Section: Training and Testing

Title: The reliability and validity of a field hockey skill test.

Running title: Reliability of a field hockey skill test.

Abstract

High test retest reliability is essential in tests used for both scientific research and to monitor athletic performance. Thirty-nine (20 male and 19 female) well-trained university field hockey players volunteered to participate in the study. The reliability of the in house designed test was determined by repeating the test (3-14 days later) following full familiarisation. The validity was assessed by comparing coaches ranks of players with ranked performance on the skill test. The mean difference and confidence limits in overall skill test performance was 0.0 ± 1.0% and the standard error (confidence limits) was 2.1% (1.7 to 2.8%). The mean difference and confidence limits for the 'decision making' time was 0.0 ± 1.0% and the standard error (confidence limits) was 4.5% (3.6 to 6.2%). The validity correlation (Pearson) was $r = 0.83$ and $r= 0.73$ for female players and $r = 0.61$ and $r = 0.70$ for male players for overall time and 'decision making' time respectively. We conclude that the field hockey skill test is a reliable measure of skill performance and that it is valid as a predictor of coach assessed hockey performance, but the validity is greater for female players.

Keywords: Intermittent exercise, team sports

Introduction

To undertake research into field hockey in a controlled setting, it is necessary to employ a skill test that can be completed in the laboratory environment. However, there are only a limited number of field hockey skill tests and very little has been done scientifically to formulate tests that measure playing ability (14). Two decades later, further developments of hockey tests had not advanced. Reilly and Borrie (10) noted that it was surprising that even though field hockey had been part of the Physical Education curriculum in Europe and North America since the beginning of the 20th Century, there had been little attention given to the design of field tests for the game.

Thus, at present the number of published tests of field hockey skill is limited and no skill tests have been published during the last fifteen years. With the advent of synthetic sportsturfs as the major playing surface over that period, it is apparent that the skills have changed significantly and thus there is a need to develop a skill test that is appropriate to modern field hockey. Furthermore, the skill tests were designed to determine differences in skill performance between players, rather than to monitor improvements or changes for a particular player, and thus were not stringently tested for reliability.

In the formulation of a skill test, it is important that technique is differentiated from skill. Technique is the production of some pattern of movements which are technically sound (7). The following definition of skill will be used for the purpose of the design of this study: “Skill is the learned ability to bring about predetermined results with the maximum certainty, often with the minimum outlay of energy, or of time and energy,” (7). This encompasses the idea that a skilled athlete must take an action that is appropriate and therefore the skill involves interpreting the needs of the situation and making the correct decision as well as carrying out the necessary movements. The main point here is that the cognitive component in the form of decision making is a fundamental element of the skill.

Over the past decade there has been an increase in the literature regarding the importance of reliability and validity studies and the statistics that should be employed and interpreted. In terms of reliability, it has been advocated that a number of statistical methods be cited and interpreted (1). Reliability has been partially defined to include the “consistency of an individual’s performance on a test” (1). It should be recognised that tests will always include some form of measurement error and therefore reliability needs to be considered as the amount of measurement error that has been deemed acceptable for the effective practical use of a measurement tool. When the tool is to be used for scientific research, the acceptable level is of paramount importance. To conclude that a measuring tool is valid, it must show logical, construct and criterion validity (13). Logical validity means that the tool is appropriate to want you want to measure, construct validity refers to a measuring tool that can discriminate between standards and criterion validity refers to how well the measuring tool correlates to previous tools used to measure the same variable (13).

The aim of this study was to design a field hockey skill test, which is both reliable and valid for the modern game of hockey and determine the acceptable levels to make it a suitable tool to use for research in a laboratory environment.

Materials and methods

Participants

Thirty-nine university hockey players volunteered to take part in the study. Twenty males and 19 females completed the validity study, whereas only 14 males and 17 females completed the reliability of the skill test. The study had Loughborough University Ethical Committee Approval and informed consent was obtained.

Skill Test Design

The test was designed to include numerous elements of the game of hockey, incorporating dribbling, passing and shooting, whilst controlling as many variables as possible. For example a field hockey rebound board was used to pass off and the surface for the test was a water-based sportsturf (Desso), the type of surface all the players regularly play and train on. The goal is the width of a normal field hockey goal and the target area for the skill test is 18 inches high, which is the height of a backboard in hockey.

