Title:

Prevalence and magnitude of preseason clinically-significant single-leg balance and hop test asymmetries in an English adult netball club

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1   **BLIND TITLE PAGE**

2   Prevalence and Magnitude of Preseason Clinically-Significant Single-Leg Balance and Hop

3   Test Asymmetries in an English Adult Netball Club

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28 **ABSTRACT**

29 *Objectives*: Side-to-side asymmetry of lower-limb motor-performance is associated with

30 increased noncontact injury risk in agility-sports. Side-to-side symmetry-analyses using single-

31 leg balance and hop tests has not been reported for community-level adult netball players. The

32 purpose of this study was to perform preseason side-to-side symmetry-analyses using eyes-

33 closed-balance (ECB), triple-hop-for-distance (THD), single-hop-for-distance (SHD), and

34 vertical-hop (VH) tests.

35 *Design*: Cross-sectional

36 *Setting*: Community-level adult netball club.

37 *Participants*: Twenty-three female players (age 28.7±6.2yr; height 171.6±7.0cm; mass

38 68.2±9.8kg).

39 *Main Outcome Measures*: Right-left group-level comparisons (paired t-test) and individual-level

40 comparisons (absolute-asymmetry (%)). A limb symmetry index was calculated for each test and

41 a clinically-significant absolute-asymmetry defined as >10%. Clinically-significant absolute-

42 asymmetry prevalence (%) was computed for each test.

43 *Results*: There were no right-left significant differences for any test. Maximum absolute-

44 asymmetries for the ECB, THD, SHD, and VH were 93.3%, 15.2%, 16.7%, and 60.3%,

45 respectively. The prevalence of clinically-significant absolute-asymmetries for the ECB, THD,

46 SHD, and VH was 91.3%, 8.7%, 8.7%, and 52.2%, respectively.

47 *Conclusions*: Group-level comparisons with statistical tests fail to expose the extent of clinically-

48 significant absolute-asymmetries. Most players demonstrated preseason clinically-significant

49 absolute-asymmetries for the ECB and VH tests. Preseason clinically-significant absolute-

50 asymmetries that may predispose increased lower-limb noncontact injury risk are widespread in

51 a community-level adult netball club.

52

INTRODUCTION

Netball is a predominantly female team sport with millions of players across more than 113 countries (1). In England in 2015, there were 2,945 netball clubs and 104,000 players (2) which increased to 180,200 players in 2017 (3). Since then, community-level netball participation in England has grown further with an increase in netball's popularity after the women's national team won the Commonwealth Games gold medal in 2018 (4). With an increase in sports participation comes an increase in the number of injuries (5). Netball injuries have reported rates of 9.49 injuries/1,000 players (6) and 500.7 injuries/1,000 playing hours (7). Of all injuries, 57.2-85.3% occur to the lower-limb (6, 8) with knee and ankle injuries being most frequent (7-10) and knee trauma representing almost one-third of netball-related hospitalisations (8). Such injuries result in profound consequences including disability (6, 11, 12), socioeconomic burden (6, 11, 13), and premature retirement from netball (14). Because netball participation in England is increasing, and because of the potential consequences of knee and ankle injury, strategies are needed to mitigate the effects of injury for players, teams, and society, and prolong players' safe participation across the lifespan.

In epidemiology, 'injury control' refers to preventing or reducing the severity of injury (15) and includes prevention, acute care, and rehabilitation phases of intervention (16). In the injury prevention phase, single-leg balance (SLB) and hop (SLH) tests are used to make side-to-side comparisons of motor-performance and inform judgements about lower-limb injury predisposition and risk (17-19). Single-leg balance and SLH tests are popular in clinical environments because they are quick-and-easy to perform and reliable and valid measures of lower-limb functional joint stability (20-23). The administration of assessments to profile athletes and identify those predisposed to injury is good clinical practice (24-26) and lower SLB and SLH performance is associated with higher lower-limb injury risk in agility-sport athletes (18, 27-30). When making SLB and SLH side-to-side comparisons that inform clinical reasoning about first-time injury predisposition, consideration is for whether statistically or clinically significant side-

82   to-side differences exist. Making a side-to-side comparison of the quantity of a variable represents

83   a between-limb symmetry analysis. Symmetry occurs when the variable is equal in magnitude in

84   both limbs. Asymmetry occurs when the variable is unequal in magnitude in both limbs.

