PHYSICAL, PHYSIOLOGICAL, AND TECHNICAL DEMANDS OF NATIONAL NETBALL UMPIRES AT DIFFERENT COMPETITION LEVELS

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Keywords: officials; referees; global positioning system; heart rate; performance analysis

Running head: DEMANDS OF DIFFERENT LEVELS OF NETBALL UMPIRES

Word count: 3727 Abstract: 198

Submitted to: Journal of Sports Sciences December 2019

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Authors report no conflicts of interest

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Abstract

To compare demands of national netball umpires between levels of competition, 22 Netball New Zealand high performance umpires participated in this investigation. These included from highest to lowest standard: 9 x semi-professional ANZ Championships (ANZC); 6 x National A Squad (NZA); and 7 x National Development Squad (DEV). Physical (global positioning system tri-axial accelerometry), physiological (heart rate), and technical (video analysis) demands were determined for 48 (16 per group) umpire match performances. Level of competition had no significant effect on physical, or mean physiological demands. However, ANZC umpires spent a lower proportion of time at low heart rates compared to DEV, and a greater proportion of time at high, rather than moderate, heart rates compared to NZA. Compared to lower standard umpires, ANZC spent lesser proportions of time standing but greater proportions of time walking backwards and sideways, and turning to change direction. Furthermore, ANZC umpires spent lower proportions of time jogging, but greater proportions of time sprinting compared to DEV. Finally, ANZC umpires spent longer mean durations than DEV on the goal third side line. As such, the difference in demands experienced by national netball umpires between levels of competition is more technical than physical or physiological.

INTRODUCTION

Netball is a 60 min (4 x 15 min) invasion ball game played between 2 teams of 7 players. Two umpires each control and give decisions for half of the court including the goal line, as well as giving decisions for the throw in on their side line (International Netball Federation, 2015). During a match, each umpire will utilise a range of movement techniques, including walking, jogging, side stepping, changing direction, and sprinting to move around their allocated side line and goal line (Otago, Riley, & Forrest, 1994; Spencer, McErlain-Naylor, Paget, & Kilding, 2020; Spencer, Paget, Farley, & Kilding, 2019). To characterise optimal performance and to aid in assessment and training methodologies, it has been necessary to determine the specific requirements of umpires.

The limited available literature (Otago et al., 1994; Spencer et al., 2020, 2019) report that on average elite netball umpires cover approximately 3850 m during a match. Up to around 50% of the match is spent standing (Spencer et al., 2019), with approximately 25% of the match in higher intensity movements such as jogging, sprinting, side stepping, or changing direction (Otago et al., 1994; Spencer et al., 2019). Mean work:rest ratios are approximately 1:3, including 140 sprints per match for a mean duration of 2.8 s (Spencer et al., 2019). Elite umpires spend around 10% of the match at greater than 92% peak heart rate, with the majority of time (~ 55%) between 75 and 92% peak heart rate (Spencer et al., 2020, 2019). Such information may be useful for umpires and strength and conditioning practitioners when designing generic umpire training programs or fitness testing procedures.

It is not clear, however, how these physical, physiological, and technical demands differ between umpires at various levels of competition. Such information would be useful for officials wishing to prepare for specific competition levels or for progression to higher levels.

An early study by Otago et al. (1994) included 1 match by a single umpire performed at a higher level of competition (exact level unclear) to the other matches in the study. The single higher standard match resulted in a greater proportion of time spent at both higher (> 93% peak heart rate: 50.5% vs 9.0%) and lower (< 75% peak heart rate: 25.0% vs 11.6%) heart rate zones than the lower standard matches, but less time at intermediate heart rates (75 – 93% peak heart rate: 24.5% vs 79.4%). The single umpire investigated, and the uncharacteristically high match standard for that umpire, call into question the generalisability of these measures.

