Title:

Preseason weight-bearing ankle dorsiflexion in male professional football players with and without a history of severe ankle injury: A novel analysis in an English Premier League club.

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BLIND TITLE PAGE

Preseason weight-bearing ankle dorsiflexion in male professional football players with and without a history of severe ankle injury: a novel analysis in an English Premier League club.

ABSTRACT

Objectives: Ankle injuries are common in professional football and have profound player/team/club consequences. The weight-bearing lunge-test (WBLT) assesses ankle dorsiflexion range-of-motion in football primary/secondary injury prevention and performance contexts. Data for uninjured and previously ankle-injured players in the English Premier League (EPL) is not available. This study analysed WBLT measurements (cm) within and between uninjured and previously severe ankle-injured players (injured-stiff group, injured-lax group) in one EPL club.

Design: Cross-sectional.

Setting: Preseason.

Participants: Forty-nine players (age 22.9±4.6yr; height 181.6±5.2cm; mass 77.7±7.6kg).

Main Outcome Measures: Prevalence (%) of previous unilateral severe ankle injury (USAI). Side-to-side (right/left, dominant/nondominant, injured/uninjured) WBLT comparisons at group-level (*t*-test [within-group]; Welch's ANOVA [between-group]; effect sizes [within-/between-group]) and individual-level (limb symmetry index [%]; absolute-asymmetry [%]).

Results: Prevalence of USAI was 38.7%. There were no statistically-significant side-to-side differences for within-/between-group comparisons. Effect sizes: just-below-large (injured-stiff) and extremely-large (injured-lax) for within-group injured-side/uninjured-side comparisons; just-below-medium (injured-lax) to just-above-medium (injured-stiff) for injured-side comparisons to uninjured players. Absolute-asymmetries: uninjured players, 15.4±13.2%; injured-stiff, 21.8±33.6%; injured-lax 20.4±13.6%.

Conclusions: Over one-third of players had previous USAI. Effect sizes indicate substantial within-group side-to-side differences and less substantial between-group differences. Across groups, some players had absolute-asymmetries that may elicit concern in ankle primary/secondary injury prevention and performance contexts.

KEYWORDS

Football, ankle, injury prevention screening, weight-bearing lunge-test

INTRODUCTION

In professional football (soccer (hereafter, 'football')), traumatic ankle injuries are common. In a European study, ankle injuries represented 14% of injuries (1). In English football, ankle injuries account for 17% of injuries (2). Many ankle injuries are classed as "severe", defined as causing player absence from team training for >28 days (1, 3). For players, football injuries can have adverse physical and psychological consequences (4). For teams, when player match availability decreases after injury, the number of points per match decreases (5). When the amount of time lost to injury increases, a team's final league ranking decreases (5). For clubs, the financial burden of injury is substantial, some costs for injured professional players being €500,000/month (>€16,000/day) (6). Some English Premier League (EPL) clubs' injury expenses were ≈£11.5-26.5 million for one season alone (7). Ankle injuries in football have profound player, team, and club-level consequences. Therefore, first-time injury prevention strategies are prudent.

Following first-time ("index" (8)) ankle injury, repeat ankle injuries (re-injury, recurrent injury, subsequent injury) are also of concern in football. Ankle 're-injury' refers to an injury of the same site and type as the index injury within two months of return-to-participation (1). Ankle 'recurrent injury' represents an injury of the same site and type as the index injury more than two months after return-to-participation (9). Ankle 'subsequent injury' refers to an injury of the same ankle but of a different type as the index injury (10). Repeat ankle injuries are evident in football (2, 11, 12) with some injuries being more severe than the index injury (1). For individuals with past ankle injuries due to single or repeated trauma, some demonstrate *decreased* range-of-motion relative to the uninjured-side whilst others demonstrate *increased* range-of-motion relative to the uninjured-side (13); this indicates different sub-groups of individuals have different residual impairments after ankle trauma which may then require different ongoing intervention strategies to support continued sports participation. Repeat ankle injuries impose a profound burden on players and clubs and, therefore, repeat ankle injury prevention strategies are also prudent.

Primary injury prevention refers to preventing first-time injury (14, 15). Secondary injury prevention refers to preventing repeat injury and mitigating long-term disability (15, 16). Primary and secondary injury prevention do not expect the prevention of all injuries but the respective prevention of as many first-time and repeated injuries as possible (14). Therefore, primary and secondary injury prevention screening procedures identify characteristics (risk factors) that increase players' probability of sustaining an injury (17). Repeated screening should occur at multiple timepoints across a season (17, 18).

