The Effect of Prior Tennis Experience on Wheelchair Tennis Players’ Visual Search

Authors:
Dr. Melissa Hunfalvay, Department of Kinesiology, University of Virginia, Virginia, USA
Nicholas Murray, Associate Professor, Department of Kinesiology, College of Health and Human Performance, East Carolina University, North Carolina, USA

Corresponding author: Dr. Melissa Hunfalvay
Address: 808 Malcolm Drive, Silver Spring, Maryland, 20901
Phone: +1 (240) 357-0026
Email: melissa@righteye.com

This paper is dedicated to the memory of Carma Lee Lewallen.
Abstract

The purpose of this study was to examine if prior biped tennis playing experience results in different visual search strategies compared to no prior biped playing experience. Thirty-two wheelchair tennis players, 17 males, 15 females, ranked between 1-16 on the International Tennis Federation rankings participated in this study. Half the players had prior experience playing tennis as a biped player and half had no prior experience in biped tennis. The athletes viewed 18 different serves from an expert wheelchair player while their gaze was monitored using eye-tracking. Results revealed significant differences between the groups in fixation duration and number of fixations. Differences were also found in fixation locations and durations across biomechanical phases of the serve. The WCO players had more fixations for shorter periods than did WB players in the ritual phase. In the preparatory and execution phases, however, the WCO players had fewer fixations for longer duration than the WB players. Results are discussed in terms of long-term memory structures, learning and considerations when coaching and training wheelchair tennis players.

Key Words: visual behavior, fixations, attentional control, open skill, adapted physical activity, eye tracking
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Introduction

Visual search (VS) is knowing where to look and what to look for while playing sport. VS influences many areas of performance such as anticipation time and accuracy (Starks & Ericsson, 2003), decision-making abilities (Millazzo, Farrow & Fournier, 2016) movement time (Williams, Davids & Williams, 1999), cognition (Williams & Grant, 1999), and long-term memory (Reina, Luis, Sanz, Sabido, Garcia & Moreno, 2004).

Past researchers have found that experts compared with novices have fewer fixations of longer duration (e.g., Perez, Mendez, Manzano & Collado, 2013; Piras, Pierantozzi & Squatrito, 2014) which reduces the experts processing time resulting in an increased response accuracy (Mann, Williams, Ward & Janelle, 2007) and reduced decision-making time and accuracy (Piras et al., 2014). Also, experts look at biomechanical cues that provide predictive information. These visual search patterns are not random, but rather based on deliberate perceptual-cognitive strategies (Bard & Fleury, 1981).

Effective visual search enables the expert to analyze a scene more efficiently and extract information which helps predict the correct response. According to Reina et al (2004) and Williams & Grant (1999), from a cognitive point of view, visual search strategies determine specific task knowledge structures, situated in long-term memory. Through learning and practice the most important areas of the scene can be visually processed. Therefore, visual search strategy is controlled by knowledge and developed through training, competing and observation (Reina et al., 2004).

Visual search patterns have been seen to be domain specific (Chen, Wu, Song, Chou, Wang, Chang et al., 2017). For instance, according to Chen et al., Taekwondo, which emphasizes kicking, might require faster perceptual processing to compensate for longer latencies to initiate
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lower-limb movements and to give rapid visual feedback for dynamic postural control, while
Karate, which emphasizes both striking with the hands and kicking, might require exceptional
eye–hand coordination and fast perceptual processing. Therefore, because you are good at one
task does not mean you will have an appropriate visual search pattern for other tasks.

Experts in racquet sports, such as badminton, tennis and squash have some broad
similarities in visual search patterns (Cauraugh & Janelle, 2002). For instance, arm, racquet, and
ball toss regions have been shown to be important visual cues that affect anticipation (Abernathy,
1988; Moreno, Ona, & Martinez, 2002). Furthermore, experts use advanced (pre-flight) cues that
occur earlier in the stroke than novices, this allows the expert greater speed and accuracy in
predicting the type and location of the stroke (Reina, Moreno & Sanz, 2007).