85

86   At group-level, symmetry analysis involves procedures to determine if statistically significant

87   side-to-side differences exist for measures of central tendency (e.g. mean, median) (31-35). A

88   disadvantage of group-level analysis is that it masks clinically-significant asymmetries in some

89   individuals in the group (31-33). Measures of central tendency can mask clinical significance

90   because they reduce group data to a single central value that does not identify extreme values

91   either side of that value, presenting an incomplete picture of data distribution across all individuals

92   in the group (36). Consequently, measures of central tendency lose clinical meaningfulness

93   because individuals who demonstrate extreme values and resulting clinical concerns are missed.

94   At individual-level, symmetry analysis involves procedures to determine if clinically-significant

95   side-to-side differences exist for individuals' mean or maximum values (31, 32, 37). Procedures

96   involve the calculation of some form of 'limb symmetry index' (LSI) (31-33, 38). Calculation of

97   an LSI involves one limb's value divided by the other limb's value and the result multiplied by

98   100 to yield a percentage (20, 33, 38); 100% represents symmetry, and the size of any difference

99   below/above 100% represents the size of the absolute-asymmetry (e.g. LSIs of 85% and 115%

100   both indicate an absolute-asymmetry of 15%) (29, 31, 32). The LSI is valuable because it

101   identifies the size of a clinically-significant asymmetry in the individual (31, 32) where

102   'clinically-significant' is historically defined as an absolute-asymmetry >10% (39-41). Recently,

103   SLH test asymmetries >10% have been prospectively associated with higher first-time lower-limb

104   noncontact injury risk (29, 30). Because lower-limb motor-performance side-to-side comparisons

105   and asymmetry-analyses are clinically valuable for preseason screening and injury predisposition

106   and risk profiling (18, 27, 29, 42, 43) the use of preseason SLB and SLH testing and symmetry

107   analyses is a clinically diligent and sensible strategy in netball.

108

Several studies have employed lower-limb motor-performance tests with female netball players. Single-leg balance tests have been performed using sophisticated computer equipment with elite players in South Africa (44) and high-grade club players in New Zealand (45). Single-leg balance tests have also been performed using the Star Excursion Balance Test (SEBT) with Superleague players in England (46), using a modified SEBT with university players also in England (47), and using eyes-closed-balance (ECB) for time with school players in New Zealand (48). Single-leg hop tests have been performed using a force-plate and a vertical/forward/lateral task with national-level players in New Zealand (37) and a vertical-hop (VH) with club-level players in Australia (49). Single-leg hop tests have also been performed using the single-hop-for-distance (SHD) and triple-hop-for-distance (THD) with regional academy players in England (50). Of the studies cited, only three engaged in preseason assessments (44, 48, 50) with two focusing on players aged <19 years (yr) (44, 48). There is, therefore, an absence of literature reporting preseason lower-limb motor-performance in adult players. Adult players in local communities represent the largest proportion of players in England (2), and so characterising preseason lower-limb motor-performance is important to provide data about the frequency of clinically-significant asymmetries and injury predisposition in this population. Also of the studies cited, three required sophisticated computer equipment (37, 44, 45) and only one performed symmetry analyses (37). There is, subsequently, also an absence of literature regarding the use of 'field-based' lower-limb motor-performance tests with widely available equipment to identify clinically-significant asymmetries and injury predisposition with any adult netball player at any netball club in any country. A battery of low-cost, portable, and reliable lower-limb motor-performance tests capable of providing data useful for injury predisposition and risk profiling is a valuable tool for informing a community club's preseason planning and rational changes in practice.

