0363-5465/103/3131-0736$02.00/0
THE AMERICAN JOURNAL OF SPORTS MEDICINE, Vol. 31, No. 5

Effect of a Prophylactic Brace on Wrist and Ulnocarpal Joint Biomechanics in a Cadaveric Model

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Background: Wrist pain from repetitive dorsiflexion and compression during pommel horse exercises is common among male gymnasts.
Purpose: To determine the biomechanical effects of a prophylactic wrist brace on the wrist and ulnocarpal joints during mechanical loading in a cadaveric model.
Hypothesis: The lateral wedge of the palmar pad of the brace will compensate for positive ulnar variance, distributing contact forces more evenly across the radioulnar carpal joint.
Study Design: Controlled laboratory study.
Methods: Six male and six female fixed cadaveric forearm-wrist specimens were subjected to a 32.13-kg compressive load applied through the long axis of the pronated forearm with a dorsiflexed wrist in contact with a support surface. Wrist joint dorsiflexion angle and ulnocarpal joint intraarticular peak pressure were assessed under three brace conditions: Ezy ProBrace with and without palmar pad and a nonbraced control.
Results: Wrist joint dorsiflexion angle was significantly reduced by the Ezy ProBrace with and without the palmar pad. However, ulnocarpal joint intraarticular peak pressure was reduced only by the brace with pad.
Conclusion: Prevention of pathologic wrist changes requires intervention in pressure attenuation, which was achieved with the Ezy ProBrace with palmar pad.
Clinical Relevance: This brace may decrease the cumulative effects of repetitive stress of pommel horse exercise training.

Wrist pain is common among both elite and nonelite male gymnasts.[11,12,14,20,21,23] The primary cause is attributed to repetitive dorsiflexion and compression that are required during pommel horse exercises.[41] The pain is dorsal or dorsal-ulnar and often bilateral.[13]

The wrist position required on the flat surface of the pommel horse is extreme dorsiflexion that "exceeds the range of motion required of most other sports and activities of daily living."[14] The forearm is usually pronated, and the wrist is compressed repeatedly in radial and ulnar deviations (Fig. 1). In an vivo study of indirect pressures, forces exerted by the hand on the pommel were two times body weight (equal to the heel strike forces when running), which are high when transmitted to an area that has not evolved biomechanically to attenuate axial compression impact (Fig. 2).[21,42] Although pressures have been determined with the wrist in neutral position in cadaveric[17,39,46] and spring models,[35] the pressure-sensitive rubber or film used in these models cannot be used in vivo. To date, there has been no direct measurement of the compression forces on the wrist joint during the support phase of pommel horse activities.

It is generally accepted in gymnastics that a "golden age" or sensitive period exists when a young male competitor must commence learning complex motor skills.[23] Accordingly, some of these athletes may continue to train despite wrist pain, and the stress may exceed the limit of developing bone, resulting in injury and permanent loss of wrist motion.[23] Several injury patterns among male gymnasts emerge as the cumulative consequence of the repet-

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No author or related institution has received any benefit from research in this study. See "Acknowledgments" for funding information.

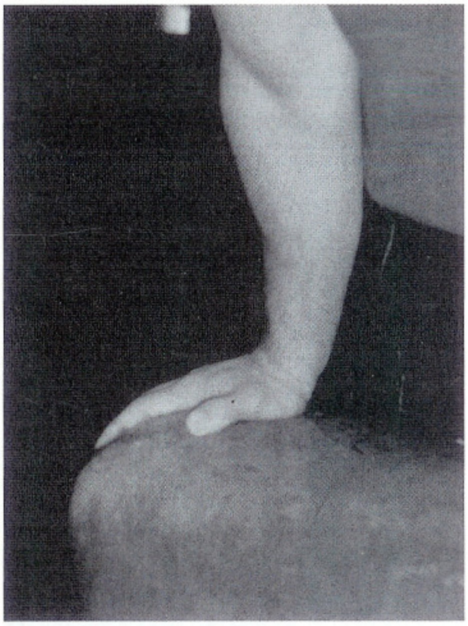

Figure 1. Position of the gymnast's wrist on the pommel horse leather in stationary support position.