In Europe, 87% of professional teams conduct repeated injury prevention screening (19). The weight-bearing lunge-test (WBLT, Figure 1, (20)) is used in football for assessing ankle dorsiflexion range-of-motion (21-23). Injury prevention screening that includes the WBLT is useful because ankle dorsiflexion range-of-motion is associated with first-time ankle/calf injury (24, 25), is associated with gradual-onset knee injuries (26, 27), is limited after ankle ligament injury (28-30) and fracture (31, 32), and is associated with persistent symptoms of ankle dysfunction (33). Performance screening that includes the WBLT is also popular because ankle dorsiflexion range-of-motion is related to athleticism defined by dynamic balance (34, 35), change-of-direction running performance (36), and lower ground reaction forces during single-leg landings (37). Given the WBLT is useful for informing reasoning in primary and secondary injury prevention and performance contexts, screening of ankle dorsiflexion range-of-motion with the WBLT is a diligent procedure in football. Within-group side-to-side comparisons (right/left, dominant/nondominant, injured/uninjured) (38, 39) and between-group comparisons (injured group/uninjured group) (40, 41) are useful particularly for informing clinical reasoning in ankle injury prevention and rehabilitation contexts.

Figure 1. Weight-Bearing Lunge-Test.

Weight-bearing lunge-test data for uninjured players in the EPL has not been published. Further, WBLT data for EPL players with a history of severe ankle injury has not been disseminated. Therefore, there were five purposes for this study:

- *Purpose 1:* to establish the prevalence of a history of traumatic unilateral severe ankle injury (USAI) in professional football players (hereafter, 'players') in one EPL team. A severe ankle injury was defined as an injury resulting in players being absent from training for >28 days (1). It was hypothesised the minority (<50%) of players would have a history of USAI. We were interested in severe injuries because injury is the reason most players (46%) retire from football (42) and because severe injuries impose the greatest logistical and financial burden on clubs (1, 6, 11).
- *Purpose 2:* to determine if there were statistically-significant side-to-side differences for the mean WBLT in a reference group of players (right/left, dominant/nondominant) and in players with a history of USAI (uninjured/injured). It was hypothesised there would be statistically-significant side-to-side differences across groups.
- *Purpose 3:* to identify if there were statistically-significant differences between the mean WBLT for the reference group and the mean WBLT for the uninjured and injured sides of

players with a history of USAI. It was hypothesised there would be statistically-significant differences between groups.

- *Purpose 4:* to establish the mean side-to-side absolute-asymmetry for the WBLT in the reference group (right/left, dominant/nondominant) and in players with a history of USAI (uninjured/injured). It was hypothesised the mean absolute-asymmetry for the reference group would be lower than that for players with a history of USAI.
- *Purpose 5:* to determine the prevalence of WBLT side-to-side absolute-asymmetries (≤5%, >5%, >10%, >15%) for the reference group (right/left, dominant/nondominant) and the players with a history of USAI (uninjured/injured). These absolute-asymmetry thresholds were selected in line with previous work (38, 39). It was hypothesised that a proportion of players would possess absolute-asymmetries at each threshold across groups.

This study is original because it is the first to examine preseason WBLT data for an EPL football team. This study's findings will be practically-significant and have real-world impact because they will inform the design and implementation of primary and secondary ankle injury prevention strategies for male professional football players.

MATERIALS AND METHODS

Study Design

This was a cross-sectional study. Data were collected within the team's mandatory 2019-2020 preseason injury prevention screening. The study involved a unique sample (one professional team) with a fixed maximum number of possible participants in the sample (based on team roster). Therefore, because it was known in advance that an inevitably "small" number of participants (n<20 (43)) would be in one or more sub-groups from the fixed maximum number of possible participants, an *a priori* power analysis was redundant.

Ethical approval, participant recruitment, informed consent

Athletes are considered a "vulnerable population" due to external pressures to perform and the potential to be coerced by others in their sport (44, 45). In line with published guidance (45), we recognised the players as a vulnerable population and designed our recruitment and consent procedures accordingly. To negate situations involving one-to-one invitation from a researcher to a participant, players were recruited using flyers on training ground noticeboards located in open plan areas. To protect a player's anonymity relative to other players and coaching staff, the flyer requested that interested players contact researchers directly for a participant information sheet. Even though data was collected as part of mandatory preseason procedures, the participant information sheet included an explicit statement that use of players' data for research purposes was entirely voluntary. The informed consent form included an explicit statement that players were under no obligation to agree to the use of their data for research purposes and were free to withdraw their data at any time without negative judgement or later detriment. Institutional approval was obtained. Informed consent was declared by all volunteers.

