

A COMPARISON OF THE PHYSICAL FITNESS, ATHLETIC PERFORMANCE, AND COMPETITIVE ACHIEVEMENTS OF JUNIOR AND SENIOR TENNIS PLAYERS

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Abstract

The Japan Tennis Association established the Tennis Field Test as a tool for aiding the development of effective coaching methods and improving the competitive achievements of individual elite tennis players. On the basis of such evaluations, specific coaching methods can be developed for individual tennis players. This study aims to evaluate the physical fitness and athletic performance of tennis players using the Tennis Field Test, and to compare these attributes between players of different ages and abilities. A total of 48 tennis players participated, of which 24 were junior players (including 15 regional representatives), and 24 were senior players (including 18 national representatives). The subjects were further subdivided into average and superior groups on the basis of their competitive achievements in regional or national tournaments. All subjects participated in the Tennis Field Test, which consists of the following six items: the number of sit-ups performed in 30 sec (an index of muscular endurance), the standing long jump distance (an index of leg power), the sit and reach test (an index of flexibility), the time taken to perform the spider run (an index of agility), the time taken to sprint 10 m (an index of speed), and the distance run in three minutes (an index of whole-body endurance capacity). In this study, the subjects' sit and reach test data were not examined due to differences in the measurement methods used between junior and senior tennis players. Among the junior tennis players, the superior group performed faster in the spider run than the average group ($p = 0.0011$). Among the senior tennis players, the superior group achieved a longer mean distance during the three-minute run than the average group ($p = 0.0223$). The test results of the remaining items for both groups were relatively similar. This study suggests that competitive achievement is associated with agility among junior tennis players, and is associated with whole-body endurance capacity among senior tennis players.

Keywords: Agility, tennis, Tennis Field Test, whole-body endurance capacity

Introduction

In competitive tennis, sport-specific technical skills are important determinants of performance. However, performance is also affected by complex interactions between physical parameters. Thus, evaluations of physical fitness play an important role during competitive tennis players' training (Fernandez-Fernandez, Ulbricht, & Ferrauti, 2014). Tennis matches are characterized by intermittent periods of whole-body effort, alternating short bouts (2-10 seconds) of high-intensity exercise, and short recovery periods (10-20 seconds) interrupted by several resting periods of longer duration (60-90 seconds; Kovacs, 2006; Fernandez-Fernandez, Mendez-Villanueva, & Plum, 2006). A typical match lasts about 1.5 hours, although in some cases, it can last for more than five hours (Kovacs, 2006, 2007; Fernandez-Fernandez, Sanz-Rivas, & Mendez-Villanueva, 2009). Tennis players run a mean distance of 3 m per shot. In pursuit of each point, they run a total of 8-15 m (with 3-4 changes of direction), and hit the ball an average of 4-5 times. In addition, they run a total distance of 1300 to 3600 m per hour during a match, depending on their fitness level, and the speed of the court surface (Kovacs, 2006; Fernandez-Fernandez et al., 2009). Thus, tennis players must possess a diverse range of physical and athletic attributes. Furthermore, physical fitness tests can be used to determine the extent each physical attribute affects performance on the tennis court (Fernandez-Fernandez et al., 2014), including during tournaments (Girard & Millet, 2009).

The Japan Tennis Association developed the Tennis Field Test as a tool for obtaining data that contributes to the development of effective coaching methods, and improving the competitive achievements of elite tennis players. This test is unique to Japan, but can be performed by anybody on a tennis court. It can also be used for comparisons among different players and conditions (e.g., age group, gender, and court surface), which can aid in the development of coaching methods that are tailored for individual players. For example, it could be used to create coaching methods that are appropriate to the growth and development of players of particular ages.

Thus, in this study, the Tennis Field Test was used to evaluate the physical fitness and athletic performance of tennis players, and to compare these attributes between players of different ages and abilities.