Figure 2. Position of the gymnast's wrist on the pommel in stationary support position.

itive stress of weightbearing axial compression and rotation. They include ulnar impaction syndrome, distal radial physeal arrest with secondary positive ulnar variance, and degeneration of the triangular fibrocartilage.[5,6,10,15,45]

Although not widely reported in the literature, it is common practice among gymnasts to use cloth, adhesive wraps, and various other braces applied snugly around the wrist to alleviate wrist pain (Refs. 31 and 45; J. George, personal communication, 1999). The Ezy ProBrace (Gibson, Inc., Englewood, Colorado), developed in 1989 by Dr. Luc Teurlings, an orthopaedic surgeon and a former collegiate gymnast, is marketed for this purpose. A design feature of the Ezy ProBrace is its wedge-shaped palmar pad, designed to compensate for positive ulnar variance (distal ulnar length that is longer than distal radial length), an anatomic anomaly that develops in the gymnastic population and that results in increased pressure at the ulnolunate articulation.[5,20,23,42] It has been theorized that it is the increased loading during growth and development of the distal radial physis that results in wrist pain and the incidence of positive ulnar variance. The lateral wedge of the palmar pad is designed to distribute contact forces more evenly across the radioulnar carpal joint. Male gymnasts have anecdotally reported that the Ezy ProBrace decreases the pain associated with pommel horse exercises.[40,41]

The purpose of this study was to assess the effects of the Ezy ProBrace on the wrist and ulnocarpal joint biomechanics during mechanical loading in a cadaveric model.

MATERIALS AND METHODS

Cadavers

Twelve fixed right upper extremities were harvested from 12 cadavers (six male and six female) with a mean age at death of 77 years (range, 57 to 96). The embalming of the cadaveric specimens allowed for their use over a longer period and decreased the risk of infection during testing[48] without compromising the forces transmitted through the radius and ulna.[46] Cadavers were also used because the safety of the Stryker intracompartmental monitoring system (model 295, Stryker Instruments, Kalamazoo, Michigan) used in the study has not been established for the ulnocarpal joint in vivo.

Criteria for inclusion in the study were intact fingers and 70° to 90° of passive wrist dorsiflexion after transection of the flexor tendons of the five fingers and palmar aponeurosis. Criteria for exclusion were a history of metastatic or bone metabolic disease, noticeable surgical scars, pathologic contractures, and previous wrist fracture as demonstrated on a posteroanterior or lateral roentgenograph.

The specimens were fixed in a 4.8% formalin solution that was diluted 1:1 with water. Specimens were transected 10.26 cm proximal to the humeroulnar joint, and the soft tissues were dissected from the humerus to the level of the medial and lateral epicondyles. The forearm was positioned in full pronation and stabilized by passing a Kirschner wire through the proximal radius and ulna. The humeroulnar joint was stabilized in 180° of extension by passing a 5.08-cm sheet metal screw through the joint. The arm was potted with Epoxy Putty (Oatey, Cleveland, Ohio) into a 10.26-cm piece of polyvinyl chloride tubing 6.0452 cm in diameter.

Transection of the finger flexor tendons and palmar aponeurosis was necessary to achieve 70° to 90° of passive wrist dorsiflexion. The finger and thumb flexors were transected at the proximal interphalangeal joint and