There were two purposes for this study: 1. to determine if there were statistically significant side-to-side differences for the preseason single-leg ECB, THD, SHD, and VH in uninjured, adult, female netball players at one English community netball club; 2. to determine the prevalence of

136 clinically-significant preseason asymmetries for the ECB, THD, SHD, and VH tests. Tests were

137 chosen because they are associated with first-time lower limb injury risk in agility-sport athletes

138 (18, 27-30) and because they are portable, practically viable at many clubs, and are meaningful

139 to players and coaches regarding athletic performance. It was hypothesised: 1. there would be

140 statistically significant side-to-side differences for the ECB, THD, SHD, and VH tests; 2. the

141 majority of players would demonstrate clinically-significant asymmetries for the ECB, THD,

142 SHD, and VH tests. This study is original because no previous work has reported side-to-side

143 comparisons and asymmetry analyses for a battery of SLB and SLH field-tests in uninjured, adult,

144 female netball players at one English community netball club. This study's findings will be

145 practically significant because they will highlight the extent to which clinically-significant

146 preseason lower-limb motor-performance asymmetries linked to injury predisposition and risk

147 exist at a single club and require subsequent consideration for intervention.

148

149 **METHODS**

150 *Study design*

151 Cross-sectional.

152

153 *Sample size calculation*

154 An *a priori* power analysis was performed using G*Power (51). To detect a side-to-side difference

155 with a medium effect size (ES) of 0.50, 80% power, and significance set at 0.05, 27 participants

156 were required.

157

158 *Ethical approval, participant recruitment, informed consent*

159 University ethics approval was obtained. Participants were recruited from an English community

160 netball club using an email invitation distributed by the Club Secretary to all adult players.

161 Informed consent and a physical activity readiness questionnaire were completed by all

162 participants.

163

164 *Participants*

165 Inclusion criteria were: females aged 18-55yr participating in one or more netball

166 training/matches per week and registered for unrestricted preseason training. Exclusion criteria

167 were: current lower-quadrant pain, any time-loss lower-quadrant injury in the previous two

168 months (i.e. injury requiring withdrawal from one or more training/matches), any history of

169 lumbar spine/hip/knee/ankle fracture or surgery, and any current neurological condition that could

170 affect sensorimotor processing at any level of the nervous system (e.g. concussion). Twenty-three

171 players volunteered and reported being uninjured and available for selection (mean±standard

172 deviation: age 28.7±6.2yr; height 171.6±7.0 centimetres (cm); mass 68.2±9.8 kilograms (kg)).

173 The club competed in the London and South East Regional League and the Surrey County League.

174

175 *Instrumentation.*

176 Height was measured with a SECA 213 stadiometer (HaB Direct, Warwickshire, UK). Mass was

177 measured with SECA 760 weighing scales (HaB Direct, Warwickshire, UK). Leg-length was

178 measured with a fibreglass anthropometric measuring tape (HaB Direct, Warwickshire, UK). The

179 ECB test was measured with a Junso JS510 digital stopwatch (Sports Warehouse, Edinburgh,

180 UK). The THD and SHD were measured with a fibreglass athletics measuring tape (Sports

181 Warehouse, Edinburgh, UK). The VH was recorded with a Panasonic HC-V720 high-definition

182 Camcorder (Panasonic UK Ltd, Berkshire, UK) and analysed using Kinovea freeware (52).

183

184 *Procedures.*

185 Data collection occurred at the club's outdoor training site (concrete netball court) in one session.

186 Players were instructed to avoid fatiguing exercise/sports for 48 hours beforehand. Test/limb

187 order considered skill demands (high-to-low), cumulative muscle fatigue, and time-efficiency.

188 Data collection occurred in station order format: anthropometry (height, mass, leg-length),

189 barefoot ECB, shod THD, shod SHD, and shod VH. Limb order was right then left, players

190   alternated between limbs for each test. After the anthropometry and ECB stations, players

191   completed a standardised warm-up (toe-walking, heel-walking, parallel squats, forward lunge-

192   walk, right lateral-lunge walk, left lateral lunge-walk, high-knee lifts, butt-kicks, right and left

193   single-leg squats). Arm movement was permitted for all SLH tests to assist balance (21, 53, 54).

194   Practice trials for all tests were followed by three measured trials for each limb. Trials were

195   terminated if players reported any pain.

196

197   For anthropometry, standing height and mass were measured using routine procedures (55). For

198   leg-length (56), players were barefoot and supine-lying on a portable treatment table. Leg-length

199   was measured once from the anterior superior iliac spine to the tip of the medial malleolus using

200   the anthropometric tape measure to the nearest millimetre (mm). Reliability (intraclass correlation

201   coefficient (ICC)=0.99) has been reported for this procedure (56).

