The validity and reliability of an established series of Badminton-specific field tests

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Introduction

The physical demands of Badminton are extensive with a high emphasis on acceleration, deceleration, agility, control and power. Players must also execute highly skilled techniques at very high intensity for up to around 60 minutes. The cardiovascular and metabolic demands of the sport are similar to those from other 'repeated sprint sports', such as soccer, hockey and squash (Glaister, 2005). Recent rule changes, alongside general developments in the sport, have led to generally shorter matches (Chen, Wu & Chen, 2011) and a greater emphasis on explosiveness (i.e., powerful movements executed at very high speeds).

The cardiorespiratory and metabolic responses to Badminton (Abian-Vicen, Del Coso, Gonzalez-Millan, Salinero & Abian, 2012; Faude et al 2007; Cabello et al 2003) and the physical capacities of players (Faude, Meyer, Rosenberger, Fries, Huber, & Kindermann, 2007; Wonisch, Hofmann, Schwaberger, von Duvillard, & Klein, 2003; Chin, Wong, So, Siu, Steiniger, & Lo, 1995) have been documented elsewhere. The explosiveness characteristics of players are less well established, with few publications of relevance to this area (Ooi et al., 2009; Hughes, 2008). This is surprising given the ever-increasing emphasis on power, speed and agility and the relative ease with which these factors can be assessed. Assessment of speed, power and agility is frequently performed using field-based test procedures with the evaluation of power being achieved indirectly through the assessment of jump performance (Gore, 2000).

Since the year 2000, Badminton England has carried out fitness assessments on their junior players at twice-yearly national squad meetings. This programme of testing now comprises around 220 different players between the ages of 11 and 18 years, and 27 of those players have gone on to become senior international players. The evaluations of power (vertical jump and standing long jump) used are well established procedures used in other sports but the tests of speed and agility were developed based on training drills and their reliability and validity has not previously been established. Establishing the reliability and validity of fitness tests is important when results are used to guide fitness development. Reliability refers to the extent to which results are consistent and repeatable. Validity (specifically, construct validity) will be investigated here by investigating whether the tests of explosiveness can discriminate between players at different levels of competitive play. The only similar research to address the validity of such fitness testing (Ooi et al., 2009) used only senior players, with slightly different test procedures and with a comparatively low number of participants.

Therefore the primary aim of this work is to investigate the reliability and validity of the test procedures used over the last fifteen years in the assessment of fitness in English Junior Badminton players. A secondary aim is to disseminate the procedures and their results for subsequent use by other nations. The extensive and comprehensive data from the English junior players may be valuable for physical talent identification and for optimising the development of fitness in other groups of players.

Methods

To address the issues of reliability and validity here, a variety of approaches were used. These approaches are reflected in the sections below but the test procedures described were consistent in all cases. Reliability was assessed from a group of 15 junior Italian national squad players performing the speed tests on three occasions, separated by at least 48 hours. Construct validity was assessed using two approaches. Firstly, by comparing the performance in speed tests between Italian and English players and secondly, by comparing performance in jump tests and speed tests between English juniors who have gone on to become senior internationals ('future elite') with their age-matched peers who did not ('non-elite').

Participants

In order to investigate validity and reliability of the tests, junior national squad players from England and Italy were used. Italian players were used to evaluate the reliability of the speed tests as they had no previous experience in the speed tests. Additionally, as Italian junior teams are consistently ranked at a lower level than the English (Badminton Europe, 2014), the validity of the tests could be investigated by comparing the performance of English and Italian players in these tests. A similar approach has previously been adopted in Badminton research by Ooi et al (2009) using male Malaysian players.

Test procedures

Jump tests

Jump tests were performed using vertical jump and standing long jump procedures. Vertical jump was measured using Vertec (JumpUSA, CA, USA) apparatus. Preparatory counter-movement was allowed and the dominant hand was raised in execution of the test jump. The standing long jump was measured from the front of the feet (taken as zero point) to the back of the foot which travelled the least distance upon landing. The best performance from at least four attempts was recorded as the test result.