Sub-Group Classification

Individuals with past ankle injuries can demonstrate decreased or increased range-of-motion relative to the uninjured-side (13). Injury categorisation and sub-group classification requires considerable clinical expertise (46). Therefore, we used previous literature (13) and our combined clinical experience (>38 years) to inform the sub-group classification of players. Players without a history of severe ankle injury (hereafter, 'reference' players) were defined as players without a history of severe ankle injury to either side. Players with a history of severe ankle injury (hereafter, 'injured' players) were divided into 'injured-stiff' and 'injured-lax' sub-groups. Injured-stiff players demonstrated a *lower* WBLT value in the ankle with a history of severe injury (hereafter, 'injured' ankle/side) versus the opposite side (hereafter, 'uninjured' ankle/side). As in typical clinical environments, the term 'stiff' (*sic*, 'stiffness') is not employed as in usual bioengineering definitions (47), but rather represents a *decreased peak joint range-of-motion* versus the uninjured-side (47). Injured-lax players demonstrated a *higher* WBLT value in the injured ankle versus the uninjured ankle. As in typical clinical environments, the term ‘lax’ represents an *increased peak joint range-of-motion* compared to the uninjured-side (48).

Participants

Inclusion criteria were: male, aged ≥18 years, with a professional contract, eligible for first-team selection, and fit for preseason training. Exclusion criteria were: current ankle injury receiving treatment and history of severe injury to both ankles. Players’ history of traumatic severe ankle injury was determined by reviewing the club’s medical database which included data on USAIs sustained by players before and after joining the club. For players injured before joining the club, data regarding a history of traumatic severe ankle injury was entered into the database from players’ medical records and imaging reports requested from the previous club’s medical department. A player was considered rehabilitated when he returned to team training (49). Severity of injury was calculated as the number of days from injury to return to team training (1).

Fifty-five players were contracted professionals. Six players were on loan to other clubs. Of the 49 available players, all volunteered to participate (Table 1). Two players (4.1%) were excluded with a history of severe injury to both ankles. Forty-seven players (95.9%) were included (hereafter, ‘the team’).

Table 1. Player descriptive statistics

	All Available Players (*n* =49)*			**Reference (*n* =28)**			**Injured-Stiff (*n* =13)**				**Injured-Lax (*n* =6)**			
	Age (yr)	Height (cm)	Mass (kg)	Age (yr)	Height (cm)	Mass (kg)	Age (yr)	Height (cm)	Mass (kg)	Days**	Age (yr)	Height (cm)	Mass (kg)	Days**
Minimum	18.0	172.0	61.0	18.0	172.0	61.0	18.0	173.0	70.0	28.0	18.0	173.0	66.0	29.0
Maximum	36.0	196.0	95.0	36.0	188.0	93.0	29.0	196.0	95.0	83.0	20.0	185.0	82.0	81.0
Median	21.0	181.0	78.0	21.5	181.5	77.0	22.0	181.0	78.0	43.0	18.5	180.0	69.5	49.5
Mean	22.9	181.6	77.7	23.3	181.4	77.3	23.1	181.8	79.1	48.6	18.7	179.8	72.0	50.0
SD	4.6	5.2	7.6	4.8	5.0	7.6	3.8	5.8	5.8	19.6	0.8	4.2	6.8	18.0
DL (R, L)	38, 11			22, 6			10, 3				6, 0			

*includes two players with bilateral severe ankle injury who were removed from subsequent sub-group analyses
yr = years; cm = centimetres; kg = kilograms
**severity of injury; see text for explanation
DL = dominant limb; R = right; L = left

Procedures

Data collection occurred at the team's training ground at the start of preseason training. The WBLT (Figure 1) was one procedure amongst several standardised assessments for injury prevention screening and was completed before more dynamic tasks. The WBLT data were collected by one of three physiotherapists with >10 years' clinical experience in sports medicine.

The WBLT trials were measured as described previously (20, 50). Players were barefoot, the foot of the test-leg positioned so that the first toe and mid-point of the calcaneus were in a straight line perpendicular to the wall. Players' hands were placed on the wall to help maintain balance. The opposite leg and foot were positioned comfortably at the side, on the floor. The player lunged forwards keeping the knee in line with the second toe to touch the wall with the knee. The foot was progressed gradually away from the wall until the furthest point at which the knee could touch the wall with the heel on the floor was identified. If the heel was raised from the floor, the foot was progressed forwards until the heel made contact with the floor. Knee contact with the wall and heel contact with the floor were monitored visually. Maximum dorsiflexion range-of-motion was the maximum distance between the tip of the first toe and the edge of the wall whilst keeping the knee in contact with the wall and the heel on the floor. Measurements were made to the nearest 0.5cm. If a player could not touch the wall with the knee when the tip of the first toe was touching the wall, a 0.0cm measurement was assigned. Because time scarcity can be a problem when screening large numbers of athletes (51), only one trial was performed for each leg as per previous work (32, 52). Inter-rater reliability for the WBLT maximum distance from one trial has been reported for uninjured individuals (intraclass-correlation-coefficient [ICC] 0.98-0.99; standard-error-of-measurement [SEM] = 0.3cm) (52) and those with ankle trauma (ICC = 0.97; SEM = 1.4cm) (32).

