Evaluation of Anthropometric, Physiological,
and Skill-Related Tests for Talent Identification
in Female Field Hockey

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Catalogue Data

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Abstract/Résumé

The purpose of the present study was to develop an effective testing battery for female field hockey by using anthropometric, physiological, and skill-related tests to distinguish between regional representative (Rep, n = 35) and local club level (Club, n = 39) female field hockey players. Rep players were significantly leaner and recorded faster times for the 10-m and 40-m sprints as well as the Illinois Agility Run (with and without dribbling a hockey ball). Rep players also had greater aerobic and lower body muscular power and were more accurate in the shooting accuracy test, p < 0.05. No significant differences between groups were evident for height, body mass, speed decrement in 6 × 40-m repeated sprints, handgrip strength, or pushing speed. These results indicate that %BF, sprinting speed, agility, dribbling control, aerobic and muscular power, and shooting accuracy can distinguish between female field hockey players of varying standards. Therefore talent identification programs for female field hockey should include assessments of these physical parameters.

Le but de cette étude est de développer une batterie de tests destinés à des joueuses de hockey sur gazon en incorporant des données anthropométriques, physiologiques, et de performance motrice de manière à bien discriminer les joueuses de niveau régional (Rep, n

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Anthropometric and physiological attributes of various athlete groups have been extensively examined. These studies have demonstrated that a battery of field-based tests can distinguish between players of different ability in the same sport (Keogh, 1999; Rigg and Reilly, 1988; Thissen-Milder and Mayhew, 1991). Similarly, differences in anthropometric and physiological parameters have been reported for field hockey players of varying standards (Bale and McNaught-Davis, 1983; Ready and van der Merwe, 1986). However, these studies have focused on only a few anthropometric or physiological characteristics such as body composition, aerobic power, and muscular power and strength, whereas sprinting speed, agility, and repeated-sprint ability (RSA) have been largely ignored. In addition, only one study has examined any of the fundamental motor skills required in field hockey (Reilly and Bretherton, 1986).

Information about dribbling control, shooting accuracy, and pushing speed would contribute to a more thorough understanding of the skill-related requirements of field hockey. It is also apparent that commonly used tests such as the Sit & Reach, Margaria-Kalamen Stair Run, and the Anaerobic Speed Test are unable to distinguish between players of varying ability or reveal training-related improvements (Ready and van der Merwe, 1986; Reilly et al., 1985; Scott, 1991).

Therefore, the present study adopted an integrative approach whereby a number of anthropometric, physiological, and skill-related parameters important for field hockey were examined simultaneously. Also, players of two ability levels (regional representative = Rep; local club = Club) were compared so as to identify the specific physical tests that can distinguish between the two groups. The purpose of the present study was to develop a concise battery of anthropometric, physiological, and skill-based field tests that can be employed to identify talent and to monitor periodized training programs in female field hockey players.
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A-reserve, A-grade. Rep players were those who had been selected to represent their respective regional area within the last 12 months. All players had at least 2 years of field hockey experience, were currently participating in a hockey competition, and were free from any injury or illness. Both groups had a similar number of fullback (Rep = 10, Club = 13), midfield (Rep = 13, Club = 15), and forward (Rep = 12, Club = 11) players in their respective squads. Goalkeepers were omitted from the analysis in the present study due to insufficient numbers.

**Testing Protocol.** Prior to each testing session, subjects completed a standard warm-up that consisted of a 5- to 10-min jog, a series of stretches, and a sequence of 20-m running drills. Each test was separated by at least a 5-min recovery period, but players were allowed more rest if they so required. All players completed the series of tests in a similar order, with the most fatiguing tests—Multistage Fitness Test Shuttle Run and 6 × 40-m RSA test—performed last in each testing session. This was implemented so as to minimize the effect of any residual fatigue on the remaining tests.

