

# Characteristics of Muscle Power and Agility in Top-Level Junior Soft Tennis Players

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## Abstract

This study examined the characteristics, such as muscle power and agility, of top-level junior soft tennis players. 36 Japanese top-level junior (under-14) boys soft tennis players (age  $13.4 \pm 0.8$  years, height  $165.0 \pm 9.7$ cm, and weight  $53.9 \pm 11.1$  kg) with experience in international meet participation and 25 junior boys soft tennis players (age  $13.1 \pm 0.7$  years, height  $158.2 \pm 9.5$ cm, weight  $47.0 \pm 8.2$  kg) with experience in prefectural meet participation were the subjects of this study. Medicine ball (2 kg) throws to the right or left by trunk rotation and forward and backward by trunk extension (exercises recommended by Japan's soft tennis association) were selected to evaluate the muscle power of the subjects. Side step, spider, and front-back shuttle run tests (used by an American tennis association) were selected to test the agility of the subjects. The top-level athletes were significantly superior to the other junior players in the forward medicine ball throw, side step, and spider tests. These results suggest that muscle power in the forward direction and agility when moving to the right, left or diagonal direction are more developed in top-level soft tennis players than in other players.

**Keywords:** boys, muscle power, competition player

## 1. Introduction

To win points, soft-tennis players must hit fast, strong serves and strokes into open spaces on the opponent's court. Hence, it is important for them to develop superior muscle power. In addition, players need excellent footwork to cover the space on their own court and avoid losing a point. To develop this capacity, they must have superior agility and be able to move quickly.

Both strength and agility among soft-tennis players have been studied by many researchers (Girard et al., 2005; Raya et al., 2013; Meckel et al., 2015). Tests to evaluate physical fitness factors, such as strength and agility, can be divided into two main categories: field tests and laboratory tests. Field tests are generally called performance tests and include such activities as vertical jumps and ball throws, which are typical performance tests, and their achievement is considered to require the whole body power. Laboratory tests gauge the local muscle power of upper and lower limbs with relatively high accuracy based on weight load and inertial load methods (Aoki & Demura, 2012).

Girard et al. (2005) compared the muscle power of the lower limbs among elite, intermediate, and beginner tennis players, finding no significant difference between the player groups. Bernard et al. (2004) reported no significant difference between the shoulder muscle power of wheelchair athletes (including both soft-tennis players and racers) and other soft-tennis player groups. These studies report on local muscle power but not on the whole body muscular power. However, it may be important for tennis players to have superior muscle power of the whole body to hit fast/strong serves and forehand and backhand strokes rather than local muscle power. Hence, it is often assumed that higher-level tennis players have superior muscle power throughout their body. However, their whole-body muscle

power has rarely been studied (Fernandez-Fernandez et al., 2016).

On the other hand, agility has been evaluated by various tests, such as the side step test, squat test, and full body reaction time test. These assessments can evaluate quick, repetitive movements or physical reactions on the spot or within a limited area. Soft-tennis players need to quickly move a ball landing position many times to hit back a returned ball (Raya et al., 2013; Meckel et al., 2015). In short, in order to move within the large court area, it is essential for them to have superior agility. Until now, the agility of tennis players has been evaluated by the spider test or the T test, in which they are evaluated when they move quickly in front–back or left–right directions. It is assumed that tennis players have superior agility in moving to these directions, and that this trend is even more noticeable at higher front–back competition levels. Although soft tennis resembles regular tennis, the ball used is lighter and softer; thus, the shot speed tends to be slower than that in regular tennis. However, soft tennis (like regular tennis) requires whole-body muscle power to hit fast serves and strokes and quick forward, backward, and sideways movements front–back to hit strokes and volleys.

There are an estimated 7 million soft tennis players in Japan of whom about 540,000 are officially registered as players; the great majority of these (370,000) are in the under-14 (junior) category.

This study examined the characteristics of muscle power and agility of top-level junior soft tennis players in Japan.

