

## DISCRIMINATIVE VALIDITY OF A NOVEL, HIGH-INTENSITY, NETBALL-SPECIFIC CIRCUIT TEST IN ELITE FEMALE NETBALL PLAYERS

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### ABSTRACT

*Limited dedicated field-tests exist assessing sport-specific qualities in netball. This study aimed to determine the discriminative validity of a novel, high-intensity, netball-specific fitness test. Fourteen female netball players from the same team participated, consisting of seven players with international experience and seven players with national experience only. All players completed the Net-Test, which closely replicates movement patterns experienced during modern netball game-play. Performance times, heart rate, and rating of perceived exertion were compared between international- and national-level players to assess discriminative validity. International-level players exhibited a significantly faster defensive shuffle time ( $p=0.001$ , effect size (ES)= -2.49, very large, very likely lower), superior total time (ES=-1.11, moderate, very likely lower), and quicker sidestep shuffle (ES=-0.89, moderate, likely lower) and dodge (ES=-0.88, moderate, possibly lower) times compared to national-level players. Differences in other performance times, heart rate and rating of perceived exertion were unclear or possibly to very likely similar. The discriminative sensitivity for specific outcome measures supports the use of the Net-Test to select players into team squads, monitor progress in players aiming to compete at elite playing level and identify players with requisite qualities likely to benefit from further training.*

**Keywords:** Assessment; Team sport; Netball; Selection; Field-test; Court.

### INTRODUCTION

Netball is a popular team sport with over 20 million players from over 70 countries encompassing five main regions, including Africa, the Americas, Asia, Europe, and Oceania (INT, 2016). This wide appeal has seen the emergence of netball competitions at many playing

levels, ranging from grassroots, developmental competitions in school, club, and academy settings to elite, professional adult competitions. While netball players compete across various playing levels, the modern game is underpinned by extensive intermittent movement demands involving frequent sprints, turns, jumps, cuts, accelerations and abrupt stops (Hewit *et al.*, 2011; Thomas *et al.*, 2017a). Consequently, netball players must have a range of sport-specific fitness and motor qualities to execute game movements successfully. Accordingly, netball practitioners rely on the use of field-tests to assess fitness and motor qualities important in netball.

The data generated from fitness tests can be used for a multitude of functions, including team member selection and talent identification (Lidor *et al.*, 2009; Stevens & Dascombe, 2015). For a test to be implemented in this way, it must be able to discriminate between players carrying different fitness, motor skill and/or performance qualities relevant to netball (Impellizzeri & Marcora, 2009). As such, tests used for team member selection must demonstrate sufficient discriminative validity at the level of sensitivity sought by coaches and practitioners (Impellizzeri & Marcora, 2009). In team sports, discriminative validity is typically measured via comparisons in test outcome measures between player groups from different playing levels or roles, such as international vs. national game-play (Mujika *et al.*, 2006; Scanlan *et al.*, 2012; Manson *et al.*, 2014).

Various field-based tests have been implemented to assess fitness and motor qualities thought to be important in netball performance, such as change of direction ability (Barber *et al.*, 2016; Thomas *et al.*, 2017b), strength (Thomas *et al.*, 2017b), speed (Thomas *et al.*, 2017b), lower-body power (Thomas *et al.*, 2017b) and reactive agility (Farrow *et al.*, 2005). However, the discriminative validity of these tests remain unreported. Moreover, the use of many independent field-tests in an assessment battery can be time-consuming and labour-intensive for netball practitioners and players, especially when testing large team squads. In turn, the Netball Specific Fitness Test (NSFT) was developed to assesses various fitness and motor qualities in combination and has been reported to discriminate between performances in netball players from different playing levels (Gasston & Simpson, 2004).

