Lawn Tennis Studied From The Medical Point of View

(Report No. 3)

By

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I. Introduction.

In 1935, a study of the arms and chests of fifty-four leading tennis players in Japan was begun. The two preceding reports dealt with the study of the upper limbs and the energy expenditure involved in playing lawn tennis, respectively. This report concerns an analysis of the X-ray findings of the chest.

II. Procedure.

The fifty-four subjects used in this study were among the leading lawn tennis players in Japan in 1935. The age range was from eighteen to forty-nine years. The number of years of continuous participation was two to thirty years with an average of twelve years. The age at which tennis was begun ranged from eight to twenty years with an average of fifteen years. Thus, I believe that the range of ages and the period of activity warrants the assumption that this is a fairly representative study.

A ventro-dorsal X-ray photograph was made using a focal distance of two meters and the lower surface of the spinous process of the fifth dorsal vertebra as the point of focus while the subjects stood with shoulders raised forwards. Each picture was taken when the subject held his breath at the end of a full inspiration after a series of deep breaths. In this study the analysis follows the procedure of Prof. Dr. Saito and Dr. Aikawa whose research took up a study of healthy individuals engaged in all walks of life whether athletes or non-athletes.

III. Observations.

From an analysis of the X-ray photographs the following may be said:

1. Clavicle.

A. "Begleitschatten" of the Clavicle.

This is the "shadow" of the skin of the region between the clavicle and the sub-clavian groove. Among the players it was perceived in 46 cases (86.8%); on both sides in 41 cases; the right only in 3 cases, and on the left in 2 cases. The above data coincides, in general, with the previous findings of Prof. Dr. Saito and Dr. Aikawa.

B. "Usurschatten" of the Clavicle.

Prof. Dr. Saito and Dr. Aikawa gave this name to a condition in which the lower surface of the clavicle has been roughened. This is brought about by the recurrence of any movement which causes friction between the head of the first rib and the clavicle. Such a condition was found in the right of 9 and on the left of 4 subjects. In the right of 7 cases and left of 4 there may be some doubt as to its authenticity. In general, there were more on the right than the left side.

Let us analyze the serve. As the racquet is swung downward backward and upward, the service arm shoulder is drawn forcefully backward and the other arm is raised aloft as the ball is tossed upward. Then, the elbow is bent and the racquet dropped behind the head. There is a transfer of weight from the back foot to the forward foot as the arm and racquet are extended forward upward to contact the ball over the forward foot and brought diagonally downward left with a bending of the trunk on the follow through. Of course, there are many variations to the overhead service and the first and second services usually differ in speed but the movements involved are fundamentally the same. Thus (we can realize) that considerable friction takes place in each serve.

In the case of the overhead smash, a similar extension of the arm and downward swinging on the follow-through are used. There are many other strokes in which approximately the same movements take place, notably the forehand stroke.

The "Usurschatten" is more marked on the side of the service arm. Tennis is a game which necessitates a great amount of this type of activity, so in considering the occurrence from the viewpoint of mechanics, it is to be expected.

C. Epiphyses at the Sternal End of the Clavicle.

In 26 of the 30 cases apparent both sides were clearly seen and 4 of one side only, 2 of which were on the right. It is interesting to note that between the ages of 19 and 26 years the condition occurred in over half the number while it did not exist at all in the case of 4 persons of 25 years of age and one person of 18 years.

Table 1.

Age	No.	Epiphyses Kernel Observed	% of Epiphyses		
			According to Age	Of 30 Observed Cases	Of 53 Subjects (All)
18	1	0			
19	2	1	50%	3.3%	1.9%
20	8	5	65%	16.3%	9.4%
21	6	6	100%	20.0%	11.3%
22	5	4	80%	13.4%	7.6%
23	10 (9)	7	70%	23.4%	13.2%
24	4	3	75%	10.0%	5.7%
25	4	0			
26	3	2	67%	6.7%	3.8%
27	3	1	33%	3.3%	1.9%
29	1	0			
30	1	0			
32	2	1	50%	3.3%	1.9%
37	1	0			
45	1	0			
47	1	0			
49	1	0			
Total	54 (53)	30			

2. Ribs.

A. Ossification of the Rib Cartilage.

It is generally accepted that the state of ossification of the rib cartilage is more complete with the advance of age. In the case of my own investigations I found this true, but in the research of Prof. Dr. Saito and Dr. Aikawa some interesting exceptions to this "rule" were brought to light. That there is a greater degree of ossification in the case of the first cartilaginous process than in any of the others is also a well-known fact. No special relationship between the state of ossification and pathological changes of the lungs was found. In 17 cases (32.1%) a complete ossification of one or more ribs was apparent.