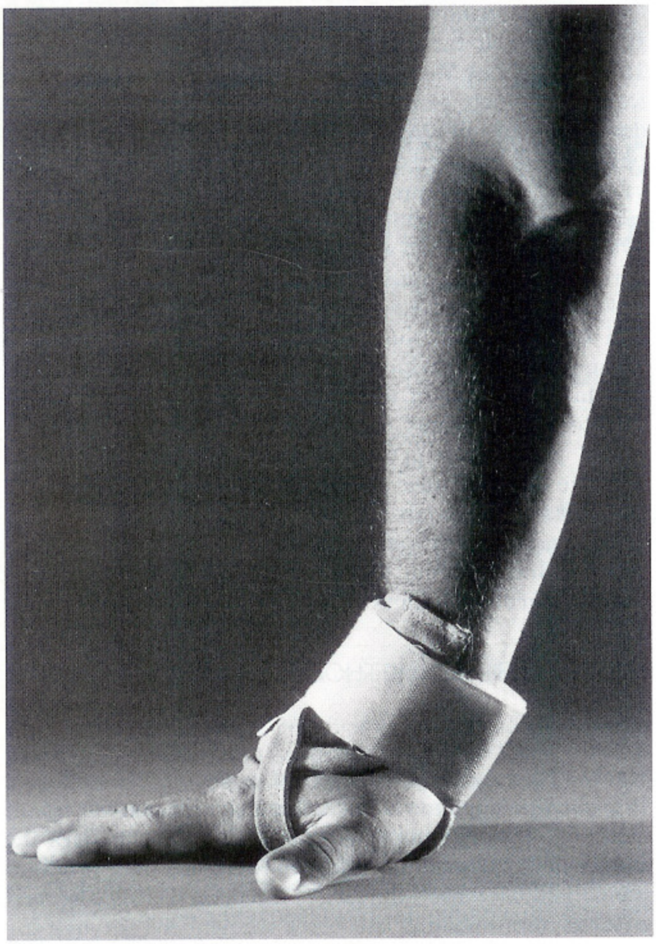

Figure 3. Ezy ProBrace (Reprinted with permission from Gibson, Inc., Englewood, Colorado).

metacarpal phalangeal joint, respectively. The palmar aponeurosis was transected at the level of the distal palmar crease. Transection was necessary because the fixation process resulted in stiffness of the tendons and ligaments due to the coagulation of proteins in the soft tissues caused by the embalming fluid (C. Schneck, personal communication, 2001).

Instrumentation and Procedures

Posteroanterior and lateral roentgenographic views of the wrist were obtained. The posteroanterior view was used to determine ulnar variance, and the lateral view was used to determine the presence of osseous abnormalities. Ulnar variance was determined by drawing two lines on the posteroanterior roentgenograph. One line extended from the distal cortical margin of the radius, and the other line extended from the distal cortical margin of the ulna. Ulnar variance was determined by the distance between the two lines and was measured in millimeters. Positive ulnar variance was defined as an ulna 1 mm or more longer than the radius.[26] Negative ulnar variance was defined as an ulna 1 mm or more shorter than the radius.[26] Neutral

Figure 4. Wrist position on the pommel horse leather with the Ezy ProBrace with palmar wrist pad in stationary support position.

ulnar variance was defined as an ulnar length that differed from the radial length in either direction by less than 1 mm.[9] A board-certified orthopaedic surgeon determined ulnar variance.

The Ezy ProBrace is leather and attaches snugly to the distal forearm via a circumferential VELCRO (VELCRO USA Inc., Manchester, New Hampshire) strap (Fig. 3). The dorsal surface of the Ezy ProBrace is reinforced by foam and a rigid plastic plate that extends approximately 2.54 cm distal to the wrist joint. A removable wedge-shaped palmar pad, thicker on its radial than on its ulnar side, is positioned in the palm. The pad attaches to the brace, under a circumferential strap, via two small leather straps with VELCRO tabs. The two straps attach to the palmar pad and extend to the VELCRO on the dorsum of the hand through the thenar web space and around the head of the fifth metacarpal. The brace can be used with the palmar pad for pommel horse exercises on the leather (Fig. 4) or without the palmar pad (Fig. 5) for exercises on the pommels.[41] The placement and unique design of the palmar pad are purported to relieve wrist joint pressure during closed-chain wrist dorsiflexion by decreasing the angle of wrist dorsiflexion and acting as a cushion that attenuates force.[41]

Each specimen was sized for a brace based on the manufacturer's specifications. A larger-sized brace was selected when the hand measurement fell between two sizes, in accordance with the manufacturer's specifications. The manufacturer's guidelines were followed for the application of the brace in this study. After the hand was placed in the brace, with the small leather straps attached, the VELCRO wrist strap was applied at the distal palmar wrist crease of the neutral wrist.