The NSFT is a continuous, circuit-based test that contains multi-directional running, ladder running, sidestepping, repeated jumps and reactive lunging bouts (Gasston & Simpson, 2004). While the discriminative validity of the NSFT was supported with higher-level players (Collegiate Division I and II) performing significantly better than lower-level players (Collegiate Division III and recreational) (Gasston & Simpson, 2004), the wide disparity in playing levels between groups may limit the discriminative sensitivity and practical utility of the NSFT. Moreover, the NSFT was developed in 2003 and elicits movement requirements and patterns not representative of modern netball game-play (Fox *et al.*, 2013).

## **PURPOSE OF RESEARCH**

Currently, there is a need for a netball-specific fitness test that extends the NSFT by eliciting movement requirements and patterns experienced during modern game-play (Fox *et al.*, 2013) and can discriminate between netball players with varying levels of representation. Therefore, the purpose of this study was to determine the discriminative validity of a newly developed, high-intensity, netball-specific fitness test, the Net-Test.

## METHODOLOGY

### Participants

Fourteen elite, female netball players from the same team competing in an elite netball competition comprising five Australian and five New Zealand clubs participated in this study. Seven players (age:  $27.6 \pm 4.4$  years; body mass:  $75.5 \pm 9.1$  kg; estimated  $\text{VO}_{2\text{max}}$ :  $47.0 \pm 2.5$  mL·kg<sup>-1</sup>·min<sup>-1</sup>) had played at an international level within the previous three years, while seven players ( $20.3 \pm 1.5$  years;  $80.8 \pm 21.4$  kg;  $44.8 \pm 2.6$  mL·kg<sup>-1</sup>·min<sup>-1</sup>) had only competed at the national (club) level.

### Ethical clearance

All procedures were granted ethical approval by the Central Queensland University Human Research Ethics Committee in accordance with the Helsinki Declaration (project number: H12/09-185). The purpose, procedures, potential risks, and benefits of participation in this study were explained verbally and in written form to all players. Written and verbal informed consent was obtained from each player prior to testing.