Data Analysis

Purpose 1: counts were made of players in each group and prevalence (%) calculated: (number of players in a group ÷ total number of players) × 100. In addition, for injured group players, counts were made of those with severe ankle injury to the dominant-side and within-group prevalence (%) calculated: (number of dominant-side injuries ÷ all within-group injuries) × 100. The dominant-side was defined as the preferred kicking side (53). Counts were also made of specific categories of ankle injury (ligament sprain, bone fracture, bone contusion) and within-group prevalence (%) calculated: (number in a specific injury category ÷ all within-group injuries) × 100.

Purpose 2 and 3: comprehensive WBLT summary statistics were computed including absolute side-to-side differences (right−left, dominant−nondominant, uninjured−injured). The minus sign was removed from negative differences. There were no missing data. For statistical analyses of group-level comparisons, normality of data was assessed with histogram inspection and Shapiro-Wilk tests. Equality of variance was assessed with Levene's test. Alpha was set *a priori* (0.05). Paired t-tests were used for within-group side-to-side comparisons. Bonferroni-corrected alpha was set *a priori* (0.01). Then, as in previous work (53, 54), reference players' dominant and nondominant sides were pooled to create a reference group of 56 data points. Because of substantial sample size differences across groups and heterogeneity of variances, Welch's one-way ANOVA was used for between-group comparisons (55) (Table 2). Dunnett's T3 *post hoc* tests for multiple comparisons were used to locate between-group differences (56). Alpha was set *a priori* (0.05). Ninety-five percent confidence intervals (CI) were estimated for all data (57). Cohen's *d* was calculated for within-group comparison effect sizes (ES) (58). Because of the unequal sample sizes between groups, and because of the small sample sizes for the injured groups, Hedge's *g* was calculated for between-group comparison ES (43). For Cohen's *d* and Hedge's *g*, ES of 0.20, 0.50, 0.80, 1.10, and ≥1.40 were considered small, medium, large, very-large, and extremely-large, respectively (59).

Table 2. Welch's One-Way ANOVA Between-Group Comparisons*

Reference group versus injured-stiff group uninjured-side
Reference group versus injured-stiff group injured-side
Reference group versus injured-lax group uninjured-side
Reference group versus injured-lax group injured-side

*see text for group and uninjured-/injured-side definitions

Purpose 4: for clinical analyses of individual-level side-to-side comparisons, three types of limb symmetry index (LSI) were calculated: right/left LSI (R/L-LSI), dominant/nondominant LSI (D/ND-LSI), and injured/uninjured LSI (INJ/UNINJ-LSI). The R/L-LSI (%) was calculated as: (right ÷ left) × 100 (60). The D/ND-LSI (%) was calculated as: (dominant ÷ nondominant) × 100 (61). The INJ/UNINJ-LSI was calculated as: (injured ÷ uninjured) × 100 (62). The size of an absolute-asymmetry is frequently the principal matter of clinical interest (60). Therefore, absolute-asymmetry for each LSI was computed: 100 − player's LSI (60). The minus sign was removed from negative differences.

Purpose 5: for each group, counts were made of participants with absolute-asymmetries (≤5%, >5%, >10%, >15%) and prevalence (%) computed: (number of players with a specific percentage of absolute-asymmetry ÷ number of players in the group) × 100.

RESULTS

Purpose 1: of the 47 players (95.9%), 28 (57.1%), 13 (26.5%), and six (12.2%) were in the reference, injured-stiff, and injured-lax groups, respectively (Table 1); the minority of players (38.7%) had a history of USAI. Five (38.5%) and four (66.6%) dominant-side injuries presented in the injured-stiff and injured-lax groups, respectively. For the injured-stiff group, nine (69.2%) were lateral ligament sprains, two (15.4%) were medial ligament sprains, one (7.7%) was a combined lateral/medial ligament sprain, and one (7.7%) was an ankle fracture. For the injured-lax group, five (83.3%) were lateral ligament sprains and one (7.7%) was a medial bone contusion.

