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Hand and forearm strength and its relation to tennis

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ABSTRACT

Eight expert tennis players and 12 nontennis playing controls were studied to determine the relationship between dominant and minor extremities in regard to hand and forearm isometric strength. The results revealed that overall strength, including wrist extension, was significantly greater (*P* 0.01) in the dominant arm in both groups. The tennis players were distinguished from the controls by significantly increased strength of metacarpophalangeal joint extension of the fingers on the dominant side. Examination of a group of 16 "tennis elbow" sufferers demonstrated no significant extensor strength differential in the dominant arm, with no reports of pain during the testing procedure. The increased strength of hand extension in elite tennis players may be significant in explaining the observed rarity of "tennis elbow" in these individuals.

Cyriax[3] proposed that the common extensor tendon is the actual site of the problem in "tennis elbow." In 1955, Bosworth[1] published his first work on the surgical treatment of tennis elbow, and cited tendinitis, bursitis, periostitis of the lateral epicondyle and pinching of the synovial fringe extending into the joint between the capitellum and the radial head, as causes of tennis elbow. His follow-up work thoroughly discusses the results of surgical intervention and points to the utility of this approach.[2] Nirschl[6] summarized his current thinking regarding the etiology of "tennis elbow," implicating an extraarticular mechanism, specifically involving the extensor aponneurosis.

Tennis elbow is often described as a pathological entity which results from the application of chronic "mini-stresses" to an unprepared or weakened musculoskeletal system. The compilation of these microtraumas can precipitate a failure at the weakest link in the chain of bones, muscles, tendons, and ligaments in the involved limb. We hypothesize that the tennis elbow syndrome may be associated with a failure to develop the usual dominant arm strength increases in the complex extensor system of the wrist and fingers. This extensor system serves to connect a rigid implement (tennis racket) in the player's hand to the sturdy, segmented appendicular skeleton.

In order to test the above hypothesis, we studied the strength of certain motions of the hand and forearm. By measuring these parameters in separate populations of expert tennis players and normal controls, we hoped to document any variations in the forearm muscular strength patterns characteristic of tennis players. For further comparison, similar testing was also performed on a group of patients suffering from "tennis elbow."

MATERIALS AND METHODS

The subject population consisted of three groups. The control group (N = 12) was comprised of individuals who did not play a racket sport, did not use their hands extensively in their occupation and were free from shoulder, elbow, and or other arm pathology. The experimental group consisted of tennis players ($N = 8$) who practiced or competed at least 20 hours per week. All were either professional or high-ranking amateurs. The tennis elbow population (N = 16) had a symptomatic lateral epicondylitis. At the time of testing, these subjects were pain-free in the motions tested, although all were tender over the lateral epicondyle.

Subjects were tested for isometric strength on a specially constructed cable tensiometer (Fig. 1).[5] Strength was quantitated through output from the load cell, which was displayed by a pen deflection on a calibrated Grass polygraph. The system was calibrated in pounds by hanging weights from the cable tensiometer through the pulley system prior to the testing of each subject. The testing device provided

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stabilization of the upper arm, forearm, and hand (when testing finger motions). Attachments were designed to allow testing for the following motions: forearm pronation and supination, radial and ulnar deviation, wrist flexion and extension and combined digit 2 through 5 metacarpophalangeal joint flexion and extension.

Both dominant and nondominant arms were tested. The total arm strength was computed as the sum of all the individual measurements for each arm. Each subject's nondominant hand served as his or her own control. This process allows comparison, without the need for matching sex, height, and weight for the population. Antagonistic muscle group ratios were also computed for each arm. No attempt was made to match the groups for such factors as age, height, weight, and sex. However, because weight varies proportionately with strength variables, strength scores are indicated as the raw strength divided by the body weight.

A paired Student's t-test was used to compare the dominant to the nondominant arm in all cases. An alpha level of .01 was used in determining significant differences.