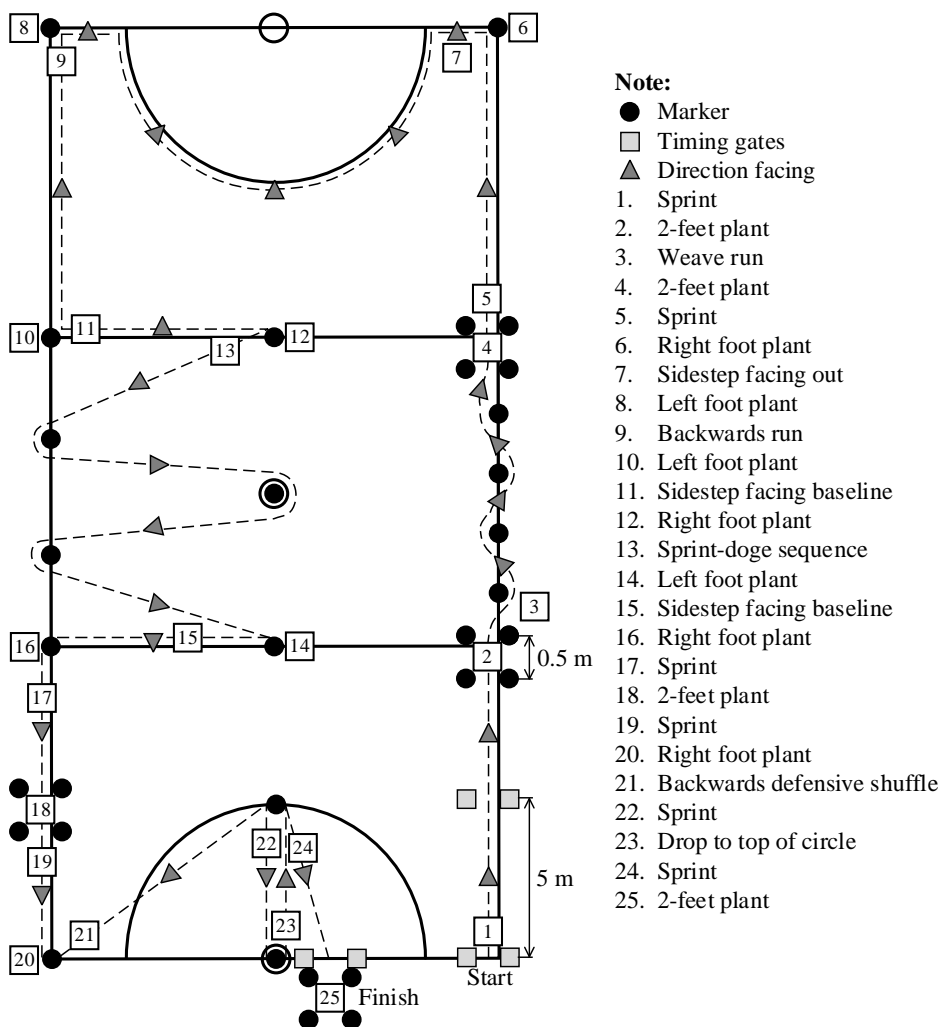
### Development of Net-Test

A novel, high-intensity, netball-specific circuit test (Net-Test) was developed with expert input from international- and national-level netball coaches ( $n=3$ ), physiotherapists ( $n=3$ ), and a sport scientist ( $n=1$ ) to identify and embed key movement patterns that bring to the fore important fitness and motor qualities experienced during netball game-play in an appropriate sequence. The Net-Test contains movement patterns that mimic modern netball game-play (Fox *et al.*, 2013).

Furthermore, total performance time during the Net-Test has been shown to be significantly ( $p < 0.05$ ) associated with various fitness qualities important in netball, including linear speed ( $r=0.74$ , *very large*), lower-body power ( $r=0.77$ , *very large*), change of direction ability ( $r=0.80$ , *very large*) and intermittent endurance ( $r=0.67$ , *large*) (Mungovan *et al.*, in press). The test-retest reliability of the Net-Test has also been supported with the majority of outcome measures exhibiting *moderate* (0.80-0.90) to *high* ( $>0.90$ ) intraclass correlation coefficients (ICC) and coefficient of variation (CV)  $<5\%$  (Mungovan *et al.*, in press). The circuit-based test is completed on a standard-sized netball court with markers indicating transitions between movement components (Figure 1).

### Design and procedures

A between-groups, cross-sectional study design was adopted. Prior to testing, all players were familiarised with the Net-Test through diagrams, explanation, demonstration and multiple active practise completions in a separate session (Scanlan *et al.*, 2012). All players were tested during the same session at an indoor venue and on a hardwood court. The testing session was administered at the mid-point of the pre-season phase in the annual plan to ensure a consistent acute training history across players. Each player was assessed only in the presence of the research team who provided standardised instructions to commence testing and no verbal encouragement during test performance.



**Figure 1. MOVEMENT COMPONENTS IN NET-TEST**

### Outcome measures

Performance times for each component of the Net-Test were taken as outcome measures. These components included:

- Initial 5m-sprint (movement 1 in Figure 1);
- Weave run across the centre third of the court (movement 3 in Figure 1);
- Sprint across the end third of the court (movement 5 in Figure 1);
- Left sidestep-shuffle around the shooting circle (movement 7 in Figure 1);
- Backward run across the end third of the court (movement 9 in Figure 1);
- Right sidestep-shuffle to the centre line of the court (movement 11 in Figure 1);

- Dodging around markers across the centre third of the court (movement 13 in Figure 1);
- Right sidestep-shuffle to the side-line (movement 15 in Figure 1);
- Rapid acceleration/deceleration into a two-foot plant (movement 17 in Figure 1);
- Backward defensive-shuffle to the top of the shooting circle (movement 21 in Figure 1);
- Sprint to the baseline from the top of the shooting circle (movement 22 in Figure 1);
- Drop to the top of the shooting circle (movement 23 in Figure 1); and
- Sprint to the baseline (movement 24 in Figure 1).

