


Development of the Basketball Exercise Simulation Test: A match-specific basketball fitness test

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ABSTRACT

Scanlan, A.T., Dascombe, B.J. & Reaburn, P.R.J. (2014). Development of the Basketball Exercise Simulation Test: A match-specific basketball fitness test. *J. Hum. Sport Exerc.*, 9(3), pp.700-712. The aim of this study was to develop a reliable and valid field test that simulates the match-specific activity demands of male basketball competition. Fourteen male basketball players (mean \pm SD, age: 24.9 \pm 2.3 yr; stature: 187.8 \pm 7.7 cm; body mass: 88.8 \pm 10.5 kg) from state- (n = 6) and regional-level (n = 8) Australian competitions volunteered to participate. The Basketball Exercise Simulation Test (BEST) was developed using notational data describing the current activity demands of male basketball competition. Participants completed a repeat-sprint protocol, Yo-Yo Intermittent Recovery Test (Yo-Yo IRT) and 12-min BEST trial. Nine participants completed a further BEST trial at least 7 days later. Measures taken across the BEST included mean sprint and circuit time (s), sprint and circuit decrement (%) and total distance covered (m). Test-retest reliability was determined by calculating the intra-class correlation coefficient (ICC), typical error of measurement, coefficient of variation (CV) and 95% confidence intervals (CI) across the two BEST trials. Criterion validity was calculated using Pearson Correlation analysis between each BEST measure and performance in the repeat-sprint protocol and Yo-Yo IRT. Mean sprint and circuit time and sprint and circuit decrement possessed high ICCs (0.92-0.99), while all measures except sprint (14.6%) and circuit decrement (16.8%) exhibited low CVs (<5%). Significant ($p < 0.01$) relationships were reported between mean sprint time, sprint decrement, mean circuit time and circuit decrement during the BEST and repeat-sprint performance ($r = 0.80-0.92$), as well as Yo-Yo IRT distance ($r = -0.71-0.85$). The present results suggest that the BEST is a reliable and valid match-specific test for the combined assessment of basketball-related anaerobic and aerobic fitness. **Key words:** TEAM SPORT, FIELD-TEST, ASSESSMENT, RELIABILITY, VALIDITY.

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INTRODUCTION

The activity requirements of basketball have been characterised as highly intermittent, with extensive involvement of anaerobic and aerobic metabolic pathways (Ben Abdelkrim et al., 2007; Scanlan et al., 2011). These demands have been previously quantified across different male basketball competitions using time-motion analysis (TMA) techniques (Ben Abdelkrim et al., 2010; Ben Abdelkrim et al., 2007; Bishop & Wright, 2006; Janeira & Maia, 1998; McInnes et al., 1995; Scanlan et al., 2011; Scanlan et al., 2012). However, past investigations have quantified the activity demands of male basketball competition during match-play following outdated rules (Janeira & Maia, 1998; McInnes et al., 1995), age-restricted playing populations (Ben Abdelkrim et al., 2010; Ben Abdelkrim et al., 2007) or limited movement intensities (Bishop & Wright, 2006). As such, the activity demands for adult male players during current competition have only recently been described in detail (Scanlan et al., 2011).

An understanding of the current activity demands in team sport competition is useful for a number of practical applications. One application of TMA data is the development of sport-specific protocols that simulate the demands of competition. Such laboratory- and field-based exercise protocols have been developed in a number of team sports, including soccer (Williams et al., 2009), rugby league (Holloway et al., 2008), and netball (Higgins et al., 2009). Given the limited available data detailing the match activity demands of current adult male basketball competition, no test protocols have yet been developed that replicate the complete activity requirements of basketball match-play. The construction of such a test might be useful for the controlled assessment of basketball-related fitness and is likely to benefit the body of knowledge surrounding the sport.

To date, generic tests measuring skill-based performance (Barfield et al., 2007) and sole anaerobic and aerobic capacities (Carvalho et al., 2011; Castagna et al., 2008; Fatouros et al., 2011; Hoffman et al., 2000) have been primarily used to determine basketball-related fitness. Previously, basketball-specific repeat sprint protocols (Carvalho et al., 2011; Fatouros et al., 2011; Hoffman et al., 2000) and the Yo-Yo Intermittent Recovery Test (Yo-Yo IRT) (Castagna et al., 2008) have been supported as valid tests for the separate assessment of anaerobic and aerobic fitness in male basketball players. However, while these tests have been shown to validly evaluate fitness components relevant to basketball they do not replicate the complete activity demands of basketball match-play.