B. Rib Deformities and "Alignment".

In briefly reviewing the variations found a few interesting cases were as follows:

Case No. 1.

There was a widening of the left second rib from the angle toward the shaft and at the anterior side of the chest a marked narrowing as though shaved crescent shaped then a return to normal width at the costal cartilage.

The upper surface of the right second rib was rough and two centimeters before reaching the costal cartilage there was a decided upward curve but the lower surface of the rib was normal. There were no indications of disease or fracture in either case.

Case No. 2.

About 3 centimeters from the angle toward the sternum there was an upward curve of both surfaces of the right second rib, then a return to normal width. No indications of disease or fracture were apparent.

Case No. 3.

The subject's thorax was small as a whole similar to a feminine thorax. The ribs had a decided downward angle, especially prominent in the lower half. There were no particular variations in the spine or diaphragma apparent in the X-ray picture. Although there were no indications disease, there was a lobular deformity of the right lung.

Case No. 4.

There was a "spine-shaped" process near the costal cartilage of the right second rib.

Case No. 5.

The first and second ribs were joined together 3 centimeters from their heads for a short distance. The second rib continued on normally while the first rib widened at the point of separation and terminated with a downward angle.

Case No. 6.

The upper half of the ribs "left" the spine horizontally and in extreme cases with an upward angle. From the "angle" the ribs continued toward the sternum with a decided downward angle. The above was a very exceptional case.

It was interesting to note that the subject was one of the very best players in Japan.

3. "Begleitschatten" of the Second Rib.

In 27 cases (50.9%) the shadow of the pleura of the apex of the lungs was clearly seen; of which 12 (44.4%) were on the right; 9 (33.3%), the left; 6 (22.2%) both sides. I shall divide them into 4 classes as indicated in the following diagram.

Class I	78.8%
Class II	15.2%
Class III	6.6%
Class IV	3.3%

4. Hair-line (Right middle lobe of the lung)

They were apparent 33 in cases (60.4%). With the exception of special cases, the hair-lines did not indicate any diseased condition. The research of Prof. Dr. Saito and Dr. Aikawa confirmed Dr. Schinz's theory that these are normal. The findings of this study further verified this theory.

In this study the hair-lines have been divided into classes according to the following diagram:

Class A		Class A	11 cases (34.4%)
Class B		Class B	8 cases (25.8%)
Class C		Class C-D	3 cases (9.6%)
Class D		Class E-F	2 cases (6.4%)
Class E		Class G-H-I	1 case (3.2%)
Class F			
Class G			
Class H			
Class I			

In comparing the location and type of the hairlines and the pathological changes of the lung space due to disease the following results were found. (Table 2)

5. Height and Shape of the Diaphragmatic Curve.

The Levy-Dorn procedure was employed in order to study the height and shape of the diaphragmatic curve. Results are indicated in the following table. (Table 3)

Table 2.