The objectivity of the skill test was paramount in the design and therefore participants were only given instructions about the penalty timing system and completing the test as quickly and as accurately as possible. No information on how to approach the test was provided. This allowed the participants to use techniques, make decisions and react to the different elements as they would in a game.

The skill test requires the participants to start from a line 16 yards from the goal. The player then runs to a hockey ball and then dribbles round the cones in a specific sequence (Figure 1). The completion of the dribbling phase requires the player’s foot or ball to break an infra-red beam which triggers a light on either side of the goal and starts a computer timing system (BBC microcomputer). The player then makes a pass against the rebound board (Figure 1) and shoots at either the right side or left side target on the goal. The player must shoot at the opposite target to where the light is on, for example if the light is on above the right side target, the player must shoot at the left side of the goal. The player must always shoot straight at the target and not diagonally. For the previous example to shoot at the left side of the goal, the player must bring the ball round the left hand side of the five cones to shoot in a straight direction (Figure 1). When the player has shot, the ball will hit the goal and stop the timing system, which is triggered by the sound of the ball. The time taken between crossing the infra-red beam and the ball hitting the backboard was termed the ‘decision making’ time as it incorporates the decision making elements of how and when to pass against the rebound board or shoot and determining which side of the goal to shoot. After the completion of the shot the player then runs back to the start line.

The player repeats the dribble, pass and shot pattern six times; each time the player has to touch the yellow line with a foot. The total time is recorded for the six continuous runs. In addition, a penalty time of 2 s per error is added, if the player misses the target area on the goal, touches a cone with the ball or the ball touches the player’s feet. The total time for the six runs and any error time is termed the ‘overall time’ and is used as the measure of performance for the field hockey skill test. The ‘decision time’ is taken as the average of the six decision timings, which incorporates three shots at the right target and three shots at the left target, in a randomised order. Three shots at each target controls for the different distance that is covered by the player depending on the side of the goal that he/she is shooting at.

The players were verbally encouraged to perform maximally and informed about the number of repetitions remaining. If the players lost control of the ball, they had to continue from wherever the ball went in an enclosed $55.5m^2$ area.

Familiarisation

Subjects were familiarised with the skill test on two occasions. During the first session they were instructed about how to complete the skill test and the timing and penalty system. They then completed 10 repetitions of the test, resting between each repetition. The pattern was randomised, but five shots were completed to each side of the goal. The second familiarisation session required the subjects to perform the skill test in its entirety. Thus, they completed the six repetitions as fast as they could, and the overall time and decision time were recorded. The mean difference ± confidence interval for the familiarisation and first trial data was -4.2 ± 2.6% and the typical error (confidence interval) was 4.8% (3.9 to 7.0%).

Reliability Trials

After being fully familiarised, 31, of the 39 subjects who completed the validity study, completed the skill test on two occasions on separate days, 3 to 14 days apart. The subjects were asked to refrain from vigorous exercise on the day of the skill test. To account for circadian rhythms, the skill tests were completed at the same time of day.

Validity Trials

Thirty-nine subjects completed the skill test after refraining from vigorous exercise on that day, but were not informed about their performance. The male players who completed the test were then ranked for performance and skill on their normal game play by one international-standard coach (coach 1) and one National League coach (coach 2). Similarly, an international-standard coach (coach 3) and one National League coach (coach 4) ranked the female players' who completed the test. The coaches were provided with a definition of skill and performance, which they could use to rank the players, so that all the coaches were working to the same criteria. Performance was defined as overall match performance and contribution to a match and skill defined as “the learned ability to bring about predetermined results with the maximum certainty, often with the minimum outlay of energy, or of time and energy,” (7). The coaches were provided with the

names of the players, but were not given any information about the performance of the players on the field hockey skill test. All the coaches regularly coached and watched the players who they ranked, so were fully aware of their abilities. The performance ranks were compared with the overall time for the skill test, whereas the skill ranks were compared with the decision time.