202

203   For the ECB test (57), players stood on the test-leg on a thin mat, the opposite leg flexed with the

204   heel level with but not touching the approximate mid-point of the standing leg's calf, the arms

205   crossed with the hands flat on the chest (Figure 1). Players were instructed to assume the test

206   position, look forwards, and acquire a steady posture before closing their eyes. Balance was

207   measured using the digital stopwatch in seconds (s) from the moment the eyes closed to the

208   moment balance was lost (opening eyes, uncrossing arms, touching heel to the calf, shifting the

209   stance leg foot, putting the non-stance leg foot to the floor). Reliability has been reported for the

210   timed ECB test (ICC=0.83) (57).

211

212

213 **Figure 1.** Eyes-Closed-Balance Test

214

215 For the THD (58) and SHD (33), players stood on the test-leg, the distal aspect of the foot aligned

216 with the posterior edge of a start-line (Figure 2). For the THD, players rapidly hopped forwards

217 on the same leg three times to stick the final landing (Figure 2). For the SHD, players

218 countermovement hopped forwards on the same leg once to stick the landing (Figure 2). For both

219 tests, loss of balance and placing the opposite foot on the floor voided the trial and resulted in

220 another attempt. Hop distance was measured from the posterior edge of the start-line to the distal

221 aspect of the foot to the nearest 0.5cm. Reliability has been reported for the THD (ICC=0.95) (59)

222 and SHD (ICC=0.96) (59).

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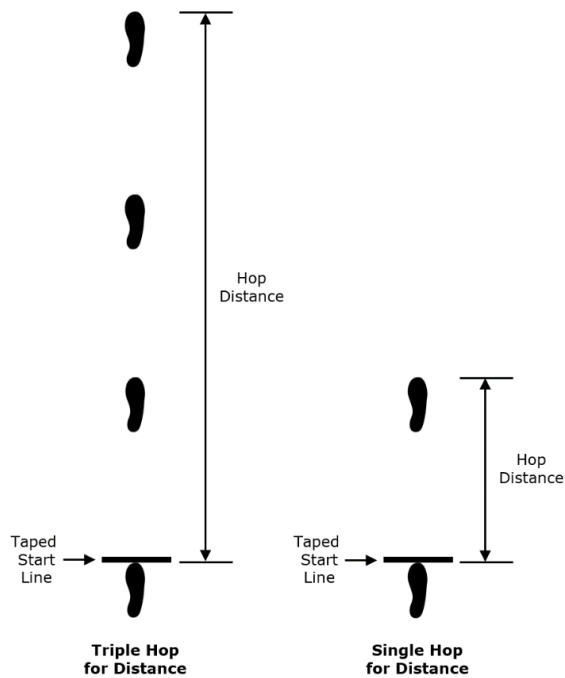
Figure 2. Triple-Hop-for-Distance and Single-Hop-for-Distance Tests

226

227 The VH was modified from previous work (38, 60). Players stood on the test-leg with the video

228 camera flat on the floor, the front of the camera 30cm from the lateral border of the foot and

229 perpendicular to the mid-point of the foot's long axis. Players countermovement hopped upwards

230 once as far as possible, straightening the leg (Figure 3), and then sticking the final landing. If the

231 test-leg failed to straighten or opposite foot touched down first the trial was voided and another

232 attempt performed. Players were given a "3, 2, 1, Go" countdown with camera recording started

233 before the "Go" and stopped after the player had both feet on the ground. The camera was not

234 moved during filming; players faced one direction for one leg and then turned to face the opposite

235 direction for the other leg. Hop distance was calculated from flight-time. Reliability for the

236 calculation of distance from flight-time has been reported (ICC=1.00) (60).

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Figure 3. Vertical-Hop Test

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Data Reduction

For the VH, video footage was transferred to a laptop computer with Kinovea freeware (52). Test-leg take-off and landing were defined as the first frame in which the foot was fully off the ground and any part of the foot was touching the ground, respectively (60). The freeware's timer was used to calculate flight-time (s), and VH height was then calculated using the formula $h = (t^2 \times 1.22625)$ where h is the height in meters and t is the flight-time in seconds (60). Hop height in meters was converted to centimetres. Normalisation of data to leg-length was performed for all SLH test trials (61): percent leg-length (%) = (distance hopped (cm) ÷ leg-length (cm)) × 100. The mean normalised values for each leg within all SLH tests were used for all analyses.