Methods

Subjects

A total of 48 tennis players consisting of 24 junior (14 boys and 10 girls) and 24 senior (9 males and 15 females) players were enrolled to participate in this study. The players were further subdivided into average and superior groups on the basis of their competitive achievements in regional (for juniors) or national tournaments (for seniors), as shown in Table 1. This study was approved by the ethical committee of the Faculty of Education, Hokkaido University. All subjects were informed about the possible risks and discomforts that might be involved in this study, and their written consent or (in the

case of the junior players) their parents' consent to participate was obtained. The subjects were instructed to warm-up as they would prior to a match before the test.

Table 1: The body compositions of the junior and senior tennis players (mean and range).

	Years (y)	Height (cm)	Body Weight (kg)
Junior			
Average group (n=9)	10.4(8-11)	144.2(138-153)	36.8(30-42)
Superior group (n=15)	12.1(10-14)	150.3(135-168)	40.1(25-58)
Senior			
Average group (n=6)	19.5(19-20)	165.0(155.3-169.5)	62.7(55.1-69.7)
Superior group (n=18)	19.7(19-21)	166.0(154.7-182.6)	60.8(49.3-73.5)

Tennis Field Test

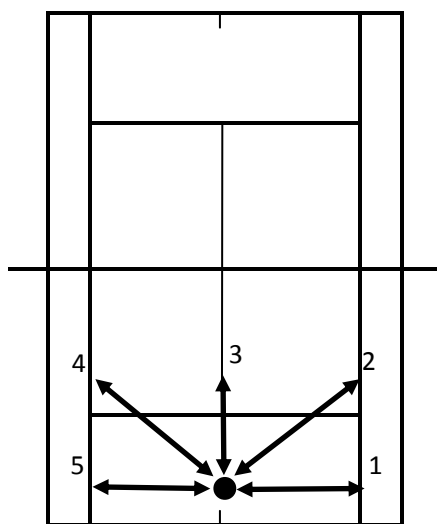
All players were evaluated using the Tennis Field Test. This test consists of six items: the number of sit-ups performed during 30 sec (an index of muscular endurance), the standing long jump distance (an index of leg power), the sit and reach test (an index of flexibility), the time taken to perform the spider run (an index of agility), the time taken to sprint 10 m (an index of speed), and the distance run in three minutes (an index of whole-body endurance capacity). However, we did not examine the subjects' sit and reach test data in this study, as the measurement methods for this task differ between junior and senior tennis players. All of the variables assessed by the Tennis Field Test were standardized to normalized scores using the conversion tables produced by the Japan Tennis Association. These tables were established based on data obtained from a total of 3,000 tennis players of different genders and ages, using different court surfaces, such as hard or clay courts. Because of the court surfaces, genders and age groups as measured by the superior and the average group were different, we used the Tennis Field Test 5-grade evaluation tables to cancel out the effect of the court surfaces, genders and age groups. Therefore, the raw data obtained in this study were converted to 5-grades using the Tennis Field Test 5-grade evaluation tables (Appendix).

Procedure

The sit-ups test: The number of sit-ups performed during a 30 second period was recorded. To perform the sit-ups, the subjects were requested to lay on the ground with their knees bent at right angles, and both hands positioned on their ears. The subjects were encouraged to use only their upper body during each repetition.

The standing long jump: From the starting position, i.e., standing just behind a line with their feet approximately shoulder width apart, the subjects attempted to jump forward as far as possible with their feet together. They had to land on both feet with their body under control, and hold their landing position for five seconds for a jump to be recorded. If a subject was unable to land successfully, the trial was repeated.

The spider run: The subjects were instructed to stand on the center mark of a tennis court. Then, they were requested to run from the center mark to point 1 (Figure 1) and back again, before immediately repeating the task for points 2-5 (in numerical order). At each of the numbered points, the subjects had to touch a tennis ball. The total time taken to run to each point and return to the center mark was recorded.