Case	Intercostal Spaces		Shape	Pathological Changes
1	VI-VII	III-IV	E	(-)
2	VII-VIII	III-IV	A	(-)
4	VII-VIII	III-IV	E	Upper lobe of the right lung pathological shadow?
6	VII-VIII	III-IV	A	(-)
7	VII-VIII	III-IV-V	A	(-)
11	VII-VIII	III-IV	I	(-)
12	VII-VIII	IV-V	A	(-)
14	VII-VIII	III-IV	G	(-)
15	VI-VII	III-IV	B	Upper lobe of the left lung pathological shadow.
16	VII-VIII	III-IV	F	Infiltration -left subclavian groove.
19	VI-VII	III-IV	B	(-)
20	VI-VII	II-III-IV	C	Both upper lobes pathological shadow.
21	VII-VIII	IV-V	A	(-)
22	VI-VII	III-IV	D	(-)
26	VII-VIII	III-IV	D	(-)
29	VIII-IX	IV-V	B	(-)
30	VII-VIII	III-IV	A	(-)
32	VII-VIII	III-IV	D	(-)
34	VI-VII	III-IV	A	Right lower lobe "primäre komplex"
35	VII-VIII	IV-V	B	Right apex pathological shadow and infiltration of the right middle lobe.
38	VI-VII	IV-V	C	(-)
39	VII-VIII	III-IV	B	(-)
40	VI-VII	III-IV	B	Both "Hilus Drüsen" swelling.
41	VII-VIII	IV-V	B	(-)
42	VII-VIII	III-IV	C	(-)
43	VI-VII	III-IV	A	Right apex infiltration. Both "Hilus Drüsen" swelling.
45	VII-VIII	III-IV	B	A plait -inner side of the right diaphragma picture.
46	VII-VIII	IV-V-VI	A	Left "Hilus Drüsen" swelling.
47	VII-VIII	III-IV	A	Right apex tuberculosis.
48	VI-VII	III-IV	F	Left "Hilus Drüsen" swelling.
50	VII-VIII	III-IV-V	A	Pathological shadow -right subclavian groove?
52	VII-VIII	III-IV	H	Right under lobe "primäre komplex".

Table 3.

Case	Height (cm.)	Dorsal Vertebrae	Distention of Stomach	Shape
1	2.4	XI	(-)	Right curve angular, left curve horizontal then sharp decline to lateral wall.
2	1.7	XI	(+)	Left curve saddle shaped.
3	1.1	XI	(-)	Right somewhat angular.
4	2.2	XI-XII	(+)	Both sides bow shaped.
5	2.5	XI-XII	(+)	Right curve waved.
6	1.1	XI	(+)	Right curve bow shaped, left curve saddle shaped.
7	1.5	XI-XII	(+)	Both curves bow shaped.
8	1.7	XI-XII	(+)	Both curves bow shaped.
9	1.4	XI	(+)	Right curve bow shaped, left curve saddle shaped.
10	1.0	XI	(+)	Both sides somewhat horizontal then sharp decline to lateral wall.
11	2.4	XI	(+)	Both sides bow shaped.
12	1.5	XI-XII	(+)	Both sides bow shaped.
13	2.5	XI	(+)	Both sides bow shaped.
14				
15	1.1	X-XI	(+)	Right curve bow shaped left curve saddle shaped.
16	1.9	XI	(+)	Both sides bow shaped.
17	1.2	XI-XII	(-)	Both sides bow shaped.
18	2.4	X-XI	o(+)	Right curve decidedly mount shaped, left side bow shaped.
19	3.1	XI	(+)	Right curve notched divided into 2, left bow shaped.
20	2.4	XI-XII	(+)	Both sides straight.
21	2.3	XI	(+)	Right side notched twice divided into 3 parts, left saddle shaped.
22	1.8	X	(†)	Both sides bow shaped.
23	1.7	XI-XII	(+)	Both sides bow shaped.
24				
25	1.8	XI	(+)	Both sides bow shaped.
26	2.5	XI-XII	(+)	Both sides horizontal.
27	1.6	XI	(+)	Both sides bow shaped.
28	2.2	X-XI	(+)	Both sides bow shaped.
29	1.8	XI	(+)	Both sides bow shaped.
30	1.9	XI	(+)	Right side notched near the lateral wall.
31	0.9	XII	(+)	Both sides bow shaped.
32	1.1	XI-XII	(+)	Both sides bow shaped.
33	1.4	XI-XII	(+)	Right curve bow shaped, left saddle shaped.
34	1.6	X-XI	(+)	Left side the outer $\frac{1}{3}$ makes a "höckerig" upward.
35	2.2	X-XI	(+)	Right curve notched divided into 2, left saddle shaped.