Previously, basketball-specific activities such as defensive shuffling and jumping have been suggested to heighten the physical demands placed on players during competition (Ben Abdelkrim et al., 2007; McInnes et al., 1995). In addition, the extensive intermittent activity and directional changes required within basketball have been reported to further intensify the metabolic load imposed upon players (McInnes et al., 1995). However, the largely straight-line running or sprinting test protocols used to assess basketball-related fitness do not account for these requirements. Furthermore, given current basketball performance has been reported to rely upon various metabolic pathways (Ben Abdelkrim et al., 2007; Scanlan et al., 2011), a test that validly assesses anaerobic and aerobic basketball-related fitness in combination might prove beneficial for basketball players, coaches, researchers, and conditioning professionals. Therefore, the development of a field test that simulates the specific activity demands of competition and assesses multiple components of basketball-related fitness is warranted. Thus, the purpose of the present study was to develop a reliable and valid basketball field test that replicates the complete activity requirements of adult male basketball match-play.

MATERIAL AND METHODS

Participants

Fourteen male participants (mean \pm SD, age: 24.9 ± 5.5 years; stature: 187.8 ± 7.7 cm; body mass: 88.8 ± 10.5 kg) competing in regional- or state-level Australian basketball leagues volunteered for the present study. All participants were of various on-court playing positions (guards: $n = 6$; forwards: $n = 6$; centres: $n = 2$). Pre-screening procedures were followed to assess participants for any health conditions or injuries that contraindicated participation. All participants voluntarily signed individual written consent forms informing them of the aims, procedures, and risks of the study. This study was approved by an institutional Human Research Ethics Committee aligned with the ethical requirements for human experimentation in accordance with the Helsinki Declaration.

Procedures

Throughout the testing period, all participants were instructed to maintain consistent dietary and sleeping patterns for 48 h prior to each session and to refrain from strenuous activity for 24 h before each session. Further, each participant was instructed to drink ~500 ml of water an hour prior to testing to protect against arriving in a hypohydrated state for each testing session. All testing occasions were conducted on regulation (International Basketball Federation) hardwood indoor basketball courts, and were within similar environmental conditions (temperature: 23.6 ± 2.2 °C; relative humidity: $57.5 \pm 11.6\%$; atmospheric pressure: 761.6 ± 2.6 mmHg).

Participants completed 3-4 testing sessions over the duration of the present study. Each participant was tested at the same time of day upon each visit to control for circadian fluctuations. All testing was conducted only in the presence of the research team, with standardised verbal encouragement given across each test to control participant arousal levels. Prior to all performance-based testing, participants underwent a 15-min standardised warm-up consisting of low-intensity jogging, whole-body dynamic stretches and brief bouts of high-intensity running. It was anticipated that training effects were unlikely to occur during the study from testing exposure given the conditioning levels of the participants and the brief stimuli of the test trials (Glaister et al., 2009).

During the first testing session, each participant was weighed using electronic scales (Tanita Corporation, Tokyo, Japan) and stature was measured using a portable stadiometer (Blaydon, Sydney, Australia). Following anthropometric data collection, all participants were familiarised with the repeat-sprint test, Yo-Yo IRT (Level 1) and Basketball Exercise Simulation Test (BEST) through explanation of the test protocols. Participants were then required to walk through the tests until familiar and then ran through the protocols at varied speeds until competent in completing each test. This familiarisation procedure has been previously used in preparing participants for similar team sport simulation tests (Williams et al., 2009).

The second testing session was conducted 7 days following the initial session. All participants completed a repeat-sprint protocol consisting of 10 maximal sprints across the length of a basketball court (10 x 28 m). Test performance was measured as the time taken to complete all sprints. Previously, similar protocols (12 x 20 m) have been used to assess repeat-sprint performance in basketball players (Meckel et al., 2009). Following adequate recovery (~30 min), each participant completed the Yo-Yo IRT using previously described methodology (Krustrup et al., 2003). Total distance (m) covered during the test was recorded as the primary performance measure (Castagna et al., 2008). Participants then underwent further familiarisation of the BEST protocol (see Figure 1) after recovering (~30 min) from the Yo-Yo IRT. Familiarisation involved participants running through the BEST at varied speeds and then completing

approximately 6-8 circuits at full intensity (Williams et al., 2009). At least 7 days following the Yo-Yo IRT, all participants completed a 12-min trial of the BEST during a third testing session. During the final testing occasion, at least 7 days following the previous session, nine participants completed an additional 12-min trial of the BEST.