General speed test

For the performance of this test, players stood astride the central line of a court and were required to make ten lateral movements at maximum speed across the court. Two sets of five shuttlecocks were placed, feathers downwards, on the outside line of each side of the court (i.e., ten shuttles in total). Each set was spread out over a distance of around 50cm. Players were instructed to knock one shuttle from its position with their racket for each lateral movement. Thus, they moved from forehand to backhand side knocking one shuttle for every movement made. Once the tenth shuttle had been hit, the test time was taken when the player crossed the central line for the last time. The best time from at least two attempts was taken as the test result.

Badminton-specific speed ('agility') test

This test required a total of eight movements in an ordered sequence in all directions around the court (see Figure 1; from points 1 to 4, twice in succession). This test used Badminton-specific 'shadow play' movements around the court, starting from a central base. For position 1, players were required to replicate an overhead forehand shot while placing a foot in the box marked on Figure 1. At position 2, players had to touch a post (around 1.2m high) positioned on the inner tramline, 1.5m back from the front service line. At position 3, players had to hit a shuttle that was resting on the net tape, 0.5m in from the inner tramline. Finally, at position 4, players had to hit a shuttle that was placed on the inner tramline 1.5m back from the front service line before returning to their central base. Once this sequence had been performed twice, the test-time was taken when the player returned to the central base. The best time from at least two attempts was taken as the test result.

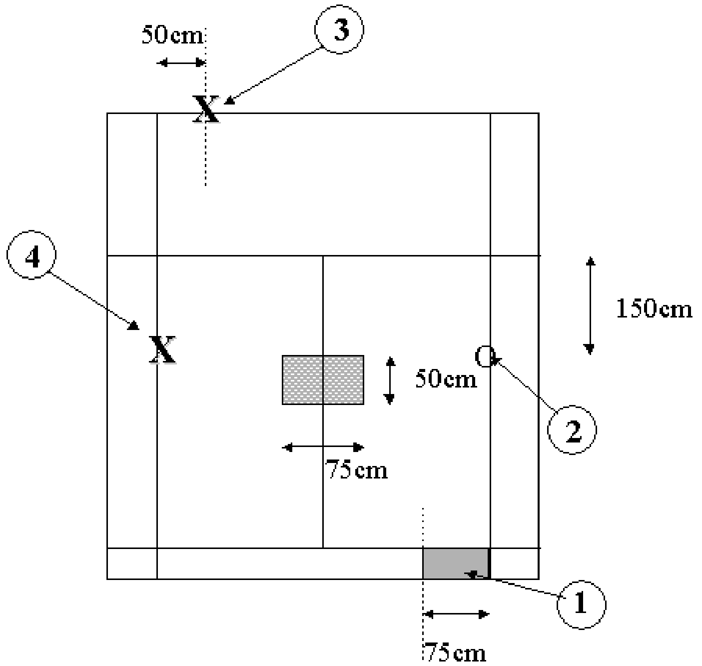


Figure 1. Layout of the half-court for the Badminton-specific speed test (set-up should be inverted for left-handed players).

Data analysis

Data are presented as mean ± standard deviation unless otherwise stated. In keeping with convention in such research, statistical significance was accepted at $P<0.05$.

Reliability

The reliability of the 'general speed' and 'agility' tests was assessed using the spreadsheet of Hopkins (2011) to derive typical error as a coefficient of variation (CV) and intra-class coefficient (ICC) values.

Validity

To compare the Italian and English juniors, the fifteen Italian players were matched for sex, age and stature with players from the records of the English test programme. Analysis was carried out using an independent t-test. To compare the test performance of English junior players who went on to become senior internationals ('future elite') or not ('non-elite') a senior coach from Badminton

England first distinguished the senior elite (n=16 females, 11 males) from non-elite players. The fitness results of those players from when they were aged 15 (females) or 16 years (males) were then retrieved and data analysis was carried out using an independent t-test.

Results

The full set of average data obtained on all junior players throughout the junior testing programme is given in Appendices 1 and 2.

