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Validity of a Squash-Specific Test of Change-of-Direction Speed

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Purpose: We examined the validity and reproducibility of a squash-specific test designed to assess change-of-direction speed. ***Methods:*** 10 male squash and 10 male association-football and rugby-union players completed the Illinois agility run (IAR) and a squash change-of-direction-speed test (SCODS) on separate days. Tests were repeated after 24 h to assess reproducibility. The best time from three attempts was recorded in each trial. ***Results:*** Performance times on the IAR (TE 0.27 s, 1.8%, 90% CI 0.21 to 0.37 s; LOA –0.12 s ± 0.74; LPR slope 1, intercept –2.8) and SCODS (TE 0.18 s, 1.5%, 90% CI 0.14 to 0.24 s; LOA 0.05 s ± 0.49; LPR slope 0.95, intercept 0.5) were reproducible. There were no statistically significant differences in performance time between squash (14.75 ± 0.66 s) and nonsquash players (14.79 ± 0.41 s) on the IAR. Squash players (10.90 ± 0.44 s) outperformed nonsquash players (12.20 ± 0.34 s) on the SCODS ($P < .01$). Squash player rank significantly correlated with SCODS performance time (Spearman's $\rho = 0.77$, $P < .01$), but not IAR performance time (Spearman's $\rho = 0.43$, $P = .21$). ***Conclusions:*** The results suggest that the SCODS test is a better measure of sport-specific capability than an equivalent nonspecific field test and that it is a valid and reliable tool for talent identification and athlete tracking.

Keywords: exercise performance, fitness, exercise physiology

In common with other racket sports, repeat-sprint capability and the ability to change direction at speed are important determinants of performance in squash.[1–3] Squash movements are characterized by rapid accelerations and decelerations over short distances and involve frequent turning, lunging, and side-stepping.[4] A recent match analysis study reported that more than 40% of squash movements occurred within 1 m of the court's T position and most movements were not in a straight line.[4]

The use of on-court sprint drills encompassing multiple direction changes (ghosting) by elite-standard squash players reflects the recognition that speed training must be undertaken in sport-specific movement patterns.[2] This is supported by findings that straight-line sprint training does not improve sprint perfor-

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mance involving changes of direction.[5] The specific movement patterns of squash provide a unique challenge to physiologists attempting to assess squash-specific explosive capabilities and suggest that tests should encompass the ability to change direction at speed. Müller[6] stated that improvements in elite sport performance arise mainly from an increase in the quality of training and that this quality is best improved through the development of sport-specific tests. Valid and reliable squash-specific, yet controlled, tests are likely to provide more useful data for the selection of players, design of training programs and tracking of sport-specific training adaptations that might otherwise go undetected by conventional nonspecific procedures.

The validity of field-based tests can be determined by: a) comparison of the new test with a "gold standard" procedure (criterion validity); b) the ability of the test to discriminate between groups of performers from sports with different characteristics or between abilities within a group of performers (construct validity); c) the test's ability to assess components of fitness known to be important for performance (logical validity).[7] Previous tests developed to assess specific fitness in squash, while addressing all of these criteria, have focused on maximum and submaximum cardio-pulmonary responses and have involved movement patterns that, although specific to squash, are performed at intensities to assess aerobic capabilities.[8,9] This is surprising as match analysis has revealed that players cover a mean distance of only 12 m during rallies lasting 16 to 21 s and recent physiological analysis has reported mean postmatch blood lactate concentrations of 8 $mmol \cdot L^{-1}$ indicating marked contributions from anaerobic metabolism.[4,10]

Despite the documented importance of qualities such as explosive strength and speed and the rapid accelerations, decelerations and direction changes that characterize squash movement, there appear to be no published squash-specific tests of sprint capabilities or change-of-direction speed.[1–4] Accordingly, the purpose of this study was to examine the validity of a squash-specific test designed to assess such change-of-direction speed.

