.** Mean data for total distance and peak distance for regional representative ($n = 12$) and club level ($n = 11$) players.

<table>
<thead>
<tr>
<th></th>
<th>Club level</th>
<th>Regional representative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total distance (m)(^*)</td>
<td>661.1 ± 31.0</td>
<td>689.9 ± 46.6</td>
</tr>
<tr>
<td>Peak distance (m)</td>
<td>120.6 ± 7.2</td>
<td>123.5 ± 6.5</td>
</tr>
</tbody>
</table>

\(^*\) Represents a significant difference between club-level and regional representative players ($p < 0.05$).

\(^\ast\) Represents a significant difference between club-level and regional representative players ($p < 0.01$).

**Table 3.** Correlation coefficients ($R$) for the comparison of data obtained from the 5-m MST fitness tests and the field hockey time-motion study ($n = 10$).

<table>
<thead>
<tr>
<th>Time-motion study</th>
<th>Displacement per minute (m·min$^{-1}$)</th>
<th>Mean displacement speed (m·s$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-m MST</td>
<td>0.63</td>
<td>0.74</td>
</tr>
<tr>
<td>Peak distance (m)</td>
<td>0.49</td>
<td>0.70</td>
</tr>
</tbody>
</table>

**Direct Validity**

Correlation coefficients were calculated for the time motion data collected with the data from the 5-m multiple shuttle test. The displacement per minute of playing time ($61 ± 6$ m), the mean displacement per 15-second period ($15 ± 1$ m), and the mean speed per 15-second period ($0.89 ± 0.1$ m) were all recorded in a time-motion study (matches, $n = 3$; players, $n = 11$) and correlated with total distance ($706.0 ± 37.5$ m) and peak distance ($122.8 ± 4.5$ m) recorded during the 5-m MST. The results are summarized in Table 3.

**Discussion**

The purpose of this study was to determine the validity of the 5-m MST field test that is used for the physical assessment of team sport athletes. For a test to be valid it must directly measure an aspect, or aspects, of actual sporting performance (13).

Two techniques for determining validity were used in this study. First, indirect methodology was used to determine logical, criterion, and construct validity. Second, using direct methodology, the fitness test data and data from a time-motion study on field hockey were compared. In determining the relationship between the 5-m MST, 20-m MST, and the 40-m sprint test, it was found that the strongest relationships occurred between the $V_{\text{O}_2\text{max}}$ data estimated from the 20-m MST and the total distance covered during the 5-m MST ($r = 0.92$), and the $V_{\text{O}_2\text{max}}$ and the peak distance from the 5-m MST ($r = 0.83$). This indicates that players with a higher estimated $V_{\text{O}_2\text{max}}$ would cover a greater distance on their first sprint and maintain that greater work throughout the 5-m MST than those with a lower $V_{\text{O}_2\text{max}}$. Although Pendleton (8) also found a relationship between $V_{\text{O}_2\text{max}}$ and total distance covered during the 5-m MST ($r = 0.72$), which was lower than the relationship reported in this study ($r = 0.92$).

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When the direct validity was analyzed, this study found significant relationships between the displacement covered per minute playing time (meters) and the total
distance of the 5-m MST \( (r = 0.63 \) for displacement per minute vs. total distance). An alternative interpretation is that about 40\% (i.e., coefficient of determination) of the variation in displacement covered per minute playing time could be explained by the total distance achieved in the 5-m MST. There were also significant relationships between the mean displacement and mean speed during the match and the characteristics of the 5-m MST. This suggests that the players that recorded a greater displacement during the field hockey matches also covered the greater distances during the fitness test.

It is acknowledged that there are many other external influences (opposition, weather conditions, amount of playing time for each player, umpiring, and importance of the match) that will determine displacement or distance covered during a field hockey match other than just level of fitness. It would also be presumptuous to expect any physiological test to be able to predict performance of a team sport more accurately than has been shown in this study, because there are psychological and skill factors that are not taken into account in a fitness test (1). Therefore, it is reasonable to suggest that correlation values of \( r = 0.6-0.7 \) indicate that a fairly strong relationship exists between physical performance during competition and performance in the 5-m MST.

In summary, this study has shown that the 5-m MST has indirect (logical, criterion, and construct) and direct validity when used in assessing fitness in field hockey. Further research is needed to determine the accuracy of the test to detect small changes in fitness.

**Practical Applications**

The 5-m MST is a reliable (2) and valid test that can be used to determine the fitness levels of field hockey players. This is a simple test to administer and requires little equipment. An entire team can be evaluated in a short space of time, and the data collected can be related to actual match fitness. The 5-m MST clearly shows that players who cover the greater distances in the fitness test also cover greater distances during competition. This may be a useful tool for a coach to evaluate which players, in terms of fitness levels, should be placed in the positions (usually the midfield) that require the most amount of running. The 5-m MST demands endurance, speed, and agility components of fitness that are also required in other sports such as soccer, rugby, and basketball. It would therefore be reasonable to suggest that the 5-m MST should be reliable and valid for other sports that have physical demands very similar to field hockey.

**References**


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