No player experienced pain/adverse event during data collection. A scatterplot of data is presented in Figure 2. Summary statistics are presented in Table 3.

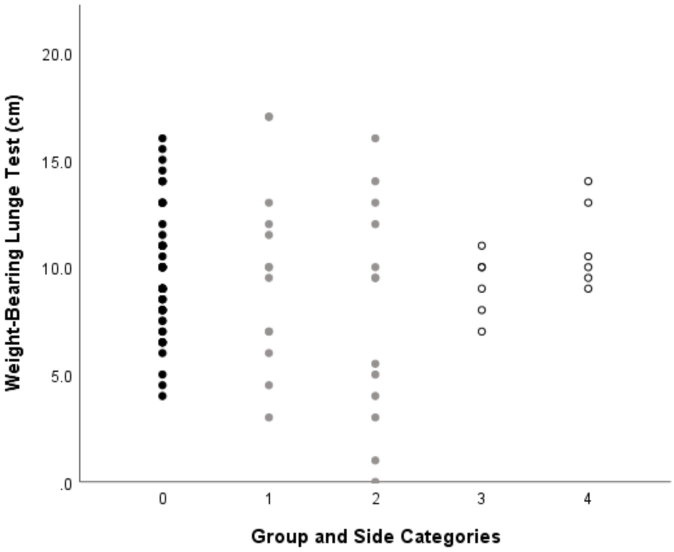

Figure 2. Scatterplot of players' data by group and side.
0 = reference group dominant-side and nondominant-side pooled data (*n*=56)
1 = injured-stiff group, uninjured-side (*n*=13)
2 = injured-stiff group, injured-side (*n*=13)
3 = injured-lax group, uninjured-side (*n*=6)
4 - injured-lax group, injured-side (*n*=6)
Note: the number of dots does not necessarily equal the number of players in a group; this is because two or more players in a group demonstrated the same value and, therefore, two or more dots superimpose in the plot.

Table 3. Summary statistics for the weight-bearing lunge test (cm) and within-group side-to-side comparison effect sizes

	Reference (*n* =28)								**Injured-Stiff (*n* =13)**			**Injured-Lax (*n* =6)**		
	R	L	R−L Absolute Difference	R+L Pooled*	D	ND	D−ND Absolute Difference	D+ND Pooled*	U	I	U−I Absolute Difference	U	I	U−I Absolute Difference
Minimum	4.0	4.5	0.0	4.0	4.0	4.5	0.0	4.0	3.0	0.0	0.0	7.0	9.0	0.5
Maximum	15.0	16.0	4.0	16.0	15.0	16.0	4.0	16.0	17.0	16.0	8.5	11.0	14.0	4.0
Median	9.0	9.5	1.0	9.0	9.0	10.0	1.0	9.0	10.0	9.5	0.5	9.5	10.3	2.0
95% CI	8.5, 10.7	8.7, 10.9	0.9, 1.7	9.0, 10.5	8.5, 10.6	8.8, 11.0	0.9, 1.8	9.0, 10.5	7.1, 12.4	4.7, 10.9	0.3, 3.5	7.6, 10.7	8.8, 13.1	0.5, 3.2
Mean	9.6	9.8	1.3	9.8	9.5	9.9	1.3	9.8	9.8	7.8	1.9	9.1	11.0	1.8
SD	2.7	2.8	1.0	2.8	2.7	2.8	1.0	2.8	4.3	5.1	2.7	1.4	2.0	1.3
ES	0.12				0.24				0.72			1.48		

R = right; L= left; R−L Absolute Difference = right − left (negative signs removed)
*R+L Pooled data represents descriptive statistics for *n* =56 ankles
D = dominant; ND = nondominant; D−ND Absolute Difference = dominant − nondominant (negative signs removed)
*D+ND Pooled data represents descriptive statistics for *n* =56 ankles
U = uninjured side; I - injured side; U−I Absolute Difference = uninjured side − injured side (negative signs removed)
95% CI = 95% confidence interval (lower bound, upper bound); SD = standard deviation; ES = Cohen's *d* effect size

