THE INFLUENCE OF STANCE WIDTH ON MOVEMENT TIME IN FIELD HOCKEY GOALKEEPING

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Minimising movement time is essential for a field hockey goalkeeper and stance width is considered important to agility. The aim of this study was to examine if an optimal stance width exists for field hockey goalkeepers and if so, does it vary for different movement directions and for different individuals. Ten state and national level goalkeepers made simulated saves from ten different stance widths ranging from 0.4 m to 1.2 m. AMTI force plate data was used to identify start of movement time and timing gates in the corner of the goals recorded the end of movement time. On a group basis, a stance width of 1.1 m was optimal for minimising movement time for high and low saves and for right and left saves. On an individual basis, 1.1 m was the optimal stance for eight of ten subjects. Only two subjects performed optimally at their preferred stance width. Where shots to the corner of the goals are likely, goalkeepers should adopt a wide stance.

KEYWORDS: Agility, preparatory stance

INTRODUCTION: A game of field hockey is won by outscoring the opposition. The goalkeeper forms the last line of defence for a team and their task is to intercept shots that are made from within a 14.6m radius from the goal. Given the ball can travel at up to speeds of 33 m/s (Ball, 1994), the goalkeeper can have less than 1 s to react to a shot from the edge of this area and move to stop it. Further, the distance from the shooter to the goalkeeper is typically shorter than the maximum distance. As such, the ability of a goalkeeper to minimise movement time is paramount.

There are few studies examining goalkeeping technique and none exist in field hockey. In soccer, technique differences have been identified between goalkeepers of different skill levels (Suzuki *et al.*, 1987) and between saves to the dominant and non-dominant sides (Spratford *et al.*, 2007). These studies reported that a more direct path towards the save point was evident in more elite performers (Suzuki, *et al*., 1987) and on the dominant compared to the non-dominant side (Spratford *et al.*, 2007). In ice hockey, Wiliberg (1979) identified three classifications of stance among 300 goalkeepers from junior to senor level; an open or "V" stance (feet parallel, legs wide apart), a closed or parallel stance (feet parallel, legs together) or a broken "V" or butterfly stance (knees angled in toward each other, legs wide apart). However, none of these studies used performance measures or focussed specifically on stance width.

Links between stance and performance have been examined in the scientific literature in a number of forms although none have specifically looked at stance width and movement time. Preparatory stance with bent knees compared to straight knees (e.g. Yamamoto, 1996) and with weight evenly balanced over flat feet compared with on the toes (Stater-Hammel, 1953) have been linked to faster reaction-movement times. A closed stance has also been reported as being better for reaction-movement time in tennis (Lockerman, 1973), although Hopkins (1984) reported that the open stance allowed players to recover from a wide forehand shot to a backhand shot significantly faster than the closed stance.

In spite of the importance of preparatory stance in numerous sports, it is perhaps surprising that there are only a few studies focussing on this feature of sport skills. The aims of this study were to examine if an optimal stance width existed for field hockey goalkeepers and if this optimal stance width differed for saves in different directions.

METHODS: Eight male and two female hockey goalkeepers competing at state or national level at the time of testing participated in this study. Table 1 reports subject details including two measures used to normalise stance width (leg and arm length). Arm length was measured from the acromion process to the tip of the middle digit on each arm while fully extended. Leg length was measured from the anterior superior iliac spine to the lateral malleolus while standing.

Table 1: Subject characteristics (N = 10)

Age (years)	Height (m)	Leg Length (m)	Arm Length (m)	Mass (kg)
21.6 ± 2.5	1.80 ± 0.06	0.94 ± 0.08	0.77 ± 0.03	86.2 ± 18.7

Each subject wore their full goalkeeping gear as used in games (pads, kickers, helmet, gloves protective equipment and stick) and performed simulated saves, one to each corner of the goal at each of 10 stance widths (total of 44 saves). Goalkeepers stood on two AMTI force plates (Advanced Mechanical Technologies, Inc, Massachusetts, USA), one under each foot. From this position, each goalkeeper's stance width was adjusted using a specialised metre ruler with arms extending perpendicularly. These arms were set apart to the required width and goalkeepers increased or decreased their stance width until the two arms were touching the lateral malleolus of each foot. Stance widths ranged from narrow (0.4m) through increments of 0.1 m up to wide (1.2 m) and included the goalkeepers preferred stance width. A flat wooden signal board (1 m x 0.76 m, figure 3.2) with an LED in each of the four corners was positioned on a camera tripod 0.87 m off the ground 4 m directly in front of the goalkeeper. For each trial, one LED was lit to indicate the diving direction (e.g. top right, bottom left). Subjects were instructed to react as fast as possible to the signal and to use their normal save movement when completing each trial. The order of stance widths and the direction of the required response were randomised. One trial was performed for each stance width-direction condition.