Expert biped tennis players, when returning serve, look first at the general body position
and non-dominant arm (or free arm that tosses the ball) during the ritual phase, which proceeds
the initiation of the serve and consists of ball bounces and foot positioning (Hunfalvay, 2004).
They then shift their gaze to the non-dominant arm (Goulet, Bard & Fleury, 1989) during the
preparatory phase, which begins at the elevation of the arm holding the ball and ends at the apex
of the ball trajectory. During the execution phase, which begins at the servers’ knee extension
and ends at the ball/racquet contact, the longest fixation durations were on the arm, racquet and
shoulder region (Goulet, Bard & Fleury, 1989; Tenenbaum, Levy-Kolker, Sade, Liebermann,
Lidor, 1996; Singer, Cauraugh, Chen, Steinberg, & Frehlich, 1996; Singer, Williams, Frehlich,
finishing phase, which begins after contact and continues throughout the flight of the ball, gaze
was then located on or in front of the ball (Hunfalvay, 2004; Murray & Hunfalvay, 2016; Singer
et al., 1998).
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According to past research by Reina, Moreno and Sanz (2007), expert wheelchair tennis players spent the most time in the ritual phase on the General (Upper) Body Position (GBP) then the ball in the preparatory, execution and finishing phases. They spend less time on the contact point, where the racquet and ball meet. Reina and colleagues postulate that the higher number of visual fixations on the ball could be due to the wheelchair server grabbing the rim of the wheelchair with the free arm in order to gain stability. In the same study Reina et al. compared wheelers’ VS patterns when viewing biped servers and during the preparatory phase found that the wheelers viewed the non-dominant arm of the biped server and not the ball during this phase. These results show differing VS patterns when wheelers view biped servers versus other wheelers. Results may be due to differences between wheelchair and biped tennis and would be consistent with past findings suggesting VS patterns are domain specific (Chen et al., 2017).

Wheelchair tennis players use the same rules (although have options to allow the ball to bounce twice), they have the same standardized courts, same surfaces, and same equipment as bipeds. However, they vary in their visual perspective of their opponent. As a biped player, the person looks over and above the net, in contrast the wheelchair tennis player looks through the net. The visual angle is therefore different. Furthermore, while the biped player uses their legs for movement on the court the wheelchair player uses the same body part to move and to swing at the ball (that is their hands).

Returning a tennis serve is a temporally constrained situation that demands all players extract the most valuable pieces of information and use them quickly to anticipate the serve (direction, spin and speed; Shim, Miller & Lutz, 2005). In the case of an expert wheeler’s serve (an average of 40-45 m/s) the player has only 500-600ms to make decisions about how to respond (Abernathy, 1991). In the case of expert biped tennis serves can reach 67 m/s allowing
the player much less time to return. Reina et al (2007) suggests that differences in VS patterns between viewing biped and wheelers servers from the perspective of a wheeler may be due to the time constraints that affect wheelers differently than biped players when returning serve.

Specifically, Reina et al. state that wheelers are “quicker in pursuing the ball’s path because wheelchair opponents’ servers are slower than ambulatory performers serves.” Therefore, allowing the wheeler more time to respond to the flight of the ball than with biped servers. In summary, the differences in speed, visual angle and use of hands to move the wheelchair may contribute to differences in wheelchair visual search skills compared to bipeds.

To date, all research conducted on wheelers has been done with wheelers who began playing tennis from a wheelchair (Reina et al., 2004; 2007, Reina, Moreno, Sanz, Damas & Luis, 2010) and had no experience playing tennis as a biped. Furthermore, there are not findings to date that has compared expert wheelchair tennis players who have previous biped experience (Wheelchair with Biped; WCB) to those who do not have biped experience (Wheelchair Only; WCO). In past research, some authors have stated that previous experience underlies visual search mechanisms and subsequent decision-making processes, as indicated by expert/novice differences in fixation location and durations (Jackson & Mogan, 2007). Visual search uses task specific knowledge based on long-term memory that is controlled and developed through training (Williams & Grant, 1999). Therefore, transitioning from playing as a biped to a wheeler leads to the following question: Does the new wheeler have visual search strategies that mirror the biped or have they transitioned to a wheeler strategy? The answer to this question is important in several ways, including time to adjust a visual search strategy as well as possible training and coaching methods. Therefore, the purpose of this study was to determine if prior biped tennis playing experience resulted in different visual search strategies (number of
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fixations, fixation durations and fixation locations) compared to no prior biped experience for wheelers.

**Method**

**Participants**

A total of 32 wheelchair (WC) tennis players (aged 19-41 years, \( M = 28.38, SD = 8.77 \), 17 males, 15 females) participated in the experiment. Players’ highest ranking between August 31st, 2002 to 2003 was between 1-16 on the International Tennis Federation (ITF) tour.

