# Tennis Forehand Volleys: Developing a Wrist Brace to Moderate Hand Strain

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## ABSTRACT

Numerous tennis players experience hand strains and sprains as novices, and consistent exposure to these types of injuries can weaken the hand over time. This experiment aimed to determine whether a wrist brace can significantly increase a player's performance in tennis, specifically in the forehand volley. The volley was chosen as it is the tennis shot in which the wrist is most vulnerable to muscle and ligament strain. A novel flexible brace design featuring a primary ulnar support as well as accessory structures was proposed for this experiment, and its effect was evaluated through the experiment. Various trials of a player's forehand volleys, with and without the brace, were compared using video analysis software. The average velocity of the returned tennis ball with a brace was 10±3m/s, and it was 8±2m/s without a brace. A paired, two-tailed t-test confirmed that these results were significant, and that a player's forehand volley can be improved when a brace is worn. Once developed further, this wrist brace may be able to aid those with hand disabilities and conditions to play tennis or used as a training implement for beginners.

## Introduction

In order to prevent wrist strain in high velocity tennis shots, a flexible brace was proposed and evaluated in this experiment. The brace provides support to the wrist and ulnar regions of the hand to decrease tendon and ligament strain. Once refined, wrist braces can provide significant aid in training tennis players or aiding those with arthritis or other hand conditions play the sport.

Excessive wrist strain is one of the most common precursors to lateral epicondylitis, or tennis elbow. This causes the swelling of the tendon extensor carpi radialis brevis, which is responsible for bending the wrist backward. Numerous tennis shots, particularly forehand shots, cause large torques when the ball impacts the racket head at a high speed (See Figure 1).

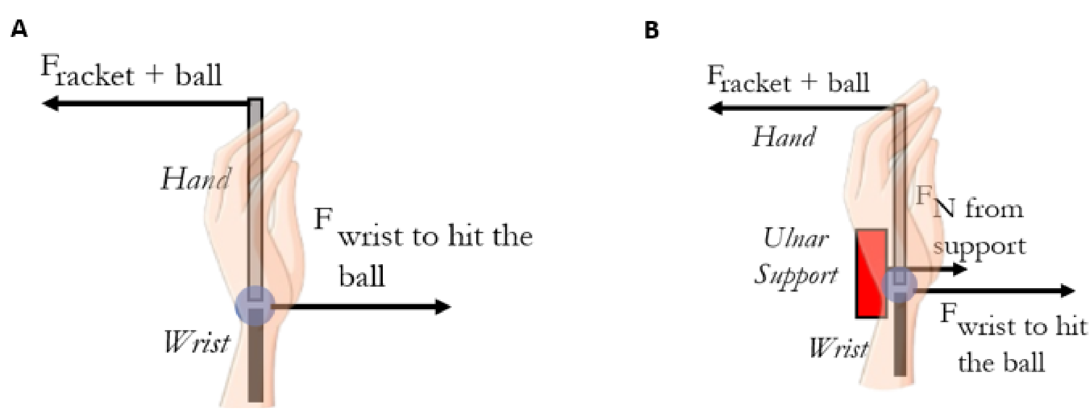

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**Figure 1.** A free-body diagram of the forces about the hand during a forehand volley. Figure 1A is a free-body diagram of the hand hitting a forehand volley with the ball approaching from the right side, while Figure 1B depicts the same phenomenon and includes the ulnar support.

As a result, the bones, tendons, and ligaments are strained in the wrist every time a shot is returned, and repeated exposure can eventually cause tennis elbow (Cross, 2010). Most commonly, the wrist extension muscles and the scapholunate ligament are strained, particularly because the gap in the lunate bone allows it to rub against its surrounding tendons and ligaments, triggering inflammation. The lunate bone corresponds to the ulnar region of the wrist (Cleveland Clinic, 2023). Moreover, recent studies indicate that the threat of wrist sprains and injuries is more pronounced in tennis than other NCAA sports (Chung & Lark, 2017). To prevent the shifting of the bone in future shots, a flexible ulnar support brace was proposed.

Overall, braces are the most effective at-home treatment for minor sprains and strains. The supports on these braces hold the bones in a neutral position so they do not rub against other bones and trigger inflammation. The initial injury then has ample time to heal, reducing pain, tenderness, and burning sensations (Wheeler, 2023). Although, in the case of tennis, in which players have to constantly receive and return shots averaging 105-120 mph, wearing a brace can aid in prevention as well as treatment (Czermack, 2023). However, most braces are rigid and incapable of being worn during high-intensity athletic activity. For this reason, a flexible brace will be advantageous in steadying the wrist during the game itself, while still allowing players to swing their racket comfortably. It will reduce the effects of “wrist snap” and effectively prevent conditions such as tennis elbow.