RESULTS

Table 1 shows the weight and sex breakdown for the three groups. The tennis player and tennis elbow groups were similar in weight and both were lighter than the control group. In addition, both the control and tennis elbow groups consisted of at least 50% males while the tennis player group consisted of only 25% males.

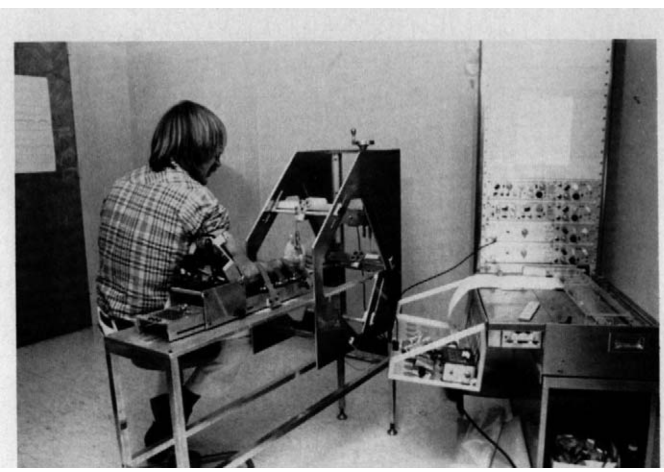


Figure 1. Instrument designed for measuring hand and forearm strength. Note stabilization of limb segments.

TABLE 1
Sex and weight breakdown of subjects

	Control	Tennis player	Tennis elbow
Female	3	6	8
Male	9	2	8
Weightpounds ± SE	166 ± 32 (134–198)	135 ± 15 (120–150)	142 ± 22 (120–164)