Players attended two testing sessions, separated by at least 48 hours. Test Session 1 involved anthropometric measurements including standing height, body mass (BM), and the sum of four skinfolds (S4SF). Standing long jump (LJ) and vertical jump (VJ) were used to assess lower body muscular power. The Multistage Fitness Test Shuttle Run was used to estimate maximal aerobic power, and a test to measure pushing speed was also conducted. Test Session 2 involved a 10-m sprint, 40-m sprint, and six 40-m all-out sprints to assess maximum sprinting speed and RSA, respectively. Agility was assessed using the Illinois Agility Run (IAR) and, during a separate trial, the IAR was modified to examine dribbling control. The isometric hand-grip test and a shooting accuracy test were also completed during Test Session 2.

**Anthropometry.** Standing height was measured without shoes using a standard wall-mounted stadiometer to the nearest 0.5 cm. Body mass was measured to the nearest 0.5 kg, using calibrated scales (Seca, Hamburg, Germany). Skinfolds were measured on the right side of the body (triceps, biceps, subscapular, and suprailliac) using a calibrated Harpenden caliper (Baty International, West Sussex, UK), according to the methods of Norton and Olds (1996). Each skinfold was measured three times and the average of the two closest readings was recorded. The S4SF was reported and body density (BD) was calculated using a prediction equation \[ BD = 1.1567 - 0.0717(\log_{10}X_1) \] developed by Durnin and Womersley (1974) where \( X_1 \) is equal to the S4SF. The Siri equation (Siri, 1961) was then used to convert BD to %BF.

**Physiological Tests.** Players initiated the LJ from a shoulder-width stance with a rapid countermovement to achieve maximal horizontal distance. The distance (cm) was measured from the toe at the starting position to the heel of the back foot upon landing. Each player undertook three trials with at least 3 min rest between trials. The best of three trials was recorded as the LJ distance.

In preparation for the VJ, players stood 10 cm from the wall in a side-on position with the arm closest to the wall raised directly above their head. Throughout the jumping action, players were required to keep their outstretched arm above their head while keeping the other arm relaxed at their side. At the top of the jump, players marked the wall with chalk and the height they reached was recorded us-
ing a wall-mounted stadiometer. The VJ height was calculated as the difference between the height of the outstretched hand in the standing position and that obtained during the jump. Each player performed three trials of the VJ, with each trial separated by 3 min rest. The best of three trials was recorded as the VJ height.

The Multistage Fitness Test Shuttle Run is a valid (Grant et al., 1995; Leger and Gadoury, 1989) and reliable indicator of $\dot{V}O_{2\text{max}}$ (Leger et al., 1988; Sproule et al., 1993) and is often used to assess aerobic power in team sport athletes. This test has been well described by the Australian Coaching Council (1988). Briefly, it involved a series of 20-m shuttle runs which became progressively faster. Subjects were required to maintain the given speed until reaching volitional fatigue. The number of shuttles completed was recorded and an equivalent $\dot{V}O_{2\text{max}}$ was estimated (Australian Coaching Council, 1988).

Sprinting speed was recorded with a precision of 0.01 s over 10 and 40 m using timing lights (Speed Light athletic timing system, model TB4, Lismore, Australia). From a stationary position, players began the sprint by breaking the laser of the timing lights positioned at the starting line. Three 40-m trials were performed and both 10-m and 40-m split times were recorded. The fastest time for both the 10-m and 40-m splits were recorded, regardless of whether they occurred in the same trial or in different trials.

Repeated-sprint ability was assessed by calculating the speed decrement during six 40-m all-out sprints (Fitzsimmons et al., 1993; Wadley and Le Rossignol, 1998). The RSA test involved the players sprinting 40 m every 30 s until they completed six sprints. The players were required to return to the starting position after each sprint, as the addition of the jog recovery between sprints was believed to more closely simulate the RSA demands of field hockey (Lothian and Farrally, 1994). Percent speed decrement was calculated for both the 10-m and 40-m distances using Equation 1 (Fitzsimmons et al., 1993):

\[
\text{Speed decrement (\%)} = \left( \frac{\text{Total time}}{\text{Ideal time}} \times 100 \right) - 100. \tag{1}
\]

where Total time = sum of the six sprint times (s) and Ideal time = best sprint time (s) multiplied by the number of sprints performed (six).

The IAR was selected as a test of the players’ agility and was conducted using the methods described by Cureton (1951), except that the subjects began in a standing position. Two trials were recorded, with at least 5 min rest between trials. Performance time was measured with a precision of 0.01 s by a hand-held stopwatch; the faster of the two trials was recorded.