Reliability

Participants in the reliability testing were previously unaccustomed to the test procedures so because they performed the tests on three occasions it is possible to evaluate reliability between consecutive visits. The reliability data expressed as intra-class coefficients and coefficients of variation are given in Table 1.

Table 1. Reliability statistics derived from three trials of the speed tests.

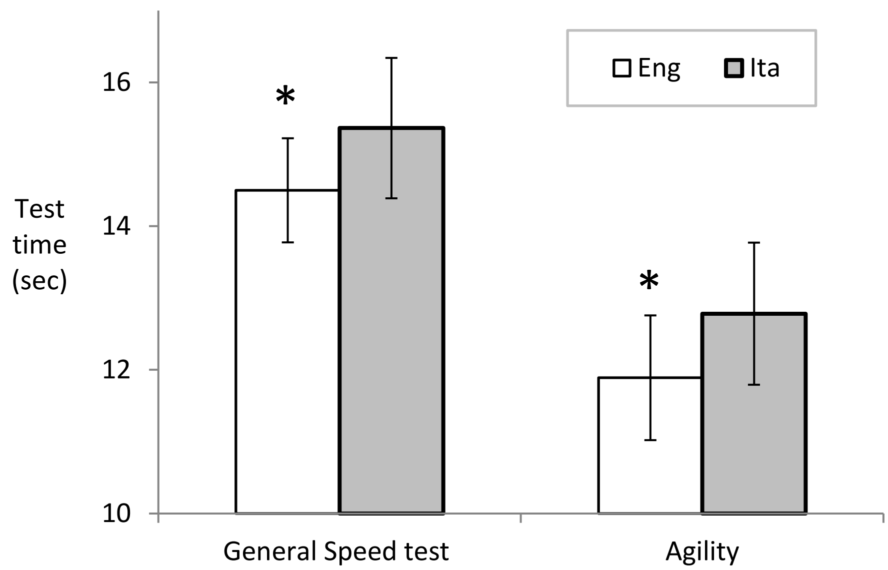
		Agility test		General speed test	
	Trials	*1 to 2*	*2 to 3*	*1 to 2*	*2 to 3*
Reliability	CV (%)	1.45	0.72	1.29	0.42
	ICC	0.97	0.99	0.96	1.00

ICC – intra-class coefficient

CV – coefficient of variation

Validity

The comparison of speed test performance in the matched groups of English and Italian junior national squad players is given in figure 2.



* Significant difference between nations.

Figure 2. Mean ± SD results during speed tests for matched groups of English (Eng) and Italian (Ita) junior players.

The comparison of ‘future elite’ with ‘non-elite’ players is given in Table 2. In the agility and general speed tests, future-elite male and female players were significantly faster than their non-elite counterparts. In the jump tests, future- elite females were also superior to those in the non-elite group. No other differences were evident between the groups.

Table 2. Mean ± SD results for ‘future-elite’ or ‘non-elite’ male and female, English junior players.

	Males		Females	
	Non-Elite (n= 48)	*Future-Elite (n=11)*	*Non-Elite (n= 26)*	*Future-Elite (n=16)*
Age (yrs)	16.5 ± 0.2	16.5 ± 0.2	15.5 ± 0.2	15.6 ± 0.2
Height (cm)	178.0 ± 5.4	179.0 ± 4.2	162.4 ± 6.3	164.8 ± 6.6
Weight (kg)	68.7 ± 7.9	67.9 ± 5.0	56.9 ± 6.8	58.6 ± 7.0
Vertical Jump (cm)	58.8 ± 6.1	61.8 ± 3.8	46.4 ± 4.0	**51.2 ± 4.3 ***
Long Jump (cm)	233 ± 14	239 ± 13	190 ± 19	**203 ± 14 ***
General speed (sec)	15.1 ± 0.6	**14.6 ± 0.6 ***	16.9 ± 0.8	**16.1 ± 0.7 ***
Agility (sec)	12.1 ± 0.6	**11.6 ± 0.5 ***	13.9 ± 1.0	**13.0 ± 0.6 ***

* Significantly different to corresponding 'non-elite' group

Discussion

This report is the first to investigate the reliability and validity of these Badminton-specific fitness tests. The strength of any programme of fitness testing is dependent on the validity and reliability of the data obtained. The evidence from this report supports of the use of these tests to show the fitness levels of junior players both in England and now, with the publication of the average data for all age-groups (Appendix 1 & 2), internationally.