## 2. Method

### 2.1 Subjects

The subjects belonged to two groups of soft tennis players. The first group consisted of 36 Japanese top junior (under-14) boys players with international meet participation experience (referred to as the top player group or TPG). Means and standard deviations for this group were as follows: age  $13.4 \pm 0.8$  years, height  $165.0 \pm 9.7$ cm, and weight  $53.9 \pm 11.1$  kg. An additional 25 subjects belonging to the general player group or GPG were junior male soft tennis players with prefectural meet participation experience (age  $13.1 \pm 0.7$  years, height  $158.2 \pm 9.5$ cm, weight  $47.0 \pm 8.2$  kg). The age difference between the two groups was insignificant, but average height and weight values of the TPG were significantly greater. The protocol for this study was approved by the Ethics Committee on Human Experimentation of the Kanazawa University Faculty of Human Science (approval number 2012–06).

### 2.2 Experimental Instruments and Methods

The following tests were selected to evaluate agility and whole-body muscle power in this study. First, a medicine ball (hereafter simply “ball”) throw test has been widely used in field tests to evaluate whole-body muscle power (Stockbrugger & Haennel, 2001) and has been recommended by the Japan Soft Tennis Association. The ball throw, which is generally evaluated in terms of the distance thrown, requires subjects to exert explosive muscle power to throw a heavy ball, as far as possible, with one motion.

A 2 kg medicine ball was used in all tests. Subjects threw it while standing on the tennis court service line (line width 5cm), and the distance to where the ball landed was measured.

In this study, a left–right rotation ball throw test as described by Kageyama et al. (2014), was used to evaluate the rotational power of the trunk; a front–back ball throw test as described by Palao et al. (2013), was used to evaluate whole-body muscle power in the forward direction. Details of each test are as follows.

Left or right trunk rotation ball throw test: Subjects stood at right angles to the line (facing forward), with both legs slightly open and parallel to the service line, holding a ball with both arms lightly extended in front of the body. They then threw the ball by twisting the trunk in the opposite direction from the throwing direction, using a spinning reaction of the upper body.

Forward ball throw test: Subjects stood with the toes of both feet inside the line, shoulder width apart, holding a ball with both hands behind the head. After that, they threw it forward from a vertical stance. If they crossed the line after releasing the ball, we judged the throw to be a foul and did not count it.

Backward ball throw test: Subjects stood with the toes of both feet inside the line, shoulder width apart, holding a ball in both hands. They leaned forward and then threw the ball backward over their heads by raising the arms and extending the body. If they crossed the line after releasing the ball, we judged the throw to be a foul and did not count it.

The throwing distance was measured as the distance from the outer edge of the line to the landing point for the left or right trunk rotation throws and from the central point between both feet to the landing point for the forward and

backward throws. All measurements were rounded down to increments of 0.1 m.

Agility has been evaluated through assessing repetitions of simple movements such as the side step test, squat thrust test, etc. However, when using tennis players as subjects, we should consider their particular competitive characteristics. The American Tennis Association (2005) has introduced tests for evaluating the agility of tennis players. From among them, we selected the side step test, evaluating the agility required for quick left–right movements, and the spider test, evaluating the agility required for quick front–back and diagonal crossover movements. In addition, a front–back shuttle run test, which implemented by Raya et al. (2013), was designed to evaluate the agility required for quick front–back movements. The specific methods for each of these tests are explained below.

Side step test: Methods from the Japan Soft Tennis Association were used. The subjects stood between the sidelines for singles and doubles (1.370 m apart) on the tennis court. At the signal, (1) they stepped across the latter sideline (left movement) and then (2) stepped back to the start position (right movement). Next, (3) they stepped across the former sideline (right movement) and then (4) returned to the start position (left movement). The subjects repeated movements (1) through (4) quickly. The number of sidelines crossed with the feet in 20 seconds was measured.

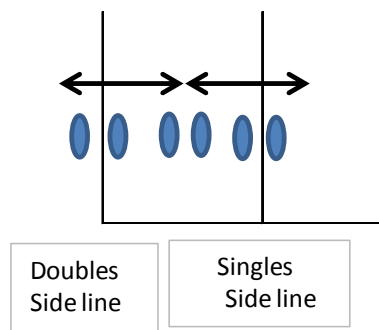


Figure 1. Reference Drawing for Side Step Test

Spider test: The method from Meckel et al. (2015) was used. Tennis balls were placed at the following five places: the intersection points between the baseline and both sidelines for singles, and the intersections between the center service line and the two baselines or the center service line (see Figure 2). At the start signal, the subjects dashed from the “center” position marked in the figure to the ball on the right side (1), picked up the placed ball, returned to the start position, and set the ball down there. Similarly, they moved to pick up the placed balls at positions (2) to (5), returning to the start position to put the ball down each time. These movements were carried out as quickly as possible, and the time required to gather all balls from the five positions to the start point was measured. The minimum possible traveling distance was 54.858 m.