Methods

Participants

With institutional ethics approval 10 trained male squash players (mean ± SD; age 23 ± 4 years; stature 1.8 ± 0.05 m; body mass 79.7 ± 5.3 kg), and 10 nonsquash players (trained association-football and rugby-union players; age 24 ± 3 years; stature 1.8 ± 0.08 m; body mass 85.9 ± 11.8 kg) who were fully habituated to the procedures participated. The squash players were English county-standard, had a competitive playing frequency of at least three times per week and had been competing at county standard for at least three years. The nonsquash players were matched to the squash players for playing standard and frequency of participation in their respective sports. All participants were given written and verbal instructions to report for testing in a well-rested, well-hydrated and well-nourished state, and to refrain from eating at least two hours before testing. Participants were also instructed to abstain from drinking alcohol and to avoid stimulants such as caffeine for at least eight hours before testing.

Experimental design

Participants performed two test sessions on a squash-specific change-of-direction-speed test (SCODS) separated by 24 hours and two test sessions on the Illinois Agility Run (IAR), also 24 hours apart. The IAR was chosen for comparison as it is a popular nonspecific field-based test of change-of-direction speed that has been used previously in the validation of other similar tests.[11] Following a standardized warm-up, each test session comprised three trials of the test in question with the best performance time recorded to the nearest 0.01 s using a hand-held electronic stop clock (FastTime 1, Click Sports, Cambridge, UK). The timer was positioned at the first set of cones as shown in Figure 1. Timing commenced when the hips of the participant broke an imaginary line at hip height and ceased when the participant's hips broke the imaginary line for a second time at the end of the looped test course. Tests sessions were performed in a counterbalanced manner at the same time of day and in the same footwear and clothing and under similar environmental conditions (temperature 21 ± 2.4°C, relative humidity 50 ± 8%, barometric pressure 1002 ± 11 mb). The IAR was performed in a nonslip sports hall and the SCODS was carried out on a marked-out squash court.

Experimental Procedures

Warm-up and Trial Performance. The standardized warm-up required participants to perform five minutes of jogging, followed by four runs through the test being performed that day at approximately 50, 60, 70, and 80% of perceived maximum effort to warm-up the specific muscle groups required for the movements involved. Each run through was separated by 60 s recovery. A four-minute period of static stretching of the quadriceps, hamstrings, gastrocnemius and soleus muscle groups was carried out following the submaximal runs and before the three experimental trial runs. This was the preferred standard practice of the squash players recruited and was therefore used for all participants to standardize pretest conditions. Participants were instructed to perform each of the three experimental trial runs on both tests "all-out" following a "3-2-1" countdown. Two-minute recovery periods were allowed between each trial run to minimize the effects of fatigue on subsequent attempts.

Squash-Specific Change of Direction Speed Test. The dimensions, layout and movement path through the SCODS are shown in Figure 1. From the start line, participants were required to move between and around the large cones (denoted by crosses on Figure 1) to reach out and touch the smaller cones (denoted by circles) with their either hand depending on their preference. No instructions were given as to the most effective movement technique. Participants were simply encouraged to complete the course as fast as possible. The movement patterns and distances were designed using match analysis data and through consultation with an England Squash advanced coach.[4]

Illinois Agility Run The dimensions, layout and movement path through the IAR are shown on Figure 2. Participants began from a standing start, and following a "3-2-1" countdown ran the course with maximum effort without knocking over