## Research

While not commonly used in tennis, other sports like weightlifting and boxing have been known to use some form of hand support. Although, there are significant forces about the hand when receiving high-speed shots that can justify the use of a hand or wrist support, particularly if the player has a hand condition or injury. Even though the force is not acting upon the hand for a prolonged period, repeatedly being exposed to “wrist snap” can still strain the hands to the point of injury. The following section evaluates different types of wrist wraps used in other sports and why they are used, as well as how certain components of these braces could be modified for tennis.

### Tennis: Wrist Guards

Once again, while not common practice, there have been several instances in which wrist braces are suggested to be worn in tennis. Such examples include the Dunimed Wrist Wraps and Supports ™, which are supports made from a lightweight and flexible material that only circle the wrists. It leaves the fingers free to grip the racket while compressing the wrist, so the bones do not rub against each other. Additionally, it omitted splints unlike traditional braces to facilitate quick movements (“The Importance of Wearing a Wrist Brace”, 2024). A study by an orthopedic surgeon also clarified indicated that tennis braces should not contain any firm support around the thumb since that would make serving difficult. Since tennis players are not typically used to wearing wrist braces, it is also recommended that they use it primarily for training and informal play before in competitions (Knight, 2023). Both these factors were taken into consideration by using a compressive athletic glove as the basis of the proposed brace for flexibility and only adding supportive wraps to the wrist and between the forefinger-pinky distance. The main component of the support, the firmer ulnar brace, was added along the length of the pinky, where the wrist movement cannot negatively affect shots.

### Boxing

In boxing, wraps are typically worn as shock absorbers and for protection of the hand's tendons and ligaments. It is also to increase punching power, as a 1984 study indicated that punches are much more effective with wraps than without (Read, 2022). Wraps also increase hand durability by evenly distributing the forces received by the hand (McDougal, 2023). This aspect of boxing supports is ideal for tennis supports as well, to help prevent ligament and muscle strain in fast shots. Regardless, the most common wraps utilized in boxing are cotton, elastic bandage, and gel wraps (Read, 2022). Of these, elastic bandage "wraps" were added to the wrist because of their compression ability and flexible nature.

### Weightlifting

Weightlifting uses wraps to limit mobility of the wrist and to decrease stress when lifting heavy weights. However, weightlifters usually take great care not to wrap over the wrist joint, as its natural abilities to remain in an extension position and withstand compressive loads is already capable of performing the exercise (Hughes, 2023) Similarly, in tennis, the brace should prioritize wrist support while still helping it develop as a result of the physical activity. Wrist supports for lifting are usually made out of nylon, cotton, or leather. All fasteners of these wrist wraps are made from Velcro. Although, of these, nylon is the most versatile and preferred by lifters as it can mold to the shape of the wrist and move with it. It can also adjust once rewrapped (Pilon, 2023). The proposed support in this experiment features straps of a similar material to nylon to provide the moldability and flexibility effect. The straps also avoid being directly upon the wrist joint to preserve mobility.

## Methods

To test the efficacy of wrist braces on forehand volleys, two procedures were performed: one was used to build a simple wrist brace prototype from household items, and the other was the experimental design. The null hypothesis was that the usage of a brace during forehand volleys does not significantly affect its maximum velocity.

### Wrist Brace Prototype

First, the distance between the index and the pinky finger was measured and recorded in centimeters. This process was repeated for the distance between the pinky and the wrist and the circumference of the wrist. Knit elastic was cut according to the index-pinky and circumference measurements, and a piece of ¾ inch piece of ¼ foam was cut to the pinky-wrist measurement. The foam was then lined with 25-gauge copper wire.

A standard athletic glove was used as the base for the wrist brace. The foam was attached along the ulnar side of the hand using fuse tape; this is the main ulnar support. The straps were attached according to the diagram below (See Figure 2) using Velcro to make them adjustable for each user.