Maximal isometric grip strength was assessed with a Baseline hydraulic hand-grip dynamometer (Chattanooga Group Inc., Hixson, TN), following a protocol similar to that described by Adams (1994). Players performed two trials of the isometric hand-grip strength test with the preferred hand, each trial separated by at least 3 min. The maximum force produced during either trial was recorded as the athlete’s maximal isometric grip strength. The preferred hand was allowed because Reilly and Bretherton (1986) as well as Scott (1991) have reported no significant differences in hand-grip strength of the left and right hands in either elite or county level field hockey players.

Skill-Related Tests. Figure 1 presents a schematic of the pushing speed test. Pushing speed was estimated by recording the time taken for a hockey ball to
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two pushes (Shots 5–6), and two flicks (Shots 7–8) (Figure 2a and 2b). A flick is similar to a pushing action. However, in executing a flick, the player angles the stick in relation to the ball so that the ball undergoes both horizontal and vertical displacement. The result of each shot was recorded, with each accurate shot being awarded 1 point and each inaccurate shot 0 points. An accurate shot was defined as one that was hit into the target zone. If the shot hit the post, it was deemed accurate only if it rebounded into the goal. A score out of 8 was recorded for each athlete, with each player’s performance then expressed as the percentage of accurate shots. As only shooting accuracy was assessed in this test, no special pushing, hitting, or flicking speed was required. Thus the accuracy component of goal scoring could be isolated from the power component, in accordance with the speed/accuracy tradeoff (Spirduso et al., 1993).

Menstrual Cycle. When testing premenopausal women, it is important to control for the potential effect of menstrual cycle status on exercise performance.
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(Tarnopolsky, 1999), as it has been demonstrated that peak power during sprint-type exercise may be lower during the luteal phase than during the follicular phase (Parish and Jakeman, 1987). Therefore, at each testing session each player was asked to record the number of days from the start of her menstrual period so that her current menstrual cycle phase could be determined.

Statistical Analysis. The mean and standard error of the mean (SEM) were calculated for all performance measures. Independent $t$-tests were used to determine whether there were any significant differences between the Rep and Club field hockey players on performance measures. Statistical significance was accepted at the 5% level. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 10.0).

Results

SUBJECT CHARACTERISTICS AND TEST RESULTS

Anthropometry. Anthropometric characteristics of Rep and Club level players are shown in Table 1. Age, standing height, and BM did not differ significantly between groups. The S4SF and %BF were significantly lower in Rep compared to Club players. Each group had a similar number of players in the luteal and follicular phases (Club: luteal = 15, follicular = 15; Rep: luteal = 16, follicular = 14). Nine Club players and 5 Rep players did not report reaching menarche. There was no significant difference in any of the anthropometric, physiological, or skill-related tests between players in the luteal compared to the follicular phase in either group. In addition, number of years of playing experience was not different between groups, $p > 0.05$. This suggests that performance differences between the two groups on the anthropometric, physiological, and skill-related tests were not caused by differences in menstrual phase at the time of testing, or by differences in hockey playing experience.

Physiological and Skill-Related Tests. The results of the physiological and skill-related tests are shown in Table 2. Rep players were significantly faster than

| Table 1 Anthropometric Characteristics (mean ± SEM) of Female Field Hockey Players of Varying Standards |
|-----------------------------------------------|----------------|---|
| Age (yrs)                                      | 19.4 ± 1.0     | 20.3 ± 1.5 | 0.608 |
| S4SF (mm)                                      | 39.3 ± 3.7     | 49.9 ± 2.5 * | 0.017 |
| % Body fat                                     | 24.8 ± 0.7     | 27.4 ± 0.8 * | 0.017 |
| Height (cm)                                    | 164.7 ± 0.7    | 163.5 ± 1.1 | 0.359 |
| Body mass (kg)                                 | 58.6 ± 1.2     | 56.5 ± .5   | 0.302 |

Note: Rep = regional representative; Club = local club. S4SF = Sum of 4 skinfolds. *Club players significantly greater than Rep players, $p < 0.05$. 
Table 2 Physiological and Skill-Related Test Results of Female Field Hockey Players of Varying Standards

