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HAPPY LANDING?
HOW DOES POSITION IMPACT ON LANDING STRATEGY IN NETBALL

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ABSTRACT

Youth netballers experience high injury levels attributed to chosen landing strategies. This study determined positional impacts on landing strategy, through investigating the distribution of landing strategies and identifying strategy differences that predict performance. Eighty-four (84) female netballers (age 16±1years; height 173±7cm; mass 68.5±10.3kg) were analysed during 12 games. Landing strategies were investigated by position (n=7). Dependent variables were zone, pressure, height of pass, jump type, landing platform, stability and balance (Sportscode Elite; Hudl, USA). Intra-observer reliability agreement was acceptable (κ=0.776, p<0.001). Descriptive data were presented using medians and inter-quartile ranges (IQR).The Kruskal-Wallis test was used to determine positional landing strategy differences, with a Bonferroni correction. The binary logistic regression identified the variables that best predict better player grade. Dependent variables were significantly differentiated by position (p<0.05; 0.0001). Logistic regression highlighted that 'catch both hands', 'Jump-turn in air-land', 'balance step' and 'land neutral feet outside shoulder width' were significant grade predictor factors (p<0.05). Knowledge regarding safe landing strategy is beneficial to netball coaches and trainers aid session design and develop conditioning strategies for injury reduction and performance improvement using a position-specific perspective.

***Key words*:** Youth Netball; Landing strategy; Injury; Balance; Pressure; Jump.

INTRODUCTION

Netball is an international sport played in more than 80 countries by over 20 million participants (IFNA, 2012) and according to Sport New Zealand, netball is currently the most popular female sport in New Zealand (Sport NZ, 2020). In 2011, there were 13,611 teams playing Netball in New Zealand. Unfortunately, there is an associated high level of intrinsic injury risk, with the majority of injuries occurring in lower limb (McManus *et al*., 2006; Fong *et al*., 2007). The majority of injuries occur during competition. The New Zealand Accident Compensation Corporation reported there is also the accompanying financial cost, a 200% increase in the number of insurance claims from 2007/8 to 2011/12 for lower limb netball injuries in the 10-19 age group, compared to a 125% increase amongst adult participants over the same timeframe (NZACC, 2016).

In the competition environment, factors that determine landing strategy are the netball footwork rule, type of pass (straight/loop/bounce), height of pass (overhead/chest/below waist), closeness of opponent (pressure high/low) (Steele & Lafortune, 1989; Otago, 2004) and landing

space available (unilateral/bilateral/action required post landing) (Dewit *et al*.,1995). Netball players have a high incidence of lower limb injuries attributed to their landing strategies used in competition (Powell & Barber-Foss, 2000; Hargrave *et al*., 2003; Otago, 2004). Player positions have specific contextual demands (Di Salvo *et al.,* 2007) that may influence landing strategies away from the New Zealand Netball Smart exemplar strategy. The footwork rule dictates the actions of the youth netballer from the moment they receive the ball. They must rapidly decelerate from their run or jump, then balance, whilst only permitted to use a maximum of one step, if they need it to maintain a stable base (Steele & Milburn, 1987).

A high experience of overhead passes compels the netballer to 'jump to receive'. These jumps (vertical, forward or lateral directions) often involve the netballer turning in the air with either unilateral or bilateral landing. This leads to ground reaction forces imposed on the netballer up to 6.8 times body mass (Hopper *et al*., 1999). However, the landing strategy chosen has the potential to reduce these impact forces and so reduce the possibility of injury (Hopper, *et al*., 1992). Research from elite adult netball suggested better players would use a bilateral or 'run-on' strategy and so experience lower impact ground force because the forces are spread more evenly throughout the foot (Otago, 2004).