Purpose 2 and 3: all data were normally distributed ($P \geq 0.26$). There was a statistically-significant between-group difference for the equality of variance (P=0.00). There were no statistically-significant within-group side-to-side differences for the reference right/left (P=0.45), reference dominant/nondominant (P=0.33), injured-stiff uninjured/injured (P=0.03), or injured-lax uninjured/injured (P=0.02) comparisons. Welch's ANOVA returned no statistically-significant between-group differences ($F(4,89)$=1.17, P=0.33). For WBLT 95% CIs (Table 3), the reference group's right/left and dominant/nondominant lower and upper boundaries were virtually identical. The injured-stiff and injured-lax groups' injured-side lower and upper boundaries were not similar to the uninjured-side. In the injured-stiff group, the injured-side 95% CIs were lower than the uninjured-side. In the injured-lax group, the injured-side 95% CIs were higher than the uninjured-side. For within-group Cohen's *d* ES (Table 3), values were: small for right/left and dominant/nondominant comparisons in the reference group; just-below-large for uninjured/injured comparisons in the injured-stiff group; extremely-large for uninjured/injured comparisons in the injured-lax group. For between-group Hedge's *g* ES, values were: reference group versus injured-stiff group uninjured-side, 0.32 (small-to-medium); reference group versus injured-stiff group injured-side, 0.58 (just-above-medium); reference group versus injured-lax group uninjured-side, 0.23 (just-above-small); reference group versus injured-lax group injured-side, 0.49 (just-below-medium).

Purpose 4: summary statistics for the LSIs and absolute-asymmetries are presented in Table 4. The mean values and 95% CIs for the R/L-LSI and D/ND-LSI were virtually identical. The minimum and maximum values for the R/L-LSI and D/ND-LSI were identical and extended far below and above 100%, indicating some players had large absolute-asymmetries. The mean value for the injured-stiff group's INJ/UNINJ-LSI was far below 100%, indicating that players' injured-sides had lost ankle dorsiflexion range-of-motion relative to the uninjured-side. The mean value for the injured-lax group's INJ/UNINJ-LSI was far above 100%, indicating that players' injured-sides had gained ankle dorsiflexion range-of-motion relative to the uninjured-side. The mean and

95% CIs for absolute-asymmetry for the right/left and dominant/nondominant comparisons were virtually identical. The mean absolute-asymmetries for the injured-stiff and injured-lax groups represented a loss and gain, respectively, of approximately one-fifth of ankle dorsiflexion range-of-motion for the injured-side.

Purpose 5: for the prevalence of absolute-asymmetry (Table 4), almost half of the reference group had an absolute-asymmetry >15%. Over one-third and two-thirds of the injured-stiff and injured-lax groups, respectively, had an absolute-asymmetry >15%.

Table 4. Summary statistics for limb symmetry indices and absolute-asymmetries

	Reference (*n* =28)				Injured-Stiff (*n* =13)		Injured-Lax (*n* =6)	
	R/L Limb Symmetry Index (%)	R/L Absolute Asymmetry (%)	D/ND Limb Symmetry Index (%)	D/ND Absolute Asymmetry (%)	I/U Limb Symmetry Index (%)	I/U Absolute Asymmetry (%)	I/U Limb Symmetry Index (%)	I/U Absolute Asymmetry (%)
Minimum	61.5	0.0	61.5	0.0	0.0	0.0	105.0	5.0
Maximum	150.0	50.0	150.0	50.0	100.0	89.5	140.0	40.0
Median	100.0	14.3	96.9	14.3	91.7	8.3	121.6	21.6
95% CI	91.2, 107.2	10.3, 20.6	90.4, 106.3	10.2, 20.5	57.9, 98.4	1.5, 42.0	106.0, 134.7	6.0, 34.7
Mean	99.2	15.4	98.3	15.4	78.2	21.8	120.4	20.4
SD	20.5	13.2	20.4	13.2	33.5	33.6	13.6	13.6
Prevalence (%) A-A ≤5%	21.4		21.4		38.4		16.7	
Prevalence (%) A-A >5%	78.6		78.6		61.5		83.3	
Prevalence (%) A-A >10%	57.1		57.4		23.1		66.7	
Prevalence (%) A-A >15%	46.4		46.4		38.5		66.7	

R/L = right/left; D/ND = dominant/nondominant; I/U = injured/uninjured
Limb Symmetry Index, see text for equation and explanation; Absolute Asymmetry, see text for equation and explanation
95% CI = 95% confidence interval (lower bound, upper bound); SD = standard deviation
Prevalence (%) A-A = prevalence of absolute-asymmetry; see text for equation and explanation for each absolute-asymmetry percentage threshold