Case	Height (cm.)	Dorsal Vertebrae	Distention of Stomach	Shape
36				
37	1.2	XI	(-)	Both sides bow shaped.
38	1.8	XI	(+)	Both sides bow shaped.
39	2.1	XI-XII	(-)	Right side somewhat straight, left horizontal then sharp decline to lateral wall.
40	Anclear			
41	0.7	X-XI	(+)	Right curve decidedly mount shaped in center. Left bow shaped.
42	1.6	XI	(+)	Left side straight, then sharp decline to lateral wall.
43	1.2	XI	(-)	Both sides bow shaped.
44	2.3	X-XI	(+)	Both sides bow shaped.
45	2.6	X-XI	(+)	Right side the inner $\frac{1}{3}$ makes a "höckerig" upward.
46	2.6	X-XI	(+)	Spine shaped deviation a. center of right curve, left saddle shaped
47	2.5	XI	(-)	Right curve notched divided into 3, left saddle shaped.
48	Anclear			
49	2.1	XI	(-)	Both sides bow shaped.
50	2.1	XI	(-)	Both sides bow shaped.
51	1.7	X	(+)	Right curve notched divided into 2, left bow shaped.
52	2.5	XI	(-)	Right curve notched divided into 3.
53	2.0	XI-XII	(-)	Both sides bow shaped.
54	1.4	X-XI	(+)	Right curve mount shaped near heart, left bow shaped.

6. X-ray of Heart and Blood Vessels.

The measurements were made according to Prof. Dr. Saito and Dr. Aikawa's method. See following diagram and table:

Table 4.