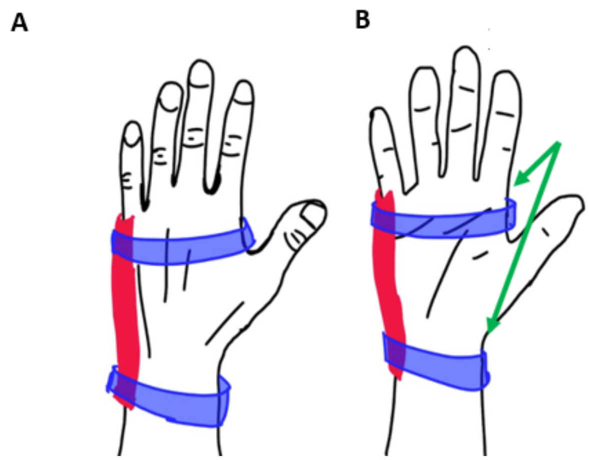


**Figure 2.** Front and back view of the hand with supports attached. The base of the brace is an athletic glove, underlying all the supports (not shown in diagram) for viewability. Wrist and hand supports are in blue, referenced by the green arrow. The main ulnar support is shown in red.

For this specific experiment, the user's measurements were employed in the brace's production. When constructing a brace for multiple users, the average hand measurements can be used as provided in table 1. However, when possible, specific measurements result in a more effective brace. The table below uses the averages between both men and women.

**Table 1.** Hand properties and average measurements

| Hand Properties | Hand Measurement |
|---|---|
| Glove Size | Medium |
| Index-Pinky Distance | 19.1 – 20.3 cm (Brennan, 2021) |
| Wrist Circumference | 15.9 – 16.5 cm |
| Ulnar Support | 7.6 – 8.9 cm (Lindner, 2024) |

## Experimental Design

The velocity of the ball from a forehand shot was measured, both with and without the brace. Three people were required; one to feed a shot, one to return, and one to film. The positions and measurements of these people are marked on the diagram of the court (See Figure 3). A video was shot for 20 trials each (brace and no brace) of forehand shots. The tennis ball was in view from the racket to the ground.

Each trial's speed was analyzed with frame-by-frame video analysis software. In Logger Pro 3, the video file was loaded into the movie analysis tool, then the reference measurement selected was the center of the net (3 meters). In each frame, starting from the moment the ball changed direction on the returners racket, the center of mass of the ball was selected. The frame analysis stopped when the ball touched the court. The maximum y-velocity within that range was then recorded.

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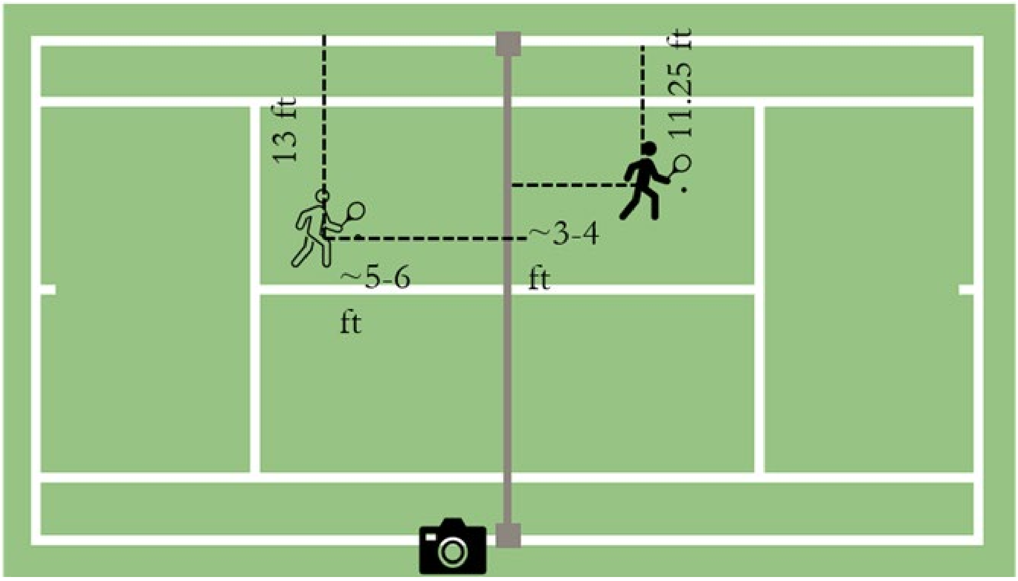


**Figure 3.** Diagram of the court. Black figure represents the returner, the outlined figure represents the feeder. Dimensions for court positions are shown as well. The camera position is shown at the bottom of the diagram; the returners racket and ball should be in view until the ball touches the court.