Reliability

The assessment of reliability can be achieved using a wide variety of statistical procedures. There are subtle differences in the methods used here for the quantification of reliability with the CV measure described here being used to quantify absolute reliability and the ICC accepted as a method to determine relative reliability (Meylan, Cronin, Hughes, Oliver & McMaster, 2012). For both of the statistical approaches adopted with these data, the performance in the speed tests looks to be highly reliable. The CV values in the present study, with values all below 2%, show very high reliability and similarly our ICC values (on a 0–1.00 scale) are all above 0.95, with both measurements confirming very good reliability of these procedures (Currell & Jeukendrup, 2006; Meylan et al., 2012). Furthermore there appears to be little evidence of a learning effect from performing these tests because trials 1 and 2 look to give similarly reliable results to those from 2 and 3.

Validity

In our tests of jumping and movement speed, there is evidence that test performance may discriminate between players of different ability. This point is demonstrated by the superior performance of the English players in comparison with the Italians. Additionally, there is evidence that junior players who go on to become senior internationals may out-perform those who do not, especially in the speed tests.

Establishing the validity of field-based tests like those described in this study is a difficult process but we are confident that the approaches used here are appropriate. The use of junior national squad players from a nation with contrasting competitive performance levels is an attempt to investigate the construct validity of the speed tests. Clearly the fitness testing programme is not embedded into the preparation of Italian players like it is for the English but the highly stable and reliable data obtained from the Italians suggests that they were performing to their maximum ability. As movement speed is so crucial to Badminton performance it is perhaps not surprising that players from a higher-ranked nation are faster on court but the evidence that this discrepancy is also seen in fitness testing suggests the validity of both the general speed and agility tests.

It is of interest that junior players who have gone through the English programme and ultimately achieved senior international recognition performed to a significantly higher level on the speed tests (and for females, also on the jump tests) than their less successful peers. This suggests that the tests may have validity for the purposes of talent identification. In the least, the data may be useful for establishing fitness standards in England and elsewhere. Although we found significant differences between the 'future-elite' and 'non-elite' juniors we would never advocate use of these test data to *predict* adult performance level in the sport. There is clearly some overlap between categories of players and the ultimate selection of a Badminton player at senior international level is dependent on a wide array of other factors, explosiveness being only one component. However, it remains informative and valuable that the assessment of young developing players may now be easier as a result of these data. It should be noted that our analysis of 'future-elite' and 'non-elite' players only included females at the age of 15 and males at 16 years. We expect that results from younger players would be far more variable and therefore less predictive of future success due to discrepancies in the timing of puberty. These ages were selected in order to increase the likelihood that both males and females were at least two years beyond the mean age of peak height velocity (Mirwald, Baxter-Jones, Bailey & Beunen, 2002).

The validity of a broadly similar set of fitness test has been previously evaluated with high-level / elite senior male players from Malaysia (Ooi et al., 2009). They concluded that performance in on-court speed tests was not different between established senior players and developing players (mean ages 25 vs. 21yrs, respectively). The main distinction between the work of Ooi et al. (2009) and the present work is that our findings are based on younger players (all under 19 years) where, presumably, greater gains in fitness can still be made due to training and also development. In contrast to the Malaysian study, we conclude that the on-court speed tests used here constitute valid tests of speed for junior Badminton players, but our data do not consider the ability to discriminate between older players at a higher competitive level.