If valid, the increase in time spent at higher heart rates may reflect a greater match play intensity at higher competition levels (Otago et al., 1994). Paradoxically, the concurrent increase in time spent at lower heart rates may suggest an improvement in umpire positioning and timing (Spencer et al., 2020). Indeed, Spencer et al. (2019) reported a reduction in side stepping and an increase in walking and standing throughout the match. The concurrent decrease in mean heart rate suggested this technical adjustment was not caused by umpire fatigue (Spencer et al., 2020). Numerous studies in invasion ball sports officiating have highlighted the importance of officials' positioning for decision making accuracy (Hossner, Schnyder, Schmid, & Kredel, 2019; Mallo, Frutos, Juárez, & Navarro, 2012). It may therefore be that elite umpires make technical adjustments, enabling them to remain stationary for longer and perhaps maintain a better viewing position from which to make accurate decisions.

As such, the aim of the present study was to compare the physical, physiological, and technical demands of national netball umpires between different levels of competition. It was hypothesised that umpires officiating in higher levels of competition would experience an increase in both high and low demand activities, but a decrease in time spent in intermediate demand activities, compared to those officiating in lower levels of competition.

METHODS

Experimental Approach to the Problem

To address the aim of the present study, data from a previous investigation (Spencer et al., 2019), in which different standards of national netball umpires were analysed as a single combined group, were reanalysed as separate groups using a cross-sectional comparative design. Physical, physiological, and technical demands of national netball umpires during competitive matches over a 1 year period were compared between different competition levels.

Subjects

Netball New Zealand high performance umpires (n = 22; 5 male, 17 female) participated in this investigation. This included, in order from highest to lowest level of competition: 9 umpires (1 male, 8 female) from the semi-professional ANZ Championships (ANZC), the premier netball league in Australia and New Zealand; 6 umpires (1 male, 5 female) from the National A Squad (NZA); and 7 umpires (3 male, 4 female) from the National Development Squad (DEV). All subjects gave written informed consent. This study conformed to the standard set by the Declaration of Helsinki (2013) and was approved by the Ethics Board of Auckland University of Technology.

Procedures

In total, 48 umpire match performances were observed during the 2012 season: 16 ANZC matches; 16 NZA matches; and 16 NZD matches. Umpires each wore the same tri-axial accelerometer (MinimaxX S4, Firmware 6.70; Catapult Innovations, Melbourne, Australia; 100 Hz) unit for each match, positioned between the scapulae inside the manufacturer's harness

30 – 40 min before the start of the match. Each umpire also wore a heart rate monitor (Polar Team2; Polar Electro, Kempele, Finland). A separate camera (Canon LEGRIA HV40) recorded the movements for each umpire. Cameras were positioned behind the goal line at the opposite corner of the court to the side line and goal line covered by the umpire, and elevated in the spectator stands if possible (Spencer et al., 2019).

Physical Measures

Load au·min^{-1} represented accumulated accelerations by tri-axial accelerometers during matches and was used as a measure of exertion (Barrett, Midgley, & Lovell, 2014; Young, Hepner, & Robbins, 2012). The physical demands of the umpires were categorised into intensity zones according to Load au·min^{-1}: zone 1 < 0.5; 0.5 ≤ zone 2 < 1.0; 1.0 ≤ zone 3 < 2.0; 2.0 ≤ zone 4 < 3.0; 3.0 ≤ zone 5 < 4.0; zone 6 > 4.0 (Spencer et al., 2019). Zone 1 typically captures 'rest/recovery' movements such as standing, slow turning/twisting and walking. Zones 2-6 typically capture 'work' movements such as jogging, fast turning/twisting, side stepping, running, and sprinting (Spencer et al., 2019). Load au·min^{-1} correlates with distance covered via GPS measurement (r = 0.95) when the main activity is running (Aughey, 2011). Therefore 'estimated equivalent distance' was used as a secondary metric of Accumulated Player Load™ due to the absence of satellite coverage during the indoor matches. Percentage of time in each intensity zone was calculated for each umpire match performance. These same methods have previously been successfully applied to the investigation of elite netball umpires (Spencer et al., 2019). Reliability of Player Load™ has been previously reported (between device coefficient of variation: 1.9%) (Boyd, Ball, & Aughey, 2011).