No.	N.W.	L.	Mr.	MI.	Mr.+1	r. Vorh.	r. Vent.	l. Vent.	Basal	Pl.	Al.	A-A'
1	38	16.3	4.2	9.1	13.3	9.2 (1.4)	11.0	10.1 (1.9)	11.8	7.6	8.8	3.2
2	41	15.2	4.0	8.3	12.3	9.2 (1.7)	10.2	11.4 (1.7)	11.2	5.9	8.4	3.2
3	43	14.4	4.6	8.0	12.6	8.2 (1.0)	10.3	10.4 (2.4)	11.4	7.0	9.6	3.8
4	40	16.1	4.3	9.2	13.5	9.8 (1.8)	11.0	9.9 (1.6)	12.1	6.6	8.1	3.7
5	46	16.2	5.1	10.2	15.3	9.1 (2.0)	12.0	10.0 (2.3)	13.2	7.1	10.3	3.0
6	40	15.0	5.3	7.4	12.7	9.4 (1.4)	10.4	9.3 (1.7)	12.1	7.8	10.0	3.1
7	35	13.2	4.6	5.8	10.4	9.6 (1.1)	7.7	10.3 (2.1)	11.3	6.5	9.3	3.2
8	43	14.3	4.0	7.8	11.8	9.1 (1.4)	9.0	11.2 (2.0)	11.6	7.4	11.5	2.4
9	45	15.3	4.1	9.3	13.4	8.3 (1.2)	12.0	10.3 (1.9)	12.0	7.0	8.8	2.5
10	48	15.0	4.2	9.3	13.5	8.6 (1.6)	12.1	9.1 (1.3)	11.6	6.4	8.8	4.6
11	50	15.1	4.7	8.5	13.2	6.7 (0.9)	12.0	10.4 (2.0)	11.2	7.7	9.8	4.3
12	42	14.0	4.3	7.8	12.1	8.8 (1.6)	8.5	10.3 (1.8)	11.8	7.6	9.7	3.2
13	39	14.6	4.5	7.0	11.5	8.1 (1.1)	10.5	12.0 (1.9)	10.2	6.5	11.0	?
14	45	15.7	5.1	7.9	13.0	8.7 (1.3)	11.7	9.9 (1.7)	12.0	7.0	8.8	4.8
15	42	14.8	4.2	8.1	12.3	9.3 (2.0)	9.6	11.0 (1.6)	11.5	6.5	8.2	3.2
16	47	14.2	4.3	8.2	12.5	6.5 (0.8)	10.7	10.8 (2.2)	10.8	7.2	9.3	3.9
17	40	15.1	3.2	9.2	12.4	9.9 (1.5)	10.1	10.0 (1.8)	11.4	5.3	7.9	2.4
18	48	16.4	4.1	10.4	14.5	8.5 (0.2)	13.4	9.5 (2.7)	11.8	7.5	8.8	2.3
19	39	15.1	3.8	8.3	12.1	8.7 (1.4)	10.3	11.6 (2.0)	11.3	6.6	9.9	2.2
20	53	13.2	3.8	8.1	11.9	8.4 (1.5)	9.9	10.2 (1.5)	10.3	6.5	9.3	4.1
21	48	14.1	4.4	8.7	13.1	8.9 (1.8)	9.0	10.6 (2.1)	12.0	7.8	9.9	4.2
22	46	15.7	4.5	9.0	13.5	7.9 (1.1)	13.2	10.0 (1.5)	10.2	5.8	7.4	2.8
23	47	18.8	3.9	9.1	13.0	7.6 (1.2)	11.5	11.6 (1.7)	11.4	7.5	9.7	3.9
24	40	14.1	4.9	8.0	12.9	7.6 (1.7)	9.2	11.2 (2.0)	10.1	6.6	8.5	3.6
25	44	15.5	4.1	9.4	13.5	9.1 (1.7)	11.4	11.8 (1.9)	11.9	8.5	9.0	4.0
26	44	15.4	4.7	9.2	13.9	8.5 (1.7)	11.2	9.4 (1.9)	11.7	7.2	9.5	4.3
27	43	15.8	3.7	9.4	13.1	8.0 (1.3)	11.8	12.3 (2.0)	11.8	6.9	9.5	3.9
28	39	12.7	3.3	7.2	10.5	8.0 (0.9)	9.5	11.6 (1.9)	11.0	5.6	8.5	3.5
29	43	16.0	4.5	9.0	13.5	8.9 (1.7)	10.9	10.3 (1.6)	11.5	6.9	9.6	2.5
30	45	13.2	4.0	6.5	10.5	7.0 (0.6)	10.4	12.5 (1.6)	11.8	6.8	10.0	3.0
31	38	14.8	5.2	7.4	12.6	9.9 (2.0)	9.4	13.0 (2.3)	12.1	5.8	8.5	3.0
32	44	13.8	4.9	8.0	12.9	7.7 (1.0)	11.2	12.1 (2.3)	12.9	7.1	8.0	2.5
33	36	15.4	4.0	8.0	12.0	9.8 (1.1)	10.3	11.0 (1.9)	12.7	5.6	7.9	3.1
34	45	14.8	5.4	7.4	12.0	8.3 (1.2)	10.7	12.8 (2.3)	12.2	7.3	9.4	3.4
35	54	14.5	5.5	8.0	13.5	5.5 (0.6)	12.4	11.7 (2.1)	12.0	8.6	10.4	3.5
36												
37	49	14.9	4.6	8.9	13.5	8.1 (1.5)	11.4	11.7 (1.7)	12.0	7.1	9.9	3.3
38	44	14.5	4.4	9.8	14.2	7.8 (1.3)	11.2	10.0 (2.7)	12.2	7.4	9.9	3.5
39	41	14.9	4.3	8.8	13.1	7.8 (1.0)	10.8	13.6 (3.2)	12.6	7.7	10.9	3.3
40	56	12.5	5.2	6.7	11.9	9.7 (1.6)	9.4	10.5 (1.4)	11.5	6.6	9.1	3.0
41	44	15.9	6.5	8.1	14.6	10.1 (2.2)	12.0	13.9 (2.3)	14.1	7.8	10.0	2.5
42	44	14.7	4.3	6.5	10.8	9.1 (1.2)	9.7	10.4 (1.8)	12.4	7.1	10.8	4.0

No.	M.W.	L.	Mr.	ML.	Mr.+1	r. Vorh.	r. Vent.	l. Vent.	Basal	Pl.	Al.	A-A'
43	38	13.5	4.0	7.4	11.4	9.6 (1.5)	8.8	10.2 (2.0)	11.3	6.2	8.8	2.7
44	44	14.6	3.1	8.0	11.1	8.2 (0.9)	9.9	11.6 (1.3)	11.2	7.7	12.0	2.8
45	44	14.4	3.5	8.9	12.4	6.6 (0.6)	11.4	11.0 (1.7)	11.3	7.2	9.4	3.0
46	42	14.1	4.0	9.0	13.0	8.4 (1.2)	10.5	11.1 (2.6)	11.5	6.2	8.5	4.2
47	37	14.9	5.4	7.4	12.8	8.8 (1.5)	10.9	11.3 (2.2)	11.8	6.3	8.1	4.1
48	43	15.5	4.5	8.2	12.7	7.3 (0.7)	11.3	11.5 (2.0)	11.6	8.2	10.9	3.7
49	43	13.9	3.3	8.1	11.4	7.8 (1.0)	10.8	9.5 (1.0)	10.8	6.1	8.8	4.0
50	48	14.4	3.5	8.5	12.0	7.8 (1.0)	10.2	9.7 (1.3)	11.2	7.4	10.0	3.3
51	46	15.4	4.6	10.2	14.8	8.5 (2.0)	12.4	9.8 (2.3)	11.3	5.5	8.2	?
52	40	15.0	4.8	8.9	13.7	8.0 (1.4)	10.6	10.2 (2.1)	10.6	7.3	10.6	3.7
53	48	13.5	3.8	7.5	11.3	8.0 (0.9)	9.7	9.4 (1.1)	11.2	7.5	12.0	3.9
54	52	13.1	4.8	8.8	13.6	7.7 (1.6)	11.8	8.6 (1.4)	10.7	5.1	6.9	3.0

