[ Athletic Training ]

# The Effect of Grip Size on the Hitting Force During a Soft Tennis Forehand Stroke

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**Background:** Grip size of a tennis racquet has been reported to influence performance, but clear evidence of a correlation has yet to be established.

**Hypothesis:** Hitting force during a soft tennis forehand stroke correlates with grip size.

**Study Design:** Controlled clinical study.

**Methods:** A total of 40 healthy volunteers (20 men and 20 women) with a mean age of 21.9 years were enrolled. Of the 40 participants, 20 were experienced soft tennis players (10 men and 10 women) and 20 were nonexperienced soft tennis players (10 men and 10 women). Based on racquets with 5 different grip sizes, the hitting force during a soft tennis forehand stroke was measured with a handheld dynamometer. Correlations between 4 factors (sex, experience, grip and pinch strengths, and middle finger length) and hitting force were evaluated with each grip size. Measurements for each factor were repeated, and a 2-way analysis of variance was performed on the obtained data.

**Results:** The hitting force was greater for male players than for female players and greater for experienced players than for nonexperienced players ($P < .01$). Men with large grip and pinch strengths demonstrated an increased hitting force with an increase in grip size. Men who had a long middle finger also demonstrated increased hitting force when grip size increased ($P < .05$).

**Conclusion:** The hypothesis proved accurate for experienced men who had a large grip strength, a large pinch strength, and a long middle finger.

**Clinical Relevance:** Large-grip-sized racquets may result in better forehand stroke performance when used by experienced male soft tennis players with a large grip strength, a large pinch strength, and a long middle finger.

**Keywords:** grip size; forehand stroke; hitting force

Although the majority of tennis players believe in the vague notion that any grip size that fits the hand and feels good is adequate, interest in selecting the appropriate grip size has grown as the correlation between grip size and the player's performance has become better understood.

Aldesberg reported that increases in grip size did not produce any difference in the electrical activity of the wrist extensors, as measured with surface electrodes.[1] Similarly, using fine intramuscular electrodes, Hatch et al demonstrated that increases in grip size had no effect on the electrical activity of the wrist extensors.[5] According to Nirschl and Ashman,[14] however, the optimal grip size is equivalent to the distance between the level of the proximal palmar crease and the tip of the ring finger. Plium and Safran[15] reported that the best choice is a grip size that allows 1 finger-width space between the palm and the ring finger tip.

Based on observation of experienced and nonexperienced male and female soft tennis players, this study sought to elucidate the optimal grip size—that is, the grip size that affords the largest hitting force of the racquet during soft tennis forehand

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strokes. Correlations between 4 factors (sex, experience, grip and pinch strengths, and finger length) and hitting force were evaluated for 5 serial grip sizes.

## MATERIALS AND METHODS

Twenty male and 20 female college students with a mean age of 21.9 years were enrolled in this study. Among them, 10 male and 10 female volunteers had greater than 3 years of experience playing tennis, and 10 male and 10 female volunteers had no history of playing tennis. Thirty-nine participants were right-handed and only 1 was left-handed. Only performance of the dominant hand was measured. There were no statistically significant differences in age, height, or body weight between the experienced and nonexperienced male groups nor between the experienced and nonexperienced female groups. Participants with a history of injury to the upper extremities were not included in the study.

The racquets used in this study were made with carbon-graphite, were 70 cm in length, and weighed 238 g (model Wyst-X, Mizuno Corp, Tokyo, Japan). The racquet strings were made with multipolymer nylon filaments and surface coating; they had a 1.35-mm diameter; and tension of the strings was set at 30 lb (model Xyst Nano Multi, Mizuno Corp). Five serial grip sizes—with grip circumferences of 13.0 cm (grip 1), 13.5 cm (grip 2), 14.0 cm (grip 3), 14.5 cm (grip 4), and 15.0 cm (grip 5)—were adopted on the basis of official recommendations from the Japan Soft Tennis Association. Many players use racquets with a 14.0-cm grip (grip 3) (Figure 1). Hitting force was measured with a handheld dynamometer (Anima Co, Tokyo, Japan). The dynamometer was rigidly fixed to a stable platform at each volunteer's waist level. Maximal hitting force for forehand strokes (54.0 cm distal to the grip end) was measured with each of the 5 grip sizes. Three measurements were taken for each grip size. The order of grip sizes (grip 1 to grip 5) was randomized for each participant. All possible order combinations of grip sizes were written down on cards. Participants blindly selected 1 card with 1 possible combination. An interval of at least 10 minutes was adopted to avoid the effect of fatigue between measurements of the different grip sizes.