WCO participants (n = 16) had played tennis from a WC for an average of 10.19 years (SD = 6.02). The WCB participants (n = 16) had played tennis (biped and wheelchair tennis) for an average of 11.63 years (SD = 6.17), they played biped tennis for an average of 7.69 years (SD = 5.64) and wheelchair tennis for an average of 4.44 years (SD = 1.93). This study was approved by the Institutional Review Board 2003-0126-00.

**Task and Measures**

*Test Film.* The current world number one ranked male (ITF, aged 30, 10 years of tennis playing experience from a wheelchair) at the time of data collection was the model in this study. The model was filmed from a “front on” perspective using a digital video camera (Sony, DCR-TRV 19). The video camera was positioned 91.44 cm behind the intersection of the sideline and baseline at the height of 120.65 cm, based on the model’s height while seated in a WC tennis chair. The model performed 18 serves, 9 on each side of the court. Serves were hit in three directions (wide, at the body or down the center) and with three types of spin (flat, slice and topspin).

The videotape was edited using the Pinnacle Studio Version 7 (Pinnacle Systems, Inc., http://www.pinnaclesys.com/ 2016) editing system. The naturally occurring sounds associated
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with each serve were included in the videotape. The serves were shown in real time and the total
duration of the video was 44.47 s, including a two-second grey screen presentation between each
of the 18 serves. The average duration of each serve was 2470 ms ($SD = 0.39$) and the serves
were presented in random order.

Each serve was recorded from when the server moved up to the baseline to begin the
service motion and terminated when the ball crossed the net. Each serve included four phases of
the wheelchair tennis serve: the first phase, ritual, precedes the initiation of the serve consisting
of ball bounces and chair positioning ($M = 1130$ ms, $SD = 0.14$). The second phase, the
preparatory phase, begins at the elevation of the arm holding the ball and ends at the apex of the
toss ($M = 630$ ms, $SD = 0.18$). The third phase, the execution phase, begins at the upward
extension of the body and ends at the point of contact between the racquet and ball ($M = 330$ ms,
$SD = 0.12$). The fourth phase, the finishing phase, starts immediately after ball/racquet contact
and ends as the ball crosses the net, at which time the video was cut ($M = 410$ ms, $SD = 0.13$).

*The Eye-gaze Response Interface Computer Aid (ERICA).* An ERICA (2003, model 000-
0-103, http://www.eyegaze.com/) system was used to collect visual search data. System
parameters were the same as (Murray & Hunfalvay, 2016). System accuracy and precision was
+/- 0.5 degrees of visual angle and a data sampling rate of 60 frames per second. Eye calibration
was automatic using a 1-point eye calibration screen and then a 16-point screen calibration. The
videos were displayed on the ERICA system which utilized a 21-inch screen at 60 Hz with a
spatial resolution of 0.5 degrees. Participants were positioned 90 cm away using $18.72^\circ \times 24.28^\circ$
field of view.

Procedure
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Testing was conducted at various locations and times during professional tennis tournaments. Upon arrival for testing, participants completed both an informed consent form and a demographic questionnaire. Participants’ eye gaze was calibrated and then they were read a statement of instructions where they were asked to watch the serve and “imagine you are on the tennis court playing this person in a competitive match situation, such as at this tournament here in (location)… you are about to return serve during the match…think about and imagine trying to return the serve as effectively as possible making it difficult for the server to return.”

If the participants had no questions they watched three serves presented in random order to familiarize themselves with the video presentation and if there were no further questions, participants were again checked for calibration and watched each of the 18-testing video in its entirety. During this viewing, their eye gaze responses were monitored in terms of number of fixations, fixation durations and pursuit tracking during temporal segments and at specific locations throughout the presentation of the serve.

Data Reduction

Visual search variables included the number of fixations and fixation durations. A fixation is defined as a period of at least 100 ms during which all gaze points are recorded within 3 degrees of visual angle of each other. The number of fixations were summed for each serve and then averaged across the eighteen serves. Pursuit tracking of the ball was also recorded. The number of fixations and fixation durations were calculated for each temporal phase (ritual, preparatory/execution, and finishing). Fixation locations were also examined and are referred to as “areas of interest” (AOI’s). Fixation durations were averaged for each area of interest and then averaged across serve type.
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Five locations (AOI’s) that have been determined to be important in past research were created (Goulet et al., 1989; Singer et al., 1998; Tenenbaum, et al., 1996). All AOIs, except AOI 5 (predictive area of interest), were present for the entire duration of the service motion and were similar to Reina et al. (2007). The “general body position” (GBP), referred to as AOI 1, included the torso, head, legs and wheelchair. The non-dominant arm (NDA), referred to as AOI 2, was created around the non-dominant tossing arm of the model server. The arm, racquet, and shoulder (ARS) region of the server’s dominant arm was referred to as AOI 3. AOI 4 was created around when the ball and racquet meet. AOI 5, the predictive area of interest, was present from when the model first appeared on the screen and until the non-dominant arm was raised to waist height during the preparatory phase. It was located along the tossing path of the arm and ball flight during the tossing phase and was designed to capture eye movements that occurred prior to the toss.