The initial 5m-sprint and total time were measured to the nearest 0.001s using electronic timing lights (Fusion Sport; Coopers Plains, Queensland, Australia). The time taken to complete other components of the Net-Test were measured using a high-speed video camera (EX-FH100, Casio Computer Co. Ltd.; Tokyo, Japan). Performance times for these components commenced and finished as detected between video frames showing breaks and contact between feet and markers to a precision of 0.004s (Scanlan *et al.*, 2014).

The reliability for measuring movement times in this way was acceptable across outcome measures (ICC=0.99-1.00; CV=0.1-1.6%). Mean and peak absolute heart rate (HR) ( $\text{b}\cdot\text{min}^{-1}$ ) across the entire test were measured using a Polar Team2 monitoring system (Polar Electro Oy; Kempele, Finland). HR data were also calculated relative to the individualised age-predicted maximum value for each player (220 minus age in years) ( $\%HR_{\text{max}}$ ) (Pinkstaff *et al.*, 2010). Players also gave their rating of perceived exertion (RPE) using Borg's Category Ratio-10 scale (Borg *et al.*, 1987) immediately following the test to indicate perceptual intensity of their effort.

### Statistical analyses

The Shapiro-Wilk test and Levene's test for equality in variances confirmed the normality and homogeneity of variance in all data. All data were calculated as mean $\pm$ standard deviation. Discriminative validity was assessed via comparisons between players with international and national playing experience for Net-Test outcome measures using independent t-tests with an alpha value of 0.05. Effects sizes (ES) with 90% confidence intervals were calculated to show the magnitude of differences between playing levels. ES magnitudes were interpreted as: *trivial*= $<0.20$ ; *small*= $0.2-0.59$ ; *moderate*= $0.60-1.19$ ; *large*= $1.20-1.99$ ; *very large*= $\geq 2.0$  (Hopkins, 2002).

Magnitude-based inferences were also calculated by determining the chances that the true differences in all pairwise comparisons were greater than, similar to, or smaller than the smallest worthwhile difference (0.2 multiplied by the between-player deviation) and interpreted as: *almost certainly not* = $<0.5\%$ ; *very unlikely* = $0.5-5\%$ ; *unlikely* = $5-25\%$ ; *possibly* = $25-75\%$ ; *likely* = $75-95\%$ ; *very likely* = $95-99.5\%$ ; *almost certain* = $>99.5\%$ . If the chances of either playing level possessing superior outcomes were both  $>5\%$ , the difference was determined as *unclear* (Hopkins *et al.*, 2009). All analyses were conducted using IBM SPSS Statistics (v20.0; IBM Corp., Armonk, NY, USA) and spreadsheet methods (Coe, 2000; Hopkins, 2007) in Microsoft Excel<sup>®</sup> (v15.0; Microsoft Corporation; Redmond, WA, USA).

## RESULTS

The mean±standard deviation for each outcome measure taken during the Net-Test and relative to level of playing experience are shown in Table 1. ES and magnitude-based inferential statistics comparing outcome measures between groups are presented in Table 2 to follow.

