

Article

Born to Score? The Relationship between Left-Handedness and Success from the 7-Meter Line

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Abstract: An asymmetry in the prevalence of left-handedness vs. right-handedness in society has supposedly resulted in negative frequency-dependent advantages for left-handers in interactive sports. The aim of this study was to test whether these advantages apply to handball by examining whether being left-handed is beneficial when executing 7 m shots, a highly unimanual movement. All 1,625 7 m shots at the men's 2016–2022 European championships were analyzed using a Bayesian two-level analysis. While the results did not indicate that left-handers were more likely to score from any single 7 m shot, left-handers were overrepresented among the designated shooters compared to both the population as a whole (38% vs. 11.6%) and left-handers on any given handball team (38% vs. 25%). The implication here was that handedness plays no role in the outcome of 7 m shots at the world-class level, but handedness does appear to play a role in who becomes a world-class 7 m shooter.



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1. Introduction

Approximately 10% of the world is left-handed, with some variations depending on sex and context [1]. While being left-handed has been linked with negative health outcomes [1,2], it has also been found to be surprisingly advantageous in sports [3,4]. The innate characteristic appears to be especially advantageous in interactive sports where an athlete must react to an incoming object, such as boxing, mixed martial arts, fencing, tennis, cricket, and volleyball [3–5]. However, the degree of advantage appears to vary greatly depending on various factors, resulting in a varying prevalence of left-handedness (as high as 37–48% in judo and fencing, and as low as 13% in badminton and baseball [4]).

The mechanism believed to explain this tendency is generally referred to as the negative frequency-dependent advantage [4]. It concerns the reduced ability to correctly anticipate the actions of those who deviate from the expected norm. Most of the world population is right-handed, so most of our learned perceptual expertise and a database of knowledge is based on interactions with, and observations of, right-handers [4,6]. The lower perceptual familiarity with the movement patterns of the relatively rarer left-handers can therefore affect the visual information processes of the would-be opponents [7]. For some reason, this advantage has been found to be greater when it comes to hands than feet [8].

Handball makes for a particularly interesting context to study the negative frequency-dependent advantage for two reasons. Firstly, the sport is highly unimanual and using the less preferred arm is practically unheard of, in contrast to sports such as boxing, mixed martial arts, and soccer that are more bimanual and -pedal. Secondly, left-handers

have a distinct tactical advantage over right-handers on the right side of the court due to the available shooting angles and the movement patterns required to create high-quality goalscoring opportunities [9,10]. Being left-handed will therefore offer players an advantage in terms of selection, resulting in an overrepresentation compared to the general public [9,10]. In fact, most teams aim to have two left-handers on the field at any given time and four left-handers on the squad.

While handball is a relatively complex interactive sport, which makes studying negative frequency-dependent effects during regular gameplay difficult, the 7 m shot represents a relatively controlled situation where two players duel against each other without direct interference. The 7 m shot itself is an uncontested throw from the 7 m line, which is given when a player is robbed of a clear goalscoring opportunity in an unauthorized manner. In contrast to sports such as basketball and ice hockey, the fouled player is not required to take the shot themselves. The shot type typically has a higher success rate than regular gameplay [11], meaning that shooter selection should be carried out with deliberation.

As the 7 m line is placed centrally on the field, any angle-related advantages that the players might otherwise have, irrespective of handedness, are wiped out. The best 7 m shooters on any given team should therefore, at least theoretically, be selected purely based on performance and not for any tactical or strategic reasons. It is therefore quite interesting that Lobinger et al. [12] found that 43% of successful 7 m shots at the 2010 men's European Championship were taken by left-handers. While no clear explanations were offered, the ratio is in no proportion to the left-handers in the general population or those on the handball field at any given time.

When attempting to save a 7 m shot, the goalkeeper is free to move between the 4 m line and the goal line, with most goalkeepers opting to take a high position to reduce the angle of the shot. Due to the proximity between the two opposing parties, the goalkeeper will have to anticipate the shooter's movements [13,14]. Reacting to the trajectory of the ball in real time would be almost impossible, so the goalkeeper has to rely on various subtle cues and kinematic knowledge to predict where the shooter is likely to place the ball [14,15].

Previous research on goalkeepers and their efforts to anticipate the trajectory of 7 m throws has indicated that goalkeepers perform worse anticipating the throws of left-handers compared to right-handers [7]. Interestingly, the goalkeepers' gaze behavior and response time were the same irrespective of handedness, indicating that the discrepancy is due to problems categorizing or interpreting the information correctly [7,16]. This appears to indicate that some kind of negative perceptual frequency effect is at play during 7 m throws.