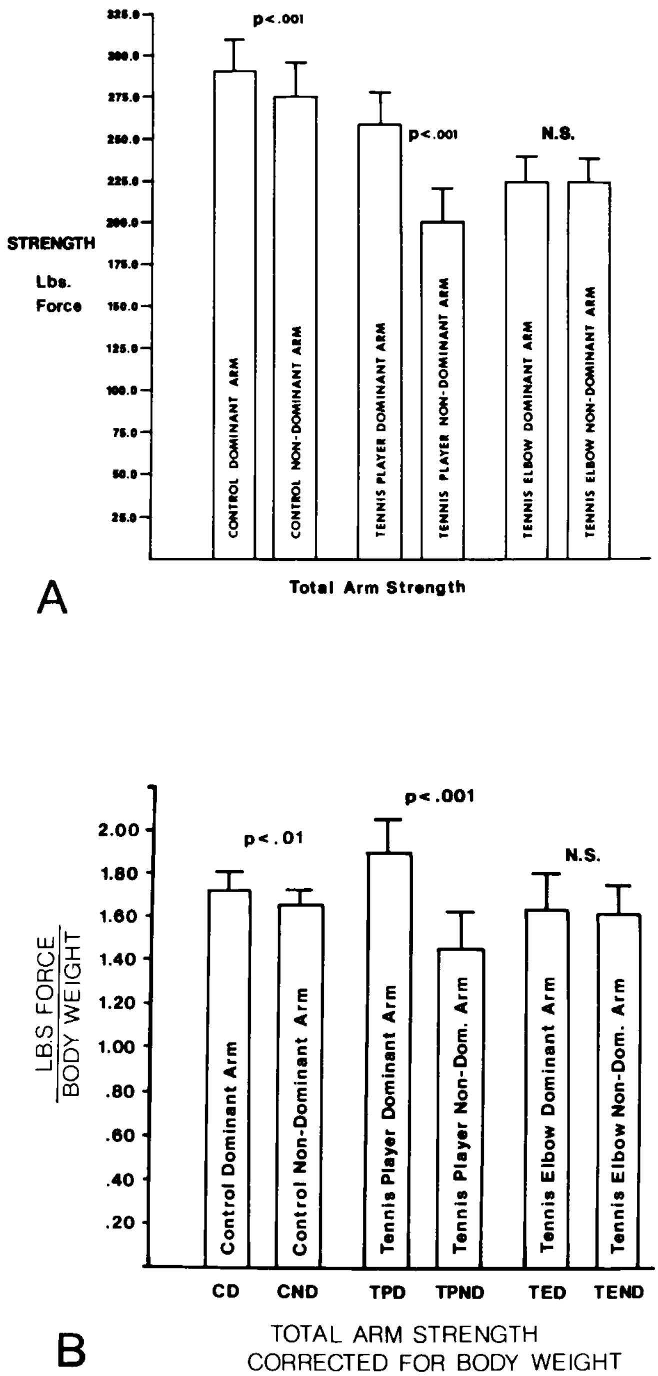
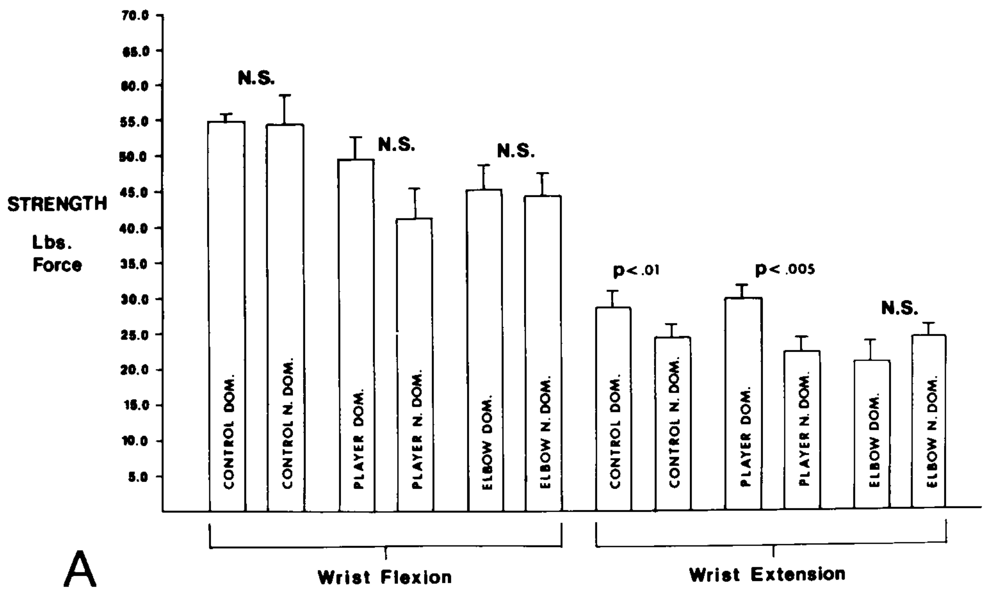


Figure 2. A, total arm strength (as defined in text) for the three populations in the dominant and nondominant arms. Bar represents mean + SE. B, bar represents mean standard total arm strength adjusted for individual body weight. N.S., not significant.

Figure 2 depicts the total arm strength values for all groups. The dominant arm was significantly stronger than the nondominant arm in both control and tennis player populations, but not in the tennis elbow group. No consistently significant differences were noted between the dominant and nondominant arms for pronation, supination, radial deviation, and ulnar deviation.

Additionally, no significant differences in strength existed for wrist flexion between arms for any of the groups, although TP demonstrated a trend in the direction of the dominant arm being stronger. In wrist extension, both control and tennis player groups showed significant dominance. These motions are illustrated in Figures 3 A and B for the raw and weight-adjusted scores. Figure 4B depicts the values for the antagonist motions of flexion and extension at the digit 2 through 5 metacarpophalangeal joints (MP). MP flexion shows no significant differences for any of the groups, and the only group to show significant differences in MP extension was the expert tennis players.