Continuous measures of heart rate (HR) ($\text{b}\cdot\text{min}^{-1}$) were recorded throughout all testing using Polar Team System HR monitors (Polar Electro, Oy, Kempele, Finland). Samples were taken every 5 s across each trial and recorded data were downloaded to a personal computer for analysis via Polar Precision Performance Software (Version 4.0, Polar Electro, Oy, Kempele, Finland) following each test.

A visual representation of the BEST design is displayed in Figure 1. The BEST was developed using a circuit design based on notational distance data calculated for various movement types across multiple adult male basketball matches (Scanlan et al., 2011). For ease of testing preparation, court line-markings were used as indicators for activity and directional changes. Approximately 1725 m is travelled across a full 12-min BEST trial, including: low-intensity activity (LIA) (standing, walking and jogging), 727 m (42%); high-intensity activity (HIA) (running and sprinting), 826 m (48%); and shuffling activity, 172 m (10%). These distances are comparable to those reported during Australian adult male basketball competition (LIA: 40-44%; HIA: 47-51%; shuffling: 3-4%) (Scanlan et al., 2011).

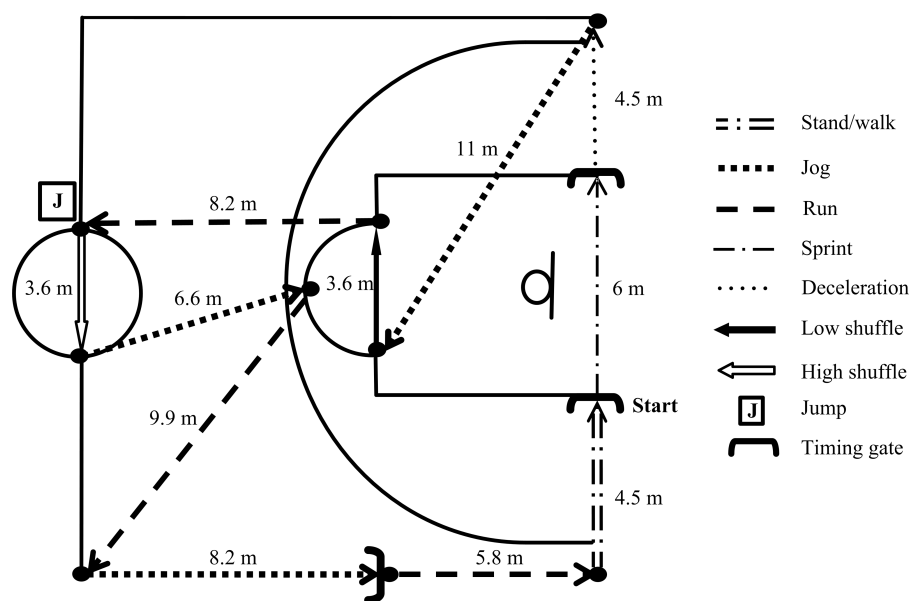


Figure 1. The Basketball Exercise Simulation Test (BEST) circuit with movement distances using previous notational data describing the activity demands of adult male basketball competition.

Each BEST circuit consisted of 30 s of activity. The circuits were performed continuously for 12 min to simulate the full playing time of a live quarter of basketball competition, with a maximum of 24 circuits being completed. Circuits were generally completed in 20-25 s, therefore allowing 5-10 s of rest before the start of the next circuit. If participants were unable to complete a circuit in 30 s then no rest was given and participants were required to begin the next circuit immediately. In such instances, participants did not

complete the required quantity of circuits (24) across testing unless adequate circuit timing was restored. To negate the effects of whole-body momentum on sprint times, participants were required to take a stationary position prior to commencing the sprint component during all circuits. Similar test designs have been previously used to replicate match activity demands in other team sport simulation tests (Bishop et al., 2001; Higgins et al., 2009; Roberts et al., 2010; Stone et al., 2011; Williams et al., 2009).

Participants had full understanding of the activities performed across the BEST prior to performance. The following activity categories were included within the design of the BEST, similar to previous descriptions provided for basketball movements (McInnes et al., 1995):

1. Standing/walking: activity at no greater intensity than walking pace.
2. Jogging: activity at a moderate intensity, higher than walking pace but without urgency (~50% of maximal velocity).
3. Running: activity at a greater than moderate intensity, with effort and purpose but still below maximal exertion (~75% of maximal velocity).
4. Sprinting: all-out effort at maximal intensity.
5. Low shuffling: activity characterised by shuffling action of the feet within a defensive stance position, performed without urgency.
6. High shuffling: activity characterised by shuffling action of the feet within a defensive stance position, performed at maximal effort.
7. Jumping: countermovement maximal effort jump initiated off both legs.