Start & Goal

Figure 1: The subjects were instructed to perform the spider run as shown in the figure. Specifically, they were asked to run from the central point to point 1 and back again, before immediately repeating the task for points 2-5 (in numerical order). At each of the numbered points, the subjects had to touch a tennis ball.

The 10-m dash: The subjects stood behind the baseline of a tennis court and adopted a sprinting stance. When the examiner raised their hand, the subjects sprinted to the opposite baseline. The time taken for them to run 10 m from the baseline was recorded.

The distance run in three minutes: The subjects were required to run between two balls placed 10 m apart. They were instructed to try to maintain a steady speed, and run as far as possible during the three-minute test period. Walking was only permitted when the subject could not continue running (Figure 2).

The spider run and the standing long jump test were performed twice, and the subjects' best record were retained, whereas the sit-ups, 10-m dash, and distance run in three minutes tests were only performed once.

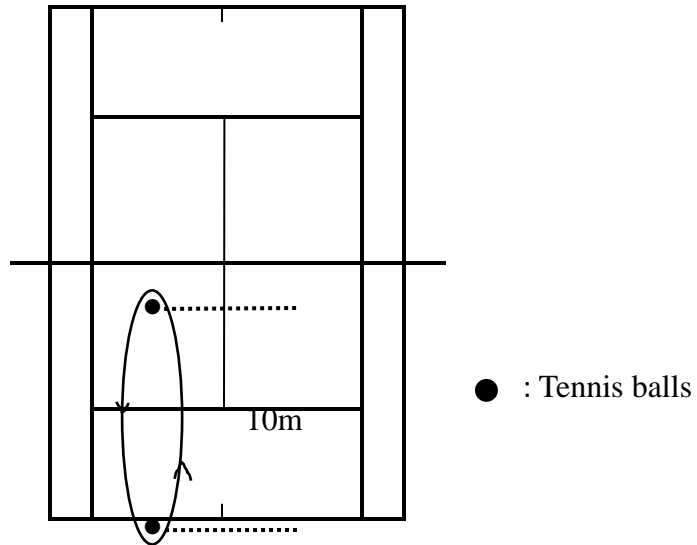


Figure 2: The subjects were instructed to run around two balls as many times as they could during a 3-minute period.

Statistical analysis

Statistical evaluations were performed using the Mann-Whitney-U test. All variables were expressed as mean \pm standard deviation values, and p-values of less than 0.05 were considered to be significant.

Results

The study data were converted from raw data into 5-grades using the Tennis Field Test 5-grades evaluation table. Comparisons between the superior and average groups were performed using the grade data.

In the sit-ups test, there was no significant difference between the number of repetitions performed in the superior and average groups in either age group. Similarly, there was no significant difference in the distance achieved during the standing long jump test between the superior and average groups in either age group. Among the junior tennis players, the superior group performed faster in the spider run than the average group (4.6 ± 0.6 vs. 3.3 ± 1.0 points; $p = 0.0011$). On the other hand, no significant difference was detected among the senior tennis players. In the 10-m dash test, there was no significant performance difference between the superior and average tennis players in either age group. Among the senior tennis players, the superior group achieved a longer distance during the 3-minute run than the average group (3.5 ± 0.8 vs. 2.7 ± 0.5 points; $p = 0.0223$; Table 2).

Table 2: The subjects' scores for the five components of the Tennis Field Test (mean±SD).

Tennis Field Test	Junior		Senior	
	Ave	Sup	Ave	Sup
Sit-ups	2.3±0.7	2.7±0.6	4.3±1.0	4.3±0.7
Standing long jump	2.9±1.3	2.9±0.7	3.7±0.8	3.4±0.8
Spider run	3.3±1.0	4.6±0.6**	3.6±0.6	3.8±0.8
10-m dash	3.8±0.8	3.3±0.8	3.8±0.4	4.2±0.5
3-minute run	3.2±0.7	3.2±0.9	2.7±0.5	3.5±0.8*