Data Analysis

To test the hypotheses of interest, a one-way ANOVA was used to analyze Group differences (AB and WC Tennis compared to WC tennis only) for average total fixation duration. In addition, two 2 (Group) x 4 (Phase) ANOVAs were conducted examining fixation durations and number of fixations for the Ritual Phase, Preparatory Phase, Execution Phase, and Finishing phase. Effect size was evaluated through partial eta squared. A multiple regression analysis was conducted to evaluate how well the fixation duration locations predicted time playing tennis. Alpha was set at p < .05 as the critical level of significance for all comparisons. When necessary, violations of the sphericity assumption were corrected using Greenhouse-Geisser adjustments of the degrees of freedom.

Results
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For the initial analysis we included gender as a factor but it was non-significant and we also examined rank between groups and it was also non-significant ($p = .152, \eta^2_p = .043$). Thus, all comparison are made by Group (WCB compared to WCO).

A one-way ANOVA for Group comparing average total fixation duration produced a significant effect, $F(2, 30) = 362.08, p < .001, \eta^2_p = .923$. The WCB players overall had shorter fixation durations (M = 499.68, SD = 10.75) than WCO only players (M = 599.25, SD = 17.95). Furthermore, the 2 (Group) x 4 (Phase) ANOVA for Duration produced a significant main effect for Group, $F(2, 30) = 27.98, p < .001, \eta^2_p = .483$, and for Phase, $F(2, 30) = 155.08, p < .001, \eta^2_p = .838$ (see Figure 1). In addition and more importantly, there was also a significant interaction effect, $F(2, 30) = 40.82, p < .001, \eta^2_p = .576$. The main effects and interactions both demonstrated large effect sizes (Cohen, Cohen, West, Aiken, 2003). The simple effects analysis revealed WCB players fixated significantly longer during the Ritual phase whereas WCO only players had longer fixation durations in the Preparatory and Execution phases of the serve (See Table 1).

The 2 (Group) x 4 (Phase) ANOVA for number of fixations revealed a significant main effect for Group, $F(2, 30) = 32.76, p < .001, \eta^2_p = .522$, for Phase, $F(2, 30) = 297.62, p < .001, \eta^2_p = .908$, and a significant interaction effect, $F(2, 30) = 90.243, p < .001, \eta^2_p = .751$ (see Figure 2). As for the other analyses, the main effects and interactions both produced large effect sizes. The simple effects analysis for number of fixations revealed WCB players had significantly fewer fixations during the Ritual phase whereas WCO players had fewer fixations in the
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Preparatory and Execution phases of the serve (See Table 2). There was no difference for the finishing phase.

It was immediately apparent that the majority of fixations during the ritual phase were on the GDP and NDA for the WCB and WCO players respectively (see Table 3). Subsequent phases also revealed a majority of fixations were located within a specific region at biomechanical phases. We conducted a qualitative assessment to examine the dominant areas for each group for each fixation location. Following this assessment, we only included the data within those areas of interest for further analysis.

Regression analysis. The linear combination of fixation duration location indices were not significantly related to time playing tennis, $R^2 = .01$, $F(4, 27) = .396$, $p = .81$ with only approximately 1% of the variance of the time playing tennis accounted for the variance in fixation duration location indices. Therefore, it was hypothesized that the fixation strategies of WCO players is different than WCB players. Following which we performed a secondary descriptive analysis and examined the fixation location strategy of WCB players compared to WCO players. During the Ritual phase, the primary location for WCB players was GBP whereas WCO players fixated on the NDA and predictive toss path. During the Preparatory phase, the WCB players shifted to NDA and predictive toss path while the WC only players shifted to the contact point and remained there until ball contact during the Execution phase. However, the
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WCB players didn’t shift to ball contact point until the Execution stage and both groups fixated on the ball during the Finishing phase.