DISCUSSION

The first purpose of this study was to establish the prevalence of a history of USAI in players in one EPL team. It was hypothesised the minority of players would have such a history. Just over one-third of players had a history of USAI. The second purpose was to determine if there were statistically-significant side-to-side differences for the WBLT in reference players and in players with a history of USAI. It was hypothesised there would be statistically-significant side-to-side differences across groups. There were no within-group statistically-significant side-to-side differences. The third purpose was to identify if there were statistically-significant differences between the WBLT for reference players and the WBLT for the uninjured and injured sides of players with a history of USAI. It was hypothesised there would be statistically-significant differences between groups. There were no between-group statistically-significant differences. The fourth purpose was to establish the mean side-to-side absolute-asymmetry for the WBLT in reference players and in players with a history of USAI. It was hypothesised the mean absolute-asymmetry for reference players would be lower than that for players with a history of USAI. The mean absolute-asymmetry for reference players was lower than that for both groups of injured players. Fifth, to determine the prevalence of WBLT side-to-side absolute-asymmetries of ≤5%, >5%, >10%, and >15% for reference players and in players with a history of USAI. It was hypothesised that a proportion of players would possess absolute-asymmetries at each threshold across groups. The prevalence of absolute-asymmetries of each threshold was consistently >20% across groups.

Here, severe ankle injury was defined as an injury that caused a player absence from team training for >28 days (1, 3). Most ankle sprains (89-95%) (63) and fractures (69.4%) (64) involve osteochondral lesions of the talus (OCL-T). Most people (53-58%) with OCL-T reduce sports and develop osteoarthritis (13). Given the frequency of severe ankle injuries in football (1, 3), many players can be expected to decrease football participation and experience talocrural joint osteoarthritis. Given there is no such thing as a simple ankle sprain (65), and many players retire after injury prematurely (42), professional clubs with players with a history of severe ankle injury may wish to consider ongoing conservative ankle joint preservation strategies to optimise players' career longevity, mitigate risk of premature retirement, and protect financial investments.

Within-group side-to-side comparisons (38, 39) of ankle dorsiflexion range-of-motion are useful for informing clinical reasoning. Within-group and within-individual side-to-side comparisons premise that one side (e.g. dominant-side, uninjured-side) serves as a reference standard for clinical judgements relative to the opposite side (66). The mean WBLT values for the reference group and the uninjured-side of the injured groups (Table 3) are consistent with those for uninjured professional football players (21, 23). In this study, there were no within-group statistically-significant differences for any side-to-side comparison. However, the just-below-large and extremely-large ES for the uninjured/injured side-to-side comparisons in the injured-stiff and injured-lax groups (Table 3), respectively, indicate substantial within-group side-to-side differences. Because side-to-side symmetry of ankle dorsiflexion range-of-motion may be important in secondary injury prevention and performance contexts, team medical staff may wish to consider targeted 'asymmetry-mitigation' interventions for players with injured-stiff and injured-lax ankles as defined in this study. Indeed, ankle sagittal plane range-of-motion impairments are associated with radiographic evidence of ankle and foot post-trauma osteoarthritis (67) and best practice clinical guidelines recommend use of targeted interventions to modify ankle joint mobility after injury (68).

Between-group comparisons (40, 41) of ankle dorsiflexion range-of-motion are also useful for informing clinical reasoning. When performing within-group/within-individual side-to-side comparisons where an injured-side is compared to an uninjured-side, use of the uninjured-side as a reference standard assumes that it has not adapted negatively following injury to the injured-side (66). When performing within-group/within-individual side-to-side comparisons with injured players it is clinically important to also routinely compare the uninjured-side values to data from uninjured cohorts; this determines whether the uninjured-side of an injured player exists within 'normal' ranges (66). Here, there were no between-group statistically-significant differences for any WBLT comparison. Hedge's *g* ES for comparison of the injured groups' uninjured-side to the reference players' data ranged from just-above-small to small-to-medium. Therefore, in this study, it was acceptable to use the injured groups' uninjured-side as a reference standard against which the status of the injured-side was compared. Hedge's *g* ES for comparison of the injured groups' injured-side to the reference players' data ranged from just-below-medium to just-above-medium indicating that, despite findings from the between-group significance tests, the injured groups' injured-side data deviated from established reference values. Subsequently, group-level analyses should then progress to individual-level analyses to determine the extent of deviation from established reference values (60, 69).

Group-level analyses with statistical tests masks individual-level clinically-significant absolute-asymmetries (60, 69). Therefore, WBLT LSI and absolute-asymmetry analyses were used to identify individual players with side-to-side ankle dorsiflexion profiles that implicate need for customised intervention (17). The mean and maximum absolute-asymmetry values (Table 4) indicate that across groups some players had substantial side-to-side proportional (relative) differences in ankle dorsiflexion range-of-motion. The size of a side-to-side proportional difference is typically the factor drawing clinicians' initial attention, after which the size of an absolute difference is determined and the side requiring intervention is identified (60, 69). A strategy for players with substantial side-to-side differences in ankle dorsiflexion range-of-motion may be to undertake individual-level training sessions containing customised interventions at certain times in the week whilst engaging in generic team-level fitness/technical sessions at other times in the week.