** : p = 0.0011, * : p = 0.0223

Discussion

This study attempted to evaluate the physical fitness and athletic performance of tennis players using the Tennis Field Test, and to compare these attributes between players of different ages and abilities. In total, 48 tennis players, including 24 junior players and 24 senior players, were examined in this study. The junior group included 15 regional representatives, and the senior group contained 18 national representatives. Among the junior tennis players, the superior group performed the spider run faster than the average group (p = 0.0011). Among the senior tennis players, the superior group achieved a longer distance during the three-minute run than the average group (p = 0.0223). None of the other variables exhibited significant differences between the age groups, or between the average and superior players.

A previous study demonstrated that agility was the physical ability that most influenced the competitive level of young tennis players. In addition, it was also suggested that skills related to tennis strokes can be used to predict competitive success at the age of 8 to 12 years (Roetert, Garrett, Brown, & Camaione, 1992). Similarly, the present study found that, among the junior players, the spider run score (an index of agility) was significantly higher in the superior group than in the average group. Tennis players are required to possess superior agility and an explosive “first step” speed to address the ball after it has been hit by their opponent (Groppe, 1986). Furthermore, according to the International Tennis Federation, senior men can cover a tennis court in 3.5 steps, whereas it takes junior players 4.7 steps to do the same. In addition, junior tennis players' bodies are still developing, and therefore, they are not able to cover a full-sized tennis court in the same way as senior players. This might explain why the highly ranked junior players demonstrated greater agility.

Boys typically undergo dramatic increases in body size, strength, and whole-body endurance capacity between the ages of 12 to 15 years (Kraemer, 1989). In this study, the ages of the senior tennis players ranged from 19 to 21 years. Our results regarding the distance run in three minutes (an index of whole-body endurance capacity) fit well with Scammon's growth curve model (Scammon, 1927). Fernandez-Fernandez et al., (2009) suggested that modern tennis competitions involve high intensity and high-speed

shots. Thus, tennis match plays are characterized by intermittent episodes of whole-body effort, alternating short bouts (2-10 s) of high-intensity exercise, and short recovery periods (10-20 s) interrupted by several resting periods of longer duration (60-90 s). A typical match lasts 1.5 h, although in some cases, it would last for more than five h (Kovacs, 2006, 2007; Fernandez-Fernandez et al., 2009), and tennis players run a total distance of 1300 to 3600 m for every hour of play (Kovacs, 2006; Fernandez-Fernandez et al., 2009). In addition, from a physiological perspective, tennis elicits a mean heart rate of 70-80% of maximum (HRmax) during long and fast rallies (Fernandez et al., 2006; Fernandez-Fernandez et al., 2009). Furthermore, winning a tournament requires a player to play competitive tennis for at least a week. Thus, it makes sense that successful adult tennis players exhibit an increased whole-body endurance capacity.

Practical applications

Junior tennis players experience marked changes in their neuromuscular systems during development. Therefore, tennis coaches need to be able to create training methods that are suitable for individual players based on their developmental stage (Warren et al., 2001; Little & Williams, 2005; Sue et al., 2010). By using the Tennis Field Test, tennis coaches can gain an understanding of the physical condition of each junior player under their instruction, which would help them to offer training that is specifically tailored to the needs of individual players.

Conclusion

Among the junior tennis players, the superior group performed faster in the spider run than the average group. Among the senior tennis players, the superior group achieved a longer mean distance during the three minute run than the average group. None of the other parameters exhibited significant differences between the groups. Thus, the present study indicated that agility is an important predictor of success among junior tennis players, while whole-body endurance performance is a key component for senior tennis players.