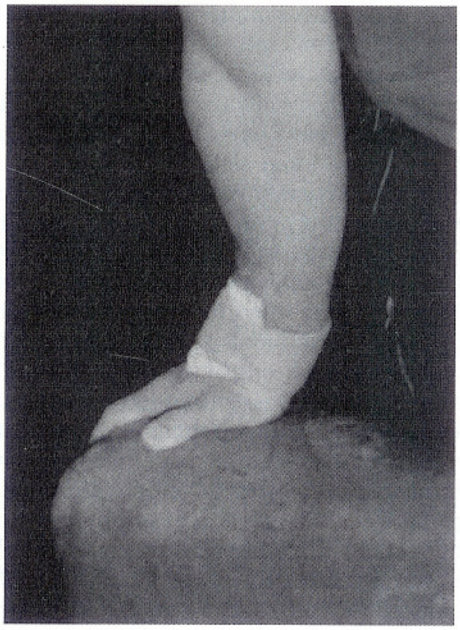

Figure 5. Wrist position on the pommel horse leather with the Ezy ProBrace without the palmar wrist pad in stationary support position.

A uniaxial tension-compression load cell (model LCF 500, Omega Engineering, Stamford, Connecticut) was used to standardize tension of the VELCRO wrist strap during application of the brace. The load cell was affixed to the VELCRO wrist strap of the brace with a 5.08-cm D ring and oriented along the axis of pull. The investigator tightened all braces to a predetermined voltage (0.7048 V) that was standardized across trials. Strap tension was based on a pilot study conducted on four gymnasts and was the equivalent of 5.96 kg.

The apparatus used for testing consisted of two upright aluminum supports welded to a horizontal beam that was 73.66 cm from the supporting surface (Fig. 6). A gravity-driven piston was positioned at the midpoint of the horizontal beam. A cylindrical receptacle, below the beam, seated the potted forearm. The potted forearm was secured to the receptacle via screws that encircled the receptacle. A cuff on the piston above the beam allowed for application of Weider (Weider Nutrition International, Salt Lake City, Utah) barbell disk weights. The weight plates used in this study were verified on a digital scale (model 5002, Scale-Tronix, Inc., Wheaton, Ilinois).

The potted humerus was secured to the piston of the testing apparatus. The wrist was positioned in 70° to 90° of dorsiflexion in neutral rotation against the base of the testing apparatus with a preload of 9.45 kg (combined 4.5 kg disk weight and the weight of the testing apparatus piston) for 24 hours before testing. Preloading of the specimen was necessary to overcome tissue stiffness resulting from the fixation process. Hysteresis was not a confounding factor because it is negligible in formalin-fixed specimens.[4,44,48] The preload position was also the test position for data collection. The fingers were maintained in extension to minimize restriction of motion caused by the finger extensors.[4]

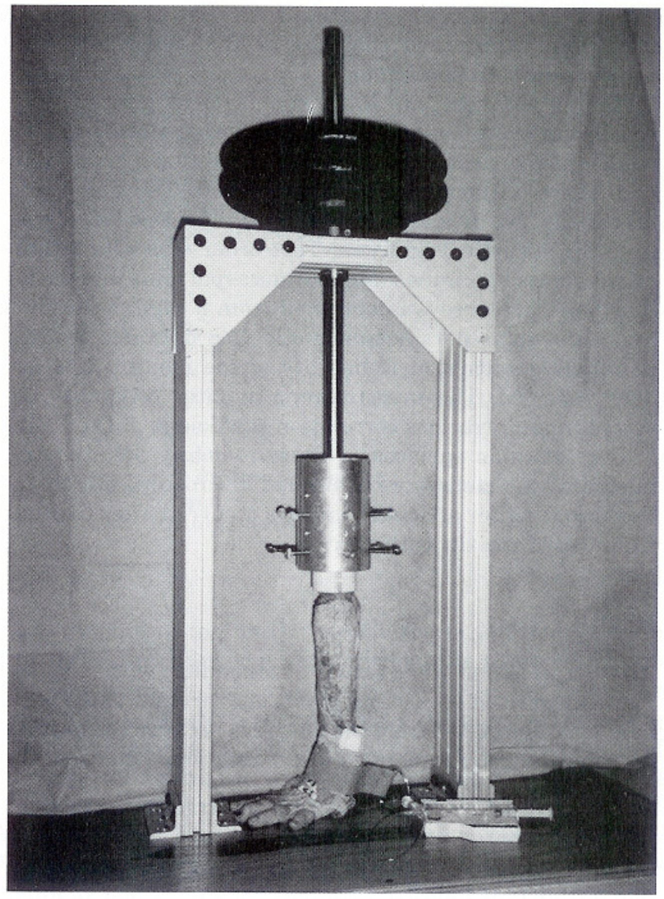

Figure 6. Testing apparatus and setup.