Statistical Analyses

The reproducibility of the skill test was determined using numerous statistical techniques. These were mean difference, Bland and Altman limits of agreement, correlations and typical error (1, 2, 5). The coaches’ ranks and skill test scores were compared using a Pearson correlation. Data were checked for non-uniformity, so that the appropriate statistical techniques could be employed.

Results

Reliability

The mean (± SD) for the overall performance time for trial 1 and trial 2 was 83.93 ± 6.60 and 84.36 ± 7.44 s for men and 96.56 ± 6.68 and 96.26 ± 6.12 s. The mean difference and confidence limits in overall skill test performance was 0.0 ± 1.0% and the standard error (confidence limits) was 2.1% (1.7 to 2.8%). The mean difference and confidence limits for the ‘decision making’ time was 0.0 ± 1.0% and the standard error (confidence limits) was 4.5%

(3.6 to 6.2%). Table 1 and 2 shows a variety of statistical results used for comparing the overall performance and 'decision making' time reliability of the skill test respectively. There is a strong relationship for overall skill test performance as indicated by a Pearson and intraclass correlation above 0.90 (Table 1). The relationship for decision time was also good, being above 0.70 (Table 2). Figure 2 shows the Bland and Altman plot for overall performance time for trial 2-1, and gives a mean difference and limits of agreement of 0.03 ± 5.11 s. The Bland and Altman plot for decision time shows a mean difference and limits of agreement of 0.01 ± 0.52 s (Figure 3).

Validity

The Pearson correlation for the mean women's' coaches rank and overall time was r = 0.83 (P<0.01) and decision time was r = 0.73 (P<0.01). The Pearson correlation for the mean men's coaches rank and overall time was r = 0.61 (P<0.01) and decision time was r = 0.70 (P<0.01). Figure 4 shows a plot of the z-score from the mean coaches rank (residual) versus the overall time for the skill test. The figure shows good uniformity of the data. The standard error of the estimate for the overall time is 0.58 for the women and 0.81 for the men. The standard error of the estimate for the decision time is 0.70 for the women and 0.74 for the men.

Discussion

The main finding from the present study was that the reproducibility of the skill test was good. Correlations between the two trials were high to very high (4). The correlations between coaches' rankings and player performance were also high for the high standard players used.

To assess test retest reliability, Hopkins (5) has advocated the use of typical error rather than the limits of agreement approach that is recommended by Atkinson and Nevill (1). Hopkins (5) suggested that the value of the limits of agreement approach is dependent upon the sample size of the reliability study. The bias of the limits of agreement are <5% if there are >25 subjects; however if there is only 8 subjects this bias is 21%. In the current study, there are over 30 subjects for the data for men and women combined and therefore the bias will be low. The Bland and Altman (2) limits of agreement provide a confidence interval for the differences between two trials and it is up to the experimenter to determine whether this range is acceptable. Hopkins (5) suggested that a 95% confidence interval used for the limits of agreement approach is too stringent a measure if used for looking at an athlete's improvement in performance and that half the limits of agreement would still leave approximate odds of 5-1 that performance had actually improved. Thus, the limits of agreement allows for an underestimation of the reliability of the protocol as it takes into account 2 standard deviations rather than the usual one that is used as an indicator of variation. The mean difference and limits of agreement for overall skill test performance was 0.03 ± 5.11 s and for 'decision making' was 0.01 ± 0.52 s. In contrast the typical error of overall performance, as advocated by Hopkins (5) of the test was 2.0 s for men and 1.7 s for women. For the 'decision making' data the typical error was 0.20 s for men and 0.18 s for women. The typical error is the within-subject standard deviation and represents the variation we could expect to see from trial to trial for each subject (5).