Sprint and circuit times (s) were measured across each BEST circuit at the start and end points for the sprinting component, and prior to the final low-intensity phase of each circuit, using a Swift Speed Light Sports Timing System (Swift, Lismore, Australia) (Figure 1). Performance measures determined across the BEST were mean sprint and circuit time (s), sprint and circuit decrement (%) and total distance covered (m). Sprint and circuit decrement were determined as the cumulative percent decline in sprint and circuit performance using mean times gathered across each two-circuit effort. Sprint and circuit decrement were calculated as $[(\text{total time/ideal time}) \times 100] - 100$, where ideal time was the fastest interval (Glaister et al., 2008). This calculation has been reported to be the most reliable and valid method to assess fatigue during repeat-sprint tests (Glaister et al., 2008). Researchers subjectively gauged high-intensity shuffling and jumping activity across the BEST and verbally encouraged participants to exert maximal effort during these movements. Recently, these methodologies were used to support the construct and longitudinal validity of the BEST in a similar sample of male basketball players (Scanlan et al., 2012).

Statistical Analyses

Means (\pm SD) were calculated for each dependent variable. Normality and homogeneity of variance for the present data were confirmed using the Kolmogorov-Smirnov Test and Levene's Test for equality. To determine the test-retest reliability of mean HR, mean sprint and circuit time, sprint and circuit decrement and total distance across the BEST, intra-class correlation coefficient (ICC) and typical error of measurement (TEM) with 95% confidence intervals (CI) were calculated as per previous methods (Hopkins,

2000a). Additionally, CV calculations with 95% CI were made using the log-transformed raw data (Hopkins, 2000a). The smallest worthwhile change (SWC) was calculated for each BEST measure as per previous methodology (Montgomery et al., 2008). If the calculated TEM for a measure was less than, equal to, or greater than the determined SWC, a rating of 'good', 'okay' or 'marginal' was applied. Criterion validity was determined by calculating the Pearson Product Moment Correlation Coefficient (r) between performance during the repeat-sprint test as well as the Yo-Yo IRT and all BEST performance measures. The magnitude of correlation values was assessed using the following criteria: <0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; and 0.9-1.0, almost perfect (Hopkins, 2002). All statistical analyses were performed using the spreadsheet methods of Hopkins (Hopkins, 2000b), Microsoft Excel® (Microsoft, Redmond, USA), and IBM SPSS Statistics (v20.0, IBM Corporation, Armonk, USA). Statistical significance was accepted at $p < 0.05$.

RESULTS

The mean (\pm SD) HR and performance data for all participants ($n = 14$) across the initial and retest ($n = 9$) BEST trials are displayed in Table 1. All reliability calculations (ICC, TEM

(95% CI) and CV (95% CI)) are also presented in Table 1. Mean sprint (ICC = 0.99) and circuit time (ICC = 0.98) and sprint (ICC = 0.93) and circuit decrement (ICC = 0.92) displayed high reliability (>0.90) according to previous recommendations for physiological-based field tests (Sassi et al., 2009). Poor (<0.80) ICC values were observed for both mean HR (ICC = 0.77) and total distance measures (ICC = 0.56). Mean circuit time (1.4%) showed the lowest CV, followed by total distance (1.5%), mean sprint time (1.7%), mean HR (2.6%), sprint decrement (14.6%) and circuit decrement (16.8%). The smallest worthwhile change for mean sprint time (0.03 s), mean circuit time (0.53 s) and total distance (28.5 m) across the BEST were equal to or greater than the related TEM values, supporting the usefulness of these measures. The smallest worthwhile change for mean HR (1.54 $b \cdot \text{min}^{-1}$), sprint decrement (1.09%) and circuit decrement (0.26%) across the BEST were greater than the associated TEM values, rating the usefulness of these measures as 'marginal'.