Stability contributes to the effective execution of landing strategy. Assessment of frequency of stability and unstable movements during game actions has been advocated as a good indicator of injury risk (Murphy *et al*., 2003; Hrysomallis, 2007; Wikstrom *et al*., 2008). Three strategies help maintain balance, the ankle, the hip and stepping. The ankle strategy is often used in static conditions, such as basketball guard defence in the end zones where a static balance is held for three seconds without falling into the opponent and creating an infringement. In dynamic situations, its function is to recover stability and is used when the disturbance to balance is minimal (King & Zatsiorsky, 2002). Netballers would use the hip strategy to recover balance when large and fast corrections are required from medio-lateral and antero-posterior instability, such as jump/jump-turn landings (Tropp & Odenrick, 1988). Stepping indicates the netballer has failed to regain balance using the previous strategies so recovers balance through the use of a step or hop. Use of this strategy may be synonymous with a lower skill level of landing strategy.

Position characterises which movement strategies are chosen at the elite grade (Lavipour *et al*., 2009), yet there is no information on distribution at the youth level. Presently, there is no netball data on player pressure, though it is frequently associated with occurrence of ankle injury (Hume & Steele, 2000; Saunders & Otago, 2009). Research in the similar sport of basketball has shown a pattern of high pressure in the 'ends' of the court (Kofotolis *et al*., 2007). Yet, this may differ in netball due to the contact rule, which minimises incidences of physical contact and the obstruction rule that prevents players being closer than 1m from an in-possession opponent. Contact is only permitted provided it does not impede with an opponent.

A review of literature has shown that there are limited studies that examine factors that may predict performance using logistic regression. Football has a few studies which have implemented logistic regression to predict goal scoring (Wright *et al*., 2011) and shots on target (Pollard & Reep, 1997). However, there have been none conducted to analyse factors of performance in netball. It is important to analyse what landing strategy factors may contribute to higher grade performance, as this benefits training design. Currently there has been a lack of investigation into the potential influence that the landing strategy variables may have on player grade. Carling *et al*. (2013) stated the importance of being contextually appropriate with the dataset utilised and recommended that the information used, must be time relevant to the particular area being investigated. The implementation of logistic regression, using a dataset

from a national tournament as a method to identify those aspects of landing strategy that predict a player grade is a novel approach in netball.

PURPOSE OF RESEARCH

Based on the limitations of the existing research, the purpose of this study was (1) to investigate the experiences in the distribution of landing strategies of youth netballers; (2) to identify differences in landing strategy that best predict grade for the sampled players. The purpose of this paper is to profile these positional contextual demands using the absolute experiences of youth netballers in high grade National Competition. Information gathered on this distribution of these landing strategies will assist netball coaches and strength and conditioning professionals to develop conditioning strategies for injury prevention and performance improvement from a position-specific perspective.

METHODOLOGY

Design

The landing strategies of youth female netballers were analysed during 12 competitive games during their New Zealand National Secondary School tournament.

Participants

A sample of convenience was recruited from the New Zealand secondary schools netball competition. Eighty-four (n=84) female netballers (age=16±1 years; height=173±7cm, mass=68.5±10.3kg) were assessed during 12 competitive games in which teams competed in two grades, A and C, representing the 1st and 3rd grade of teams at the tournament. Landing strategies were investigated of each of the seven positions throughout the duration of the tournament (Figure 1).

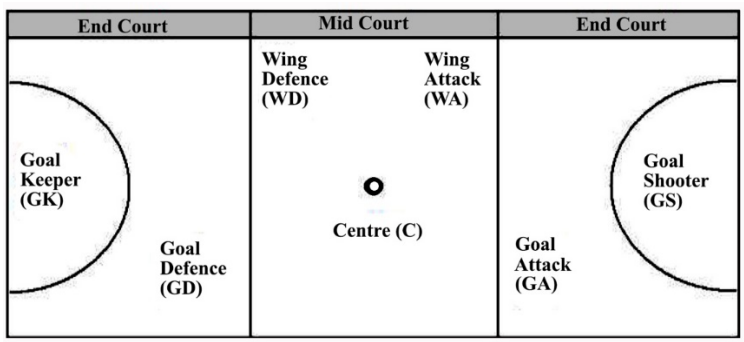

Figure 1. **NETBALL COURT WITH PLAYER POSITIONS FOR A TEAM ATTACKING TO THE RIGHT**

Ethical considerations

This study conformed to the standard set by the Declaration of Helsinki and was approved by the Ethics Board of Auckland University of Technology.