252

Data Analyses

Summary statistics were calculated including the absolute between-limb differences (right mean – left mean). The $+/-$ sign was removed from the difference. There were no missing data. For statistical analyses (group-level), normality of data was assessed with histogram inspection and Shapiro-Wilk tests. Alpha was set *a priori* at 0.05. Paired t-tests were used to compare within-test right- and left-side mean values (20, 33). Bonferroni-corrected alpha was set *a priori* at 0.01 (62, 63). In addition, 95% confidence intervals (CI) were calculated for within-test right- and left-side

260   values (63-65) and Cohen's *d* was estimated for within-test right-left ES (62). Effect sizes of 0.20,

261   0.50, and 0.80 were considered small, medium, and large, respectively (62).

262

263   For clinical analyses (individual-level), an LSI (%) was calculated for each player: (right mean ÷

264   left mean) × 100 (32, 39, 66). An LSI of 100% represented side-to-side symmetry, <100% lower

265   ride-side/higher left-side performance, >100% lower left-side/higher right-side performance; the

266   LSI, therefore, indicated both the magnitude (size) and direction (side) of asymmetry. Because

267   the size of asymmetry is the principal matter of clinical interest (20), absolute-asymmetry was

268   calculated: 100% − player's LSI. The +/− sign was removed from the difference. Because a

269   clinically-significant absolute-asymmetry is historically defined as an asymmetry >10% (39-41)

270   and an asymmetry >10% has been reported as prospectively associated with first-time noncontact

271   lower limb injury risk (29, 30), an absolute-asymmetry >10% was used in this study to define

272   'clinically-significant' and players 'at-risk' of injury (30). Counts were made of players with

273   absolute-asymmetries >10% and overall-prevalence (%) computed for each test: (number of

274   players with an absolute-asymmetry >10% ÷ total number of players) × 100 (67, 68). For the

275   players with an absolute-asymmetry >10%, side-prevalence was calculated for those with right-

276   side lower performance (% = number of players with right-side lower performance ÷ number of

277   players with absolute-asymmetry >10%); the remaining proportion represented those with left-

278   side lower performance.

279

280   **RESULTS**

281   Although the power analysis required 27 players, only 23 volunteered to participate from a

282   potential pool of 50 players. No player experienced pain during testing, and there were no adverse

283   events. Summary statistics are presented in Table 1 and 2.

284

Table 1. Summary statistics for right and left leg-length and non-normalised hop test values (n=23)

	Leg-Length (cm)			Triple Hop (cm)			Single Hop (cm)			Vertical Hop (cm)		
	R	L	Absolute Difference	R	L	Absolute Difference	R	L	Absolute Difference	R	L	Absolute Difference
Min	79.3	80	0.0	347.0	389.7	1.0	119.3	122.3	0.0	9.6	13.1	0.5
Max	104.5	104.9	1.5	592.0	541.0	65.3	202.3	191.0	25.0	26.7	27.5	6.0
95% CI	88.8, 94.3	88.7, 94.0	0.6, 0.9	440.1, 486.1	447.9, 481.3	12.8, 27.3	159.2, 174.8	159.6, 173.2	3.3, 8.6	18.4, 21.6	18.2, 20.9	1.6, 2.8
Mean	91.5	91.4	0.7	463.1	463.6	20.0	167.0	166.4	6.0	20.0	19.5	2.2
SD	6.3	6.2	0.4	53.2	38.7	16.8	18.0	15.7	6.1	3.7	3.1	1.3

cm = centimetres; R = right; L= left; Absolute Difference = right − left (+/− sign removed)
Min = minimum; Max = maximum; 95% CI = 95% confidence interval (lower bound, upper bound); SD = standard deviation

285

286

Table 2. Summary statistics and effect sizes for right and left balance and normalised hop test values (n=23)