A key aspect of determining whether the reliability of the test is appropriate to the tests use is to assess the minimum worthwhile change that matters to the coach, player or scientist. This worthwhile change value may vary between the player, coach and scientist. For team sports particularly this is a very difficult value to determine as the performance on a skill test, such as that presented in this paper may not directly reflect performance on the pitch due to numerous and complex interactions that occur during team sports. To try to overcome this issue the validity for this test was assessed by ranking players on their overall pitch performance and correlating this with the performance on the skill test. In terms of the minimum worthwhile change for reliability of tests associated with team sports, Hopkins (6) outlined that the smallest worthwhile change should be <0.2 of the between athlete SD. For the current test the error of the measurement or typical error related to the between athlete SD is 0.26 for the women and 0.28 for the men respectively. Therefore this is slightly higher than the value indicated. Based on this data, in practical terms the smallest worthwhile change for the field hockey skill test should be 2s. If the performance of a player on the test improves by 2s, you can be confident that the player has improved his or her performance on the skill test.

These data show that the reliability of the skill test is considerably better than any previously published data for field hockey (3, 11, 12, 14). The tests that have been formulated during the last 20 years have been designed as field tests to determine differences between players rather than for repeated measures on the same player. The Chapman Ball Control Test (3) isolates the ability of an individual to control the ball manipulatively by arm, wrist and hand action within a 9.5” (24 cm) diameter circle. This could be described as measuring dribbling technique rather than field hockey skill per se. Thus, it cannot be a measure of playing ability since this is not what constitutes the entire domain of field hockey skill. The testing took place on a gymnasium floor, which is a considerably different surface from the outdoor game. While the results from the Chapman test correlate well with subjective opinions of playing ability, it does not attempt to measure any other characteristics. Testing of ball control is obviously important, but analyses of match play highlight how little time players spend with the ball during a match and the very short duration of each period with the ball. The validity of the Chapman test would be reasonable if the test scores were compared with subjective ratings of ball control and not overall playing ability. Reilly and Bretherton (11) developed a field-based skill test, namely the “T”-dribbling test and a dribbling and accuracy test, to help determine the fitness of female hockey players. The T-dribbling test was shown to be correlated with aerobic fitness (r = 0.48; estimated $\dot{V}O_2$ max and physical working capacity) and anaerobic power (r = 0.6; stair run test). The accuracy was correlated with ectomorphy (r = -0.63). The skill tests provide useful field tests, but do not provide us with a test that includes a passing aspect and ‘decision making’ element. Furthermore, the “T”-dribbling test, is restrictive in that the players were unable to use reverse sticks, which is an integral part of the game and therefore would not be a suitable measure of hockey performance per se.

In our laboratory, previous soccer skill tests have been developed for use in researching the effects of fatigue on skill performance. The reliability in terms of mean difference (± limits of agreement) for the Loughborough Soccer Passing Test was –0.1 ± 11.2% (9). The limits of agreement are much greater than those in the current study (0.0 ± 5.6%), suggesting that the reliability of the field hockey skill test is good and acceptable for scientific research.

The validity of the field hockey skill test is moderate to good. The term ‘validity’ used in the current study, refers to both logical validity and construct validity. Logical validity means that the test is appropriate to what you want to measure, whereas construct validity refers to a test which can discriminate between groups of performers (13). A further type of validity, should be tested for, namely criterion validity, which means that the test needs to be compared with an established test. However, as there does not seem to be a previous field hockey skill test that is regarded as ‘established’, this is inapplicable. The skill test shows better validity for the women than the men for both the correlations and typical error or standardised error of the estimate values. The typical error values were 0.58 for the women and 0.81 for the men. Though these values are larger than we would hope for they are justifiable from the method used. The coaches ranks were based off performance and are extremely subjective so the variation will be much greater between players. Further more the players used were all of a high standard so the variation between players would have been low increasing the difficulty for coaches rankings. The greater validity for women may be due to the different demands and styles of play adopted by men and women. In field hockey there are “physical and physiological differences between the sexes” that means that the game of hockey will be played differently by men and women (8). For elite hockey players, men were found to have a higher $\dot{V}O_2$ max and haemoglobin content and were faster, taller and heavier than the women (8).

Skill tests need to be objective as well as valid and reliable. Though the objectivity of the test has not been statistically determined, the test should exhibit good objectivity. The test performance is determined by timings, which are completed by a computer and stopwatch and penalty time. The players are only instructed in what order to complete the test and the penalty system, and thus the inferences of the testers are minimal. The tester is only responsible for timing and counting the number of penalties so the results should be similar, if not identical between all testers.