Procedures

All matches were 40 minutes in duration with no substitutions within each quarter. Video recordings of each match was analysed using commercially available performance analysis software (Sportscode Elite Version 10; Hudl, USA). A camera (Canon LEGRIA HV40) recorded the movements for each player. 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). Data was collected for each position, across 12 matches, resulting in 84 participants. The parameters coded for each game (Table 1) were determined by position and playing grade (1st and 3rd). These variables are considered important determinants of netball landing strategy and are comparable with recent movement studies.

Table 1. **RELATIONSHIP POSITION AND FREQUENCY OF GAME ACTIONS IN YOUTH NETBALL PLAYERS**

Variable (no. of possible actions)	Operational definitions of game actions
Context	
Court Area (3)	Area of court in which the landing strategy occurred Circle, End thirds or Mid-Court.
Pressure (3)	HIGH (a close opponent making an active attempt to intercept the ball) MEDIUM (opponent moving towards the receiver) LOW (direct opponent in a sag back position taking up space)
Receiving	
Hand(s) (3)	Either left, right or both
Ball position relative to body (3)	Ball reception position (central, received to players right, received to players left)
Ball height relative to body (3)	Height of pass received (overhead, chest, below waist)
Player leg movement (4)	Action player used to successfully receive pass (stationary, leap/step, run, jump)
Jumping	
Jump direction (5)	Jump direction player used to successfully receive pass (vertical, lateral, forward, jump and turn in air, jump, land and pivot)
Landing	
Ankle Joint (3)	Player foot landing: plantar flexion, dorsiflexion, neutral
Landing foot (4)	Single foot (L or R)/both symmetrical/both unsymmetrical
Balance	
Body-weight sway once ball in possession (3)	Sway over left foot/sway over right foot/neutral central position
Balance Strategy (3)	Hip/ankle/step

Statistical analysis

Analysis was conducted to determine if, across a complete youth netball tournament, differences occurred in the distribution of landing strategy. Each landing strategy indicator was

assessed for normality using the Shapiro-Wilk test and homogeneity of variance was assessed using the Levene's test (Field, 2005).

The assumptions of normality were not met so non-parametric tests were implemented. Due to the non-normal distribution, descriptive data were presented using medians and inter-quartile ranges (IQR). A Kruskal-Wallis test was applied with the aim of analysing differences in landing strategy between positions. Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure, with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented.

In the second stage of analysis, binary logistic regression was used to identify the variables that best predict *better* player level. Player grade was recorded as either grade A or grade C. Independent variables on player grade were examined. The logistic regression analysis was conducted using the binary outcome, grade A versus grade C, as the dependent variable. Beta values and odds ratios were reported for those variables identified in the final step of the logistic regression using backward elimination. The logistic regression analysis and tests of normality and homogeneity of variances were carried out using SPSS (version 24.0, SPSS Inc., Chicago, IL). The level of significance was set at $p<0.05$ for all tests.

RESULTS

Intra-observer ***reliability*** was assessed by way of repeat analysis of 1 quarter (15 min) of video for 1 position (goal shooter [GS]). The level of agreement between categorisations of the landing actions in successive trials was assessed using the kappa statistic, which found a substantial level of agreement ($\kappa=0.776$, $p<0.001$). Descriptive results of the landing strategy statistics by position are presented in Table 2 to follow.