Physiological Measures

Heart rate data were expressed both as absolute values and as a percentage of the individuals' peak heart rate, previously determined from a Level 1 Yo-Yo Intermittent Recovery Test (Krustrup et al., 2003) as part of routine pre-season fitness testing (Spencer et al., 2019). Heart rate data were further categorised according to percentage of time in discrete heart rate zones: zone 1 < 60% peak heart rate; 60% ≤ zone 2 < 75%; 75% ≤ zone 3 < 85%; 85% ≤ zone 4 < 93%; zone 5 > 93% (Edwards, 1993; Spencer et al., 2019). This categorisation corresponds to different energy systems and has previously been utilised to study both elite netball umpires and Premier League association football referees (Spencer et al., 2019; Weston, Castagna, Helsen, & Impellizzeri, 2009). Percentage of time in each heart rate zone was calculated for each umpire match performance.

Technical Measures

Video of each match was analysed using commercially available performance analysis software (Sportscode Elite Version 10; Hudl, USA). The study adopted a simplified Bloomfield Movement Classification system (Bloomfield, Polman, & O'Donoghue, 2004; O'Donoghue, 2007), with additional movement classifications as previously used specifically for netball umpiring (Spencer et al., 2019). Movement patterns were coded as standing, walking sideways, walking backwards, walking forwards, side stepping, jogging, sprinting, or turning to change direction. Additionally, the area of the court in which the umpire was positioned was coded as either center third side line, goal third side line, or goal line. Percentage of time performing each movement type was determined for each umpire match performance, as was mean duration in each court location. Intra-class correlation coefficients were calculated for the percentage of time spent performing each movement classification (1.00; 95% confidence interval: 0.99, 1.00), indicating excellent reliability (Koo & Li, 2016).

Dependent variables

The following dependent variables were determined for each umpire match performance: (a) estimated equivalent distance covered; (b) percentage of time in each of the 6 intensity zones; (c) mean heart rate; (d) mean heart rate as a percentage of peak heart rate; (e) percentage of time in each of the 5 heart rate zones; (f) percentage of time performing each of the 8 movement classifications; and (g) mean duration in each of the 3 court locations.

Statistical Analyses

Data were reported as mean ± standard deviation. For each dependent variable, between groups (level of competition: ANZC vs NZA vs DEV) comparisons were performed using a one-way ANOVA. Statistical significance was set at $p < 0.05$. Where significant overall between-groups effects were reported, Tukey HSD post-hoc comparisons were conducted to identify any significant differences between groups. Estimates of effect size (Cohen's d; ES) and 95% confidence interval (CI) were calculated. ES was interpreted as follows: trivial < 0.2; 0.2 ≤ small < 0.6; 0.6 ≤ moderate < 1.2; 1.2 ≤ large < 2.0; very large ≥ 2.0 (Hopkins, Marshall, Batterham, & Hanin, 2009).

RESULTS

Physical Measures

Level of competition had no overall significant effects on physical demands of national netball umpires (Table 1; $0.00 \leq F(2,45) \leq 1.25$; $0.298 \leq p \leq 1.000$).

*****Table 1 near here *****

Physiological Measures

Level of competition had overall significant effects (Table 2) on the percentage of time spent in heart rate zone 1 ($F(2,45) = 5.58$; $p = 0.007$), heart rate zone 3 ($F(2,45) = 10.59$; $p < 0.001$), and heart rate zone 5 ($F(2,45) = 3.52$; $p = 0.038$). Level of competition had no further overall significant effects on physiological demands of national netball umpires ($1.16 \leq F(2,45) \leq 2.79$; $0.072 \leq p \leq 0.323$). Post-hoc pairwise comparisons revealed that DEV spent significantly more time in heart rate zone 1 compared to ANZC (mean difference: 5.5%; CI: 1.4%, 9.6%; $p = 0.006$; ES: 0.97, moderate). NZA spent significantly more time in heart rate zone 3 compared to ANZC (mean difference: 19.3%; CI: 8.9%, 29.7%; $p < 0.001$; ES: 1.53, large) and DEV (mean difference: 13.2%; CI: 2.8%, 23.6%; $p = 0.010$; ES: 1.13, moderate). ANZC spent significantly more time in heart rate zone 5 compared to NZA (mean difference: 13.7%; CI: 0.8%, 26.5%; $p = 0.035$; ES: 1.05, moderate).