The ratios of wrist flexion to wrist extension in the three



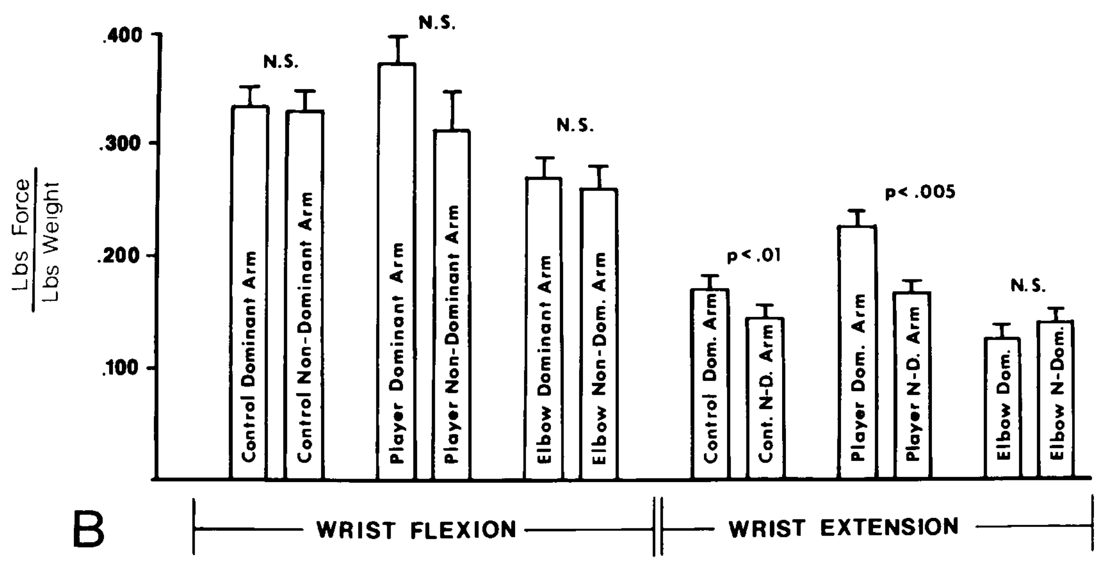


Figure 3. A, raw values for wrist flexion and wrist extension. Mean + SE. B, wrist flexion and wrist extension adjusted by body weight. Mean + SE. N.S., not significant.