Centre (C)

Most actions occurred in the end zone with pairwise tests revealing this was significantly different for the GK, GD, WD and GS ($p<0.0001$). The centre position largely experienced medium pressure from the opposition, which was significantly different to the GK ($p<0.0001$). The preferred catching technique was using both hands that was significantly greater than the GD and GK ($p<0.0001$). Most passes were received centrally significantly more than the GD and GK ($p<0.0001$), and at chest height significantly more than the GD and GK ($p<0.0001$). The position primarily received passes while stationary and significantly more than the GK, ($p<0.0001$) or jumping significantly more than the GS, GD and GK ($p<0.0001$). When jumping, the directions most used were forward significantly more than the GS and GK ($p<0.0001$) and turn-in-air significantly more than the GD and GK ($p<0.0001$). Landing was primarily with both feet in neutral, which was significantly more frequent than the GD and GK ($p<0.0001$). The feet were largely symmetrical, which was significantly different than the GD and GK ($p<0.0001$). The ankle strategy was predominant in maintaining balance and was significantly different than the GK ($p<0.0001$) with body sway right significantly different than the GD, GK and GS ($p<0.0001$).

Table 2. **DIFFERENCES BETWEEN LANDING STRATEGY WITH POSITION**

Related to Variable Median (IQR)	**C**	**GA**	**WA**	**GD**	**GS**	**WD**	**GK**	***H*(6)**	***p-Value***
Context									
Zone									
Circle	N/A	23(11)[a]	N/A	4(5)	27(16)	N/A	5(3)	79.18	0.000
End third	41(11)[abcg]	20(11)[a]	31(24)[abcg]	5(5)	7.5(15)	11(7)	4(4)	59.59	0.000
Mid court	16(9)	15(8)	26(16)	14(19)	N/A	24(15)	N/A	59.12	0.000
Pressure									
High	6(4)	6(5)	5(5)	3(2)[de]	6(5)	3(3)[g]	0(0)[fg]	29.02	0.000
Med	30(12)	28(13)	33(16)	12(15)	20(11)	16(8)[e]	2(2)[defg]	55.23	0.000
Low	21(8)	21(19)	19(14)	12(12)	8(7)[def]	14(10)	4(3)[cdef]	44.39	0.000
Receiving									
One hand	2(2)[a]	1(3)[a]	1(3)[a]	1(1)	2(3)[a]	1(2)	None	24.94	0.000
Both Hands	55(12)[ab]	55(20)[ab]	55(30)[ab]	23(25)	30(13)	30(14)[e]	6(4)	57.72	0.000
Related to body									
Central	24(8)[ab]	26(13)[ab]	23(8)[ab]	11(10)	13(13)[a]	12(10)	5(3)	50.39	0.000
Left of body	13(10)[a]	12(4)[a]	15(12)[a]	8(8)	7(8)[ae]	9(8)	2(3)	41.80	0.000
Right of body	18(10)[a]	17(7)[a]	18(12)[a]	8(8)	10(11)[a]	7(11)	3(1)	43.64	0.000
Ball Height									
Overhead	18(9)[a]	17(7)[a]	15(6)[a]	9(11)	11(3)	8(11)	3(5)	36.92	0.000
Chest	38(30)[ab]	36(13)[ab]	41(28)[ab]	13(15)	20(13)	23(10)[a]	5(4)	54.57	0.000
Below Waist	2(3)	2(5)[a]	2(3)[a]	1(1)	2(4)[a]	1(1)	0(1)	20.83	0.002
Leg Movement									
Stationary	23(7)[a]	20(15)[a]	20(13)[a]	13(10)	19(16)[a]	13(12)	4(3)	40.16	0.000
Leap/step	14(3)[ag]	12(7)[ag]	17(6)[ag]	9(9)	5(2)	10(5)	2(2)	46.39	0.000
Run	1(3)	1(2)	0(1)	1(2)	0(1)	0(2)	0(1)	8.661	0.941
Jump	20(6)[abg]	13(11)[ab]	19(16)[ab]	7(7)	8(7)	10(6)	2(4)	46.21	0.000