Additional weight (22.68 kg) was added to all specimens to achieve a total of 32.13 kg for the test protocol. The weight selected for this study represents the portion of the load borne on the wrist during the single-arm support of a 63 kg person. A mass of 27 kg was used in a cadaveric study to determine wrist compression loading patterns[42]; radiographs were obtained in the weightbearing condition and showed no evidence of carpal subluxation.

Intraarticular peak pressure at the ulnocarpal joint was determined by introducing the catheter of the Stryker Intracompartmental Pressure Monitor into the pronated wrist. The primary investigator introduced the break-away needle, threaded with the slit catheter, into the ulnocarpal joint via the 6-U standard arthroscopic portal. The catheter was advanced 2.54 cm from the external skin surface, and the break-away needle was withdrawn. The catheter was held in place with Cover-Roll stretch tape (Biersdorf AG, Hamburg, Germany). A 7.62-cm "tunnel" of Orthoplast (Johnson & Johnson, New Brunswick, New Jersey) was secured to the wrist with Cover-Roll stretch tape to protect the catheter from compression during brace strap application. The tunnel remained in place throughout all testing conditions. A board-certified orthopaedic surgeon performed an arthrogram on two randomly selected specimens after testing to verify catheter placement and determined that the desired placement was achieved in both specimens.

Mean ulnocarpal joint intraarticular peak pressure and wrist joint dorsiflexion angle data were collected in five trials during each of the three test conditions: brace with pad, brace without pad, and nonbraced. The data from across the five trials were averaged, and the mean was used for statistical analysis. Test order was counterbalanced across specimens. Mean ulnocarpal joint intraarticular peak pressure was obtained from a digital readout, and wrist joint dorsiflexion angle was obtained from a handheld goniometer. Reliability of the monitor has not been reported. The investigator's monitor reliability resulted in an intraclass correlation coefficient (2,1) of 0.92.

The articular surfaces of four randomly selected triquetrum specimens were examined macroscopically to determine whether articular damage occurred after fixation from use of the slit catheter.

RESULTS

All 12 specimens were tested successfully, with 1 specimen categorized as a negative ulnar variant. This specimen was eliminated from the analyses because the normal distribution requirement of the statistical test was not met. Repeated-measures multivariate analysis of variance indicated no significant interactions ($P > 0.844$). Significant main effects existed for condition and sex ($P \leq 0.002$). The univariate analyses of variance revealed a significant difference in wrist joint dorsiflexion angle for condition ($P = 0.002$) (Table 1) and significant differences in ulnocarpal joint intraarticular peak pressures for condition ($P < 0.001$) and sex ($P < 0.001$) (Table 2). Results of the post hoc extended Scheffé analyses are presented in Tables 3 and 4. Wrist joint dorsiflexion angle was significantly lower for the Ezy ProBrace with palmar pad (80.72° ± 5.9°) and without palmar pad (82.73° ± 5.0°) than for the nonbraced control (87.52° ± 4.1°) ($P \leq 0.05$).

The results of this investigation indicated that the Ezy ProBrace, with and without palmar pad, significantly reduced wrist joint dorsiflexion angle compared with the nonbraced condition. However, no significant difference was found between the two brace conditions in wrist joint dorsiflexion angle. Ulnocarpal joint intraarticular peak pressure was significantly lower for the Ezy ProBrace with palmar pad (110.5 ± 13.5 mm Hg) than for the Ezy ProBrace without palmar pad (142.0 ± 19.3 mm Hg) ($P \leq 0.05$). Additionally, ulnocarpal joint intraarticular peak pressure was significantly lower for the Ezy ProBrace with palmar pad than for the nonbraced control (161.7 ± 18.3 mm Hg) ($P \leq 0.05$). Ulnocarpal joint intraarticular

TABLE 1
Wrist Joint Dorsiflexion Angle Measurements (in Degrees) by Sex and Brace Condition