The aim of this study was therefore to examine (1) the prevalence of left-handed 7 m shooters and (2) the relationship between handedness and scoring from 7 m shots. The expectation was that left-handers would be overrepresented compared to both the general population and the population of handball players, and that they would be more likely to score from the 7 m line than their right-handed counterparts.

2. Methods

2.1. Procedure and Data

All 7 m shots at the four European championships for men between 2016 and 2022 were observed and logged into the official play-by-play match reports by representatives from the European Handball Federation. A total of 185 different players from 27 teams executed a total of 1625 7-m shots in 229 games ($M_{\text{shots}} = 7.1$, $SD = 2.86$).

The identity of the shooter, the outcome of the shot, and the score at the time of the 7 m shot were retrieved from the play-by-play data. Player height was gathered using the official webpage of the European handball federation and handedness was assessed using information from the same webpage in addition to image and video searches. The total number of 7 m shots during each game and the ratio between goals and misses were cross-referenced with the official match reports from each game to validate the information.

As the data that were used in this study are openly available online and are part of the public domain, no ethical approval was needed, and informed consent was not obtained from the players.

2.2. Statistical Analyses

Binomial tests of proportions were performed to determine whether left-handers were overrepresented within the sample. In line with previous studies on negative frequency-dependent advantages in interactive sports [17,18], the study sample was tested against a conservative estimate of expected left-handed males in the population (11.6% [1]). Additionally, the number of left-handed 7 m shooters was compared to the actual prevalence of left-handers at the four championships (25%; see Supplementary File S1).

The relationship between handedness and scoring from 7 m shots was analyzed using a Bayesian two-level analysis in Mplus 8.4. To account for dependency within the data, the outcomes of the 7 m shots (level one) were nested within the shooters (level two), with handedness being included as a covariate on level two. The height of the shooter and the goal difference at the time of the 7 m shot were controlled for on level one. If the 7 m shot had missing data on independent variables, it was excluded from this analysis, giving a total of 158 players and 1,615 shots. A Monte Carlo simulation, following the guidelines from Muthén and Muthén [19] was performed to determine sufficient power for the study. Specifying small effect sizes for all estimated relationships between independent and dependent variables, the results showed that 1,615 shots spread across 158 individual shooters yielded sufficient power ($\text{Beta} > 0.80$) to detect an effect.

A Bayesian estimator was used for the two-level analysis (for a comparison between the Bayesian estimator and the more traditional frequentist estimator, see Wagenmakers et al. [20]) and Markov Chain Monte Carlo simulation procedures with a Gibbs sampler with 200,000 iterations were performed. A potential scale-reduction factor of around 1 was used to indicate adequate convergence. Model fit was assessed using the posterior predictive p (PP p) value and its accompanying 95% confidence interval [21]. Credibility intervals (CI) were estimated for all parameters within the models. The null hypothesis was rejected if the 95% CI did not include zero [22].

3. Results

Of the 1,625 7 m shots, 1,224 (75.3%) resulted in a goal and 2,401 (24.7%) resulted in a miss. A total of 890 throws (54.8%) were performed with the right hand, while 735 throws (45.2%) were performed with the left hand. Out of the 158 different shooters, 98 were right-handed (62%), and 60 were left-handed (38%). The results of the binomial tests of proportions indicated that left-handers were overrepresented compared to both the general population (38% vs. 11.6%; $p < 0.001$) and handball teams in general (38% vs. 25%; $p < 0.001$).

The results from the Bayesian two-level analysis showed a good model fit to the data (PP p = 0.53, 95% CI = $-10.99, 10.74$). The included variables explained 0.5% of the variance of scoring on level one and 3.4% on level two, respectively. Handedness had no credible relationship with scoring ($\beta = 0.14$, 95% Confidence Interval = $-0.32, 0.59$). The other two covariates had no relationship with the likelihood of scoring.

4. Discussion

This study examined whether left-handed shooters were overrepresented as 7 m shooters in men's elite handball. While an overrepresentation of left-handers in handball compared to the general population is to be expected, left-handed 7 m shooters were also overrepresented compared to the prevalence of left-handers at the championships in question. These results are in line with findings from other contexts, where left-handed boxers, MMA fighters, fencers, and cricket bowlers have been found to be overrepresented at both the elite and amateur level [3,5,23,24]. Congruent with the findings of Lobinger et al. [12], almost half of the 7 m shots at the four championships were executed by left-

handed shooters. This was disproportionate to the ratio of right- vs. left-handed 7 m shooters at the four championships, indicating that left-handers take a disproportionate number of 7 m shots compared to their right-handed counterparts.