Table 1. Overall group data (mean \pm SD) and test-retest measures of reliability for mean heart rate (HR), sprint decrement, mean sprint and circuit time and total distance covered across a 12-min trial of the Basketball Exercise Simulation Test (BEST)

BEST Measure	Group (n = 14)	Trial 1 (n = 9)	Trial 2 (n = 9)	ICC	TEM (95% CI)	CV (95% CI)
Heart rate ($b \cdot \text{min}^{-1}$)	176 \pm 8	175 \pm 9	177 \pm 10	0.77	4.78 (3.23-9.15)	2.6% (1.8-5.1%)
Sprint decrement (%)	11.5 \pm 5.4	11.7 \pm 4.8	12.2 \pm 5.2	0.93	1.41 (0.95-2.71)	14.6% (9.7-29.9%)
Mean sprint time (s)	1.53 \pm 0.16	1.53 \pm 0.18	1.54 \pm 0.17	0.99	0.03 (0.02-0.05)	1.7% (1.1-3.2%)
Circuit decrement (%)	6.8 \pm 1.3	8.4 \pm 6.3	7.5 \pm 5.5	0.92	0.19 (0.13-0.32)	16.8% (11.8-30.5%)
Mean circuit time (s)	20.92 \pm 2.64	20.96 \pm 2.31	20.73 \pm 2.24	0.98	0.30 (0.21-0.58)	1.4% (0.9-2.6%)
Total distance covered (m)	1639.5 \pm 142.3	1718.4 \pm 15.8	1703.4 \pm 45.6	0.56	25.0 (16.9-47.9)	1.5% (1.0-2.8%)

ICC = Intra-class Correlation Coefficient; TEM = Typical Error of Measurement; CV = Coefficient of Variation; CI = Confidence Intervals.

The mean performance time for all participants ($n = 14$) across the repeat-sprint protocol was 57.8 ± 5.3 s. Very large significant correlations were evident between repeat-sprint performance and mean sprint time ($r = 0.92$, $p < 0.001$), mean circuit time ($r = 0.88$, $p < 0.001$), sprint decrement ($r = 0.81$, $p < 0.001$), circuit decrement ($r = 0.80$, $p < 0.001$) and total distance ($r = -0.71$, $p = 0.003$) across the BEST (see Figure 2). During the Yo-Yo IRT, all participants covered a mean total distance of 995.7 ± 464.3 m. Very large significant correlations were observed between Yo-Yo IRT distance and mean sprint time ($r = -0.85$, $p < 0.001$), sprint decrement ($r = -0.84$, $p < 0.001$), circuit decrement ($r = -0.79$, $p < 0.001$), mean circuit time ($r = -0.71$, $p = 0.003$) and total distance covered ($r = 0.71$, $p = 0.003$) across the BEST (see Figure 3).