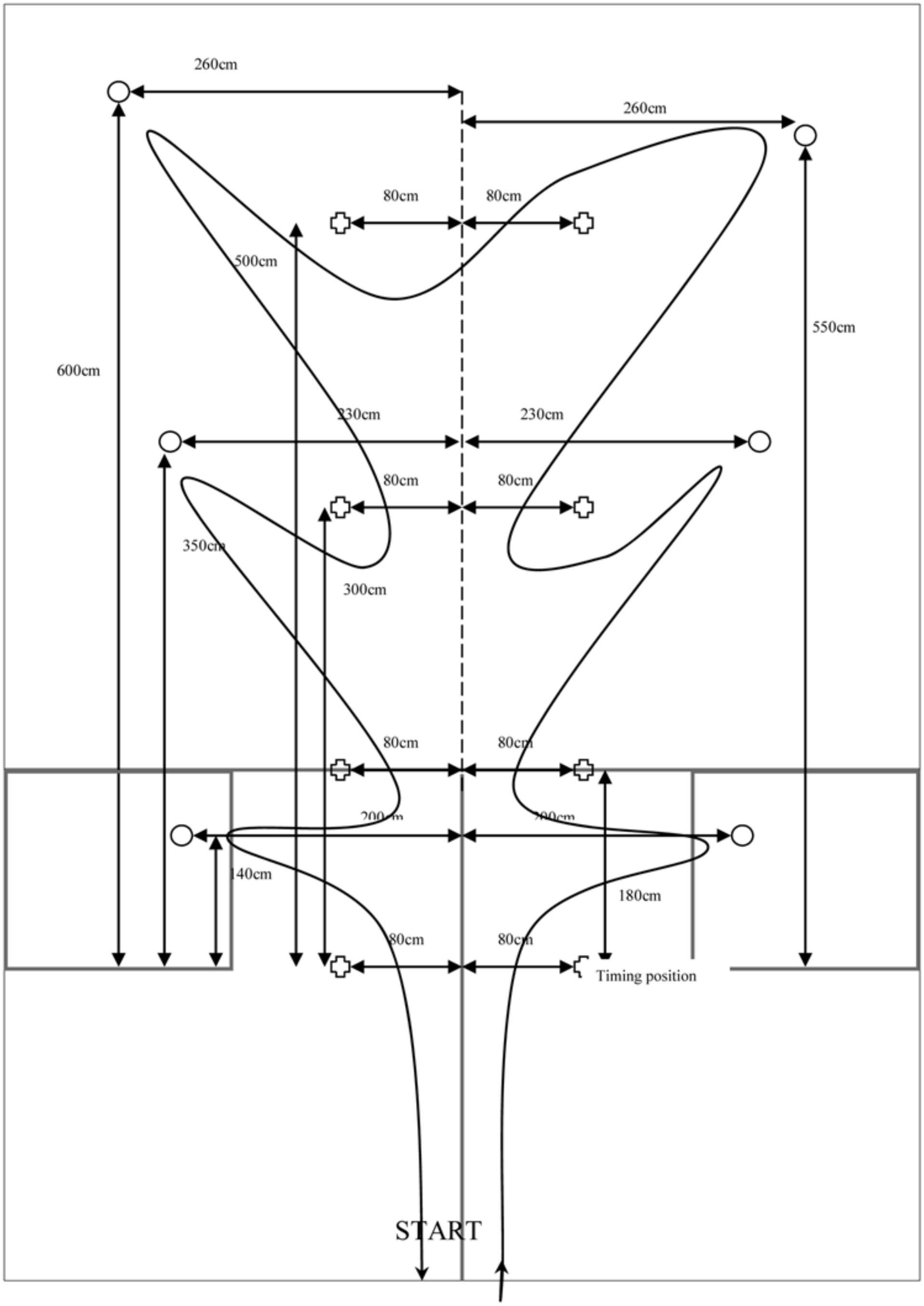

Figure 1 — Dimensions and route for the squash-specific test of change-of-direction-speed.

any cones. Participants were encouraged to complete the course as fast as possible and performance time was recorded in the same manner as the SCODS test.

Ranking of squash players

Two England Squash qualified coaches (part three—advanced level), located in the area where the study was performed, independently assigned a rank to each squash player using personal knowledge of the players and recent performances in local regional league matches. Where independent ratings differed, a resolution was obtained through discussion between the two coaches.