<table>
<thead>
<tr>
<th>Tests</th>
<th>Rep players</th>
<th>Club players</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M ± SEM</td>
<td>Range</td>
</tr>
<tr>
<td>10-m sprint</td>
<td>2.01 ± 0.02</td>
<td>(1.88–2.99)</td>
</tr>
<tr>
<td>40-m sprint</td>
<td>6.53 ± 0.09</td>
<td>(5.90–7.24)</td>
</tr>
<tr>
<td>10-m RSA (%)</td>
<td>10.1 ± 1.4</td>
<td>(5.7–16.9)</td>
</tr>
<tr>
<td>40-m RSA (%)</td>
<td>13.1 ± 1.0</td>
<td>(6.2–19.7)</td>
</tr>
<tr>
<td>Multistage Shuttle Run (level : shuttle)</td>
<td>9:1 ± 0:4</td>
<td>(7:3–11:1)</td>
</tr>
<tr>
<td>Predicted V O₂ max (ml·kg⁻¹·min⁻¹)</td>
<td>43.7 ± 1.2</td>
<td>(37.3–50.2)</td>
</tr>
<tr>
<td>Vertical jump (cm)</td>
<td>35 ± 1</td>
<td>(28–47)</td>
</tr>
<tr>
<td>Standing long jump (cm)</td>
<td>187 ± 3</td>
<td>(169–215)</td>
</tr>
<tr>
<td>Hand-grip strength (kg)</td>
<td>36 ± 1</td>
<td>(33–48)</td>
</tr>
<tr>
<td>IAR (s)</td>
<td>16.68 ± 0.16</td>
<td>(15.63–18.32)</td>
</tr>
<tr>
<td>IAR-D (s)</td>
<td>21.05 ± 0.34</td>
<td>(18.03–24.71)</td>
</tr>
<tr>
<td>Agility Dribbling Index (%)</td>
<td>26.3 ± 2.0</td>
<td>(9.5–47.8)</td>
</tr>
<tr>
<td>Shooting accuracy (%)</td>
<td>37.5 ± 3.5</td>
<td>(12.5–75.0)</td>
</tr>
<tr>
<td>Pushing speed (m·s⁻¹)</td>
<td>6.8 ± 0.4</td>
<td>(1.3–2.9)</td>
</tr>
</tbody>
</table>

Note: Rep = regional representative; Club = local club. IAR = Illinois Agility Run; IAR-D = Illinois Agility Run dribble. Repeated-sprint ability (RSA) calculated using Equation 1; Agility Dribbling Index (ADI) calculated using Equation 3; Pushing speed calculated using Equation 2.

*Club players significantly different from Rep players, p < 0.05.

Club players in the 10-m and 40-m sprints, and achieved a greater predicted VO₂ max, as indicated by the number of shuttles achieved during the Multistage Fitness Test Shuttle Run. Likewise, the height and distance achieved during the VJ and LJ were significantly greater in Rep players. Consistent with their greater speed in the 10-m and 40-m sprints, Rep players were significantly faster than Club players through the IAR course, both with and without dribbling a hockey ball. The ADI was also significantly lower in Rep players than in Club players, which means that for Club players the act of dribbling a hockey ball caused a greater decrement in agility performance. Rep players were also significantly more accurate than Club players in the shooting accuracy test. No significant differences were observed between groups for percent decrement in sprinting speed, as measured in the RSA test, nor for hand-grip strength and pushing speed.
Discussion

A greater understanding of the physical requirements of female field hockey is required before an effective testing battery can be developed. Whereas a number of studies have assessed some of the anthropometric, physiological, and skill-related characteristics of female field hockey players, no comprehensive study has evaluated all of these parameters on players of varying standards. The purpose of the present study was to determine which series of physical tests best describe the attributes common to Rep female field hockey players when compared to Club level players. By examining players at both levels, we developed a testing battery that would clearly distinguish female field hockey players of greater ability.