IV. Conclusion.

Part 1. Clavicle.

A. "Begleitschatten" of the Clavicle.

It was determined and clearly seen in 86.8% of the cases and in greater part on both sides.

B. "Usurschatten" of the Clavicle.

The condition occurred in 24.5% of the subjects. If the "doubtful" case, were included, the percentage, would be increased to 45.3%. In considering the movements involed in playing tennis, this state was one to be expected.

C. Epiphyses.

This state existed in 56.6% of the examined. In comparing the age range with the occurrence, the relationship concured with previous reports.

Part 2. Ribs.

A. Ossification.

Complete ossification of one or more ribs occurred in 32.1% of the players.

- 1) Ossification of the first rib cartilage was in general very marked.
- 2) The ossification of the first rib in comparison with that of the second and lower rib was more complete and marked.
- 3) In general the state was in direct proportion to the age but exceptions to the rule might occur.
- 4) In considering the relationship between the pathological changes present in the lung field and the state of ossification, it is interesting to note that 9 of the 17 cases (53%)

showed no changes. 6 cases (35%) had indications of changes and 2 (12%) were doubtful. I believe that this presents a problem for further research.

B. Rib Deformities of the deviations noted 4 cases may be considered rib deformities. They occurred mainly on the right side. 2 cases may be considered deformities involving the "alignment" of the ribs.

Part 3. "Begleitschatten" of the second rib.

It was found to exist in about half of the subjects examined:

- 1) Among which the greater proportion may be considered normal.
- 2) In the few abnormal cases there was an accompanying pathological change;
- 3) The presence of a diseased condition did not necessarily have an accompanying "Begleitschatten";
- 4) Even though the "Begleitschatten" may be considered normal, it did not follow there was no pathological condition existent.

Part 4. Hair-line. (Right inter-lobes pleura picture.)

Although found in 60.4% of the players, with the exception of the very unusual cases there seemed to be no relationship to pathological conditions of the lungs.

Part 5. Height and Shape of the Diaphragmatical Curve.

In the greater number of cases the right curve was higher than the left. It was interesting to note that notches appeared in 7 cases but only on the right side.

Part 6. Heart and Blood Vessels.

- 1) The enlargement of the heart of the tennis players was on a par with that of the "model" sportsman; in fact greater in several cases.
- 2) There was no comparison possible of the enlargement of the heart between that of a non-participant and that of a tennis player an indication of the rigorous training required of an excellent tennis player.
- 3) The Vena Cava Inferior appeared less frequently on the X-ray photograph than that of the "model" sportsman.
- 4) The appearance of the Vena Cava Superior and Inferior and the arch of the pulmonary vein on the photograph indicated that the "Lungen Zeichnung" was clear.

Part 7. Pathological Changes of the Lungs.

22.6% of the subjects had clear indications of such conditions. If the "borderline" cases were to be included, the percentage mounted to 39.6%. Although this problem must await further research, I am led to believe that those of relatively weaker constitutions are partici-

pating in tennis. They may have chosen tennis, because at a glance it may appear to be a less rigorous game than other sports. The fact that in the greater number of cases the x-ray findings indicate that the pathological changes are of long-standing further substantiates the foregoing statement.

With the exception of the lungs there was no outstanding difference in the X-ray findings of those of tennis players and the participants of other sports.

日 本 醫 學 雜 誌

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