Determining the prevalence of health-/injury-related conditions highlights the potential impact of such conditions for a team and is important for planning the delivery of interventions (70). The range-of-motion absolute-asymmetry thresholds used in this study (Table 4) were selected as in previous work where an absolute-asymmetry >15% was identified as a threshold for clinical concern (38, 39). Across groups, approximately one- to two-thirds of players had WBLT absolute-asymmetries >15% (Table 4). Consequently, large proportions of players may require targeted interventions to modify ankle dorsiflexion range-of-motion as part of primary/secondary ankle injury prevention and performance enhancement strategies.

This study, along with other work (13), demonstrates that individuals with injured ankles can have both decreased and increased range-of-motion relative to the uninjured-side. We defined groups of players with decreased and increased WBLT values relative to the uninjured-side as being in the injured-stiff and injured-lax groups, respectively. Therefore, two categories of ankle dorsiflexion range-of-motion asymmetry-mitigation interventions can be employed: mobility and stability interventions. Mobility interventions include joint mobilisations (71) and mobility exercises (72) for injured-stiff players, both of which can increase ankle dorsiflexion range-of-motion (73, 74). Stability interventions refer to neuromuscular exercises (e.g. strength training, plyometric training) (75) for injured-lax players, which are able to increase ankle plantarflexor unit stiffness (76, 77) and, in turn, can then resist potentially excessive ankle dorsiflexion displacement. Within-individual side-to-side comparisons, followed by a comparison of both sides to other reference data, is necessary to accurately classify the status of players' injured and uninjured ankles and properly inform clinical-reasoning for individualised interventions targeted to players' unique impairment profiles (17, 60, 69).

Potential limitations include not undertaking an *a priori* power analysis. Power analyses should consider a study's real-world context and practicality (78). When working with one professional team, it is not possible to recruit the sample sizes returned from an *a priori* power analysis for between-group analyses for three or more sub-groups. We did not undertake an *a priori* power analysis because it was known in advance that a small number of participants would be in one or more sub-groups from the fixed maximum number of possible participants; therefore, such analysis was redundant. Potential limitations also include not undertaking a *post hoc* power analysis. A *post hoc* power analysis employs the *P*-value returned from significance tests (79). Because nonsignificant *P*-values always correspond to low beta values and power (79), *post hoc* power analyses do not add value to the interpretation of research findings and are discouraged (79, 80). Given the anticipated small number of participants for the two injured groups, and the limitations of statistical significance testing discussed elsewhere extensively (57, 81, 82), we also used 95% CIs, Cohen's *d*, and Hedge's *g* explicitly to better estimate the size of within-group side-to-side and between-group differences (57, 70, 82); these procedures aided determining the contextually-specific clinical-meaningfulness of our novel data (57, 58, 83). Potential limitations further include that this study sub-grouped players by a history of USAI only, where "severe" was defined as player absence from team training for >28 days (1, 3). Consequently, some players in the 'reference' group could have had unilateral or bilateral ankle injuries that were not severe and were, for example, "moderate" or "mild" (player absence from team training for 8-28 or 4-7 days, respectively) (1, 3). Therefore, given it is plausible to have persistent impaired ankle dorsiflexion regardless of the severity of ankle injury (defined by number of days absence from training), some players in the present reference group may also have had post-injury absolute-asymmetries above the 15% threshold for clinical concern due to past mild or moderate ankle trauma (Table 4).

This study's findings are only generalisable to similar unique samples of male professional football players. Future research should replicate this study with other EPL teams to establish the consistency of findings. Future research should also replicate this study with female professional football players to inform reasoning in female-specific injury control and performance optimisation. Future research should further give careful consideration to how injured players are sub-grouped in order to best inform the planning and delivery of clinical and performance interventions in professional football.

CONCLUSION

Over one-third of the present EPL team had a history of USAI. There were no within-group statistically-significant differences for any WBLT side-to-side comparison although ES analyses indicate within-group side-to-side differences were substantial. There were no between-group statistically-significant differences for any WBLT comparison although ES analyses indicate the injured groups' injured-side data deviated from established reference values. In all groups, some players had substantial side-to-side absolute-asymmetries in ankle dorsiflexion range-of-motion.

Large proportions of players in all groups had absolute-asymmetries in range-of-motion that were above a threshold for clinical concern. For players with substantial side-to-side differences in ankle dorsiflexion range-of-motion, individual-level training sessions containing customised interventions should be considered. This study's findings are practically-significant and have real-world impact because they inform primary and secondary ankle injury prevention strategies for male professional football players.

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