**Table 1. PERFORMANCE SCORES FOR NET-TEST FOR INTERNATIONAL (n=7) AND NATIONAL (n=7) NETBALL PLAYERS**

Outcome measure	International	National	p-Value
<i>Performance times (s)</i>			
Initial sprint	1.30±0.13	1.31±0.10	0.93
Weave	2.10±0.23	2.22±0.21	0.33
1/3 court sprint	1.90±0.13	2.00±0.12	0.21
Left sidestep shuffle	5.51±0.32	5.96±0.62	0.15
Backward run	2.75±0.18	2.87±0.35	0.47
1 <sup>st</sup> right sidestep shuffle	2.01±0.19	2.14±0.30	0.37
Dodge time	8.57±0.16	8.81±0.34	0.15
2 <sup>nd</sup> right sidestep shuffle	2.23±0.20	2.24±0.22	0.92
Acceleration/deceleration	2.54±0.14	2.65±0.25	0.35
Defensive shuffle	3.00±0.17	3.45±0.19	0.001†
Circle sprint	1.13±0.13	1.14±0.10	0.92
Drop to top of circle	1.28±0.18	1.31±0.13	0.80
Final sprint with stop	1.41±0.08	1.43±0.12	0.76
Total	40.56±1.85	42.77±2.13	0.08
<i>Perceptual/physiological measures</i>			
RPE (AU)	8.9±0.8	8.7±0.7	0.75
Mean absolute HR (b·min <sup>-1</sup> )	160±9	169±8	0.10
Mean relative HR (%HR <sub>max</sub> )	83±4	84±4	0.50
Peak absolute HR (b·min <sup>-1</sup> )	172±12	182±7	0.12
Peak relative HR (%HR <sub>max</sub> )	90±5	91±3	0.57

p-Value derived from independent t-tests international vs. national level players

† Significant difference p<0.05

Players with international-level experience possessed superior performance times compared to players with national-level experience across all Net-Test components (*trivial to very large* differences). More precisely, a statistically significant difference was only evident during the defensive-shuffle component (p=0.001, ES= -2.49, *very large, very likely* lower), with *possibly to very likely* different total (ES= -1.11, *moderate*), sidestep-shuffle (ES= -0.89, *moderate, likely* lower), and dodge (ES= -0.88, *moderate, possibly* lower) times. Players with international-level experience also had lower absolute and relative HR responses (ES= -0.34 to -1.03, *small to moderate*) and higher RPE scores (ES=0.19, *trivial*) than players with national-level experience. However, these differences were *unclear*.

**Table 2. COMPARING PERFORMANCE, RPE AND HR DURING NET-TEST INTERNATIONAL (n=7) AND NATIONAL (n=7) NETBALL PLAYERS**

Outcome measure	Effect size (90-% CI)	Magnitude	% chance higher/similar/lower	Interpretation
<i>Performance times (s)</i>				
Initial sprint	-0.04 (-0.91–0.85)	<i>Trivial</i>	0 / 99 / 01	<i>Very likely similar</i>
Weave	-0.58 (-1.44–0.35)	<i>Small</i>	1 / 71 / 28	<i>Possibly similar</i>
1/3 court sprint	-0.77 (-1.62–0.19)	<i>Moderate</i>	0 / 91 / 09	<i>Likely similar</i>
Left sidestep shuffle	-0.89 (-1.75–0.09)	<i>Moderate</i>	3 / 18 / 79	<i>Likely lower‡</i>
Backward run	-0.43 (-1.29–0.49)	<i>Small</i>	4 / 64 / 32	<i>Possibly similar</i>
1 <sup>st</sup> right sidestep shuffle	-0.54 (-1.40–0.39)	<i>Small</i>	2 / 65 / 33	<i>Possibly similar</i>
Dodge time	-0.88 (-1.73–0.10)	<i>Moderate</i>	1 / 40 / 59	<i>Possibly lower‡</i>
2 <sup>nd</sup> right sidestep shuffle	-0.06 (-0.94–0.82)	<i>Trivial</i>	5 / 87 / 08	<i>Likely similar</i>
Acceleration/deceleration	-0.56 (-1.41–0.37)	<i>Small</i>	1 / 76 / 23	<i>Likely similar</i>
Defensive shuffle	-2.49 (-3.45– -1.18)	<i>Very large</i>	0 / 2 / 98	<i>Very likely lower‡</i>
Circle sprint	-0.06 (-0.94–0.82)	<i>Trivial</i>	1 / 98 / 01	<i>Very likely similar</i>
Drop to top of circle	-0.15 (-1.02–0.74)	<i>Trivial</i>	1 / 95 / 04	<i>Very likely similar</i>
Final sprint with stop	-0.18 (-1.05–0.71)	<i>Trivial</i>	0 / 99 / 01	<i>Very likely similar</i>
Total	-1.11 (-1.97– -0.10)	<i>Moderate</i>	3 / 2 / 95	<i>Very likely lower‡</i>
<i>Perceptual/physiological measures</i>				
RPE (AU)	0.19 (-0.71–1.05)	<i>Trivial</i>	45 / 32 / 23	<i>Unclear</i>
Mean absolute HR (b·min <sup>-1</sup> )	-1.03 (-1.89– -0.03)	<i>Moderate</i>	5 / 1 / 94	<i>Unclear</i>
Mean relative HR (%HR <sub>max</sub> )	-0.39 (-1.25–0.52)	<i>Small</i>	23 / 6 / 71	<i>Unclear</i>
Peak absolute HR (b·min <sup>-1</sup> )	-0.95 (-1.81–0.03)	<i>Moderate</i>	6 / 1 / 93	<i>Unclear</i>
Peak relative HR (%HR <sub>max</sub> )	-0.34 (-1.20–0.57)	<i>Small</i>	26 / 6 / 68	<i>Unclear</i>