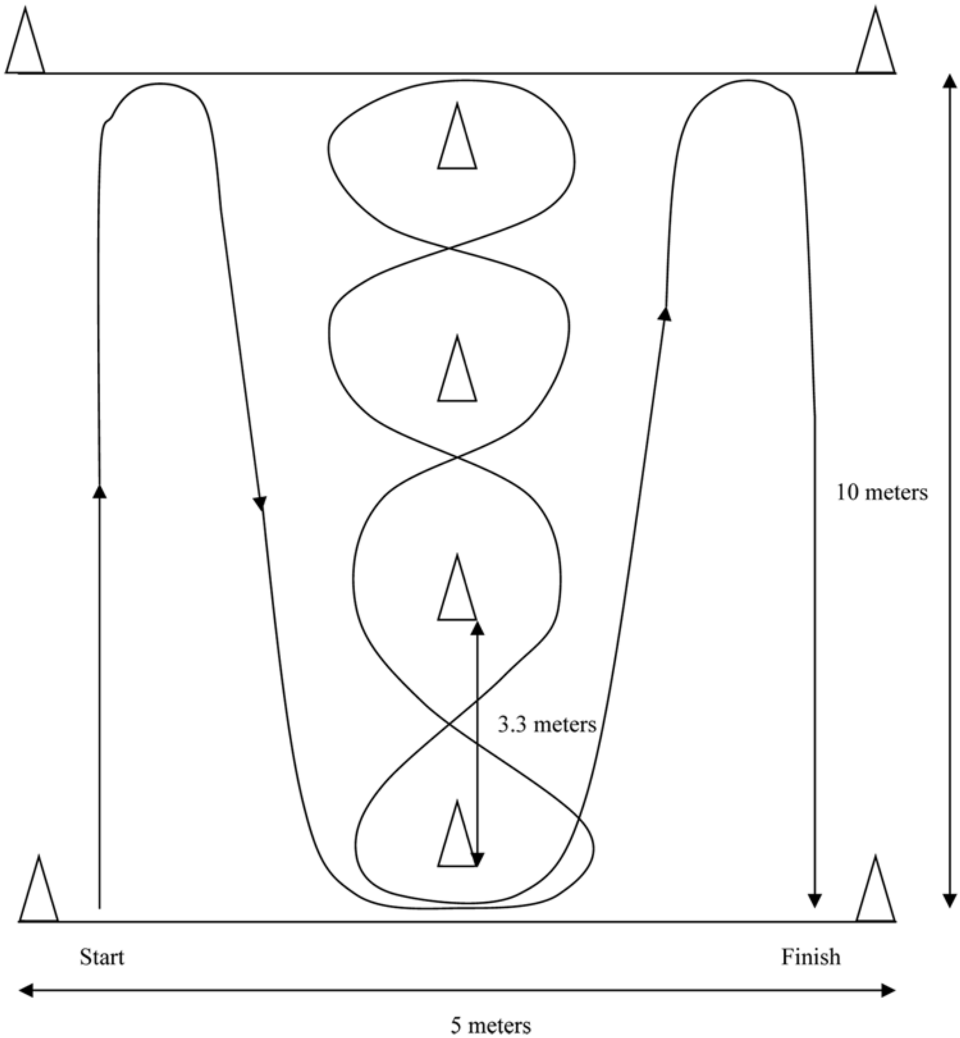

Figure 2 — Illinois agility run dimensions and completion route.

Statistical Analysis

Data were analyzed using SPSS v 12 (SPSS Inc., Chicago, IL) statistical software package. Mean and standard deviation were calculated for performance time on the SCODS and IAR. Following verification of underlying assumptions such as normality and homogeneity of variance, independent *t* tests were used to compare the best performance times on both the SCODS and IAR between the squash players and the nonsquash players. Spearman's ρ examined the relationship between best scores on the SCODS and IAR and subjective ranking of the squash players' ability. Pearson's correlation examined relationships between best scores on the SCODS and IAR in squash players. Statistical significance was accepted at $P \leq .05$. Typical error (TE) and the 90% confidence interval thereof (90% CI), limits of agreement (LOA) and least products regression (LPR) were calculated and used to assess reproducibility of performance time on both the SCODS and the IAR.[12–14]

Results

Differences in Performance on the IAR and SCODS Tests Between Squash and Nonsquash Players

The results are illustrated in Table 1. There were no statistically significant differences in performance time between squash and nonsquash players on the IAR ($P = .86$). However, squash players were faster than nonsquash players on the SCODS ($t_{18} = -7.38$, $P = .001$, effect size = 3.33).

Reproducibility of Performance Scores on the IAR and SCODS Tests

Performance times of squash players and nonsquash players combined on the IAR were reproducible (TE 0.27 s, 1.8%, 90% CI 0.21 to 0.37 s; LOA −0.12 s ± 0.74; LPR slope 1, intercept −2.8), as were times on the SCODS (TE 0.18 s, 1.5%, 90% CI 0.14 to 0.24 s; LOA 0.05 s ± 0.49; LPR slope 0.95, intercept 0.5). For squash players alone, reproducibility of performance on both tests was further improved (SCODS TE 0.13 s, 1.2%, 90% CI 0.09 to 0.21 s; IAR TE 0.21 s, 1.7%, 90% CI 0.15 to 0.34 s). Bland–Altman and LPR plots for performance time on the SCODS for all participants are shown in Figure 3.