To provide a 'target' for the goalkeepers to save, Four tennis balls were suspended 1.67 m either side of the centre of the force plates, and 0.3 m and 2.0 m above the ground approximately corresponding to shots to the corner of the hockey goal. Four sets of custom built timing gates were mounted on steel rods and were aligned just to the goalkeeper's side of each tennis ball such that a beam of light was broken once the goalkeeper reached the target tennis ball.

All data including data from the force plates, the timing gates, the directional LED indicator and the 1s flashing LED was passed through 16 analog channels into the Optotrak Certus Motion Capture System (Northern Digital Inc, Canada). All data was sampled at a rate of 1200Hz. Movement time was defined as the difference between the onset of forces (Fz) associated with the save to the point at which the timing gates positioned near the tennis balls were broken. A 50 Hz camera recorded all trials and was used to correct any trials where the timing gates did not function correctly and to evaluate any inconsistencies with breaking the timing gates such as when the hockey stick rather than the glove broke the timing gate beans.

RESULTS: Figure 1 shows movement time for each of the set stance widths and figure 2 compares movement time for high and low saves (figure 2a) and for saves to the right compared to the left (figure 2b). The fastest mean movement time (0.6 s) occurred at a stance width of 1.1 m and the slowest movement time (0.774 s) occurred at the narrowest stance of 0.4 m. Movement time progressively decreased from the 0.4 m to the 1.1 m stance width after which it increased again at 1.2m. For all save directions, 1.1 m produced the fastest movement times. For three of the four individual corners, the lowest movement time was produced at a stance width of 1.1 m, with producing the lowest movement time for the remaining corner.

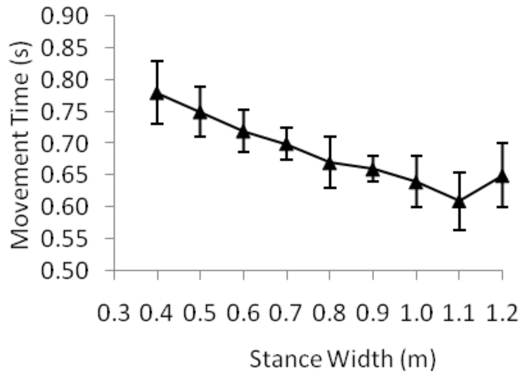
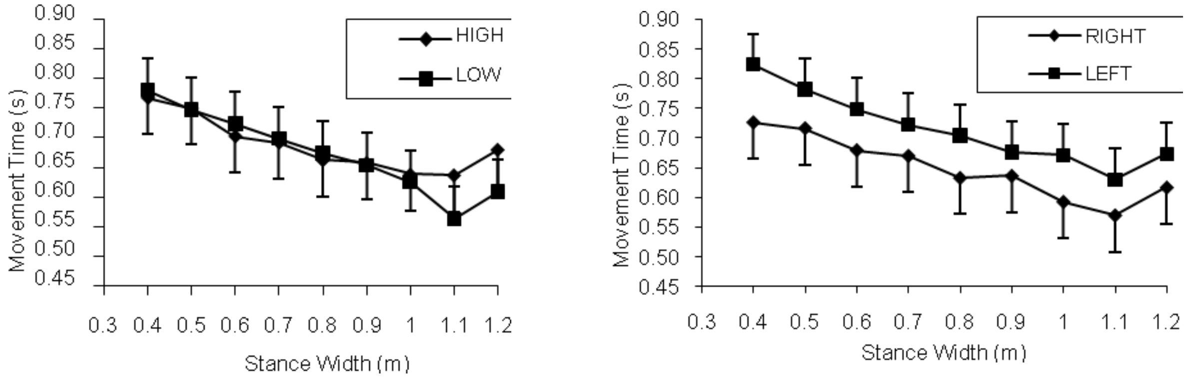


Figure 1: Mean Group Movement Time (s) at each stance interval.



