Management of Upper Extremity Injury in Divers

Steven C. Haase, MD[a,b,*]

KEYWORDS

• Hand injury • Wrist injury • Divers • Diving

KEY POINTS

- Competitive diving techniques apply repetitive stress to the hands and wrists.
- Injury may be acute or chronic in nature and is often bilateral.
- Many injuries require operative intervention.

INTRODUCTION

Diving is a popular sport around the world, having been a part of the Olympic Games since 1904. In that year, the competitors were all men, and the diving events consisted of 10-m platform diving and a plunge for distance event. Although the latter was quickly dropped from the Games, 10-m platform diving was expanded to include women in 1912 and continues to be an Olympic event in the twenty-first century. Modern Olympic diving events also include 3-m springboard for men and women as well as synchronized diving counterparts for each of these disciplines.[1,2]

Competitive diving requires great strength and flexibility as well as proprioception and kinesthetic sense so that the diver can execute complex acrobatic maneuvers in the course of the dive. In this regard, the diver's skill set closely resembles that of a gymnast. A dive is scored by a panel of judges, with consideration to all 3 parts of the dive: takeoff, flight, and water entry. The basic technical score is then subjected to a multiplier that increases depending on the difficulty of the attempted dive. The difficulty of dives at competitions has steadily increased over the past 30 years.

DIVING PHYSICS

Applying the laws of physics, it is known that a diver falling from a 10-m height accelerates to just about 14.1 m/s (31.5 mph) before impacting the surface of the water. le Viet and colleagues[3] were able to confirm speeds of 14 m/s to 15 m/s with cinematographic analysis. If a diver's launch from the platform adds additional height to the dive, the final speed is even greater. Speeds in excess of 16.4 m/s (36.8 mph) have been postulated.[2] This leads to a significant impact at the surface of the water: between 2.0 g and 2.4 g (1 g = 9.8 m/s^2). With this force of impact comes the risk of serious injury.

During the flight portion of the dive, the diver often spins and/or twists through several complex rotations while airborne. Due to inertia, it is impossible to halt these motions completely at the end of a dive to obtain a smooth, vertical entry into the water. To create the illusion of a more vertical entry, divers time their entry into the water carefully and rely on underwater saves to quickly rotate the body forward or backward, camouflaging any residual rotational motion that might detract from their score. Often, these saves require rapid shoulder and wrist motions to swim out of the dive quickly and minimize splash. These maneuvers can lead to additional upper extremity injury.

WATER ENTRY

Every competitive diver's goal is to enter the water in a vertical position, with as little splash as

Disclosure Statement: The author has nothing to disclose.
[a] Department of Surgery, University of Michigan Health System, Ann Arbor, MI, USA; [b] Department of Orthopaedic Surgery, University of Michigan Health System, Ann Arbor, MI, USA
* 1500 East Medical Center Drive, 2130 Taubman Center, Ann Arbor, MI 48109.
E-mail address: shaase@med.umich.edu

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possible, to maximize the score for the dive. A perfect water entry—vertical position with minimal splash—is termed a *rip entry*. Choices for water entry are feet-first, with arms held against the sides of the body, or hands-first, with the arms raised over the head and elbows extended. Although dives with advanced difficulty, including multiple flips and twists, have been developed for both feet-first and hands-first entries, divers prefer hands-first dives for several reasons. First, hands-first dives are typically more graceful and appealing to both audience and judges. Second, hands-first dives offer better consistency and control. The diver can see the water during the entry for better timing and positioning. Also, the hands-first position allows the diver to more easily execute a forward or backward somersault (or swim out) on entry—these moves are critical to creating a good save for a nonvertical dive. Finally, the hands-first position provides a cleaner entry (ie, one with less of a splash) than a feet-first entry. For these reasons, Olympic and other elite divers always choose a hands-first entry over feet-first.[4]

The position of the diver's hands at the time of impact with the water has a direct effect on how much of a splash is created. Two principal types of hand positions have been used over the years. The older thumb-in-fist technique involved positioning the hands into side-by-side fists, with the radial sides of the hands together, and the thumb of the dominant hand held in the nondominant fist (Fig. 1).[3]

The newer technique involves creating a larger, flatter surface with which to contact the water. This has been referred to as the flat-hand grab.[5] With arms over the head and elbows in full extension, the wrists are both completely extended and the fingers then turned toward each other, so that the thumbs interlock, with the dominant hand placed palmar to the nondominant hand (Fig. 2A). The nondominant hand then grasps the dominant hand to further secure the position, pulling the dominant hand into an even more extended position (Fig. 2B). Finally, the shoulders are shrugged, pressing the arms against the diver's ears, eliminating as much potential space between the arms as possible. It was with this newer technique that ripping a dive became more predictable and less sporadic, as evidenced by the strong performance of the Soviet dive team in the 1972 Olympic Games.

Contact with the water accounts for a large proportion of diving injuries: 32.0% of men's injuries and 16.2% of women's injuries according to one report.[6] In hands-first entry techniques, the hands and wrists break the surface of the water first, taking the brunt of the initial impact on the upper extremity. The flat-hand grab position presents more than twice the contact surface area at the time of water penetration compared with the thumb-in-palm (closed fist) hand position (175 cm^2 vs 83 cm^2).[3] This larger surface area leads to a more pronounced braking effect using the flat-hand grab technique. At the moment of entry, the diver's speed slows abruptly from 31.5 mph to 20.5 mph, and the hands absorb the energy of this deceleration.

EPIDEMIOLOGY

A standard diving practice regimen involves approximately 200 dives per week.[7] Given the

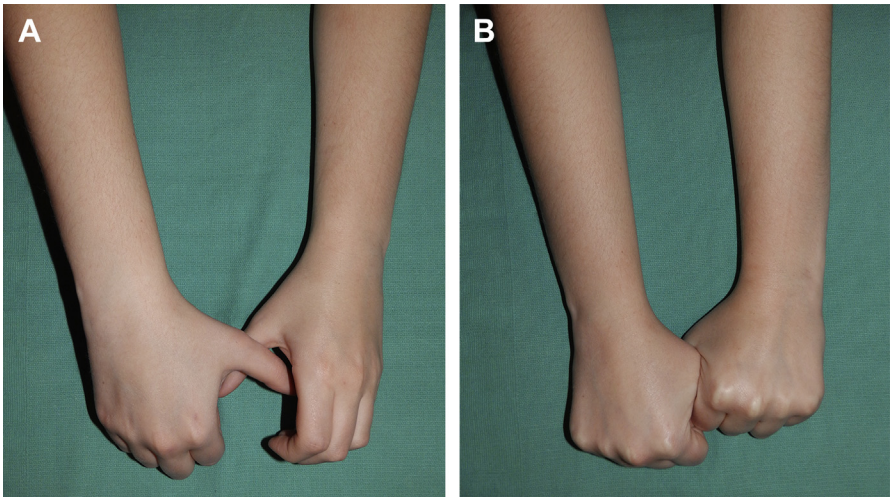

Fig. 1. Demonstration of the thumb-in-palm position. (*A*) The thumb of the dominant hand is placed within the palm of the nondominant hand. (*B*) In the final position, the nondominant fist grasps the dominant thumb.