Comparison: International vs National players

CI=confidence intervals

RPE=Rating of Perceived Exertion

HR=Heart Rate

‡ =possibly to very likely lower time for international-level players compared to national-level players

## DISCUSSION

The data support the discriminative validity of selected outcome measures during the Net-Test. Specifically, netball players with international experience were shown to possess: faster defensive-shuffle time (*very large, very likely*); superior total performance time (*moderate, very likely*); faster sidestep-shuffle time (*moderate, likely*); and faster dodge time (*moderate, possibly*) compared to players with national experience only. These findings add to the limited data available supporting the discriminative validity of netball-specific fitness tests.

To date, the NSFT is the only existing netball test encompassing various sport-specific movements shown to discriminate between players from separate playing levels (Gasston & Simpson, 2004). Specifically, performance during the NSFT was superior ( $p=0.016$ ) in a higher playing group (Collegiate Division I/II players) compared to a lower playing group (Collegiate Division III/recreational players). However, given these comparative groups exhibited a wide disparity in playing level, likely underpinned by varied training regimes, game loading, and fitness qualities, the performance differences reported during the NSFT might have been expected (Scanlan *et al.*, 2012). Use of comparative groups derived from the same team may overcome this limitation given the similar training and game demands encountered across players. However, intra-team analyses are rarely performed at the elite level to assess the discriminative validity of sport-specific tests (Young *et al.*, 2005; Manson *et al.*, 2014). Given the international- and national-level player groups in our study were from the same team, the Net-Test might possess a higher level of discriminative sensitivity than the NSFT. Furthermore, the NSFT was constructed using game data provided in 2003, and modern competition (Fox *et al.*, 2013) has been shown to impose heightened intermittent, multidirectional shuffling/skipping, and sprinting than documented previously (Gasston & Simpson, 2004; Davidson & Trewartha, 2008). Thus, given the Net-Test was developed using expert insight from current practitioners and resembles present game data (Fox *et al.*, 2013), it might offer a sport-specific testing option that better resembles the demands of modern netball competition.

Comparisons between netball players with international- and national-level experience may also assist in identifying key requisite qualities desired at the international level. The *moderate* to *very large* differences observed in the defensive-shuffle, sidestep-shuffle, and dodge components of the Net-Test suggest that qualities underpinning these movements might be necessary for successful performance at the international level. Recent research has quantified the movement demands of modern netball game-play and highlighted significant proportions of netball playing time are spent shuffling (up to 52%) and defending (up to 41%) (Fox *et al.*, 2013). Further, netball game data emphasise the extensive intermittent demands (~803-1473 movements) (Fox *et al.*, 2013) and multidirectional loads (Chandler *et al.*, 2014) imposed on players. Taken together, modern netball game data (Fox *et al.*, 2013; Chandler *et al.*, 2014) highlight the importance of shuffling actions to guard opponents and move laterally across the court, as well as dodges to rapidly change movement directions and intensities. The Net-Test effectively discriminates performance of these key game movements between international- and national-level netball players, enhancing the practical translation of the findings.