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Appendix

[The modified Tennis Field Test 5-grade evaluation tables]

Clay and sand-contained artificial grass court (Slippery)

Male under 10 years old

	score	1	2	3	4	5
Sit-up	times	~10	11~15	16~21	22~27	28~
Standing long jump	cm	~131	132~145	146~160	161~175	176~
Sit and reach	sec	~0.3	0.4~6.1	6.2~11.8	11.9~17.6	17.7~
Spider run	sec	~21.91	21.90~20.66	20.65~19.40	19.39~18.14	18.13~
10-m dash	sec	~2.88	2.87~2.67	2.66~2.46	2.45~2.24	2.23~
3-minute run	m	~397	398~433	434~468	469~504	505~

Male 11 ~12 years old

	score	1	2	3	4	5
Sit-up	times	~14	15~19	20~25	26~30	31~
Standing long jump	cm	~151	152~168	169~185	186~202	203~
Sit and reach	sec	~-1.3	-1.2~4.5	4.6~10.4	10.5~16.2	16.3~
Spider run	sec	~21.11	21.10~19.92	19.91~18.73	18.72~17.54	17.53~
10-m dash	sec	~2.76	2.75~2.55	2.54~2.34	2.33~2.13	2.12~
3-minute run	m	~419	420~455	456~491	492~527	528~

Male 13 ~14 years old

	score	1	2	3	4	5
Sit-up	times	~20	21~25	26~30	31~35	36~
Standing long jump	cm	~177	178~195	196~212	213~229	230~
Sit and reach	sec	~-0.8	-0.7~6.0	6.1~12.7	12.8~19.4	19.5~
Spider run	sec	~19.91	19.90~19.03	19.02~18.15	18.14~17.28	17.27~
10-m dash	sec	~2.60	2.59~2.38	2.37~2.16	2.15~1.94	1.93~
3-minute run	m	~468	469~495	496~522	523~549	550~

Male 15 ~16 years old

	score	1	2	3	4	5
Sit-up	times	~21	22~26	27~32	33~37	38~
Standing long jump	cm	~182	183~203	204~224	225~245	246~
Sit and reach	sec	~-0.5	-0.4~7.0	7.1~14.5	14.6~22.0	22.1~
Spider run	sec	~20.65	20.64~19.37	19.36~18.10	18.09~16.82	16.81~
10-m dash	sec	~2.84	2.83~2.51	2.50~2.19	2.18~1.86	1.85~
3-minute run	m	~432	433~472	473~512	513~552	553~

Male 17 ~ years old

	score	1	2	3	4	5
Sit-up	times	~21	22~27	28~33	34~39	40~
Standing long jump	cm	~191	192~211	212~232	233~252	253~
Sit and reach	sec	~-3.6	-3.5~6.0	6.1~15.5	15.6~25.0	25.1~
Spider run	sec	~20.72	20.71~19.29	19.28~17.85	17.84~16.41	16.40~
10-m dash	sec	~2.73	2.72~2.37	2.36~2.01	2.00~1.64	1.63~
3-minute run	m	~430	431~486	487~541	542~597	598~

Hard, floor and indoor court (Not slippery)

Male under 10 years old

	score	1	2	3	4	5
Sit-up	times	~10	11~15	16~21	22~27	28~
Standing long jump	cm	~137	138~153	154~168	169~183	184~
Sit and reach	sec	~0.3	0.4~6.1	6.2~11.8	11.9~17.6	17.7~
Spider run	sec	~21.17	21.16~19.60	19.59~18.03	18.02~16.46	16.45~
10-m dash	sec	~2.99	2.98~2.75	2.74~2.51	2.50~2.26	2.25~
3-mintute run	m	~402	403~447	448~492	493~537	538~

Male 11 ~12 years old

	score	1	2	3	4	5
Sit-up	times	~14	15~19	20~25	26~30	31~
Standing long jump	cm	~149	150~170	171~191	192~212	213~
Sit and reach	sec	~-1.3	-1.2~4.5	4.6~10.4	10.5~16.2	16.3~
Spider run	sec	~19.59	19.58~18.36	18.35~17.41	17.13~15.91	15.90~
10-m dash	sec	~2.76	2.75~2.56	2.55~2.36	2.35~2.16	2.15~
3-mintute run	m	~447	448~481	482~515	516~549	550~