Practical considerations

It is undeniable that more complex alternatives to these tests may be more valid or reliable but the strength of the English testing programme is its continuity and the number of players that have been observed. The procedures are fairly easy to administer and to process but now, after 15 years of data, we have confidence in the judgements that are made based on past results. As a result of being involved in national squad sessions throughout their development from 11yr old onwards many players have been tested more at least ten times. Indeed, results from every current senior England international are included within the tests and this represents an unusually thorough and useful set of data.

Although the tests described here are relatively simple to perform, it is crucial that players are well prepared and motivated to perform to the very best of their ability. Additionally, it is crucial that the staff administering the tests are aware of the details of the test procedures. If test procedures are not standardised then comparisons with previous data will not be valid.

Conclusions

Evidence is presented here to support the validity and reliability of the tests performed in the test programme for English junior national squad players. This testing programme has been in operation for 15 years and the resulting data could provide a valuable resource for the fitness assessment of junior players in other nations.

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Appendix 1

Normative data (Mean ± SD) from the female English junior players that have been tested through the 15 years of the junior fitness testing programme.

FEMALES

AGE	11		12		13		14		15		16		17		18	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Age at test (years)	11.5	0.4	12.5	0.3	13.5	0.3	14.5	0.3	15.5	0.3	16.5	0.3	17.5	0.3	18.5	0.3
Height (cm)	150.6	6.8	157.8	7.3	159.5	6.9	161.8	5.7	163.9	5.9	165.1	6.8	165.4	7.3	166.2	6.2
Weight (kg)	40.6	6.1	47.8	8.3	51.4	7.2	55.0	6.8	58.1	7.0	59.3	7.4	61.2	7.5	64.9	7.4
BMI	17.8	1.6	19.1	2.3	20.1	1.9	21.0	2.2	21.6	2.3	21.5	2.0	22.1	1.9	23.0	1.8
Jump tests																
Vertical jump height (cm)	37.1	7.1	40.0	7.6	44.1	6.1	46.1	6.2	48.0	5.4	48.1	6.1	50.2	5.9	50.7	5.5
Standing long jump (cm)	171	21	184	18	194	12	198	14	197	16	200	16	202	16	203	13
Speed tests																
General speed test (sec)	18.4	1.6	16.9	1.3	16.2	1.1	16.1	1.0	16.3	0.9	16.1	0.9	15.9	0.9	15.7	0.8
On-court agility (sec)	16.0	1.6	14.7	1.3	13.8	0.9	13.6	0.8	13.4	0.9	13.2	0.9	12.9	0.8	12.9	0.7

Appendix 2

Normative data (Mean ± SD) from the male English junior players that have been tested through the 15 years of the junior fitness testing programme.

MALES

AGE	11		12		13		14		15		16		17		18	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Age at test (years)	11.4	0.5	12.5	0.3	13.5	0.3	14.5	0.3	15.5	0.3	16.5	0.3	17.5	0.3	18.4	0.3
Height (cm)	147.2	6.2	153.3	7.3	162.4	8.5	170.1	6.5	174.6	5.5	177.7	5.2	180.7	5.5	180.5	5.7
Weight (kg)	38.7	5.7	42.5	6.9	50.6	8.4	57.7	7.5	63.7	6.8	68.1	6.8	71.8	6.5	73.8	7.0
BMI	17.8	1.9	18.0	1.9	19.0	1.9	19.8	1.9	20.8	2.1	21.5	2.0	22.2	2.0	22.4	2.0
Jump tests																
Vertical jump height (cm)	34.8	4.3	39.9	5.6	44.6	5.9	50.4	5.1	55.4	5.2	59.7	6.0	61.9	6.8	63.7	6.1
Standing long jump (cm)	168	17	185	18	200	17	217	14	225	12	236	13	243	14	249	15
Speed tests																
General speed test (sec)	17.5	1.1	16.5	1.1	16.1	0.7	15.4	0.7	15.1	0.8	14.8	0.7	14.6	0.7	14.3	0.6
On-court agility (sec)	15.4	1.5	14.2	1.0	13.5	0.8	12.9	0.9	12.4	0.8	11.9	0.6	11.7	0.8	11.5	0.8