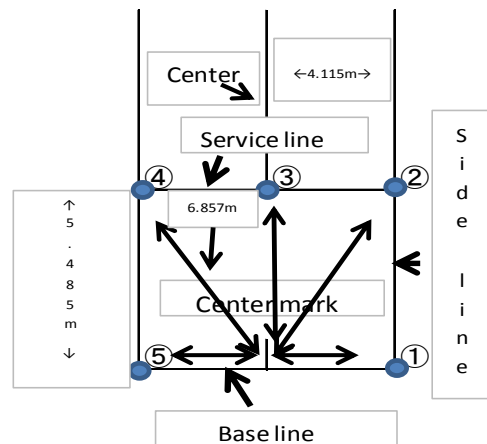
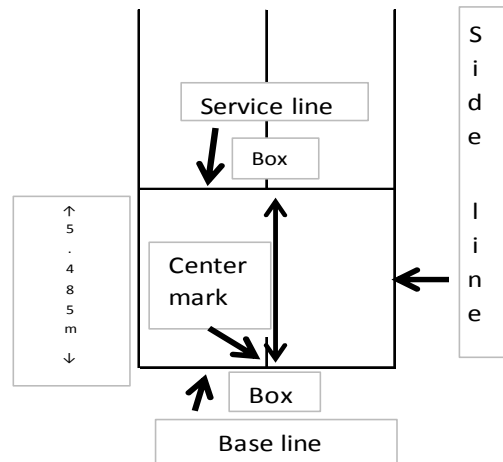


Figure 2. Reference Drawing for Spider Test

Front-back shuttle run test: Pursuant to Raya et al. (2013), this test was carried out as follows. Boxes were placed behind the baseline of the tennis court and in front of the service line, and two balls were placed in the baseline box and one in the service line box. The subject stood at the center mark, took one ball out of the box behind the baseline at the signal, moved quickly to the box in front of the service line, replaced the ball in the box with the transported ball, moved backwards to the baseline box, and replaced the ball in this box with the ball that the subject was carrying. The time required to complete this series of movements four times was measured. The distance between the two lines was 5.485 m, and the minimum total distance traveled was 43.88 m.



**Figure 3.** Reference Drawing for Front-Back Shuttle Run Test

*2.3 Statistical Analysis*

A non-repeated t-test was used to reveal the significance of the difference between the groups’ means on each test. To examine the degree of difference, an effect size (ES) was calculated. The level of significance was determined to be 0.05.

**3. Results**

Table 1 shows basic statistics for both groups on the medicine ball throw tests and results of the t-tests comparing the two groups’ performances. A significant difference was found in the forward medicine ball throw test, with the TPG achieving longer distances. The effect size (ES) was large at 1.10. Differences in the other three throw tests were not statistically significant, although the TPG had higher mean distances in all three cases.

**Table 1.** Basic Statistics of the Two Groups and Results of the *t*-Tests for the Medicine Ball Throw Tests

	TPG		GPG		T	ES
	Mean	SD	Mean	SD		
Right trunk rotation ball throw test(m)	9.3	1.7	8.4	2.0	1.89	0.48
Left trunk rotation ball throw test(m)	8.9	1.9	8.0	1.9	1.91	0.50
Forward ball throw test(m)	7.2	1.6	5.4	1.7	4.24*	1.10
Backward ball throw test(m)	9.8	2.3	8.3	2.4	2.39	0.62

\* $\alpha = 0.05/4 = 0.0125$

Table 2 shows basic statistics for both groups on the agility tests and results of the t-tests comparing their performances. The TPG significantly outperformed the GPG on both the side step test and spider test. The effect sizes were large at 2.24 and 2.31, respectively. The difference between groups in the front-back shuttle run test was not statistically significant.