Condition	Sex	Ulnar variance	*N*	Mean ± SD
Nonbraced control[a]	Male	Positive	2	91.6 ± 2.2
		Neutral	4	86.3 ± 4.4
	Female	Positive	2	85.2 ± 5.9
		Neutral	3	87.9 ± 2.9
Ezy ProBrace with pad[a]	Male	Positive	2	81.7 ± 0.7
		Neutral	4	79.8 ± 9.1
	Female	Positive	2	83.9 ± 7.0
		Neutral	3	79.3 ± 2.7
Ezy ProBrace without pad[a]	Male	Positive	2	84.5 ± 0.6
		Neutral	4	81.1 ± 8.5
	Female	Positive	2	82.7 ± 2.9
		Neutral	3	83.6 ± 1.2

[a] Significant difference among conditions ($P = 0.002$).

TABLE 2
Ulnocarpal Joint Intraarticular Peak Pressure Measurements (in Millimeters of Mercury) by Sex and Brace Condition

Condition	Sex	Ulnar variance	*N*	Mean ± SD
Nonbraced control[a]	Male[b]	Positive	2	163.3 ± 6.9
		Neutral	4	148.1 ± 18.6
	Female	Positive	2	162.7 ± 5.9
		Neutral	3	178.1 ± 11.7
Ezy ProBrace with pad[a]	Male[b]	Positive	2	98.8 ± 0.3
		Neutral	4	101.8 ± 7.6
	Female	Positive	2	132.7 ± 7.0
		Neutral	3	114.8 ± 4.5
Ezy ProBrace without pad[a]	Male[b]	Positive	2	125.2 ± 7.1
		Neutral	4	139.9 ± 9.5
	Female	Positive	2	148.7 ± 49.1
		Neutral	3	151.3 ± 5.5

[a] Significant difference among conditions ($P = 0.000$).
[b] Significant difference between sexes ($P = 0.000$).

TABLE 3
Wrist Joint Dorsiflexion Angle (Range of Motion) Within Brace Condition

Condition	Dorsiflexion angle (deg)		Contrast	Mean difference
Nonbraced control	87.52 ± 4.1	vs.	Ezy ProBrace with palmar pad	6.8[a]
Ezy ProBrace with palmar pad	80.72 ± 5.9	vs.	Ezy ProBrace without palmar pad	2.0
Ezy ProBrace without palmar pad	82.73 ± 5.0	vs.	Nonbraced control	4.8[a]

[a] Significant at $P \leq 0.05$ level.

TABLE 4
Ulnocarpal Joint Intraarticular Peak Pressure Within Brace Condition

Condition	Mean pressure (mm Hg)		Contrast	Mean pressure difference
Nonbraced control	161.7 ± 18.1	vs.	Ezy ProBrace with palmar pad	51.3[a]
Ezy ProBrace with palmar pad	110.5 ± 13.5	vs.	Ezy ProBrace without palmar pad	31.5[a]
Ezy ProBrace without palmar pad	142.0 ± 19.3	vs.	Nonbraced control	19.8

[a] Significance at $P \leq 0.05$ level.

peak pressure was 12% higher in female specimens (148.08 ± 26.6 mm Hg) than in male specimens (129.67 ± 25.05 mm Hg) ($P < 0.001$).

DISCUSSION

Inherent in the use of a cadaveric model in this study are several limitations. Cadaveric specimens do not have viable neurologic and contractile properties. Additionally, the effect of the fixation process on tissue proteins resulted in stiffness that prevented the wrist dorsiflexion desired for this investigation. The transection of the flexor tendons and the aponeurosis was an unavoidable consequence of these limitations and was standardized in all specimens. Tissue tension in the in vivo wrist has not been quantified and warrants further study.

The decrease in wrist joint dorsiflexion angle is attributed to the design, material composition, and application of the Ezy ProBrace. Wrist joint dorsiflexion requires sufficient moment of force (torque) to produce rotation at the wrist joint.[22] This rotation is accomplished by a counterforce pressure applied at the axis of rotation of the wrist joint at the same time that torque is applied proximal and distal to the wrist. The brace's distal lever arm of 2.54 cm, as well as the dorsal foam and rigid plate, necessitated increased force to dorsiflex the wrist joint. Other more pliable materials, such as elastic or athletic tape alone, would not have been likely to have the same beneficial properties, although this has yet to be determined through empirical analysis.[22] However, gymnasts use the biomechanical advantage of taping a block of foam or orthopaedic felt on the dorsum of the wrist to resist closed-chain dorsiflexion.