	Eyes Closed Balance (s)			Triple Hop (%LL)			Single Hop (%LL)			Vertical Hop (%LL)		
	R	L	Absolute Difference	R	L	Absolute Difference	R	L	Absolute Difference	R	L	Absolute Difference
Min	3.0	7.2	0.8	383.4	427.6	1.3	131.9	133.0	0.6	8.5	6.5	0.6
Max	57.9	60.0	27.7	686.8	632.0	68.7	234.7	223.1	26.4	28.4	28.9	8.7
95% CI	15.6, 29.3	22.9, 36.3	8.3, 15.9	477.5, 539.5	486.4, 535.4	12.2, 28.6	172.7, 194.0	173.7, 192.4	4.2, 9.8	19.0, 23.5	18.4. 22.3	1.7, 3.3
Mean	22.5	29.6	12.1	508.5	510.9	20.4	183.4	183.0	7.0	21.3	20.6	2.5
SD	15.8	15.5	8.8	71.8	56.7	19.0	24.6	21.5	6.4	5.2	5.0	1.8
ES	0.50			0.04			0.01			0.18		

s = seconds; %LL = percentage of leg-length; R = right; L= left; Absolute Difference = right − left (+/− sign removed)
Min = minimum; Max = maximum; 95% CI = 95% confidence interval (lower bound, upper bound); SD = standard deviation; ES = effect size

287

288

289 All data were normally distributed (P>0.05). There were no significant side-to-side differences

290 for the ECB (P=0.02), THD (P=0.69), SHD (P=0.87), or VH (P=0.31) tests. The ECB test right

291 and left mean values and 95% CI were, however, quite different (Table 2). The right and left mean

292 values and 95% CI for the THD, SHD, and VH were similar (Table 2). The ECB test demonstrated

293 a medium ES, all other ES were small (Table 2).

294

295 Summary statistics for LSIs and absolute-asymmetries are presented in Table 3. The minimum

296 and maximum LSIs for the ECB and VH tests extended below and above 100% indicating some

297 players had large absolute-asymmetries where the lower performance was demonstrated by the

298 right or left side, respectively (Table 3). Very large absolute-asymmetries were evidenced by the

299 maximum absolute-asymmetries for the ECB and VH tests (Table 3). The overall-prevalence of

300 absolute-asymmetries >10% was high for the ECB test indicating the vast majority of players

301 demonstrated clinically-significant asymmetries (Table 3). The overall-prevalence of absolute-

302 asymmetries >10% for the VH indicated that more than half of the players demonstrated

303 clinically-significant asymmetries (Table 3). The overall-prevalence of clinically-significant

304 absolute-asymmetries was low for the THD and SHD (Table 3). For side-prevalence, the majority

305 of players had right-side lower performance for the ECB test whereas for the VH test the majority

306 of players had left-side lower performance (Table 3).

307

Table 3. Summary statistics for limb symmetry indices and absolute-asymmetries (n=23)

	Eyes Closed Balance		Triple Hop		Single Hop		Vertical Hop	
	LSI (%)	Absolute Asymmetry (%)	LSI (%)	Absolute Asymmetry (%)	LSI (%)	Absolute Asymmetry (%)	LSI (%)	Absolute Asymmetry (%)
Min	17.5	1.3	84.8	0.2	83.3	0.3	72.2	2.8
Max	193.3	93.3	112.1	15.2	116.4	16.7	160.3	60.3
95% CI	59.6, 99.5	33.3, 54.0	96.8, 101.9	2.4, 5.9	97.6, 102.7	2.2, 5.9	96.8, 112.7	8.3, 19.4
Mean	79.6	43.7	99.3	4.2	100.2	4.1	104.7	13.1
SD	46.2	24.0	5.8	4	6.0	4.3	18.4	12.8
O-Prevalence (%)	91.3		8.7		8.7		52.2	
S-Prevalence (%)	76.2		50.0		50.0		41.7	

LSI = limb symmetry index (see text for equation)
Absolute Asymmetry = absolute difference (+/− sign removed) between an LSI of 100% and an actual LSI
Min = minimum; Max = maximum; 95% CI = 95% confidence interval (lower bound, upper bound)
SD = standard deviation
O-Prevalence = overall-prevalence (see text for definition and equation)
308 S-Prevalence = side-prevalence (see text for definition and equation)

309

310 **DISCUSSION**

311 Netball participation in England is rapidly increasing at community-level versus elite-

312 /professional-level (3, 4) and, therefore, netball injury prevention efforts at community-level are