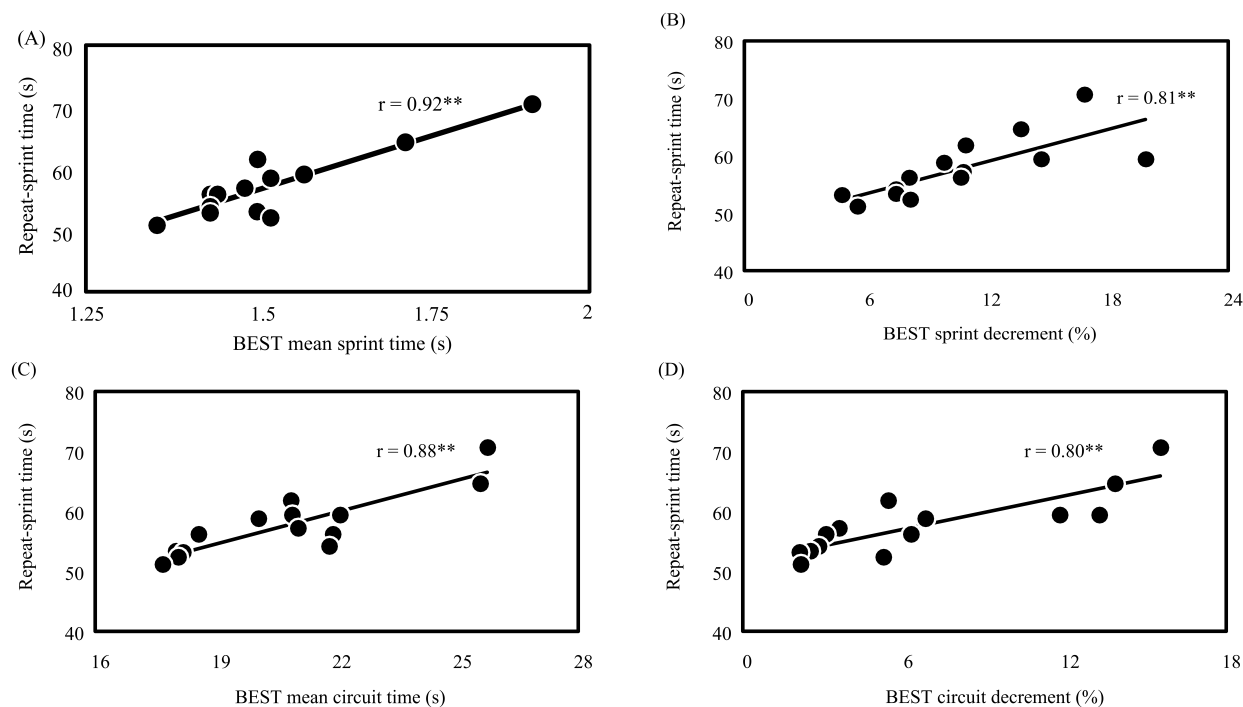
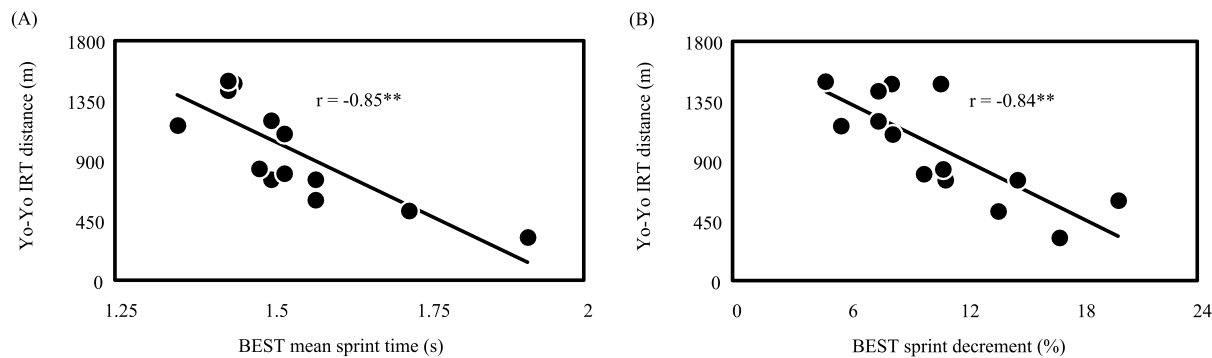


Figure 2. Scatterplots showing the relationships between repeat-sprint performance (s) and (A) mean sprint time (s), (B) sprint decrement (%), (C) mean circuit time (s) and (D) circuit decrement (%) across the Basketball Exercise Simulation Test (BEST) ($n = 14$). $^{**}p < 0.001$



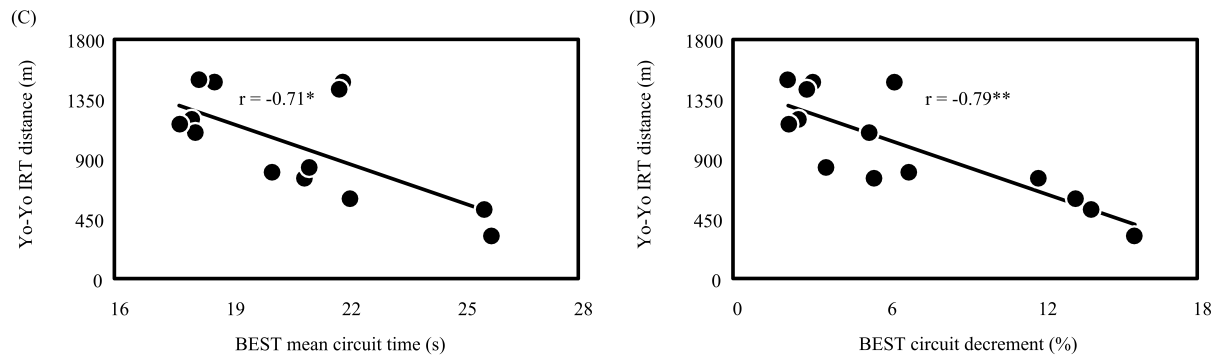


Figure 3. Scatterplots showing the relationships between Yo-Yo IRT distance (m) and (A) mean sprint time (s), (B) sprint decrement (%), (C) mean circuit time (s) and (D) circuit decrement (%) across the Basketball Exercise Simulation Test (BEST) ($n = 14$). $^*p < 0.01$; $^{**}p < 0.001$

DISCUSSION

The present study describes the development of a field-based test replicating the specific activity demands of adult male basketball competition. Heart rate and all performance measures of the BEST displayed high ICC and/or low TEM and CV across test-retest trials. Furthermore, significant relationships were observed between each BEST measure and repeat-sprint performance as well as distance covered during the Yo-Yo IRT. Taken together, these results support the BEST as the first reliable and valid match-specific test to assess basketball-related anaerobic and aerobic fitness.