The test was performed on a typical sportsturf and is thus easily transferable between pitches. The field hockey skill test could be easily transferred to the pitch, using the goal and could be made as realistic as is required. The movement of a goal keeper could determine the side for shooting, with another attacker playing the pass and a defender taking the place of the five cones to shoot around. Thus, the test could be as scientific or match-like as is required, and could range from a coaching aid to a selection aid.

The limits of agreement and typical error indicate the reliability of the skill test is very good and that changes in overall performance of greater than 2.1% could be attributed to the intervention. In summary, the field hockey skill test provides a reliable, objective and valid tool for testing the skills of good to elite field hockey players. The high reliability and validity allows it to be used for scientific research as well as determining how the skills of individual players are developing.

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Table 1 Statistical summary of the reproducibility for the overall time of the skill test.

	Men	Women	All
Mean (± SD) time trial 1 (s)	83.93 ± 6.60	96.56 ± 6.86	90.85 ± 9.21
Mean (± SD) time trial 2 (s)	84.36 ± 7.44	96.26 ± 6.12	90.89 ± 9.18
Mean difference (s) (confidence interval -, +)	0.4 (-1.2, 2.1)	-0.3 (-1.6, 1.0)	0.0 (-0.9, 1.0)
Typical error (s)	2.0	1.7	1.9
Pearson correlation (r)	0.93 P <0.0001	0.94 P <0.0001	0.96 P<0.0001
Intraclass correlation (r)	0.92	0.94	0.96

Table 2 Statistical summary of the reproducibility of the ‘decision making’ time of the skill test.

	Men	Women	All
Mean (± SD) time trial 1 (s)	3.82 ± 0.37	4.43 ± 0.41	4.17 ± 0.49
Mean (± SD) time trial 2 (s)	3.78 ± 0.35	4.47 ± 0.53	4.17 ± 0.57
Mean difference (s) (confidence interval -, +)	-0.04 (-0.2, 0.13)	0.04 (-0.1, 0.17)	0.0 (-0.1, 0.11)
Typical error (s)	0.20	0.18	0.19
Pearson correlation (r)	0.70 P <0.01	0.89 P <0.0001	0.89 P <0.0001
Intraclass correlation (r)	0.70	0.85	0.88

Figure Captions

Figure 1. Schematic representation of the field hockey skill test.

Figure 2. Bland-Altman plot for the overall time raw data.

Figure 3. Bland-Altman plot for the ‘decision making’ time raw data.

Figure 4. A residuals versus predicted plot for the overall time for men and women.