Discussion

The purpose of this article was to examine the visual search patterns of wheelchair tennis players, “wheelers” who had past biped playing experience with wheelers who had no past biped playing experience. Results revealed that past playing experience may influence visual search patterns. The WCB group has significantly different visual search patterns than the WCO group. WCB players fixated significantly longer during the Ritual phase whereas WCO only players had longer fixation durations in the Preparatory and Execution phases of the serve. WCB players had significantly fewer fixations during the Ritual phase whereas WCO players had fewer fixations in the Preparatory and Execution phases of the serve. The WCO group had overall fewer fixations for longer duration than the WCB group. Furthermore, the groups differed in the locations of their fixations at the biomechanical phases of the serve (see Table 3).

The WCB group had past playing experience as biped tennis players. Their visual search patterns are similar to biped players visual search patterns (Goulet et al., 1989; Tenenbaum et al., 1996; Singer et al., 1996; Singer et al., 1998, Hunfalvay, 2004, Murray & Hunfalvay, 2016). Expert biped tennis players look at the GBP during the ritual phase, then the NDA in the preparatory phase then the contact point during execution and follow the ball during the finishing phase. These results suggest that past playing experience may be reflected in visual search patterns for this group.

The WCO group only played tennis from a wheelchair and had no prior experience playing biped tennis. Their visual search pattern was significantly different than those with past
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biped experience. These results are consistent with Reina et al (2007) in that their results showed

different VS patterns between wheelers who viewed other wheelers serving and those who

viewed biped servers. These results are also consistent with research by Murray and Janelle

(2003) who found that the visual search process is likely context dependent and influenced by

the task, the skill, and the environmental conditions.

The WCO players had more fixations for shorter periods than did WCB players in the

ritual phase. Past research has shown that longer durations with fewer fixations are consistent

with individuals who are more experienced at the task (Starkes & Ericsson, 2003). In the

preparatory and execution phases, the WCO players had fewer fixations for longer duration than

the WCB players. Shorter durations and more fixations have been associated with less

experience (Starkes & Ericsson, 2003). However, this group of athletes are all world class,

highly ranked tennis players. One possible explanation could be the biomechanical differences

associated with the serve from a biped to a wheelchair. As the WCO players had a more “expert”

visual search pattern during this phase (longer durations, fewer fixations) it may be due to a

domain specific knowledge required in WC tennis. The results may also be due to the specific

model used for the study. Future research should consider several models to further generalize

results. Another explanation may be the trade-off that occurs in the efficiency of the visual

search pattern between fixations and scanning behavior indicated by saccades and smooth pursuit

eye movements. Longer fixations increase fidelity from each location at the expense of exploring

fewer locations. If fixations are shorter then additional locations can be explored (Najemnik &

Geisler, 2009). Some research has shown that adopting different cognitive strategies (passive

versus active) influences visual search behavior of participants at the same skill level of a task

(Watson, Brennan, Kingstone & Enns, 2010).
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Furthermore, some research suggests that execution and finishing phases may be key service components in which wheelchair players must focus Reina et al (2007). It is possible that the differences in the ritual and preparatory phases may therefore be of little importance in terms of ability to return the serve (from a visual search perspective) although, these differences are interesting from the lasting effects of previous biped tennis experience. In other words, differences exist as stored in memory, however, all players are WC tennis experts therefore the differences are not necessarily affecting the most important components of the serve, which have been adapted to comply with new task (WC serve) constraints.

The current article differs from past research in that the scan path adopted by the WCO was different than what was found by Reina et al. (2007; see table 4). Participants in Reina’s study also had no past playing experience as a biped tennis player. The WCO players in this article looked at the contact point for longer than the ball in the preparatory and execution phases compared to Reina et al. It is possible these differences are negligible as the ball and contact point are together the areas most viewed in these phases. A limitation in the Reina et al. is the low number (N = 5) of expert wheelers. However, additional research with more highly skilled wheelers could assist in clarifying which location of gaze is used in the most preparatory and execution phases.

As all participants were highly experienced, with similar years of tennis playing experience in a wheelchair the results cannot be related to age, years playing or level of expertise as a wheelchair tennis player. As VS patterns are domain specific it seems the WCO group developed different VS patterns than those who had no prior biped tennis experience. As VS patterns are based on long term memory, it may be that the wheelchair server is still considered...
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in their mind, to be “chunked” into a memory pattern that does not enable them to differentiate
the biomechanical pattern of a wheelchair player serving compared to a biped player serving.
Future research should explore the amount of past playing experience to determine if there is a
period of biped playing experience that is needed before the VS patterns change.