*****Table 2 near here *****

Technical Measures

Level of competition had overall significant effects (Table 3) on the percentage of time spent standing ($F(2,45) = 13.31$; $p < 0.001$), walking sideways ($F(2,45) = 9.76$; $p < 0.001$), walking backwards ($F(2,45) = 9.63$; $p < 0.001$), jogging ($F(2,45) = 5.91$; $p = 0.005$), sprinting ($F(2,45) = 5.94$; $p = 0.005$), and turning to change direction ($F(2,45) = 19.17$; $p < 0.001$). Level of competition also had an overall significant effect on the mean duration spent on the goal third side line ($F(2,45) = 4.01$; $p = 0.025$). Level of competition had no further overall significant effects on technical demands of national netball umpires ($0.65 \leq F(2,45) \leq 3.13$; $0.054 \leq p \leq 0.527$). Post-hoc pairwise comparisons revealed that ANZC spent significantly less time standing compared to NZA (mean difference: 10.7%; CI: 5.6%, 15.7%; $p < 0.001$; ES: 1.78, large) and DEV (mean difference: 6.8%; CI: 1.7%, 11.9%; p = 0.006; ES: 1.06, moderate). NZA spent significantly less time walking sideways compared to ANZC (mean difference: 4.2%; CI: 1.9%, 6.6%; p < 0.001; ES: 1.69, large) and DEV (mean difference: 2.5%; CI: 0.1%, 4.8%; p = 0.038; ES: 0.88, moderate). ANZC spent significantly more time walking backwards compared to NZA (mean difference: 2.6%; CI: 1.1%, 4.1%; p < 0.001; ES: 1.48, large) and DEV (mean difference: 2.2%; CI: 0.7%, 3.7%; p = 0.004; ES: 1.03, moderate). ANZC spent significantly less time jogging compared to DEV (mean difference: 2.6%; CI: 0.7%, 4.5%; p = 0.005; ES: 1.30, large). DEV spent significantly less time sprinting compared to ANZC (mean difference: 1.8%; CI: 0.3%, 3.3%; p = 0.016; ES: 1.02, moderate) and NZA (mean difference: 1.9%; CI: 0.4%, 3.4%; p = 0.010; ES: 1.10, moderate). ANZC spent significantly more time turning to change direction compared to NZA (mean difference: 0.6%; CI: 0.3%, 0.8%; p < 0.001; ES: 2.24, very large) and DEV (mean difference: 0.4%; CI: 0.1%, 0.6%; p = 0.001; ES: 1.12, moderate). ANZC spent significantly greater mean durations on the goal third side line compared to DEV (mean difference: 0.8%; CI: 0.1%, 1.5%; p = 0.025; ES: 0.90, moderate).

*****Table 3 near here *****

DISCUSSION

The present study is the first to directly investigate the effects of level of competition (i.e. ANZC > NZA > DEV) on physical, physiological, and technical demands on national netball umpires. Level of competition had no effect on physical demands, or on mean physiological (e.g. heart rate) demands. However, ANZC umpires spent a lower proportion of time at low heart rates compared to DEV umpires, and a greater proportion of time at high, rather than moderate, heart rates compared to NZA umpires. Compared to the lower standard umpires, ANZC umpires spent lesser proportions of time standing but greater proportions of time walking backwards and sideways, and turning to change direction. Furthermore, ANZC umpires spent lower proportions of time jogging, but greater proportions of time sprinting compared to DEV umpires. Finally, ANZC umpires spent longer mean durations than DEV umpires on the goal third side line.