## Results

After conducting a series of tests, the following results were obtained. The average velocities of the forehand shots over the 10 trials with and without brace were compared using a t-test. The average velocity of the tennis ball with a brace was 10±3m/s. This is significantly greater than without a brace, which had 8±2m/s. As the reference p-value was 0.05 and the experimental p-value was 0.01505, the data is statistically significant. Therefore, we accept that wearing a wrist brace can improve the speed of a forehand volley, thus rejecting the null hypothesis. See Appendix, Table 1 for data table.

### Phases of Data

1. All videos featuring the forehand volleys were separated based on two groups: without the brace and with the brace.
2. The y-velocities of the tennis ball were selected and recorded from the video analysis.
3. The maximum y-velocity of each trial was recorded in the final data table.
4. The y-velocities of each group were averaged and a two-sampled, paired, assuming equal variances t-test was applied.

**Table 2**. Two groups with average

| | **With Brace** | **Without Brace** |
|---|---|---|
| **Average** | 8.13585 m/s | 10.3011 m/s |

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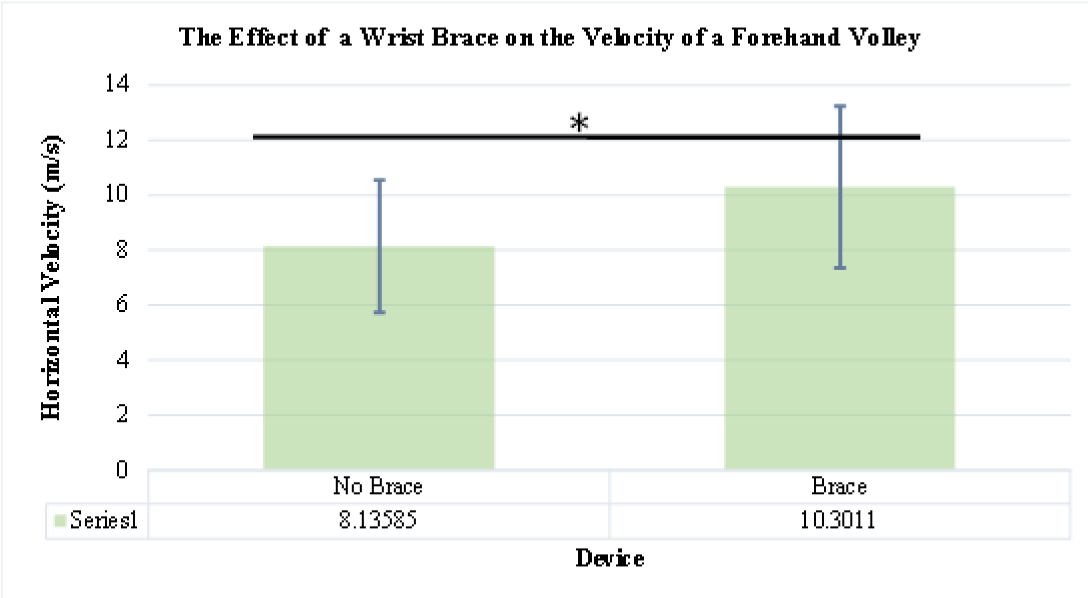


## Discussion

The ball had a greater velocity when using a brace because it both provided an opposing force and also offered ulnar and wrist stabilization in the ligaments and extensor muscles. Compressing the lunate bone prevented structures in the wrist from rubbing against each other, thus reducing risk of injury and strain. In literature, reducing the force from the ball and racket to the ulnar side of the hand and stabilizing the wrist reduces pain, thus improving performance (Kevin).

## Conclusion

This study proposed a novel wrist brace design to help combat the effects of wrist strain and stress in tennis players, particularly those at the novice level or having hand disabilities. The brace compressed the lunate bone while providing ulnar support to the hand. The brace was then evaluated for the forehand volley shot and the speed of the return was measured with video analysis software. The shots with the brace had a greater maximum velocity upon return. The future of this brace includes further development with more refined materials, testing across a wider pool of subjects to create a generalized design, and developing accessory structures to support a wider range of skill levels or disabilities.

## Limitations

Limitations to this experiment included that the brace is only a prototype and needs to be refined, data was collected on one person (who had a slightly weak wrist), other shots and distance tests need to be conducted. Future improvements include condition more trials on different types of tennis shots and testing a larger pool of people. This pool would consist of athletes, novices, and those with hand conditions. Regardless, these findings are important as they can potentially improve the shots of weaker tennis players, as well as help support any hand or wrist conditions.

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