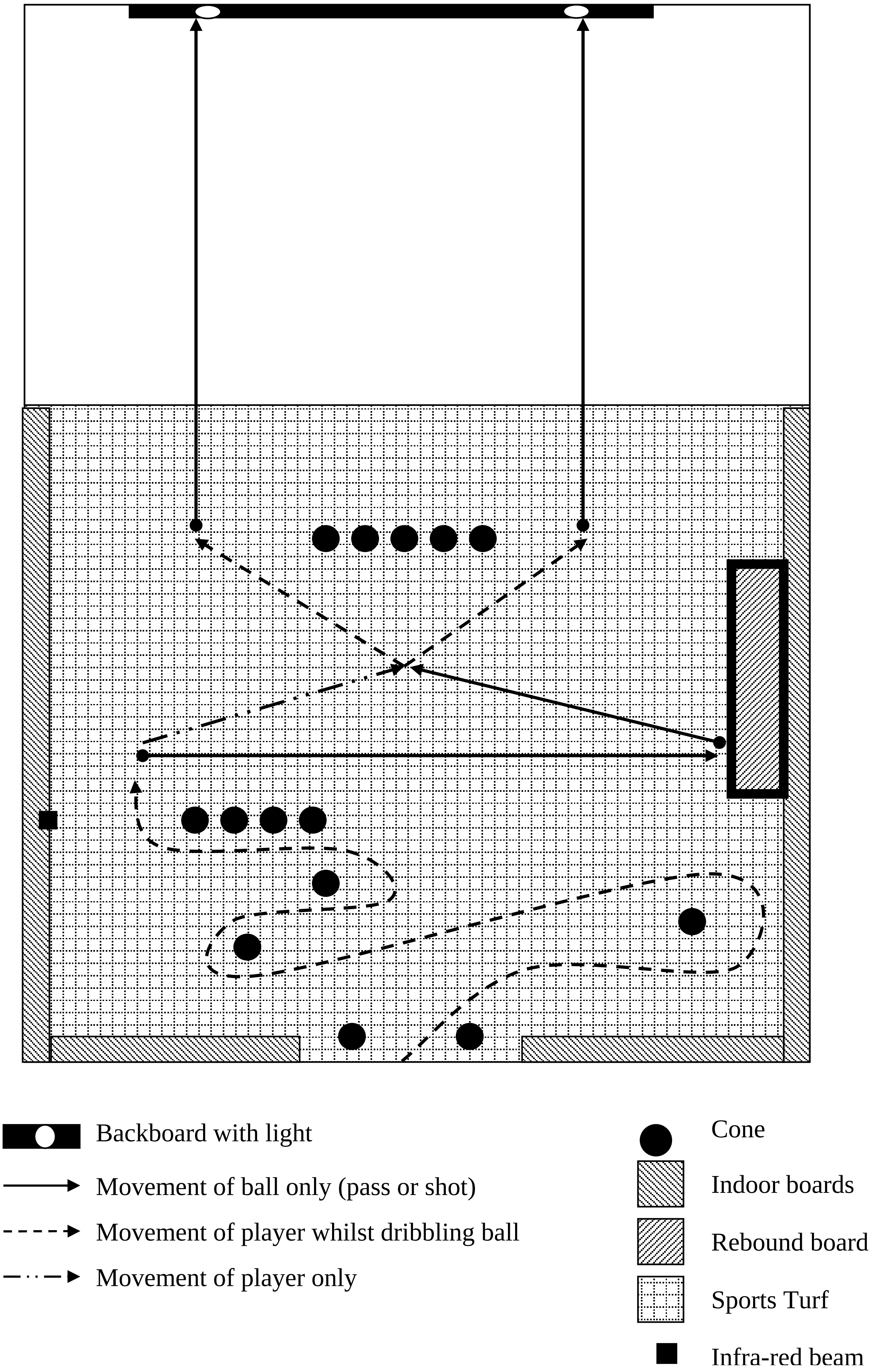
Backboard with light
Movement of ball only (pass or shot)
Movement of player whilst dribbling ball
Movement of player only
Cone
Indoor boards
Rebound board
Sports Turf
Infra-red beam

Figure 1

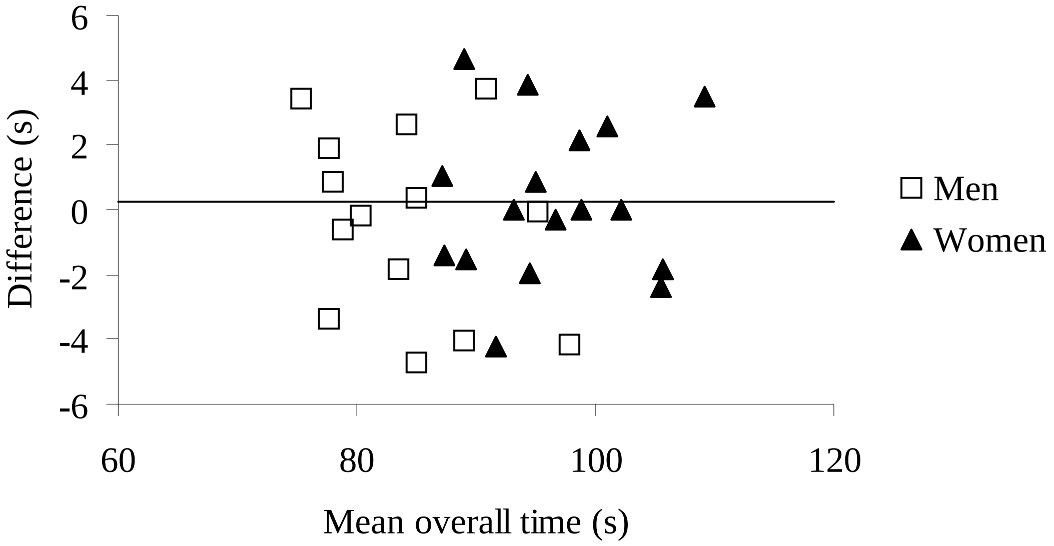
6
4
2
0
-2
-4
-6
Difference (s)
60
80
100
120
Mean overall time (s)
Men
Women