From a clinical perspective, if reduction in wrist joint dorsiflexion angle is the only biomechanical objective sought, then use of the brace without the palmar pad is all that is required. No significant differences existed in wrist joint dorsiflexion angle between the two Ezy ProBrace conditions. Although this finding is moot for the gymnast who is performing on the mushroom or leather, because the brace can be used with or without the palmar pad, it is important for exercises on the pommel. Use of the palmar pad would prohibit a secure grip on the pommel, resulting in a compromise in performance and safety. The effect of bracing or taping on gymnastic performance is unknown and warrants further study.

Ulnocarpal joint intraarticular peak pressure was significantly lower with use of the Ezy ProBrace with the palmar pad than with the brace without it or in the nonbraced control. Peak wrist pressure was measured in the cadaveric model in a position that also closely simulated a gymnastic upper extremity weightbearing activity (80° to 90° of dorsiflexion).[42] Teurlings et al.[42] reported that peak pressure at the ulnolunate articulation decreased with wrist joint dorsiflexion from 90° to 80°, but the decrease was not significant ($P = 0.06$). Their small sample size ($N = 8$) most likely resulted in low statistical power and the inability to detect significant differences. Similarly, although the Ezy ProBrace without palmar pad used in the current study did not result in a significant reduction in ulnocarpal joint intraarticular peak pressure, statistical significance was relatively low, with an alpha level of 0.076. The lack of significance was attributed to low statistical power (0.436).

The reduction in ulnocarpal joint intraarticular peak pressure provided by the Ezy ProBrace with palmar pad is attributed to one of several or a combination of mechanisms: soft tissue hydraulics, corset effect, force distribution and attenuation, and load-sharing in impact dissipation. Although the latter has been espoused by Staebler et al.[36] as the mechanism underlying the efficacy of an inline skating brace, brace load-sharing has been refuted.[34] Sarmiento and Latta[34] reported that braces were minimally effective in fracture stabilization; the primary stabilization was provided by soft tissue hydraulics.[18] Although the cadaveric model used in this study may be a limitation, this finding has been corroborated through cineradiographic observation in the in vivo limb.[32] These results have been corroborated in other fracture studies as well.[33,38] Latta et al.[18] instrumented pressure fracture braces on patients with overriding tibial-fibular fractures. They reported that soft tissue provided 80% and the brace provided 17% of the ambulatory load in fracture bracing. The extent to which these data apply to the Ezy ProBrace and nonfracture bracing is unknown.

The Ezy ProBrace encapsulates the soft tissues of the forearm, which function as an elastic sleeve. When pressure is applied to confined static fluid, it is equally distributed.[27] In the treatment of fractures, braces are used to prevent hydro-based tissues from extruding, resulting in less pressure on the bone and providing fracture stabilization.[18] The same principle may apply to use of the Ezy ProBrace, whereby the brace creates pressure on the soft tissues, decreasing pressure on the joint and resulting in decreased ulnocarpal joint intraarticular peak pressure. In the present study, the Ezy ProBrace that bound the fascia under load was likely aided by the dense collagenous fibers of the interosseous membrane between the radius and the ulna.[32]

Another factor in the efficacy of the Ezy ProBrace in reducing ulnocarpal joint intraarticular peak pressure is the corset-like effect of the brace. A corset is an appliance with a stiffened reinforcement that contains soft tissues through increased pressure, supporting soft tissue or restricting motion.[30] A tight corset around the abdomen, such as a thoracolumbosacral corset, increases intraabdominal pressure and enhances, and in some cases replaces, the effect of the trunk muscles.[30] The action of the trunk musculature is to convert the solid- and liquid-filled spinal column and air-filled abdominal and thoracic cavities into rigid-walled cylinders capable of transmitting forces, distracting the vertebrae, and decreasing compression loads on the spine.[1,7,8,25,30] A corset-like effect of the Ezy ProBrace would have resulted in compression of soft tissue, distraction of the ulnocarpal joint, and the corresponding decrease in ulnocarpal joint intraarticular peak pressure.