While Rep players had a significantly lower %BF than Club players, no significant differences were observed for standing height or BM between the two groups. These results suggest that Rep players have more lean body mass (LBM) than Club players. This is consistent with the results of Bale and McNaught-Davis (1983), who reported higher levels of mesomorphy in elite female field hockey players compared to aged-matched controls. In comparison to regional representative and elite level players described in previous studies, the Rep players in the present study were generally of similar height, BM, and %BF (Bale and McNaught-Davis, 1983; Reilly and Bretherton, 1986; Reilly et al., 1985). However, levels of 15.7% body fat have been recorded for elite level players immediately prior to Olympic competition (Ready and van der Merwe, 1986), further supporting the suggestion that the %BF of elite players may be substantially lower than in those of less ability. Therefore a measure of %BF is a useful tool for describing in part the anthropometric characteristics of hockey players of different ability.

Compared to Club players, Rep players were significantly faster over 10 m and 40 m. Their greater sprinting speed is consistent with Reilly and Bretherton (1986), who reported that elite players were faster than county standard players over 50 yd. These findings suggest that sprinting speed is an important characteristic of field hockey. The time-motion analysis performed by Lothian and Farrally (1994) further supports the importance of sprinting speed, as it was reported that elite players spent 22% of total game time performing short duration (5.2 ± 0.6 s), high-intensity activities. Consequently, tests that assess short-duration sprinting speed are required for the monitoring of female field hockey players.

There was no difference between groups in speed decrement measured during the RSA test for both the 10-m and 40-m distances. These results indicate that while Rep players were significantly faster than Club players over short distances, both groups demonstrated the same relative decrement in sprinting speed over the course of six all-out 40 m-sprints. The speed decrement values observed in the present study for the 6 × 40-m sprints (12.7–13.1%) were substantially greater than the 5–6% speed decrement rates reported by previous studies (Dawson et al., 1993; Fitzsimmons et al., 1993; Wadley and Le Rossignol, 1998).

The higher speed decrement reported in the present study may be due to the inclusion of a jog recovery between each 40-m sprint compared to the passive recovery used in other studies. Also, gender-related as well as sport-specific differences may have contributed to the greater speed decrement values observed in our female field hockey players when compared to male athletes participating in various other sports. Dawson et al. (1993) reported that speed decrement may be
negatively correlated to $\dot{V}O_2\text{max}$, thus a smaller decrement in the RSA test may have been expected for Rep vs. Club players. However, the magnitude of the speed decrement in RSA tests has also been shown to be positively correlated to maximum sprinting speed (Fitzsimmons et al., 1993; Wadley and Le Rossignol, 1998). Therefore the similar rate of speed decrement found in both groups appears reasonable, as the Rep group had significantly greater maximum sprinting speed as well as a significantly greater predicted $\dot{V}O_2\text{max}$. These findings suggest that the RSA test may be useful in determining a player’s specific attributes when both the $\dot{V}O_2\text{max}$ and maximum sprinting speed are known. However, speed decrement values cannot distinguish between Rep and Club players.

Rep players achieved a significantly higher level in the Multistage Fitness Test Shuttle Run, consequently obtaining a greater predicted $\dot{V}O_2\text{max}$ than Club players. Previous research has demonstrated that aerobic power is an important component of field hockey performance (Reilly and Borrie, 1992). However, in comparison to the $\dot{V}O_2\text{max}$ values of 52.2–59.3 ml·kg$^{-1}$·min$^{-1}$ reported for elite and regional representative players from previous studies (Cheetham and Williams, 1987; Ready and van der Merwe, 1986; Reilly et al., 1985), Rep players in the present study had substantially lower levels of aerobic power. While the Multistage Fitness Test Shuttle Run has been shown to be a reliable test of $\dot{V}O_2\text{max}$ (Grant et al., 1995; Leger and Gadoury, 1989), Grant et al. (1995) reported that field-based testing of aerobic power may underestimate a laboratory-based assessment of $\dot{V}O_2\text{max}$ by as much as 4.5 ml·kg$^{-1}$·min$^{-1}$.