The lack of any significant effect of competition level on physical demands of national netball umpires is contrary to the hypothesis of the present study. This may partly explain the extraordinary similarity in total distance covered by netball umpires as reported in previous studies (3850 m vs 3840 ± 708 m: (Otago et al., 1994; Spencer et al., 2019)). The similar physical demands at various levels of competition may reflect the reactive role of sports officials, whose total distance covered is dictated at least partly by the teams on court (e.g. the number of goals, center passes, transitions between court areas, etc.). This finding implies that all high performance netball umpires are required to cover a similar distance, and at similar intensities, regardless of the specific level of competition. Similarly, previous research reported no difference in distance covered by soccer referees between high school and college matches when normalised to match duration (Staiger, 2010).

Physiologically, there was no difference in overall mean heart rate of the different levels of umpire, whether expressed in absolute or relative terms. This is likely a consequence of the similar physical demands discussed above, and suggests little difference in fitness levels between groups if they are meeting equivalent physical demands with equivalent mean physiological demands. However, the higher level ANZC umpires spent less time in lower heart rate zones than the lower level DEV umpires, and more time in higher heart rate zones rather than moderate zones compared to the intermediate level NZA umpires. This may suggest that higher level umpires utilise a greater frequency of intense movements. Umpires looking to progress to higher levels of competition may therefore wish to spend more time training in higher heart rate zones. It must be remembered, however, that there was no difference in the proportion of time spent in higher physical intensity zones between the 3 levels of umpire. The physiological results of the present study are in agreement with the hypothesis that umpires officiating in higher levels of competition would experience an increase in high demand activities and a decrease in time spent in intermediate demand activities, compared to those officiating in lower levels of competition. However, the anticipated concurrent increase in low demand activities was not observed. This may reflect the lack of difference in physical demands and/or the slow nature of heart rate recovery following previous movements (Watson, Brickson, Prawda, & Sanfilippo, 2017).

Heart rate response among sports officials may be affected by alternative factors influencing arousal levels. Heart rate has been shown to increase in cricket umpires, despite little locomotive movement, from 121 to 139 beats·min^{-1} 15 s after an appeal for a catch given 'not-out', and from 89 to 106 beats·min^{-1} during a hat-trick (3 wickets in 3 balls) despite not being required to make a decision as all 3 batsmen were bowled (Stretch, Tyler, & Bassett, 1998). Further research is needed to determine the effect of heart rate on decision making accuracy and vice versa in elite netball umpires (Mascarenhas, Button, O'Hare, & Dicks, 2009; Spencer et al., 2020). If lower heart rates were found to be beneficial for decision making accuracy, this would suggest beneficial effects of increased fitness levels despite the lack of observed difference in physical or mean physiological demands between competition levels.

Compared to the physical and physiological demands, level of competition had a greater quantity, and generally a greater magnitude, of significant effects on the technical demands of national netball umpires. It appears that despite covering a similar total distance to the lower level umpires, the higher level ANZC umpires utilised different movement patterns in order to cover that distance. They spent less time umpiring from a stationary position, and more time changing direction and moving around the court by walking backwards and sideways. These changes of direction and low intensity backwards and sideways movements likely reflect minor adjustments in positioning in response to play, whilst maintaining a view of the court for more successful decision making. Indeed, the previously reported tendency of elite umpires to walk more as the match progresses may indicate that these adjustments reflect superior anticipation of patterns of play (Spencer et al., 2019).