To simulate the forehand stroke, volunteers were instructed to use a semi-Western grip and to stand in profile, in a relaxed stance, so that the ball's point of impact was on the same vertical plane as the center of the body. The shoulder and elbow of the dominant hand were flexed at 20° to 30°, with the forearm in a neutral position and the wrist slightly flexed and ulnar deviated. To adjust for the hitting site of the ball per individual, participants were advised to adjust the distance between their bodies and the hitting sites so that they felt comfortable hitting the balls without any weakness in their grips. During trials of hitting force measurement, volunteers were advised to keep their weight between their legs. They were also directed to not twist the shoulders or the body, to not bend and twist the knee, and to keep the grip and racquet straight in front of the body at the waist level. Before the measurement of nonexperienced players, a 10-minute demonstration was performed by an examiner (M.O.) (Figure 2).


Figure 1. Five serial grip sizes, with circumferences of 13.0 cm (grip 1), 13.5 cm (grip 2), 14.0 cm (grip 3), 14.5 cm (grip 4), and 15.0 cm (grip 5). Many players use racquets with 14.0-cm grip (grip 3).

Grip and pinch strengths were measured using a JAMAR Hydraulic Grip Strength and Pinch Gauge (WisdomKing.com Inc, Oceanside, California). The gauge was set at handle spacing 2 for all measurements. Length of the middle finger (distance from the base line of the metatarsophalangeal joint of the thumb to the tip of the middle finger) was measured using a digital caliper (Max-Cal, Foler, Newton, Massachusetts; accuracy 0.05 mm) (Figure 3).[14]

## DATA ANALYSIS

Correlation between 4 factors (sex, experience, grip and pinch strengths, and finger length) and hitting force were evaluated for 5 serial grip sizes. Measurements for each factor were repeated and a 2-way analysis of variance was performed. A Tukey post hoc test was performed on each factor when there was a significant variation among the data. In this analysis, the mean grip strength, pinch strength, and middle finger length were used to divide participants into groups of high and low grip strength, pinch strength, and middle finger length. Intrarater reliability of all measurements by the examiner (M.O.) was greater than .95. All statistical analysis was performed using SPSS 11.5J. The level of statistical significance was set at $P < .05$.

## RESULTS

### Comparisons of Grip and Pinch Strengths

The grip and pinch strengths of the experienced male players (46.4 ± 5.5 kgf, 3.0 ± 0.4 kgf) were significantly greater than those of nonexperienced male players (40.9 ± 5.8 kgf,

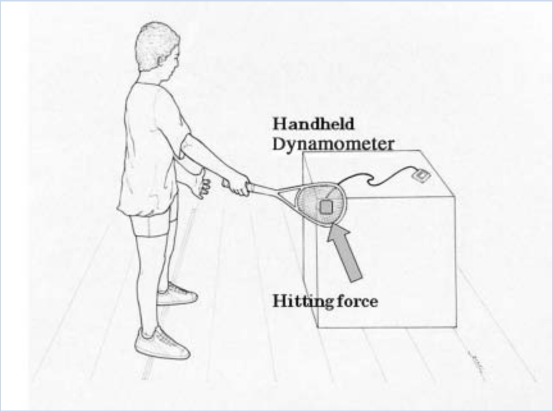


Figure 2. Measurement of the hitting force was conducted with a handheld dynamometer (Anima Co, Tokyo).

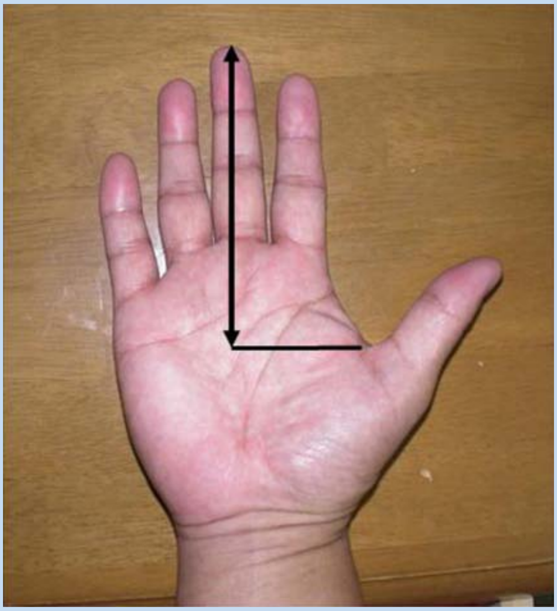

Figure 3. Measurement of middle finger length (mm): distance from the base line of the metatarsophalangeal joint of the thumb to the tip of the middle finger.

2.5 ± 0.6 kgf; $P < .05$). No significant differences were observed in grip and pinch strengths between experienced female players (30.6 ± 3.7 kgf, 2.3 ± 0.6 kgf) and nonexperienced female players (28.2 ± 3.2 kgf, 2.6 ± 0.6 kgf). Furthermore, no significant differences were observed in middle finger length between experienced male players (12.9 ± 0.5 cm) and nonexperienced male players (12.8 ± 0.5 cm) or between experienced female players (11.6 ± 0.6 cm) and nonexperienced female players (11.7 ± 0.8 cm).