The reliability of repeat-sprint and circuit-based team sport simulation tests have been frequently determined using similar sample sizes ($n = 7-8$) (Mujika et al., 2006; Roberts et al., 2010; Wragg et al., 2000) and statistical calculations (Roberts et al., 2010; Sheppard et al., 2007; Williams et al., 2009) to those used in the present study. Previously, it has been suggested that ICC values >0.90 indicate high reliability, while values between $0.80-0.90$ and <0.80 represent moderate and poor levels of reliability, respectively (Sassi et al., 2009). Moreover, an ICC of 0.81 has been put forward as the critical reliability value for a sports performance test (Hopkins, 2000a). The present results revealed that mean sprint (ICC = 0.99) and circuit time (ICC = 0.98), and sprint (ICC = 0.93) and circuit decrement (ICC = 0.92) all displayed high ICC values, indicating a strong reliability for these measures. Furthermore, it has been recommended that ICC calculations be performed to determine the reliability of physical tests aimed at discriminating between participants (Impellizzeri & Marcora, 2009). As such, the present ICC data suggest that mean sprint and circuit time, and sprint and circuit decrement taken from the BEST all possess sufficient reliability to differentiate basketball-related fitness between individuals. This indicates that the BEST could be used during team selection or comparing players from different competition levels.

In contrast, poor reliability was observed for mean HR (ICC = 0.77) and total distance (ICC = 0.56) covered during the BEST. However, these findings may be explained by limitations associated with each of these measures. Previously, HR responses during intermittent exercise have been suggested to be influenced by factors other than exercise intensity including dehydration, thermal stress, and the emotional state of participants (Achten & Jeukendrup, 2003). Furthermore, it has been proposed that immediate changes in activity intensity are not reflected in HR responses during intermittent activity (Achten & Jeukendrup, 2003). As such, the HR values gathered across the BEST may not be representative of the actual work intensities encountered by participants. Moreover, the poor reliability observed for total distance during the BEST may

be due to the finite nature of this measure, with a maximum number of circuits (and total distance) able to be completed.

Due to the limitations of using correlation analysis (low sensitivity to changes in means between trials and strong influence of inter-subject variation), the calculation of TEM can provide a more comprehensive analysis of test reliability (Hopkins, 2000a). Within the present study, TEM was also used to assess the reliability of the BEST, as well as providing an indication of the random variation between test trials. Relative to TEM calculations, the determination of the smallest worthwhile change for each BEST measure provided insight into the practical usefulness of the BEST (Montgomery et al., 2008). The present results indicate that the smallest worthwhile change for mean sprint time, mean circuit time and total distance taken across the BEST were less than the related TEM values, and thus able to detect real changes in performance. Further, CV calculations allowed comparison of reliability between measures and tests irrespective of units and scales used. As such, it has been proposed that measures displaying a CV of <5% have high reliability and a CV of 10% is the upper limit of acceptance for reproducibility of a performance test (Atkinson et al., 1999). The present CV values suggest that most measures taken from the BEST possess high reliability (CV <5%). The only parameters with a CV >10% were sprint (14.6%) and circuit decrement (16.8%), though these are comparable to fatigue measures taken from other field tests (Spencer et al., 2006).

Previously, decrements in sprint performance and movement times have been reported to display poor reliability in many team sport simulation tests (Glaister et al., 2009; Sheppard et al., 2007; Spencer et al., 2006). Similar reliability values for fatigue measures to those observed in this study (CV = 14.6-16.8%) have been reported for a repeat-sprint field hockey simulation test (CV = 14.9%, 95% CI = 10.8-31.3%) (Spencer et al., 2006). Furthermore, poorer levels of reliability have been observed for fatigue measures in generic team sport (CV = 38.7%, 95% CI = 30.9-51.7%) (Glaister et al., 2009) and volleyball simulation tests (CV = 82.3%) (Sheppard et al., 2007). These findings suggest that fatigue measures in team sport simulations may inherently be less reliable than other performance measures, and therefore should be used with discretion during performance analysis. It should also be mentioned, that the use of CV has been suggested to be most useful when tests are aimed at evaluating changes in responses with time (Impellizzeri & Marcora, 2009). Thus, the BEST measures displaying strong CV values may be useful when assessing basketball-related fitness throughout the playing season and determining sport-specific changes in player conditioning across training plans.