Figure 2

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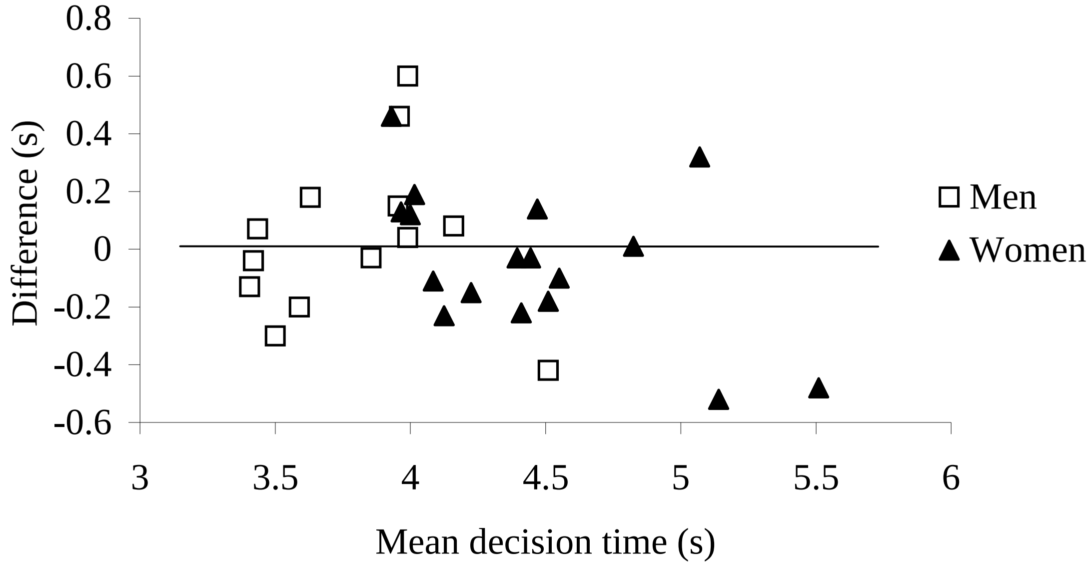

371 Figure 3

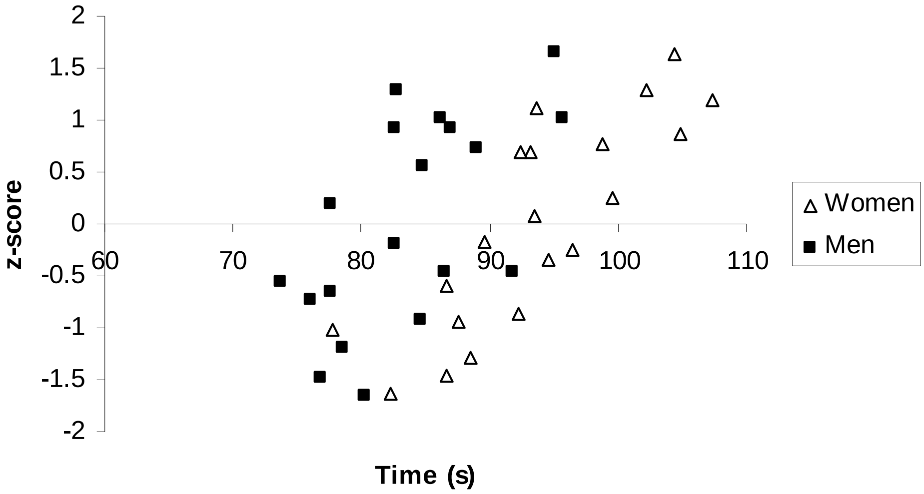

Figure 4