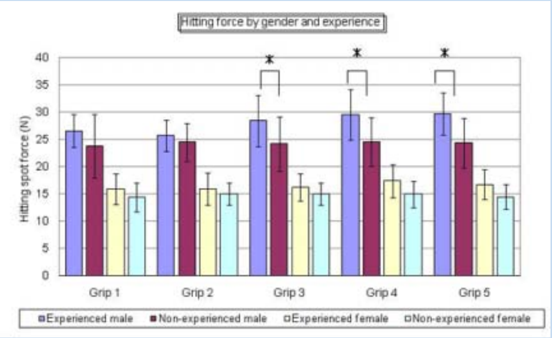


Figure 4. Measurement of hitting force by sex and experience for 5 grip sizes.

## Hitting Force by Sex and Experience

Hitting force for men (26.1 ± 4.7 kgf) was significantly greater than that for women (15.6 ± 2.6 kgf; $P < .001$); furthermore, hitting force for experienced men was significantly greater than that for nonexperienced men ($P < .001$). No significant difference was observed in hitting force between experienced women and nonexperienced women.

## Hitting Force by Grip Size: Experienced and Nonexperienced Players

Hitting force for experienced men significantly increased with increases in grip size, compared to that for nonexperienced men ($P < .001$). For experienced men, using grips 4 and 5 resulted in a hitting force that was significantly larger than that of nonexperienced men ($P < .05$). For women, an increase in grip size did not increase the hitting force (Figure 4).

## Hitting Force by Grip Size: Grip and Pinch Strengths and Middle Finger Length

For experienced men, large grip strength significantly increased with increases in grip size, compared to that of nonexperienced men ($P < .01$). In grips 3, 4, and 5, the hitting force of men with more grip strength was significantly higher than that of men with less grip strength ($P < .05$). No increase in hitting force was observed by increases in grip size for women (Table 1).

Regarding pinch strength, hitting force for men with higher pinch strength significantly increased with increases in grip size, compared to that for men with lower pinch strength ($P < .01$). For grip 5, the hitting force of men with higher pinch strength was significantly larger than that of men with lower pinch strength ($P < .05$). No increase in hitting force was observed by increases in grip size for women.

Regarding middle finger length, hitting force for men with long finger length significantly increased with increases in grip size, compared to that for nonexperienced men ($P < .01$). No

Table 1. Hitting force by grip strength, pinch strength, and finger length for the 5 grip sizes (in newtons).

| | Grip Strength | | | | Pinch Strength | | | | Finger Length | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | | Female | | Male | | Female | | Male | | Female | |
| | Large[a] | Small | Large | Small | Large[a] | Small | Large | Small | Large[a] | Small | Large | Small |
| Grip 1 | 26.9 ± 3.1 | 23.4 ± 5.7 | 16.4 ± 2.9 | 13.8 ± 2.0 | 25.5 ± 5.5 | 24.9 ± 4.4 | 15.3 ± 2.6 | 15.0 ± 2.9 | 25.0 ± 4.8 | 25.0 ± 4.4 | 14.1 ± 2.2 | 15.5 ± 3.4 |
| Grip 2 | 26.5 ± 1.7 | 23.7 ± 3.8 | 16.1 ± 2.8 | 14.8 ± 2.1 | 25.0 ± 3.7 | 25.1 ± 2.9 | 15.3 ± 2.4 | 15.5 ± 2.6 | 24.7 ± 3.9 | 25.7 ± 1.7 | 15.5 ± 2.8 | 15.4 ± 2.2 |
| Grip 3 | 28.4 ± 3.1[b] | 24.2 ± 6.1 | 16.7 ± 2.3 | 14.5 ± 1.6 | 27.4 ± 6.9 | 25.6 ± 3.7 | 15.7 ± 2.2 | 15.5 ± 2.3 | 26.2 ± 5.5 | 26.5 ± 4.9 | 15.5 ± 2.1 | 15.6 ± 2.6 |
| Grip 4 | 29.4 ± 3.4[b] | 24.6 ± 5.6 | 17.6 ± 3.1 | 14.7 ± 1.8 | 29.0 ± 6.1 | 25.7 ± 4.1 | 16.1 ± 2.5 | 16.1 ± 3.2 | 27.4 ± 5.1 | 26.3 ± 5.3 | 16.2 ± 2.7 | 16.0 ± 3.2 |
| Grip 5 | 29.4 ± 3.3[b] | 24.7 ± 5.3 | 17 .0 ± 3.1 | 14.1 ± 1.3 | 29.7 ± 4.8[b] | 25.2 ± 4.4 | 15.4 ± 3.0 | 15.6 ± 2.6 | 27.6 ± 4.8 | 26.1 ± 5.3 | 15.1 ± 2.6 | 16.1 ± 2.8 |

[a]Significant difference ($P < .05$) in hitting force between large and small groups.
[b]Significant difference ($P < .05$) in hitting force between large and small groups in each grip size.

increase in hitting force was observed by increases in grip size for other men and women.