**Table 2.** Basic Statistics of the Two Groups and Results of the *t*-tests for the Agility Tests

	TPG		GPG		T	ES
	Mean	SD	Mean	SD		
Side step test(Count)	36.6	3.9	28.1	3.7	8.56*	2.24
Spider test(Sec)	17.1	1.1	20.0	1.4	9.14*	2.31
Front-back shuttle run test(Sec)	17.9	1.3	17.4	1.6	1.47	0.37

\* $\alpha = 0.05/3 = 0.017$

#### 4. Discussion

In this study, we selected various medicine ball throw tests to evaluate whole-body muscle power, and we used the side step, spider, and front–back shuttle run tests to evaluate agility. The results showed that the TPG was superior to the GPG in the forward medicine ball throw test (ES = 1.10), the side step test (ES = 2.24), and the spider test (ES = 2.31).

The medicine ball throw has been used to evaluate the explosive power of the whole body (Stockbrugger & Haennel, 2001). It is considered that subjects need to exert the explosive power of the whole body, including both lower and upper limbs, to throw a heavy medicine ball a long distance. Girard et al. (2005) reported that comparisons of the lower limb muscle power of groups with high and low tennis performance, respectively, showed insignificant differences. However, in a tennis match, whole-body power, including that of the trunk and upper limbs in addition to lower-limb muscle power, is required to hit fast serves and strokes. According to David (1988), in the toss and take-back phases of the service action, power in the vertical direction is created by powerfully extending the bent knees. Among the medicine ball throwing actions selected in this study, those associated with the forward throw most resemble the actions used to hit strong serves and strokes in tennis. It is believed that because the best soft tennis players have excellent extension power of the knees and the trunk, they can hit strong serves and strokes; this ability probably caused them to perform better in the forward medicine ball throw. On the other hand, Szymanski et al. (2009) reported a significant relationship between muscle power of the trunk and the bat swing speed in baseball; however, Miyaguchi and Demura (2012) reported that the above relationship was not found (relative value power). Because the bat swing action uses the twisting action of the upper body, it is similar to throwing a ball by means of trunk rotation. In the present study, between-group differences in the left or right medicine ball throw tests were not significant. This could be because the power exerted in the body rotations do not contribute significantly to the service and stroke actions of junior high school players, even those of high skill. Hiruma (2011) reported that the delivery speed and shot speed of baseball players are unrelated to performance on the backward medicine ball throw. Moreover, the present study's finding of no significant difference on the backward ball throw supports the belief that the muscles exerted in this throw do not contribute to achievement of the serve and stroke actions. In soft tennis matches, players exert great power mainly in forward motions such as serves and smashes, but rarely in backward motions except for quick windups.

The side step test evaluates the agility required for left and right movements, and the spider test evaluates the agility required for quick front–back and diagonal crossover movements. In tennis matches, quick actions are required to deal with balls hit to various parts of the court. The present study clarified that top soft tennis players are superior in the quick left–right and crossover movements required in their matches. Salonikidis and Zafeiridis (2008) reported that tennis players can improve the agility of their side steps through training. Because the top-level soft tennis players have superior agility for shifting their center of gravity in the left, right, and diagonal directions quickly, for their long-term footwork training, they were likely to outperform lesser rank players on the side step and spider tests.

On the other hand, no significant difference was found in the front–back shuttle run test with front and back movements. In soft tennis matches, players must make short dashes to reach a returned ball, and thus general players frequently perform forward dashes in practice or training. In addition, in soft tennis matches, when moving backwards to deal with a long returned ball, players are generally instructed to quickly change their physical direction and use cross-steps (i.e., running diagonally) without relying on back steps. Hence, it is not surprising that top players are not necessarily superior in ability to move backwards. This relative lack of importance of backward motions in soft tennis probably explains why there was no significant difference between player groups on the front–back shuttle run test.

Top players did perform better on the side step and spider tests, which demand quick side-to-side movements; hence,

this may be more useful in evaluating a soft-tennis player's ability.

Overall, the results of this study have indicated that there is no significant difference between groups of different competitive levels on tests of whole-body muscle power for movements in the sideways and backward directions, or on tests of the agility required for quick front-back movements. It seems that these are not the motions of greatest importance to one's success as a soft tennis player. In the future, additional relationships between physical fitness factors and performance should be examined.

## 5. Conclusion

This study has indicated that top-level soft tennis players are superior to general players in whole-body muscle power in the forward direction and in agility in the left-right and diagonal directions.

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