Table 2. **DIFFERENCES BETWEEN LANDING STRATEGY WITH POSITION *(cont.)***

Related to Variable Median (IQR)	**C**	**GA**	**WA**	**GD**	**GS**	**WD**	**GK**	***H*(6)**	***p-Value***
Jumping *Direction*									
Vertical	5(5)	7(6)[a]	5(3)	3(4)	6(5)	3(3)	2(3)	16.54	0.011
Lateral	7(4)[ab]	7(5)[a]	11(7)[ab]	2(4)	3(5)	4(3)	1(2)	40.40	0.000
Forward	11(4)[ag]	9(6)[a]	13(7)[ag]	8(12)[a]	2(3)	11(5)[ag]	1(1)	47.70	0.000
Jump, turn, land	11(9)[ab]	6(5)[ab]	7(6)[ab]	1(3)	2(4)	2(4)	0(1)	40.64	0.000
Jump, land, pivot	0(1)	0(1)	0(1)	N/A	0(1)	0(0)	0(0)	10.88	0.092
Landing *Ankle Joint Movement*									
Plantarflexion		10(6)[a]	13(6)[ag]	8(10)	5(2)	7(5)	2(3)	40.64	0.000
Dorsiflexion	2(2)	1(2)[a]	4(4)[ag]	2(2)[ag]	0(1)	2(4)[ag]	0(1)	34.21	0.000
NWSW	22(13)[ab]	19(13)[a]	18(14)[ab]	7(9)	9(4)	16(10)[a]	3(3)	46.19	0.000
NOSW	22(18)[a]	19(16)[a]	18(28)[a]	11(8)	17(9)[a]	8(8)	3(2)	44.25	0.000
Feet Movement									
Single ft left	6(4)[a]	4(6)[a]	6(4)[ag]	4(4)	2(3)	3(4)	1(2)	30.60	0.000
Single ft right	10(8)[ag]	9(6)[ag]	13(7)[ag]	6(7)	3(4)	6(6)	2(2)	39.65	0.000
Both (sym)	30(13)[ab]	20(12)[a]	27(28)[a]	11(12)	16(7)[a]	15(14)	5(5)	43.03	0.000
Both (asym)	14(9)[ab]	13(10)[ab]	15(7)[ab]	5(7)	10(13)[a]	9(5)	2(1)	49.80	0.000
Balance									
Sway left	21(9)[a]	19(10)[a]	27(15)[abc]	12(12)	13(7)[a]	12(8)	4(2)	46.54	0.000
Sway right	28(10)[ab]	23(15)[a]	26(14)[a]	11(9)	15(10)[a]	14(11)	3(3)	47.72	0.000
Neutral	11(6)[abg]	7(7)[a]	6(11)[a]	4(4)	3(5)	5(5)	2(2)	32.15	0.000
Stabilisation									
Hip	21(16)[ac]	18(12)[a]	17(15)[abc]	7(10)	11(5)[a]	7(5)	3(2)	49.58	0.000
Ankle	29(11)[a]	30(8)[ab]	25(25)[a]	15(12)	16(14)	23(12)[a]	5(4)	45.03	0.000
Step	7(7)[a]	7(6)[a]	5(5)[a]	2(4)	5(4)	3(4)	1(2)	30.87	0.000

[a] Significantly different from GK, [b] Significantly different from GD, [c] Significantly different from WD, [d] Significantly different from C, [e] Significantly different from WA, [f] Significantly different from GA, [g] Significantly different from GS.
NWSW=Neutral Within Shoulder Width NOSW=Neutral Outside Shoulder Width

Goal Attack (GA)

Most actions occurred in the circle zone with pairwise tests revealing this was significantly different to the GK and GD $p<0.0001$). The position largely experienced medium pressure from the opposition which was significantly different to the GK ($p<0.0001$). The preferred catching technique was using both hands, which was significantly greater than the GD and GK ($p<0.0001$). Most passes were received centrally significantly more than the GD and GK ($p<0.0001$) and at chest height significantly more than the GD and GK; $p<0.0001$). The position primarily received passes while stationary (significantly more than the GK, $p<0.0001$). When jumping, the directions most used were forwards (significantly more than the GK; $p<0.0001$), and vertical (significantly more than the GK; $p<0.0001$). Landing was primarily with both feet in neutral which was significantly more frequent than the GK ($p<0.0001$). The feet were largely symmetrical which was significantly different than the GK ($p<0.0001$). The ankle strategy was predominant in maintaining balance, which was significantly different than the GK and GS, ($p<0.0001$) using body sway right (significantly different than the GK; $p<0.0001$).