Correlation of SCODS and IAR Performance With Player Rank in Squash Players

Spearman's ρ indicated a moderate and significant positive correlation between performance time on the SCODS and player rank for the squash players (Spearman's $\rho = 0.77$, $P < .01$). The correlation between performance time of squash players on the IAR and rank was low and nonsignificant (Spearman's $\rho = 0.43$, $P = .21$).

Table 1 Performance times from two trials of the SCODS and the IAR tests performed on separate days (values are mean ± SD).

	Squash-Specific Change-of-Direction-Speed Test			Illinois Agility Run test		
	Test 1 (s)	Test 2 (s)	Best score (s)	Test 1 (s)	Test 2 (s)	Best score (s)
Squash (n = 10)	10.99 ± 0.44	10.97 ± 0.44	10.90 ± 0.44	14.94 ± 0.75	14.79 ± 0.54	14.75 ± 0.66
Nonsquash (n = 10)	12.37 ± 0.47	12.49 ± 0.38	12.20 ± 0.34	14.99 ± 0.45	14.90 ± 0.49	14.79 ± 0.41

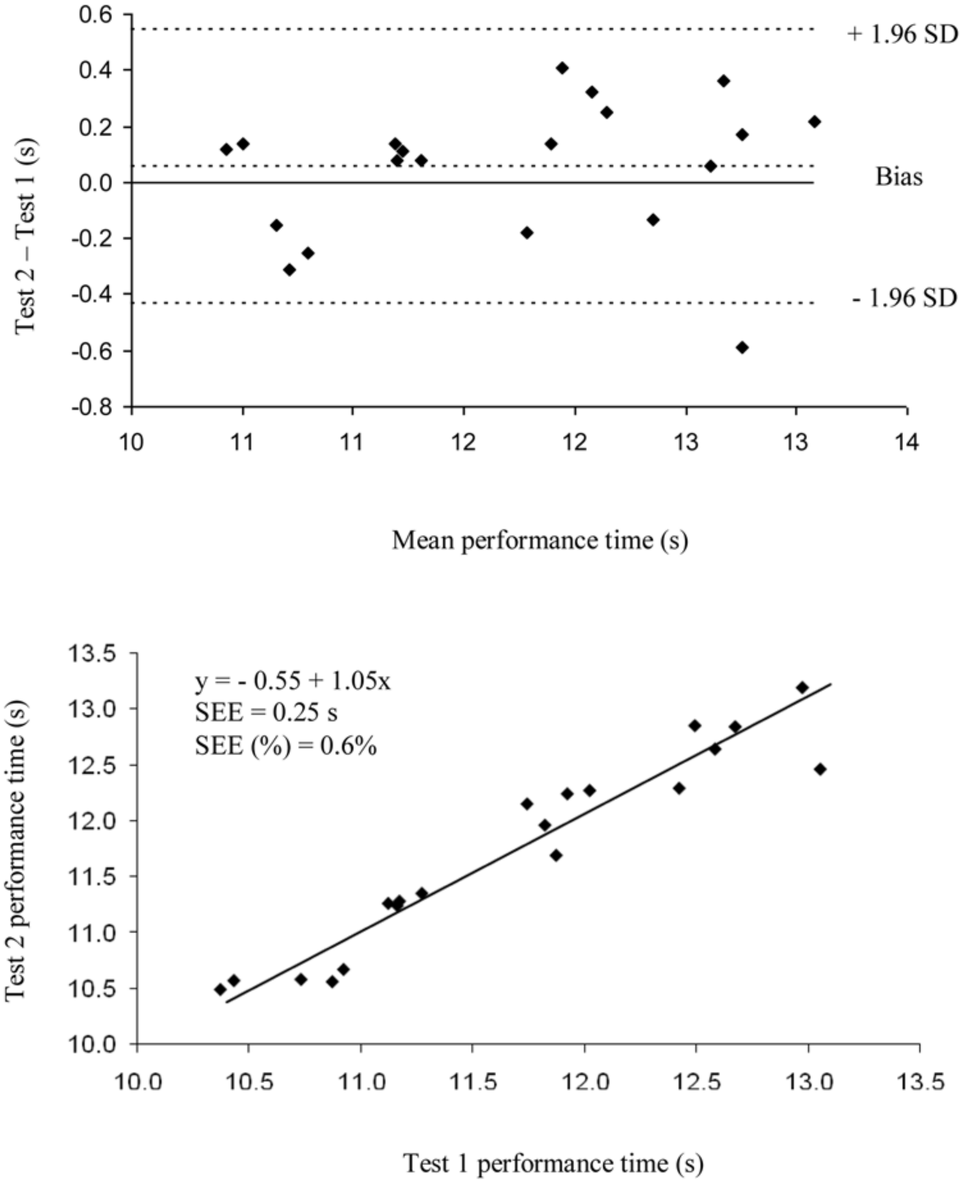

Figure 3 — Bland–Altman (top) and LPR plots (bottom) for performance time measured in two trials of the SCODS test performed 24 hours apart.

Correlation of Performance on the IAR and SCODS Tests.

Pearson's correlation showed a low and nonsignificant relationship between performance time on the IAR and SCODS tests in the squash players ($r = .32$, $P = .37$).

Discussion

The purpose of the study was to examine the validity and reproducibility of a squash-specific test of change-of-direction speed. Despite similar non-sport-specific change-of-direction speed measured on the IAR, squash players outperformed non-squash players on a change of direction speed test that used squash-specific movements. Moreover, the significant positive correlation between squash player rank and performance on the SCODS showed that the test discriminated ability in a group of squash players. The ability of the squash-specific test to discriminate both between groups with similar non-sport-specific change of direction speed and in squash players suggests that it possesses construct validity.[7]

The difference in SCODS performance between groups suggests that squash training and the associated skill in squash-specific movements conferred a performance advantage on a test involving repeated changes of direction at speed over short distances as is required in squash.[4] Young et al previously demonstrated improvements in the performance of change-of-direction-speed tests with specific training and also showed no improvements in such performance with nonspecific training that consisted of straight-line sprinting.