Additionally, ANZC umpires spent less time jogging and more time sprinting compared to lower levels of umpire. This, combined with the fact that they also spent longer mean durations on the goal third side line, may suggest that they waited to observe play from the side line for longer, aiding decision making regarding the timing of transition to the goal line, and then transitioned at a faster pace. It cannot be confirmed from existing literature, however, how these technical differences relate to play, and so the above suggestions require further testing and clarification. As with the physiological demands, these technical findings again support the hypothesis that umpires officiating in higher levels of competition would experience an increase in high demand activities and a decrease in time spent in intermediate demand activities, compared to those officiating in lower levels of competition. However, the concurrent lower proportion of time spent standing again refutes the hypothesis that higher level umpires would also utilise low demand activities more than the other umpires.

Furthermore, no attempt has been made to relate umpire movement and positioning to decision making accuracy as in other sports (Hossner et al., 2019; Mallo et al., 2012). For example, does the tendency of ANZC umpires to remain on the goal third side line result in a greater proportion of correct decisions, or a decrease in unnecessary positional readjustments? Recent research in rugby union referees has shown gaze fixation locations to significantly predict decision making accuracy (Moore, Harris, Sharpe, Vine, & Wilson, 2019) and so it may also be beneficial to identify the perceptual-cognitive processes used by elite umpires to make superior decisions regarding positioning and movement. It is currently unclear whether lower levels of umpire can be successfully coached to move differently or whether they must first learn to anticipate patterns of play and perceive the action on court.

The observed physiological and technical differences may be at least partly caused by differences in styles or patterns of play on court. However, they nonetheless highlight the demands upon umpires in those leagues. Despite the lack of a difference in physical demands between the levels of competition in the present study, it remains necessary to quantify the minimum acceptable fitness levels for umpires and how current or novel fitness tests correlate with these. As pointed out in a recent review (Spencer et al., 2020), no attempt has currently been made to relate physical, physiological, and technical demands of netball umpires to appropriate fitness testing requirements or to validate existing fitness testing protocols for umpires. Such investigations have proved useful for netball players (Gasston & Simpson, 2004) or for officials in other sports (Mallo, Navarro, Aranda, & Helsen, 2009; Mallo, Navarro, García-Aranda, Gilis, & Helsen, 2007) and should be a priority in the near future for netball umpiring.

The present study has a number of practical implications. Umpires wishing to officiate at national levels of competition must be capable of meeting the required physical and mean physiological demands. However, further progression to the highest levels of competition will be facilitated by a greater focus on technical development. Umpires should make minor adjustments to their position, rather than standing, in order to maintain appropriate vision of the court. Backwards and sideways movements will facilitate this without disrupting necessary lines of sight. Furthermore, umpires should maintain their position on the goal third side line for as long as possible before sprinting, rather than jogging, to the goal line. Coaching and talent identification of netball umpires should prioritise such technical aspects.

CONCLUSIONS

Competition level had no effect on physical demands or mean physiological demands of national netball umpires. However, higher level umpires spent less time standing but more time walking backwards and sideways, and turning to change direction compared to lower level umpires. Furthermore, higher level umpires spent less time jogging, but more time sprinting compared to lower level umpires. The highest standard of umpires also spent longer mean durations than lower level umpires on the goal third side line. As such, the difference in demand experienced by national netball umpires between lower and higher levels of competition is more technical than physical or physiological. This information is useful for umpires, umpire coaches, and strength and conditioning practitioners when designing training programmes or fitness testing criteria.

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Table 1. A comparison of physical demands of national netball umpires in different levels of competition: ANZ Championships (ANZC) vs National A Squad (NZA) vs National Development Squad (DEV).

	ANZC (n = 16)	**NZA (n = 16)**	**DEV (n = 16)**
estimated equivalent distance (m)	3826 ± 578	3923 ± 601	3780 ± 677
time in intensity zone 1 (%)	76.9 ± 2.8	76.5 ± 5.5	77.0 ± 3.5
time in intensity zone 2 (%)	8.3 ± 0.9	7.6 ± 2.5	7.9 ± 1.3
time in intensity zone 3 (%)	12.3 ± 1.5	13.4 ± 2.6	12.6 ± 1.6
time in intensity zone 4 (%)	2.5 ± 1.7	2.4 ± 1.2	2.5 ± 1.5
time in intensity zone 5 (%)	0.0 ± 0.0	0.0 ± 0.1	0.0 ± 0.0
time in intensity zone 6 (%)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

Note: zone 1 < 0.5 au·min^{-1}; 0.5 ≤ zone 2 < 1.0; 1.0 ≤ zone 3 < 2.0; 2.0 ≤ zone 4 < 3.0; 3.0 ≤ zone 5 < 4.0; zone 6 > 4.0.