Wing Attack (WA)

Most actions occurred in the end zone with pairwise tests revealing this was significantly different for the GK, GD, WD and GS ($p<0.0001$). The position largely experienced medium pressure from the opposition, which was significantly different to the GK ($p<0.0001$). The preferred catching technique was using both hands, which was significantly greater than the GD and GK ($p<0.0001$). Most passes were received centrally significantly more than the GD and GK ($p<0.0001$) and at chest height, significantly more than the GD and GK ($p<0.0001$). The position primarily received passes while stationary significantly more times than the GK ($p<0.0001$) and jumping significantly more than the GK and GS ($p<0.0001$). When jumping, the direction most used was forward and significantly more than the GK; $p<0.0001$). Landing was primarily with both feet in neutral and was significantly more frequent than the GK and GS ($p<0.0001$). The feet were largely symmetrical and was significantly different than the GK ($p<0.0001$). The ankle strategy was predominant in maintaining balance, which was significantly different than the GK ($p<0.0001$) and using a body sway left was significantly different to the GK, GS and WD ($p<0.0001$).

Goal Defence (GD)

Most actions occurred in the mid-court zone. The position experienced significantly less high pressure than the C and WD ($p<0.0001$). The preferred catching technique was using both hands. Most passes were received centrally at chest height. The position primarily received passes while stationary. Jumping occurred mainly in a forward direction and was significantly more than the GK ($p<0.0001$). Landing was primarily with both feet in neutral, but outside of shoulder-width. The feet were largely symmetrical. The ankle strategy was predominant in maintaining balance with body sway both left and right.

Wing Defence (WD)

Most actions occurred in the mid-court zone. The position largely experienced medium pressure from the opposition, which was significantly different to the WA ($p<0.0001$). The preferred catching technique was using both hands. Most passes were received centrally and at chest height significantly more than the GK ($p <0.0001$). The position primarily received passes

while stationary. When jumping, the direction most used was forward significantly more than the GK and GS ($p<0.0001$). Landing was primarily with both feet in neutral, which was significantly more frequent than the GK ($p<0.0001$). The feet were mainly symmetrical. The ankle strategy was predominant in maintaining balance and was significantly different than the GK ($p<0.0001$) and using a body sway right.

Goal Shooter (GS)

Most actions occurred in the circle zone with pairwise tests revealing this was significantly different to the GK and GD ($p<0.0001$). The position largely experienced medium pressure from the opposition. The preferred catching technique was using both hands. Most passes were received centrally and at chest height. The position primarily received passes while stationary being significantly more than the GK ($p<0.0001$) and jumping significantly more than the GK and GS ($p<0.0001$). When jumping, the direction most used was vertical. Landing was primarily with both feet in neutral with feet outside of shoulder-width and was significantly more frequent than the GK ($p<0.0001$). The feet were largely symmetrical. The ankle strategy was predominant in maintaining balance using a body sway right, which was significantly different to the GK ($p<0.0001$).

Goal Keeper (GK)

Most actions occurred in the circle zone. The position largely experienced low pressure from the opposition. The only catching technique used was using both hands. Most passes were received centrally and at chest height. The position primarily received passes while stationary. When jumping, the direction most used was vertical. Landing was primarily neutral and the feet were largely symmetrical. The ankle strategy was predominant in maintaining balance while using a body sway left.