313 critical to maximise positive impacts on the largest numbers of players and help mitigate the

314 socioeconomic burden of netball lower-limb injury. The first purpose of this study was to

315 determine if there were statistically significant side-to-side differences for the preseason single-

316 leg ECB, THD, SHD, and VH tests in uninjured, adult, female netball players at one English

317 community netball club. It was hypothesised there would be statistically significant side-to-side

318 differences for all tests. Findings demonstrate there were no statistically significant side-to-side

319 differences for any test. The second purpose of this study was to determine the prevalence of

320 clinically-significant preseason asymmetries for the ECB, THD, SHD, and VH tests. It was

321 hypothesised the majority of players would demonstrate clinically-significant asymmetries for all

322 tests. Findings demonstrate the majority of players had clinically-significant asymmetries for the

323 ECB and VH tests only.

324

325 Comparison of the ECB and normalised SLH test values for this study (Table 2) to previous

326 literature is not possible because no other work has reported such data for uninjured, adult, female

327 netball players at one English community netball club. The alternative is to compare the ECB and

328 non-normalised hop test values for this study (Table 1) to data reported for uninjured female

329 netball players of different age and other similar adults. For the ECB test, mean values of 15.8-

330 20.8s for female netball players aged 15-17yr (48) and 28.8s for a mixed-sex group aged 20-29yr

331 (69) have been reported. For the THD, mean values of 586.0-590.0cm for female regional

332 academy netball players aged 17-19yr (50) and 519.4-532.4cm for female elite basketball players

333 with mean age 20.5yr (70) are recorded. For the SHD, mean values of 153.8-154.6cm for female

334 elite basketball players with mean age 20.5yr (70) and 187.0-188.0cm for female regional

335 academy netball players aged 17-19yr (50) have been reported. For the VH, mean values of 16.9-

336 17.6cm for female recreational agility-sport athletes (33) and 29.0-30.0cm for female elite tennis

337 players aged over 16yr (71) are recorded. Based on the studies cited here, mean test values for the

338 present work appear comparable with some literature. Until more literature examining preseason

339 single-leg motor-performance in uninjured, adult, female community-level netball players

340 become available, the present data serve as reference data for such players.

341

342 This study found no statistically significant side-to-side difference in group mean values for any

343 test (Table 2). Such findings are consistent with ECB and SHD right-left comparisons in uninjured

344 adults (69, 72). However, such findings are inconsistent with other work that identified

345 statistically significant differences for THD right-left comparisons in uninjured female elite

346 basketball players (70) (right-left ES=0.20). Use of ES alongside *P*-values is advocated because

347 *P*-values alone do not give an indication of the magnitude of difference between two central

348 tendency values for the same variable (63, 64). Use of the 95% CI is advocated because ES

349 themselves can distort study findings and be misleading (65). Although the ECB test

350 demonstrated a non-significant side-to-side difference, the right-left ES was medium and the right

351 and left 95% CI were quite different (Table 2) suggesting there were, in fact, real performance

352 differences between the right and left sides. Such findings are aligned with ECB data for

353 adolescent female netball players (48) (right-left ES=0.46). In contrast, for the THD, SHD, and

354 VH, right-left ES were small (trivial) and right and left CI were very similar (Table 2). Such

355 findings are also aligned with THD and SHD data for regional-level netball players (50) (right-

356 left ES=0.09-0.10). Regardless of the advocated use of ES alongside *P*-values, and regardless of

357 the trivial right-left ES for the THD, SHD, and VH in this study (Table 2), ES analysis still

358 represents group-level analysis which employs a variable's mean and/or standard deviation value

359 for its calculation (65). Such procedures, therefore, do not account for individuals with extreme

360 values either side of the central value and for whom there may be individual clinical concerns.

361 Consequently, although group-level right-left comparisons may demonstrate trivial side-to-side

362 ES, such comparisons are not useful in injury prevention because they fail to identify individuals

363 within the group who possess clinically-significant side-to-side differences and asymmetries (31-

364 33, 37).