Table 2. A comparison of physiological demands of national netball umpires in different levels of competition: ANZ Championships (ANZC) vs National A Squad (NZA) vs National Development Squad (DEV).

	ANZC (n = 16)	**NZA (n = 16)**	**DEV (n = 16)**
mean heart rate (b·min^{-1})	159 ± 9	155 ± 11	151 ± 15
mean heart rate (% peak heart rate)	82.5 ± 6.9	80.8 ± 5.3	77.5 ± 8.1
time in heart rate zone 1 (%)	0.9 ± 1.3‡	2.5 ± 2.2	6.4 ± 7.9*
time in heart rate zone 2 (%)	18.5 ± 25.4	27.1 ± 14.6	28.1 ± 16.8
time in heart rate zone 3 (%)	25.1 ± 12.9$^{\#}$	44.4 ± 12.4‡	31.2 ± 11.0$^{*\#}$
time in heart rate zone 4 (%)	35.4 ± 17.9	24.4 ± 19.3	22.0 ± 13.4
time in heart rate zone 5 (%)	15.2 ± 18.1$^{\#}$	1.5 ± 3.6*	11.2 ± 18.2

Note: * significantly different to ANZC; $^{\#}$ significantly different to NZA; ‡ significantly different to DEV; zone 1 < 60% peak heart rate; 60% ≤ zone 2 < 75%; 75% ≤ zone 3 < 85%; 85% ≤ zone 4 < 93%; zone 5 > 93%.

Table 3. A comparison of technical demands of national netball umpires in different levels of competition: ANZ Championships (ANZC) vs National A Squad (NZA) vs National Development Squad (DEV).

	ANZC (n = 16)	**NZA (n = 16)**	**DEV (n = 16)**
time standing (%)	$43.4 \pm 7.0^{\#\ddagger}$	$54.1 \pm 4.8^{*}$	$50.3 \pm 5.8^{*}$
time walking sideways (%)	$11.9 \pm 2.6^{\#}$	$7.7 \pm 2.4^{*\ddagger}$	$10.1 \pm 3.1^{\#}$
time walking backwards (%)	$4.3 \pm 2.4^{\#\ddagger}$	$1.7 \pm 0.8^{*}$	$2.1 \pm 1.9^{*}$
time walking forwards (%)	14.1 ± 5.2	15.3 ± 5.7	16.1 ± 3.7
time side stepping (%)	5.0 ± 2.0	4.0 ± 2.7	3.0 ± 2.1
time jogging (%)	$4.3 \pm 1.8^{\ddagger}$	5.1 ± 2.5	$6.9 \pm 2.2^{*}$
time sprinting (%)	$10.3 \pm 1.8^{\ddagger}$	$10.4 \pm 1.7^{\ddagger}$	$8.5 \pm 1.7^{*\#}$
time turning to change direction (%)	$0.7 \pm 0.4^{\#\ddagger}$	$0.1 \pm 0.0^{*}$	$0.3 \pm 0.3^{*}$
mean duration on centre third side line (s)	29.2 ± 3.9	30.8 ± 4.7	30.3 ± 2.8
mean duration on goal third side line (s)	$5.1 \pm 1.2^{\ddagger}$	4.4 ± 0.7	$4.2 \pm 0.5^{*}$
mean duration on goal line (s)	10.5 ± 1.4	11.4 ± 1.1	10.4 ± 1.5

Note: * significantly different to ANZC; $^{\#}$ significantly different to NZA; ‡ significantly different to DEV.