Many studies that have measured $\dot{V}O_2\text{max}$ in female field hockey players have used laboratory-based treadmill or cycling protocols. Thus the differences found in $\dot{V}O_2\text{max}$ between players in the present study and those in previous studies (Cheetham and Williams, 1987; Ready and van der Merwe, 1986; Reilly et al., 1985) may be due in part to the different testing protocols used to determine $\dot{V}O_2\text{max}$. Nevertheless, the findings of the present study still indicate that aerobic power can distinguish between female field hockey players of different standard. Consequently, the measurement of aerobic power is useful for assessing female field hockey players.

Based on the results of the VJ and LJ tests, Rep players had greater levels of lower body power compared to Club players. The greater VJ and LJ performance in the Rep group is consistent with previous studies which reported superior VJ and LJ performance in elite vs. county or regional representative female field hockey players (Bale and McNaught-Davis, 1983; Reilly and Bretherton, 1986). Compared to county and regional representative players from previous studies, the Rep players in the present study had similar scores for the VJ and LJ (Bale and McNaught-Davis, 1983; Reilly and Bretherton, 1986). Thus it appears that superior lower body muscular power is associated with higher standards of play in female field hockey, and assessments of lower body muscular power should be included in a testing battery for female field hockey.

No significant differences in the hand-grip strength of the preferred hand were observed between the two groups in the present study. This is in contrast with the findings of Reilly and Bretherton (1986) and Scott (1991), who reported significantly greater hand-grip strength in elite vs. county players or age-matched controls in both the left and right hands. Thus the differences reported in hand-grip strength between hockey players of different ability remain unclear.
Rep players performed significantly better on the IAR test, and obtained a smaller ADI than Club players. Therefore, Rep players were more agile and could maintain a higher proportion of their maximum speed while dribbling a hockey ball through the agility course when compared to Club players. These findings are consistent with Reilly and Bretherton (1986), who reported greater dribbling control in elite vs. county players. Consequently, agility and dribbling control are important in field hockey. The time-motion analysis performed by Lothian and Farrally (1994) further supports the importance of agility to field hockey, as they reported that elite players spent 11.6% of game time moving in directions other than forward. Thus the inclusion of tests that assess agility and dribbling control are required for the monitoring of female field hockey players.

The shooting accuracy test in the present study was designed to assess shooting accuracy from several locations using skills frequently executed to score goals in competitive field hockey. Rep players achieved a shooting accuracy rate of 37.5%, which was significantly superior to the 18.3% accuracy rate of Club players. However, the results for our Rep players indicate inferior shooting accuracy compared to the 74.8% accuracy rate recorded by Reilly and Bretherton (1986) for county level players. Unfortunately, the shooting accuracy test used by Reilly and Bretherton was not clearly described. Thus the shooting accuracy test in the present study may have been more difficult than the one used in the test by Reilly and Bretherton. Nevertheless, the shooting accuracy test in the present study is a valuable tool for distinguishing between Rep and Club players.

No significant differences in pushing speed were observed between groups. This was somewhat unexpected, as the Rep players performed significantly better on the tests of lower body muscular power and sprinting speed compared to Club players. However, previous research has found only moderate correlations between scores obtained on tests of upper body and lower body power (Baker and Nance, 1999; Fields et al., 1997), suggesting that the expression of muscular power may be muscle-group, movement-pattern, and/or skill-dependent. Therefore, the similarity in pushing speed between Rep and Club players may be a reflection of their similarities in upper body power and/or pushing skill. Consequently, it appears that tests of pushing speed do not adequately distinguish between Rep and Club level players.

The results of the present study suggest that only a specific number anthropometric, physiological, and skill-related field tests are required to adequately distinguish between female field hockey players of different ability. Consequently, female field hockey players share similarities with Australian Rules football (Keogh, 1999), Rugby Union (Rigg and Reilly, 1988), and volleyball athletes (Thissen-Milder and Mayhew, 1991), wherein a number of anthropometric and physiological characteristics have been shown to distinguish between players of varying standards. Based on the results of the present study as well as findings reported in previous research, assessments of %BF, sprinting speed, aerobic power, lower body muscular power, agility, dribbling control, and shooting accuracy are required in order to effectively distinguish between players of varying standards. This suggests that these characteristics may be the most important physical attributes for successful performance in female field hockey, and these are the ones that should be assessed to identify talent and monitor player programs.
References


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