The results of this research touch on athletic, coaching and performance expertise
concepts. Reina et al., (2007) states that “common coaching situations are that wheelchair tennis
players train with biped coaches, we should consider that they may be cuing strategies that are
not optimal for real-game conditions.” The results of this study only partially support this
statement as all these players are at the top of wheelchair tennis world rankings could there be
two possible VS patterns that are acceptable in wheelchair tennis? Alternatively, as we are only
examining one area of expertise, that is vision and not say physical strength, mental toughness,
or flexibility, if one pattern is better than the other then could the players who do not have the
“ideal VS pattern” become even better if they were to adopt the best pattern? Future research
should examine the performance statistics of these elite players who have differing VS patterns
and compare them to who have the best return of serve. This is a limitation of this study.

Another limitation of this study is that the video model observed by WCO and WCB
participants was a male player. The male participants in this research, may have played against
the model player and may have been more familiar with his serve than the female participants.
Although wheelchair tennis players often play mixed doubles, which allows females to view
males serving and vice versa, future research should consider female and male models. Future
research should also consider examining other past experiences that could influence the groups,
such as past sports played.
Future research should examine the long-term memory and learning that has taken place to determine if there is a time when playing experience is associated with long-term memory of VS patterns. If such patterns need to be overcome could there be different coaching strategies associated with learning, for the first time, versus relearning, that is overcoming an old VS pattern that may not be as advantageous in a new context.

This study uniquely examines wheelers with no prior experience in biped tennis and those with experience in biped tennis. Results reveal significant differences between the groups. These differences may reflect experience and should be considered when coaching and training wheelers.
References


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Table 1: Average Fixation Duration (SD) by Group and Phase

<table>
<thead>
<tr>
<th>Phase</th>
<th>WCB</th>
<th>WCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1: Ritual</td>
<td>499.68 (10.75)*</td>
<td>375.31 (46.31)*</td>
</tr>
<tr>
<td>Phase 2: Preparatory</td>
<td>203.93 (15.65)*</td>
<td>396.25 (13.99)*</td>
</tr>
<tr>
<td>Phase 3: Execution</td>
<td>242.37 (10.56)*</td>
<td>404.87 (12.72)*</td>
</tr>
<tr>
<td>Phase 4: Finishing</td>
<td>91.68 (3.55)</td>
<td>91.87 (3.91)</td>
</tr>
</tbody>
</table>

*p < .001

WCB = Wheelchair Both, WCO = Wheelchair Only.
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Figure 1: Average Fixation Duration by Phase for WCB and WCO players.

![Graph showing average fixation duration by phase for WCB and WCO players.]

- PHASE 1: RITUAL
- PHASE 2: PREPARATORY
- PHASE 3: EXECUTION
- PHASE 4: FINISHING

Fixation Duration (ms)
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Table 2: Number of Fixations (SD) by Group and Phase

<table>
<thead>
<tr>
<th>Phase</th>
<th>WCB</th>
<th>WCO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1: Ritual</td>
<td>1.25 (0.35)*</td>
<td>1.75 (0.44)*</td>
</tr>
<tr>
<td>Phase 2: Preparatory</td>
<td>2.21 (0.34)*</td>
<td>1.06 (0.25)*</td>
</tr>
<tr>
<td>Phase 3: Execution</td>
<td>1.68 (0.47)*</td>
<td>1.125 (0.51)*</td>
</tr>
<tr>
<td>Phase 4: Finishing</td>
<td>0.12 (.49)</td>
<td>0.11 (.39)</td>
</tr>
</tbody>
</table>

* p < .001

WCB = Wheelchair Both, WCO = Wheelchair Only.
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Figure 2: Number of Fixations per Group Separated by Phase
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Table 3: Fixation location at each biomechanical phase for the WCB group and the WCO group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Ritual Phase</th>
<th>Preparatory Phase</th>
<th>Execution Phase</th>
<th>Finishing Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>WCB</td>
<td>GBP</td>
<td>NDA</td>
<td>Contact</td>
<td>Ball</td>
</tr>
<tr>
<td>WCO</td>
<td>NDA</td>
<td>Contact</td>
<td>Contact</td>
<td>Ball</td>
</tr>
</tbody>
</table>
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Table 4: Fixation location at each biomechanical phase for Reina et al., 2007 study compared to the WCO group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Ritual Phase</th>
<th>Preparatory Phase</th>
<th>Execution Phase</th>
<th>Finishing Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reina et al., 2007</td>
<td>GBP</td>
<td>Ball</td>
<td>Ball</td>
<td>Ball</td>
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<tr>
<td>WCO</td>
<td>NDA</td>
<td>Contact</td>
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