[5] Results from the IAR showed that the squash players and nonsquash players possessed similar capabilities in this test that involved four straight sprints of 10 m and weaving around four cones. The SCODS in contrast possesses no straight sprints, but instead comprises numerous lateral movements of short distances requiring rapid and forceful changes of direction. Squash movements are characterized by rapid accelerations and decelerations over short distances and involve turning, lunging, and side-stepping.[4] Squash players spend much time training in these movement patterns to improve court coverage and movement speed.[2,15,16] The superior performance of the squash players in their habitual movement patterns shown in this study provides evidence for the specific nature of change-of-direction speed and also for the logical validity of the SCODS test. The low and nonsignificant correlation between performance of the squash players on the IAR and SCODS tests is further evidence for the specificity of change-of-direction speed.

Applications to Squash-Specific Testing

Sport-specific testing is important for accurate prescription of training, talent identification and tracking of training-induced adaptations.[6] Repeat-sprint capability and the ability to change direction at speed are important determinants of performance in squash.[1–3] As such, a valid and reliable squash-specific test that examines these capabilities is a useful addition to existing test batteries for squash players. The ability of the SCODS test to discriminate ability in a group of squash players confirms the construct validity of the test and suggests that it could be used for screening purposes. Moreover, the reproducibility reported provides further support for the use of the SCODS as an assessment tool for the tracking of squash players. The confidence intervals reported for the squash players could be used to assess the extent to which a training intervention has resulted in a meaningful alteration in change-of-direction speed, with the upper confidence interval representing the lower boundary for a meaningful change. However, future studies should examine reproducibility over greater test–retest durations to confirm the usefulness of the test to track training-induced adaptations in fitness and performance. Test–retest variability should also be established for other samples of squash players such as juniors, females and subelite groups.

Conclusions

The results suggest that the squash-specific change-of-direction-speed test is a better measure of sport-specific capability than an equivalent nonspecific field test and that it is a valid and reliable field based assessment that could be used for talent identification and athlete tracking. However, further studies should be carried out using squash players of different age, sex and ability and across greater test-retest durations to confirm these findings.

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