Male 13 ~14 years old

	score	1	2	3	4	5
Sit-up	times	~20	21~25	26~30	31~35	36~
Standing long jump	cm	~175	176~197	198~219	220~240	241~
Sit and reach	sec	~-0.8	-0.7~6.0	6.1~12.7	12.8~19.4	19.5~
Spider run	sec	~18.17	18.16~17.23	17.22~16.28	16.27~15.34	15.33~
10-m dash	sec	~2.54	2.53~2.37	2.36~2.20	2.19~2.03	2.02~
3-mintute run	m	~496	497~520	521~545	546~569	570~

Male 15 ~16 years old

	score	1	2	3	4	5
Sit-up	times	~21	22~26	27~32	33~37	38~
Standing long jump	cm	~201	202~220	221~238	239~257	258~
Sit and reach	sec	~-0.5	-0.4~7.0	7.1~14.5	14.6~22.0	22.1~
Spider run	sec	~17.35	17.34~16.48	16.47~15.61	15.60~14.74	14.73~
10-m dash	sec	~2.49	2.48~2.29	2.28~2.09	2.08~1.89	1.88~
3-mintute run	m	~506	507~533	534~560	561~587	588~

Male 17 ~ years old

	score	1	2	3	4	5
Sit-up	times	~21	22~27	28~33	34~39	40~
Standing long jump	cm	~208	209~225	226~242	243~259	260~
Sit and reach	sec	~-3.6	-3.5~6.0	6.1~15.5	15.6~25.0	25.1~
Spider run	sec	~16.96	16.95~16.16	16.15~15.37	15.36~14.57	14.56~
10-m dash	sec	~2.48	2.47~2.26	2.25~2.04	2.03~1.82	1.81~
3-mintute run	m	~508	509~539	540~569	570~600	601~

Clay and sand-contained artificial grass court (Slippery)

Female under 10 years old

	score	1	2	3	4	5
Sit-up	times	~10	11~15	16~20	21~25	26~
Standing long jump	cm	~125	126~144	145~162	163~180	181~
Sit and reach	sec	~0.6	0.7~7.1	7.2~13.6	13.7~20.0	20.1~
Spider run	sec	~22.12	22.11~20.98	20.97~19.84	19.83~18.70	18.69~
10-m dash	sec	~3.00	2.99~2.76	2.75~2.53	2.52~2.29	2.28~
3-minute run	m	~383	384~420	421~458	459~495	496~

Female 11 ~12 years old

	score	1	2	3	4	5
Sit-up	times	15~	16~20	21~25	26~30	31~
Standing long jump	cm	145~	146~161	162~177	178~193	194~
Sit and reach	sec	1.0~	1.1~8.2	8.3~15.3	15.4~22.5	22.6~
Spider run	sec	20.63~	20.61~19.79	19.78~18.96	18.95~18.14	18.15~
10-m dash	sec	2.74~	2.73~2.55	2.54~2.35	2.34~2.16	2.17~
3-minute run	m	436~	437~459	460~483	484~506	507~

Female 13 ~14 years old

	score	1	2	3	4	5
Sit-up	times	~17	18~20	23~27	28~32	33~
Standing long jump	cm	~149	150~168	169~186	187~205	206~
Sit and reach	sec	~3.9	4.0~10.4	10.5~17.0	17.1~23.5	23.6~
Spider run	sec	~20.63	20.62~19.63	19.62~18.64	18.63~17.64	17.63~
10-m dash	sec	~2.63	2.62~2.46	2.45~2.28	2.27~2.11	2.10~
3-minute run	m	~438	439~467	468~496	497~525	526~