Landing strategy variables

The results of the logistic regression analysis are presented in Table 3. The data was explored using a number of logistic regression models with the final model identifying that more 'catching with both hands', fewer 'jump-turn in air-lands', more 'balance using step strategy' and fewer 'landing neutral feet wide outside border' were significant factors ($p<0.05$). The model correctly predicted 88.1% of the not grade A and grade A representation.

***Table 3*. LANDING STRATEGY VARIABLES PREDICTING GRADE FOR SAMPLED PLAYERS**

Variable	B	SE	df	p-Value	Odds Ratio
Catch both hands	0.112	-0.049	1	0.022	1.119
Jump-turn in air-land	-0.466	0.222	1	0.036	0.627
Balance step	0.366	0.147	1	0.012	1.442
Landing neutral and feet outside shoulder width	-0.375	0.110	1	0.001	0.687

The model explained 60% (Nagelkerke R^2) of the variance in grade and correctly predicted 88.1% of the grade representation. Sensitivity was 95%, specificity was 67%, positive predictive value was 90% and negative predictive value was 52%. Of the four predictive variables, all four were statistically significant. Increasing 'catch with both hands' and 'balance step' were associated with an increased likelihood of being in grade A, but increasing 'Jump-turn in air-land' and 'land neutral feet outside shoulder width' were associated with a reduction in the likelihood of being in grade A.

DISCUSSION

The first aim of the study was to identify variation in the landing strategies that may distinguish between the netball positions. The findings suggest that over the course of a National netball tournament experiences relating to landing strategy can differentiate between netball positions. The results support the concept that for the sampled players, the coach and the trainer should look to incorporate variation in the training design and conditioning strategies to adequately prepare the athlete to be able to maintain a consistent performance throughout the duration of the tournament. This design needs to be specialised for position.

On completion of the tournament, the athletes in the positions of WA, C and GA had experienced significantly more actions than the GS, GS, WD and GK. This greater physical demand associated with those specific position supports previous findings from elite grade netball (Fox *et al*., 2013) and the increased likelihood of injury for those positions (Stuelcke *et al*., 2016).

The zones where these landing strategies occurred are noticeably differentiated by position. The GS, GA and GK were predominantly active in the Circle Zone, the C and WA mainly active in the End Zone, with the GD and WD principally active in the mid-court. Due to the movement restrictions placed on each position by the rules of the game, the GS, GK zones are as expected, but the C player's greater involvement in the end zone is contrary to previous research, which states the mid-court as the main area of engagement for the C (Otago, 1983; Saunders & Otago, 2009). This suggests that when planning tactical training sessions at the National Schools level, coaches should consider planning actions that involve the C player as receiving the ball in the end zones rather than as a mid-court position.

Regardless of position, players at this grade are principally static when they receive the ball. This reduces the impact of the footwork rule and suggests that deceleration may not be such a mitigating factor in injuries in secondary age group netball. This does explain the high incidence of the ankle strategy as a mechanism for achieving balance throughout the tournament (King & Zatsiorsky, 2002). The WA, C and GA use significantly more ankle balance strategy than the other positions, which may be attributed to the greater involvement in ball contacts throughout the tournament.

The Leap/step receiving action was most frequently used by the WA and C. This movement requires a large degree of stability on landing and has been associated with high injury risk (Wikstrom *et al*., 2008). The implication is for coaches and conditioners to increase player awareness in training to use the hip balance strategy to reduce instability on landing to lessen the likelihood of injury from this action (Tropp & Odenrick, 1988).

Pressure on the receiver is often attributed as a mechanism for ACL injury (Cochrane *et al*., 2007). The results suggested that medium to low pressure is the main experience of the receivers in all positions in National Schools netball. This conflicts the experience at the elite grade (Young *et al*., 2016), where regular indirect contact occurs on the receiver as a result of

high defensive pressure (Stuelcken *et al*., 2016). The necessity is for coaches at the National School grade to increase the frequency of pressure scenarios on the receiver in the training environment, to allow the player to develop effective movements based on the relationship between environmental and task constraints, decision-making and injury to allow the player to develop effective landing strategies, which will reduce their possibility of injury as they progress to the elite level.