While limited weight can be placed on anecdotal evidence, the last four tiebreaking 7 m shootouts at the highest level of handball (Champions League semi-final in 2014, Champions League final in 2016, World Championship quarter-final in 2021 and Champions League final in 2022) have also seen an overrepresentation of left-handed shooters. A total of 16 out of the 38 (42%) 7 m shooters were left-handed (see Supplemental File S2), adding further support to left-handers being overrepresented at the 7 m line at the elite level.

This study also aimed to determine whether left-handed players were more likely to score from the 7 m line than their right-handed counterparts. In line with the findings of Pollet et al. [17] and Dochtermann et al. [18], who did not find a relationship between handedness and winning in the UFC when comparing the outcome of individual fights, no relationship was found between handedness and goalscoring from the 7 m line. However, both Loffing and Hagemann [25] and Richardson and Gilman [3] found evidence for left-handed superiority by studying the population using a different methodology, where the career record of fighters was compared instead of the outcome of any individual fight.

While negative frequency-dependent effects may explain the results of this study, an alternative theory suggesting that left-handers possess innate abilities such as increased neural processing speed and beneficial hormonal configuration that give them advantages in sports has been proposed [4,26]. While the lack of evidence pointing to left-handed advantages in non-invasive sports indicates limited evidence for this theory [4], mixed and inconsistent results from previous studies that only partially confirm the existence of negative frequency-dependent effects leave some researchers suggesting that innate abilities may at the least play some role e.g., [17,27]. This perspective becomes even more relevant in light of evidence that the advantages of negative frequency-dependency can be ameliorated through training [28]. Even though a goalkeeper may have only trained with and played against a handful of left-handed players during their early years in the sport, their constant exposure to left-handed players, and their specific training against left-handed shooters, at the top level should result in increased perceptual familiarity.

Due to the tactical advantages being left-handed offers handball players, left-handed players have an edge when it comes to selection throughout their career (e.g., receiving more playing time, getting into academies, and being more likely to receive a call-up to regional and national training groups and teams [9,29]). However, that does not explain why left-handers are so overrepresented at the 7 m line. If anything, left-handers should be underrepresented when it comes to 7 m throws, at least from a purely logical perspective. The tactical advantages that favor the selection of left-handers are wiped away at the 7 m line, and the right-handed players on the roster, most of whom have had to outperform a greater number of potential candidates to qualify for a spot on the team, would be expected to have superior abilities [30]. However, Loffing et al. [7] found that left-handed players are routinely overrepresented among the top scorers at international tournaments as well, indicating that the advantages of being left-handed in handball may exceed the 7 m line. This may be due to them getting more playing time throughout their career, as left-handers are likely to have less competition for minutes on the field.

The number of 7 m shots any given 7 m shooter took across the four championships varied greatly (from 1 to 64). This is natural as some players took part in all four championships while others only took part in one. Additionally, most teams have a designated first-choice 7 m shooter that takes most of their 7 m shots. When that first-choice option misses a 7 m shot, most teams opt for their second-choice shooter to take the next 7 m shot. It is important to note that the second- and third-choice 7 m shooters are usually highly proficient from the 7 m line, and most likely the first choice at their club team. Any 7 m shot at this level will therefore be taken by a 7 m specialist.

While most studies on negative frequency-dependent advantage from the 7 m spot have been simulated, the current study is based on actual 7 m shots at the world-class level

and therefore has high ecological validity. Even though important preliminary knowledge can be gained from controlled simulated experiments, findings have varied depending on the degree of ecological validity [31]. Although the data in the current study are reliable, have high ecological validity, and adequate statistical power, the study design and limited available information related to each 7 m shot constrained which possible covariates could be accounted for. Variables such as shot speed, number of feints, and the time from the referee's whistle to the execution of the shot could therefore not be included in the study.

Future research should examine whether these trends apply to the same degree at the amateur level, because previous research from other sporting contexts has found the degree of negative frequency-dependent advantage to vary depending on proficiency level [17,32]. Slight modifications to the methodology would also be recommended, as analyzing the individual shooters' records as opposed to analyzing every single 7 m shot as a data point could lead to different results [3]. This would require a substantially larger dataset. Examining whether these trends apply to female players would also be of interest, as previous studies have indicated that both left-handedness and lateral biases may be less pronounced among female players [1,5,32]. Finally, future research should address whether left-handers have a scoring advantage during regular gameplay.

5. Conclusions

While the results of this study did not indicate that left-handers were more likely to score from any single 7 m shot, left-handers were greatly overrepresented among the designated shooters compared to both the population as a whole and the proportion of left-handers on any given team. The implication here is that handedness does not appear to play a role in the outcome of 7 m shots at the world-class level, but that handedness does play a role in players becoming world-class 7 m shooters.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/sym14102163/s1>, Supplemental File S1: An overview of handedness at the 106-2022 European championships; Supplemental File S2: An overview of handedness in 7-meter shootouts at the world-class level.

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