Female 15 ~16 years old

	score	1	2	3	4	5
Sit-up	times	~16	17~21	22~26	27~31	32~
Standing long jump	cm	~147	148~165	166~184	185~202	203~
Sit and reach	sec	~2.0	2.1~9.9	10.0~17.8	17.9~25.7	25.8~
Spider run	sec	~22.24	22.23~20.79	20.78~19.34	19.33~17.89	17.88~
10-m dash	sec	~2.80	2.79~2.59	2.58~2.38	2.37~2.17	2.16~
3-minute run	m	~390	391~431	432~472	473~513	514~

Female 17 ~ years old

	score	1	2	3	4	5
Sit-up	times	~17	18~22	23~26	27~31	32~
Standing long jump	cm	~155	156~174	175~193	194~212	213~
Sit and reach	sec	~1.6	1.7~10.1	10.2~18.6	18.7~27.1	27.2~
Spider run	sec	~21.94	21.93~20.44	20.43~18.93	18.92~17.42	17.41~
10-m dash	sec	~2.74	2.73~2.49	2.48~2.24	2.23~1.98	1.97~
3-minute run	m	~409	410~449	450~490	491~531	532~

Hard, floor and indoor court (Not slippery)

Female under 10 years old

	score	1	2	3	4	5
Sit-up	times	~10	11~15	16~20	21~25	26~
Standing long jump	cm	~131	132~146	147~160	161~174	175~
Sit and reach	sec	~0.6	0.7~7.1	7.2~13.6	13.7~20.0	20.1~
Spider run	sec	~21.97	21.96~20.53	20.52~19.08	19.07~17.64	17.63~
10-m dash	sec	~2.97	2.96~2.77	2.76~2.57	2.56~2.37	2.36~
3-minute run	m	~424	425~451	452~478	479~504	505~

Female 11 ~12 years old

	score	1	2	3	4	5
Sit-up	times	~15	16~20	21~25	26~30	31~
Standing long jump	cm	~144	145~162	163~181	182~199	200~
Sit and reach	sec	~1.0	1.1~8.2	8.3~15.3	15.4~22.5	22.6~
Spider run	sec	~20.10	20.09~18.91	18.90~17.71	17.70~16.51	16.50~
10-m dash	sec	~2.79	2.78~2.60	2.59~2.40	2.39~2.21	2.20~
3-minute run	m	~446	447~476	477~506	507~536	537~

Female 13 ~14 years old

	score	1	2	3	4	5
Sit-up	times	~17	18~22	23~27	28~32	33~
Standing long jump	cm	~153	154~173	174~193	194~213	214~
Sit and reach	sec	~3.9	4.0~10.4	10.5~17.0	17.1~23.5	23.6~
Spider run	sec	~19.60	19.59~18.45	18.44~17.29	17.28~16.14	16.13~
10-m dash	sec	~2.79	2.78~2.55	2.54~2.31	2.30~2.08	2.07~
3-minute run	m	~452	453~484	485~515	516~547	548~

Female 15 ~16 years old

	score	1	2	3	4	5
Sit-up	times	~16	17~21	22~26	27~31	32~
Standing long jump	cm	~165	166~180	181~195	196~210	211~
Sit and reach	sec	~2.0	2.1~9.9	10.0~17.8	17.9~25.7	25.8~
Spider run	sec	~18.99	18.98~18.03	18.02~17.07	17.06~16.11	16.10~
10-m dash	sec	~2.61	2.60~2.40	2.39~2.19	2.18~1.98	1.97~
3-minute run	m	~474	475~498	499~523	524~548	549~

Female 17 ~ years old

	score	1	2	3	4	5
Sit-up	times	~17	18~22	23~26	27~31	32~
Standing long jump	cm	~161	162~179	180~197	198~215	216~
Sit and reach	sec	~1.6	1.7~10.1	10.2~18.6	18.7~27.1	27.2~
Spider run	sec	~18.90	18.89~17.94	17.93~16.98	16.97~16.01	16.00~
10-m dash	sec	~2.72	2.71~2.47	2.46~2.23	2.22~1.98	1.97~
3-minute run	m	~464	465~491	492~519	520~546	547~