While the performance data showed pronounced differences between player groups, *unclear* differences were evident in the measured HR and RPE data. Specifically, players with international-level experience had lower %HR<sub>max</sub> (*small*) and higher RPE scores (*trivial*) than players with national-level experience. These minor variations in responses may be explained



by the higher age ( $27.6 \pm 4.4$  vs.  $20.3 \pm 1.5$ yr) and cardiorespiratory fitness ( $47.0 \pm 2.5$  vs.  $44.8 \pm 2.6$  mL·kg<sup>-1</sup>·min<sup>-1</sup>) in international-level players. Specifically, the lower RPE in players with national-level experience might be underpinned by their lower age given it has been suggested that exercise experience impacts on perceived exertion (Gros Lambert & Mahon, 2006) and the ability of young athletes to self-assess their effort can be unreliable (Bourdon *et al.*, 2017). Further, cardiorespiratory training has been shown to improve exercise efficiency in females of varying ages (Woo *et al.*, 2006). As such, the lower %HR<sub>max</sub> evident during the Net-Test in players with international-level experience might have been attributed to their superior cardiorespiratory fitness and muscle oxidative capacity, resulting in a lower oxygen cost to complete the exercise bout (Woo *et al.*, 2006). However, it should be noted that this notion is based on the assumption that HR is an indirect indicator of oxidative metabolic recruitment and further research is needed with direct metabolic measurement of oxygen uptake to support this mechanism.

While the present study provides novel and practical insight, it was open to some limitations that require acknowledgement. Firstly, the intra-team analysis adopted limited the sample size permissible for each player group, which has been shown to impact the percentage of identified statistically significant group comparisons (Bates *et al.*, 2016). Secondly, the intra-team analysis also reduces the wider applicability of the findings to other elite teams and player samples. Consequently, further research is encouraged to examine the utility of the Net-Test and identify normal values for a range of netball players competing in other teams across varying playing levels. Thirdly, the aim of this study was to compare performance and physiological responses between netball players with different levels of experience rather than according to playing position. Given playing position influences the game demands experienced in netball (Fox *et al.*, 2013; Chandler *et al.*, 2014; Fish & Greig, 2014), future studies should provide position-specific data during the Net-Test across a larger sample of players. Fourthly, the Net-Test was developed to assess fitness and motor qualities important for netball game-play and omitted skill-based tasks centred on ball use, such as shooting (Delextrat & Goss-Sampson, 2010) and passing (Bruce *et al.*, 2009). Further research may modify the Net-Test or develop additional focused assessments to measure skill-based tasks if desired.

## PRACTICAL APPLICATION

The differences detected between players with international- and national-level experience in total performance time, as well as defensive-shuffle, sidestep-shuffle, and dodge times during the Net-Test provide various practical applications for netball coaches, strength and conditioning staff and sport scientists. More precisely, the Net-Test may be validly implemented to select netball players into team squads at various seasonal phases and assess the progress of elite players aiming for international selection. Furthermore, the Net-Test may be used for talent identification purposes in detecting players who possess requisite qualities likely to benefit from further focused training. The superior performance evident for players with international-level experience across the defensive-shuffle, sidestep-shuffle and dodge movements, as well as the entire test, highlight the importance of developing relative bilateral and unilateral strength and power, change of direction speed and repeated sprint ability in netball training plans (Thomas *et al.*, 2017a).

## CONCLUSION

The Net-Test is a novel, netball-specific fitness test, which extends upon existing, dated tests by eliciting movement requirements and patterns experienced during modern netball game-play. The Net-Test provides a sport-specific testing option for netball practitioners, with the superior performance evident for international level compared to national level players in many test outcome measures, signifying it possesses adequate discriminative validity.

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