The fact that ulnocarpal joint intraarticular peak pressure was significantly reduced with use of the Ezy ProBrace with palmar pad leads to the conclusion that the pad in isolation or in combination with the aforementioned factors was responsible for the reduction. The Ezy ProBrace with palmar pad resulted in a 31.6% decrease in ulnocarpal joint intraarticular peak pressure, whereas, without the pad, use of the brace resulted in a nonsignificant 13% pressure reduction. The palmar pad most likely reduced the ulnocarpal intraarticular peak pressure by increasing the area in which the force was distributed and, because of its dense foam construction, facilitating dissipation of energy.[2,16,30]

Female specimens had higher ulnocarpal joint intraarticular peak pressure than male specimens, although age was a confounding factor. There was an average difference of 20.67 years between female (87.17 ± 6.85 years) and male (66.50 ± 7.71 years) specimens. A sex effect on ulnocarpal intraarticular peak pressure has not been previously reported because only male specimens have been used.[23,35,39,42,46] Within the delimitation of overlap near the center of the normal distribution, which occurs between the ranges of men and women within the same population, male bones are longer, larger, and have more pronounced features than female bones.[3,37,43,47] Although the bones were not measured in this study, the female specimens most likely had smaller bone surface areas than the male specimens. Under a constant load, which in the current study was 32.13 kg, smaller bone surface area would result in increased pressure per unit area.

Proper sizing and fit is integral to the clinical efficacy, biomechanics, and function of a brace. Moore et al.[24] reported that fit of the brace was a limiting biomechanical factor in cadaveric bracing studies. Conversely, Staebler et al.[36] disagreed with this finding but provided no supportive empirical data to support this conclusion. In the current study, brace sizing and application were controlled as confounding factors.

Ulnar variance did not significantly affect ulnocarpal joint intraarticular peak pressure or wrist joint dorsiflexion angle. The design of the wedge-shaped palmar pad in the Ezy ProBrace is purported to "correct" for positive ulnar variance and decrease ulnar side pressure. The extent to which this is true is yet to be determined. In the current study, we used specimens that were available, resulting in four with positive ulnar variance, one with negative ulnar variance, and seven with neutral ulnar variance. The specimen with negative ulnar variance was eliminated from the analysis because the assumptions of the test statistic were not met. The ulnar variance definitions of Nakamura et al.[26] and De Smet[9] were used in this study, with positive ulnar variance defined as 1 mm or greater. In contrast, the ulnar variance of adult gymnasts ranges from 0 to +5, and positive ulnar variances are significantly greater in gymnasts than in nongymnasts.[5,9,11,19,20,42] Accordingly, the mitigating effects of a nonrepresentative sample and small sample size should result in cautious interpretation of the ulnar variance findings in the current study.

From a clinical perspective, if reduction of ulnocarpal joint intraarticular peak pressure is the objective, gymnasts would be advised to wear the Ezy ProBrace with pad when possible. In situations where this is not possible, because the performance of the skill would be compromised, the results of the current study would suggest that use of the Ezy ProBrace without palmar pad would be helpful in mildly reducing forces. Anecdotally, male gymnasts circumferentially tape the distal radius and ulna above the wrist during pommel horse exercises, indicating that the effect of taping is protective by decreasing pressure rather than restricting motion at the joint.

CONCLUSIONS

Within the limitations of the cadaveric model and the test protocol used in this study, wrist joint dorsiflexion angle was reduced by use of the Ezy ProBrace with and without the palmar pad. However, ulnocarpal joint intraarticular peak pressure was reduced only by use of the Ezy ProBrace with palmar pad. From a clinical perspective, prevention of pathologic gymnastic wrist changes requires intervention in pressure attenuation. Use of the Ezy Pro-Brace by gymnasts may be beneficial in decreasing the cumulative consequences of the repetitive stress of pommel horse exercise training in the pediatric and adolescent gymnastic population.

ACKNOWLEDGMENTS

This research was partially supported by Stryker Instruments (Kalamazoo, Michigan). David Middlemas, EdD, ATC, (statistics) and Zebulon Kendrick, PhD, (original manuscript revision) are acknowledged for their significant contributions to this research.

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