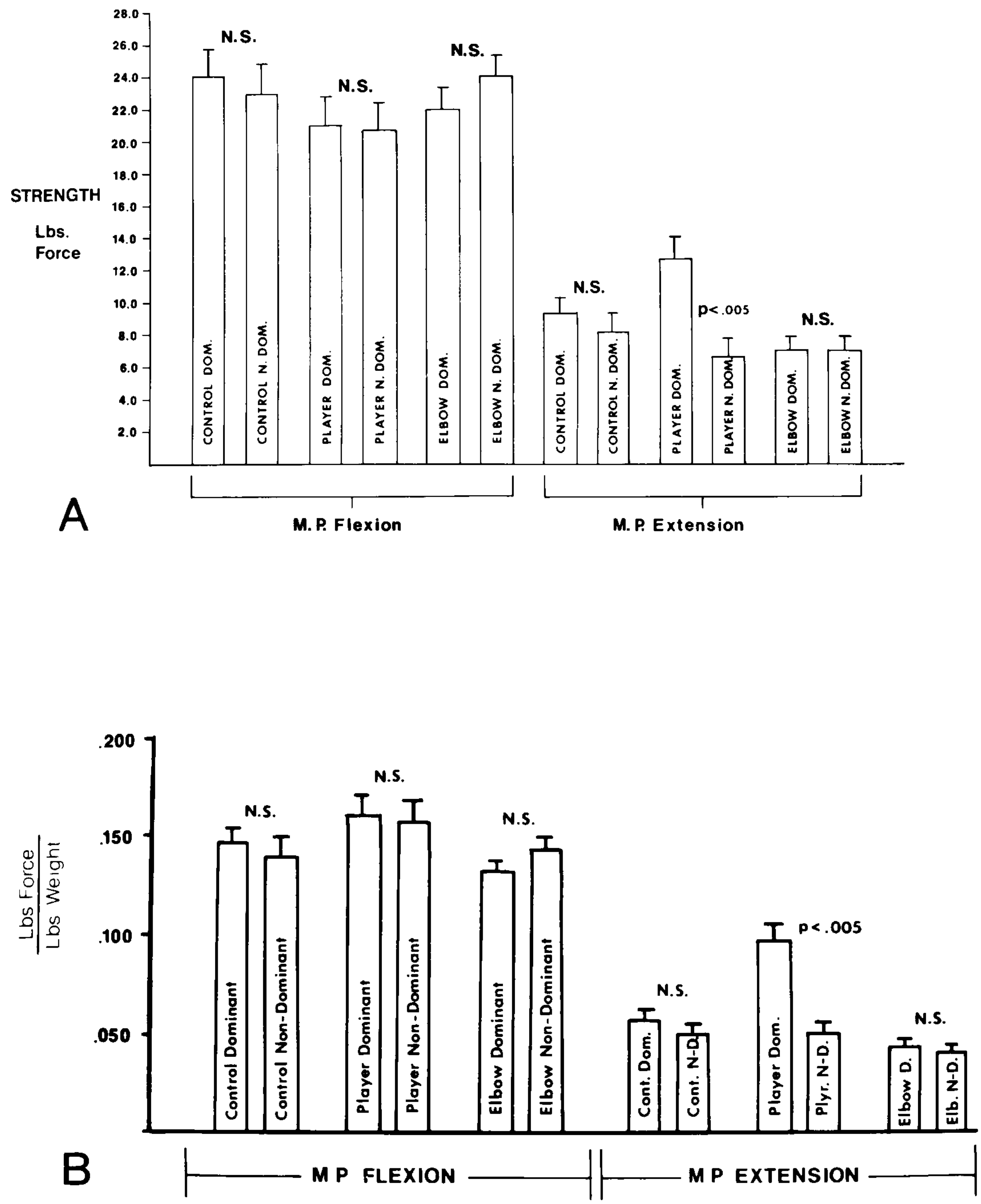


Figure 4. A, raw values for MP joint flexion and extension. Mean + SE. B, MP flexion and extension adjusted for body weight. Mean + SE. N.S., not significant.

groups as seen in Figure 5 demonstrate no significant differences between dominant and nondominant arms. The ratio of MP flexion to MP extension demonstrates that only in the expert tennis players is the ratio significantly different between dominant and nondominant arms. In addition, the mean value of dominant MP flexion to MP extension is much lower in this group than in other groups. This is a reflection of the higher outputs generated by the dominant arm of the experienced tennis players in MP extension and not lower outputs in MP flexion.

DISCUSSION

This study was performed by examination of the forearm and hand strength profiles of three separate populations. We compared dominant and nondominant arm strength in

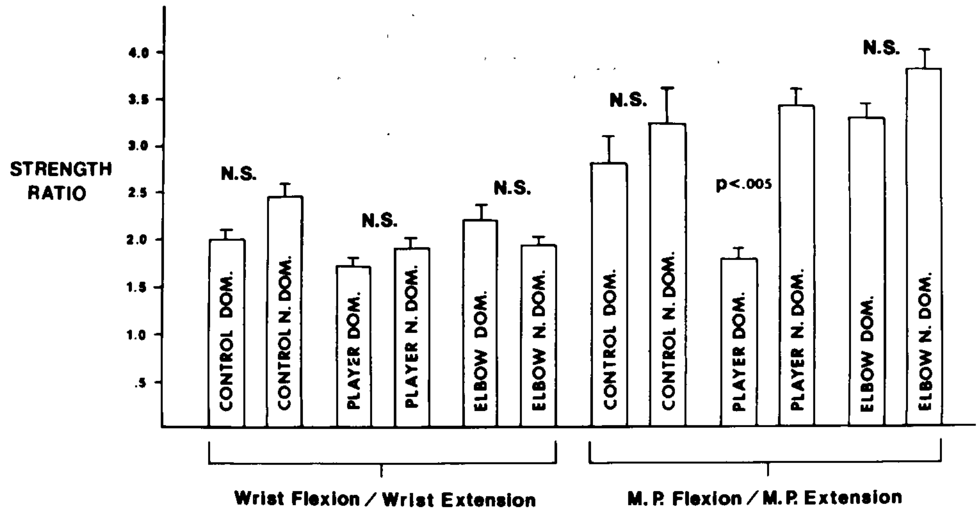


Figure 5. Ratio of wrist flexion to wrist extension and MP flexion. Mean + SE. N.S., not significant.