(a) High compared to low saves

(b) Right compared to left saves

Figure 1: Mean Group Movement Time (s) comparing high and low saves and comparing right and left saves

On an individual basis, the 1.1 m stance width produced the lowest movement times for eight subjects, while for the remaining two subjects, stance widths of 0.9 m and 1.0 m produced the lowest times. Seven subjects produced a smaller minimum movement time at a stance width other than their preferred stance width (figure 3). There was no association between anthropometric measures and optimal stance width.

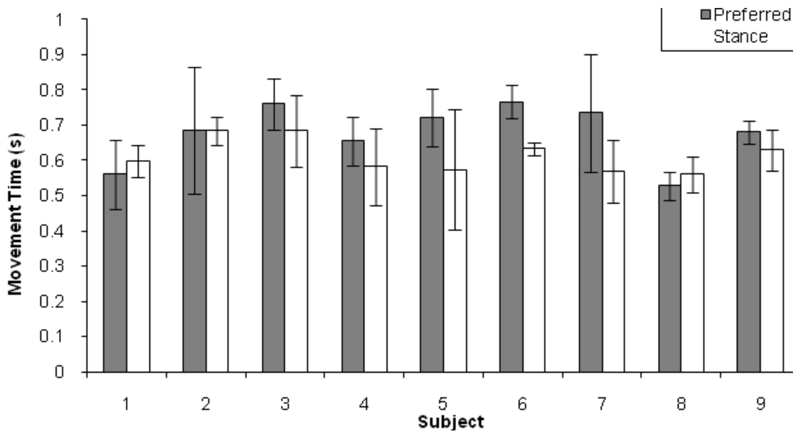


Figure 3: Movement time (s) for preferred and test-optimal stance

DISCUSSION: An optimal stance width exists for hockey goalkeeping to minimise movement times. A stance width of 1.1 m was optimal for saves to the corner of the goals. This stance width was optimal on an overall basis, for saves to the right and left side, for high and low saves and for eight of the ten subjects. Further, this stance width was optimal for three of the four corners of the goal and while differences in total movement times occurred between males and females, optimal stance widths were the same. Based on this very strong support, it would seem that this stance width should be employed by hockey goalkeepers where wide shots are likely.

Optimal stance width was not related to height, mass, leg length or arm length. This was an interesting finding as it might be expected, for example, that a longer legged goalkeeper might have an optimal stance width that was wider than a shorter legged subject. However, the data in this study indicated that no relationship existed between the anthropometric measures used in this study and optimal stance width. Rather, very strong support existed for an absolute (1.1 m) rather than a relative (normalised to body dimensions) relationship between stance width and movement time.

Only two subjects produced faster movement times at their preferred stance compared to their optimal stance as identified in the specified stance widths (test-optimal stance widths). The remaining seven subjects adopted a stance, which was sub optimal for shots directed to each of the four corners. Based on this finding, a sound recommendation for hockey goalkeepers is to evaluate their stance width to determine if they are optimising their preparatory position for wide saves.

This research has identified a wide stance of 1.1m as optimal for saving shots directed at the four corners of the goal. Future work needs to look at the kinematic and kinematic factors associated with this movement and examining saves to different areas of the goal, such as between the legs or nearer to the goalkeeper. To assist with this analysis, a profile of common shot placements evaluated from games would provide information on the most common shot targets in the goal. Another important direction is to examine stance width in specific game situations such as where shots nearer the goalkeeper or in situations where the point of shot is not imminent (i.e. if a player passes rather than shooting). Finally, the target of the movement was a stationary ball and while this was appropriate for this study as it was concerned with movement time only, it did not allow for evaluation of save success. The addition of ‘real’ saves would allow for evaluation of movement time along with success of the save and perceptual and reaction timing aspects of the skill.

CONCLUSION: An optimal stance width exists for hockey goalkeeping to minimise movement times for shots to the corner of the goal. A stance width of 1.1 m was optimal on a group basis for all save directions and on an individual basis for eight of ten subjects. Only two subjects produced faster movement times at their preferred stance width. Where wide shots are likely, goalkeepers should adopt a wide stance width.

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