The results of our static testing thus suggest that players with larger hands who use larger-sized grip exert a larger hitting force.

## DISCUSSION

Lawn tennis organized in England in 1874 and from there developed into a worldwide sport. It was brought to Japan in 1879, developed as soft tennis in the 1880s, and gradually spread throughout eastern Asia. Today, 600 000 athletes and 7 million fans in Japan enjoy soft tennis.

The basic grip for the forehand stroke in soft tennis is a mid-Western or Western grip, which is similar to the grip used in contemporary lawn tennis. The racquet of soft tennis is approximately 70 cm long, and it weighs between 200 and 320 g. The smooth rubber ball has a 6.6-cm diameter and weighs 30 g. The court size is the same as lawn tennis. Like lawn tennis players, soft tennis players enjoy singles and doubles games; however, rules differ somewhat from those of lawn tennis (see Japan Soft Tennis Association, http://www.jsta.or.jp/world/, and Japan Tennis Association, http://www.jta-tennis.or.jp/)

### Factors That Influence Hitting Force

The results indicate that sex and experience influenced hitting force during the forehand stroke. Large grip and pinch strengths were found to have a positive influence on hitting force in experienced male players. Furthermore, for these participants, hitting force significantly increased with increases in grip size.

Previous studies reported that muscle strength in the dominant forearm of experienced tennis players was larger than that in nonexperienced players.[4,11] In this study, the grip and pinch strengths of experienced male players was greater than that of nonexperienced male players. In addition, participants with strong grip and pinch strengths produced greater hitting force when grip size increased. Therefore, to increase forehand performance, experienced tennis players with greater grip and pinch strengths can choose a racquet with a larger grip size.

Another factor related to the racquet that concerns tennis performance is the twisting motion of the racquet around its longitudinal axis.[3] If the racquet face is twisted downward, the ball will run into the net; however, if the racquet is twisted upward, the ball will likely sail over the baseline. A secure grip to prevent twisting at the moment of impact may contribute to the control of this phenomenon; therefore, the effect of grip size on this twisting motion should be studied.[7,16]

### Middle Finger Length and Optimal Grip Size for the Hitting Force

When players hold a small grip, the flexion angle of the fingers is large; conversely, when players hold a large grip, the flexion angle of fingers is small. Kapandji[6] reported that the grip strength of participants who held a column was dependent on the size of the column and that grip strength was optimal when the tip of the thumb and the index finger were in contact with each other. Nirschl[14] reported that the distance from the proximal palm crease to tip of the ring finger corresponds to the optimal grip size for players.[15] However, the results of this study demonstrated that the hitting force of the forehand stroke in experienced men who had long fingers increased with increases in grip size. This finding suggests that players with long fingers have the potential to generate large hitting force and so may benefit by the selection of a large grip size.

Even though the effect of lower extremities on the hitting force by the racquet was not eliminated, we tried to diminish the effect by advising participants to keep their weight between their legs, to not twist the shoulder or the body, and to not bend and twist the knee.

### Muscle Activity of the Forearm and Hitting Force

Adelsberg reported that muscle activity of the wrist extensors showed minimal change with changes in grip size during forehand and backhand stroke.[1] Hatch et al reported that the grip size had no significant effect on muscle activity of the wrist extensors in 16 college tennis players[5]; these researchers measured percentage electromyographic activity of the forearm muscles during ground strokes but did not measure the hitting force. Grip performance was considered to be achieved by coactivation of the flexors and extensors of the wrist and fingers.[12,13] The results of this study show that hitting force of the forehand stroke depends on grip strength and grip size in experienced men; as such, minimal changes in racquet grip size may influence hitting performance.[2,7,9]

### Limitations of Study

Measurement of hitting force in this study was not performed under dynamic condition with the full swing motion of a handheld racquet but rather under static conditions using a stationary racquet. However, the potential strength of the hitting force of the forehand stroke in players may be individually estimated by static force. The correlation between data obtained under dynamic and static conditions should be examined in future studies.

## CONCLUSION

This study was designed to elucidate the hypothesis that hitting force during a soft tennis forehand stroke correlates with grip size. Sex and experience were found to correlate with the hitting force, and increases in grip size influenced the hitting force in experienced men with large grip and pinch strengths and long middle fingers.

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