In addition to reliability measures, criterion validity of the BEST was determined in the present study through correlation analysis with repeat-sprint and Yo-Yo IRT performance. Previously, many team sport simulation tests have been validated using alike sample sizes ($n = 7-12$) (Oliver et al., 2007; Wragg et al., 2000) and criterion tests (Williams et al., 2009; Wragg et al., 2000) to those employed in the present study. To date, there appears to be no single test to holistically assess basketball-related fitness. However, individual tests have been reported to validly measure separate fitness components thought to contribute to basketball performance. Previously, repeat-sprint test protocols similar to the one used in the present study, have been observed to validly assess anaerobic fitness in basketball players (Carvalho et al., 2011; Fatouros et al., 2011). Furthermore, the Yo-Yo IRT has been reported to possess adequate reliability and a strong relationship ($r = 0.77$, $p < 0.001$) with aerobic capacity in basketball players (Castagna et al., 2008). Thus, the use of these tests as criterion measures within the present study provides insight concerning the validity of the BEST in assessing elements of basketball-related fitness. The present data showed significant relationships between each BEST performance measure and repeat-sprint performance time, as

well as Yo-Yo IRT distance. As a result, it may be suggested that the BEST is a valid assessment tool for the combined evaluation of basketball-related anaerobic and aerobic fitness.

Comparisons between responses observed across the BEST with those previously reported during adult male basketball competition can indirectly provide support for the ecological validity of the BEST. The mean HR observed during the BEST was $176 \pm 8 \text{ b}\cdot\text{min}^{-1}$ ($90 \pm 3 \text{ \%HRmax}$), which is similar to the HR responses previously reported for adult male basketball competition ($151\text{-}171 \text{ b}\cdot\text{min}^{-1}$ or $89\text{-}96 \text{ \%HRmax}$) (Ben Abdelkrim et al., 2007; McInnes et al., 1995; Vaquera Jimenez et al., 2008). These data suggest that the cardiovascular strain of the BEST replicates that placed on players during actual matches. However, given the previously discussed dissociation between HR response and workload during intermittent exercise (Achten & Jeukendrup, 2003), direct comparisons between multiple physiological and activity responses during basketball match-play and BEST performance should be made within the same participant sample to definitively assess the ecological validity of the BEST.

During the present study, some limitations were identified. Firstly, the present results are only representative of performance during the BEST in the participants measured in this study. Thus, these data are unlikely to be representative of BEST performance in other basketball participants, including female players, professional players, and participants of different ages. Secondly, HR was the only physiological response investigated in this study. Given the variability of rest time accrued by each participant during the BEST, limited opportunity was available for blood sampling. For more detailed physiological data, future assessments using the BEST might include standardised break periods to permit frequent blood sampling as well as measure oxygen uptake using portable gas analysers. Thirdly, no performance measures were taken during shuffling and jumping activity across the BEST. Previously, shuffling and jumping activity have been postulated to increase the physical demands placed upon basketball players during matches (Ben Abdelkrim et al., 2007; McInnes et al., 1995). As such, measurement of these movements using available technologies such as electronic timing devices and videography might permit the acquisition of more detailed performance measures during the BEST. Finally, the performance of isometric contractions during static activity across basketball competition has been suggested to heighten the physiological stress placed upon players (Ben Abdelkrim et al., 2007). However, due to the difficulties associated with incorporating these activities into the design of field-based tests, the BEST did not include any static actions specific to basketball competition.

CONCLUSIONS

In summary, the present study describes the development of the first known field test that replicates the activity demands of adult male basketball competition. The present data demonstrate that the BEST is a reliable and valid test for assessing basketball-related anaerobic and aerobic fitness concurrently. Moreover, mean sprint time seemed to be the most reliable and valid BEST measure, and the limitations of the other measures should be considered when using them to assess basketball players.

The BEST might be reliably and validly used by basketball players, coaches, researchers, and conditioning professionals across a number of applications. Firstly, the BEST could be used as an effective training tool to target specific fitness components and movement demands required in the sport. Secondly, basketball coaching staff might use the BEST to precisely assess match-specific fitness in players during team selection. Finally, the BEST might prove useful in applied research settings to determine the effects of training programs, nutritional interventions, and ergogenic aids on basketball-related fitness.

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