365

366 An absolute-asymmetry >10% was used in this study to define clinically-significant asymmetry

367 because an absolute-asymmetry >10% is prospectively associated with first-time noncontact

368 lower-limb injury risk (29, 30). The majority of players demonstrated a clinically-significant

369 absolute-asymmetry for the ECB and VH tests (Table 3). Such findings are consistent with

370 previous work in uninjured agility-sport athletes (31). Because the majority of players in this

371 study demonstrated a clinically-significant absolute-asymmetry for either the ECB test or VH

372 (Table 3), this could indicate the majority of players were predisposed to and at-risk of first-time

373 noncontact lower-limb injury at that point-in-time. As such, preseason correction of clinically-

374 significant absolute-asymmetries using appropriate interventions should be considered by team

375   coaches and clinical personnel. Generic injury prevention interventions (i.e. standardised whole-

376   team exercise programmes) are known to be effective for reducing knee and ankle injury

377   incidence in agility-sport athletes (73-75). Alternatively, specific and targeted injury prevention

378   interventions (i.e. individualised exercise programmes) are also advocated for beneficially

379   modifying injury risk factors in agility-sport athletes (76-78). Because some players had right-

380   side lower performances and other players had left-side lower performances for different tests

381   (Table 3), individualised interventions may need to be prioritised over generic whole-team

382   training sessions (26, 79). Coaches and clinical personnel will need to decide which intervention

383   method best suits their team's logistical needs. Based on the present data, because clinically-

384   significant preseason absolute-asymmetries were highly prevalent, preseason screening for

385   clinically-significant absolute-asymmetries is a clinically diligent and overall sensible strategy in

386   English community-level adult netball. Correction of preseason clinically-significant absolute-

387   asymmetries may then contribute to the prevention of in-season knee and ankle injuries.

388

389   Potential limitations include not performing dominant-to-nondominant side-to-side comparisons

390   (33, 37, 72). Such comparisons were not performed because dominance changes according to task

391   demands (e.g. skill versus load-bearing) (80, 81) and because the size of an absolute-asymmetry

392   is the principal factor that first draws clinical attention after which the side with the lower task

393   performance is identified. Potential limitations also include using a simple LSI formula compared

394   to other more complex equations employing right and left designators within several

395   mathematical operations (82). Such equations were not used because the LSI formula used in this

396   study is indeed simple with few mathematical operations, is quick to complete, and ultimately

397   yields a clinically meaningful value. Potential limitations further include not sub-grouping players

398   into different team positions because different positions have distinct physiological/technical

399   demands (83). Sub-grouping was not performed in this study because individual-level analysis

400   and intervention-customisation are of most clinical importance when considering injury control

401   interventions (26). Future research should replicate this study's design with other similar player

402   samples to corroborate its findings. Future research should also replicate this study's design with

403   community-level child/adolescent samples to establish the prevalence of clinically-significant

404   absolute-asymmetries in the growing player. Both contexts of suggested future research will

405   provide valuable information for the community-level netball-specific lower-limb injury control

406   process.

407

408   **CONCLUSION**

409   The test battery used in this study was safely employed with a community-level netball club.

410   Uninjured, adult, female netball players did not demonstrate preseason statistically significant

411   side-to-side differences in ECB, THD, SHD, or VH performance. Group-level asymmetry

412   analyses using statistical significance tests, however, masked the extent to which individual

413   players possessed clinically-significant absolute-asymmetries that may require corrective

414   intervention. Researchers should use individual-level as well as group-level data analysis methods

415   when reporting asymmetry analyses with groups of athletes. The ECB and VH tests may be

416   particularly useful for identifying preseason clinically-significant asymmetries, although the THD

417   and SHD should also be employed for thoroughness because they are also capable of identifying

418   players with clinically-significant absolute-asymmetries. This study highlights the widespread

419   existence of preseason clinically-significant lower-limb motor-performance absolute-

420   asymmetries linked to injury predisposition and risk in a single English adult netball club. This

421   study also highlights a battery of low-cost and portable field-tests that are capable of contributing

422   to diligent and sensible netball club preseason screening.

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Highlights

- Group-level statistics fail to expose preseason clinically-significant asymmetries

- Most players had clinically-significant asymmetry for the eyes-closed-balance test

- Most players had clinically-significant asymmetry for the vertical-hop test

- Clinically-significant asymmetry is widespread in a community-level adult netball

Conflicts of Interest

None declared.

Ethical statement

This study received institutional ethics approval and all participants gave informed consent to participate.

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