The most prevalent jump involved a forward direction with WA, C and WD experiencing significantly more actions than players in the GD and GS position. This may be due to the limitation of space in the circle zone, where GD and GS are most active. The resultant posterior ground reaction force required to slow these players' horizontal momentum may increase the external flexion at the knee (Olsen *et al*., 2004). This ultimately acts as a mechanism for ACL injury. Implications for coaches and conditioners, therefore, should encourage a bilateral or 'run-on' strategy, whilst training in order to lower the forces generated on the knee with these forward jumps.

The second aim of this study was to identify those variables that predicted Grade from the sampled positions. The results of the logistic regression highlighted that the variables 'catch both hands', 'jump-turn in air-land', 'balance step' and 'land neutral feet outside shoulder width' were significant factors in predicting player grade (Table 3).

The negative Beta values reported for the variables 'Jump-turn in air-land' and 'Landing neutral and feet outside shoulder width' suggests that the fewer rotational jumps and wider base landings are associated with a higher-grade. The odds ratio (OR=0.627) indicates the probability of the position being in grade A is decreased by around 37% when the mean number of rotational jumps is increased by one (per position). The player is less likely to be in grade A by 31% (OR=0.687) if the mean number of wider base landings increases by one (per position). These results provide further support for the notion that the sample positions are Grade A when they use non-rotational jumps and limit the number of excessively-wide landings. A coaching implication from this would therefore be to encourage players to use jumps, which are direct (non-rotational) as frequently as possible and discouraging a wide base on landing.

The positive Beta values recorded for the variables 'Catch both hands' (B=0.112; OR=1.119) and 'Balance step' (B=0.366; OR=1.442) implies that these landing strategies are associated with higher grade players. Catching with both hands leads to retaining possession, which has been identified as a key aspect of netball performance. It is a positive defensive mechanism which reduces the grade of opposition ball possession and so reduces their opportunity for scoring or interception. On the attacking perspective, strong two handed catching provide a source of attack for the team through maintaining possession, which can lead to greater frequency of goal shooting opportunities.

Previous research has supported the finding that successful teams are more effective at converting possession into goal chances (Hughes & Franks, 2005). Grade A was 12% more likely if the mean double hand catching score was increased by one (per position). This has a positive training implication for coaches and conditioners. Knowledge of the use of double handed catches by position, completed in a game, can be used to determine if players need to improve their frequency of using double handed to catching compared to the average of the team. Increasing the player's knowledge of their performance, and the areas that they need to improve during practice, can be a focus of the design of the training environment. The use of various levels of pressure, to create a realistic game environment in the training context would also be a positive action from the coach to improve the grade at which the team participates.

Grade A was 14% more likely if the mean balance step score was increased by one (per position). The 'balance step' is a strategy that slows the player's momentum on landing and reduces the posterior ground reaction force on the knee, thus reducing the possibility of injury. By reducing the external flexion movement of the knee through the 'step' the player has reduced the strain on the knee and the ACL. The higher-grade players that use the balance step are therefore less prone to have experienced knee pain or ACL injury.

CONCLUSION AND RECOMMENDATIONS

Coaches and conditioners need to design the training environments to embrace the landing strategies associated with each specific position. The 'balance-step' strategy has a positive training implication as it enables more practice and game play without inhibited movement. Therefore, coaches and conditioners should encourage the 'balance step' in the training environment.

When selecting teams for matches and tournaments, coaches and conditioners need to prepare each athlete for the demands of the position that they play and not rely on a *general level* of physical conditioning. This is important across a tournament where, due to the intensity and duration, the level of injury risk is high. If a coach rotates a player to a different position in a match (without having done so in training), then they must be more aware of the detrimental impact that the variation of landing strategies will have on the player's performance when placed in their non-usual position.

A limitation of this study is the participants only being selected form one age group. It would be beneficial to understand the landing strategies used across age ranges and the implication to injury.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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