a control population who did not play a racket sport with a group of high-ranking amateur or professional tennis players. We also studied a group of patients with chronic tennis elbow who did not experience pain during testing, with the recognition that the measured results could be influenced by subliminal noxious stimuli. The results demonstrate that the expert tennis player has developed a specific strength profile which differs from the control population.

This study did not attempt to demonstrate any differences in overall or upper extremity strength between the population groups, but was designed to demonstrate how the dominant arm might differ from the nondominant arm. The pattern of dominant strength in the tennis players is worth noting. The strength of wrist flexion, wrist extension, radial and ulnar deviation, pronation, supination, and MP flexion are not significantly different when comparing one arm with the other. It can be inferred that tennis does not cause a significant gain of strength in these muscle groups. The distinguishing feature of tennis players from the control group is their significantly increased strength of MP extension on the dominant side.

Kaplan[4] pointed out that hand function involves a complex and intricate balance between flexors and extensors utilizing the extrinsic and intrinsic musculature. Two possible ways of disturbing this relationship are inadequate flexibility and inadequate strength.

Therefore, one approach to preventing pathology may be to increase the flexibility of these muscle and tendon units. In the case of tennis elbow, this can be accomplished through such treatment modalities as stretching, manipulation, and surgical release of the extensors.

The alternative approach involves strengthening the extensors. Strengthening the intrinsic musculature of the hand can also play an important role in the prevention and treatment of tennis elbow due to the role of the "intrinsics" as complex mediators of the flexion/extension force couples of the hand. It can be useful in itself or in coordination with any of the preceeding remedies and yet it is frequently ignored. Our results demonstrate that the extensors at the MP joint are clearly stronger in the tennis player group. This may be one reason that, as Nirschl[12] pointed out, this population does not typically suffer lateral epicondylitis, but rather its medial counterpart.

To strengthen the extensors and intrinsic system, we have employed a very simple exercise, using an assortment of rubber bands spread around the fingertips. The rubber band provides a dynamic resistance and the fingers are spread for 25 repetitions every hour. This motion rarely causes pain even during the acute phases of tennis elbow and therefore may be instituted early in treatment. We have been using this method (combined with direct, local ice massage when sharp pain exists) since 1960, with success in many cases.

SUMMARY

We have shown in a cross-sectional study that real differences exist between the dominant and nondominant hand strength of tennis players, when compared to normal controls. The epidemiology of tennis elbow, as documented by Nirschl, indicates that the classical "lateral" type of tennis elbow is much less common in elite tennis professionals than in players with less experience. This may be due to differences in the ratios of flexion to extension strength in both the wrist and MP joints of the population studied. The tennis players in our groups showed that the arm holding the racket demonstrated significantly increased strength, which was largely in the extensor musculature. This finding supports the contention that tennis professionals acquire a strength pattern in their dominant arm which may be protective against the development of "tennis elbow."

CONCLUSIONS

- Total arm strength and wrist extension are stronger in the dominant arm of tennis players and nontennis playing controls, but are not in those individuals studied with "tennis elbow."
- Metacarpophalangeal joint extension strength is significantly greater in the dominant arms of only the tennis player group, the nondominant arm being indistinguishable from the controls.
- Isolated strength measurements of pronation, supination, radial, and ulnar deviation and flexion of the wrist and joints show symmetry in all three groups.
- Metacarpophalangeal extension strength would seem to be an important measure for future prospective studies of "tennis elbow syndrome" and may have prognostic value in the selection of expert tennis players, as well as implications for their training programs.

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