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SUCCESS AND FAILURE IN MUSICAL PERFORMANCE

BIOMECHANICS OF THE HAND

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Legend has it that Artur Rubinstein once said that he owes his career to his hands. Obviously he was joking. More seriously, the great pedagogue Heinrich Neuhaus (1967) wrote in his well-known book: "Look upon the hands of our great contemporary virtuosos, Richter, Gilels, Horowitz. You will after the first impression immediately be convinced that these are hands of peculiar, *rare* and unusual qualification for great piano playing." How much of the success is determined by the hand, really? As you know, there are extremely differing opinions.

A widespread view, as expressed by Kochevitsky (1967), is the following: "Any abnormal bone-muscle apparatus is sufficient for the development of a high degree of technique because of the brain behind the hands." However, the assumption of a so-called "normal bone-muscle apparatus" of the hand contains the same fallacy as the notion of the "average man" (Hertzberg, 1972). It is, in my opinion, the origin of many fruitless discussions in the field of instrumental training.

Nearly fifty years ago, Otto Ortmann (1929) devoted a special chapter of his book to "individual differences of the hand." At the same time the physiologist Wilhelm Trendelenburg (1925) also noted the large extent of individual differences of joint mobility in respect to string playing. Their observations and arguments were hardly taken seriously and remained largely unknown, despite the instrumentalists' daily experience that, in the words of Ortmann, "...in the fine adjustments used in piano playing even the slightest restriction is a hindrance." It is this aspect of our question that interests me. How do we explain the thousands of instrumental students, professionals and amateurs, who even after ten or fifteen years of concentrated training do not reach that "high degree of technique"? Is the hand, due to its individual nature, responsible for the failure in these cases? And if so, was it merely a matter of training which had been neglected? The teacher would then be responsible for the student having failed. Or is it a question of manual characteristics genetically determined and therefore resistant to training?

There are many variables related to success or failure in music performance. I am not going to discuss the relevance of manual factors in comparison with other factors. I want to ask only one question — is it possible that the individual biomechanics of the hand can be a limiting factor in instrumental training?

Biomechanical Factors — Measuring; Reliability

The biomechanical characteristics which are, in principle, able to influence the dexterity of the hand can be summarized in the following groups:

1. Shape and size of the hand (and of the arm)
2. Mobility of the joints of the hand (and of the arm)
3. Strength of the muscles which act upon the joints of the hand (and those of the arm).

The manual requirements for the various instruments are quite different.For this reason it is necessary to examine separately the essential biomechanical factors for each instrument. We have largely restricted ourselves to the piano and string instruments in relation to factors of the first two groups, shape and mobility (see Figure 1).

Shape of the Hand: This includes the length of hand, breadth of hand, breadth of wrist, length of the back of the hand, length of the middle finger, and difference of the fingertip 1-3 and 5-3.

Active Mobility: Included here are the ten maximum spans between the fingers of one hand, the range of flexion of the basal joint of the thumb, the range of ulnar and radial abduction in the wrist as well as the range of supination and pronation in the elbow joint.

Passive Mobility: This includes the range of passive lateral movement of the basal joints of the fingers 2, 3, 4, 5; the range of passive abduction of the thumb; the range of passive hyperextension of the basal joints 2, 3, 4, 5; and the range of passive supination and pronation, each under the effect of a given external torque. Measuring passive joint mobility means determining the

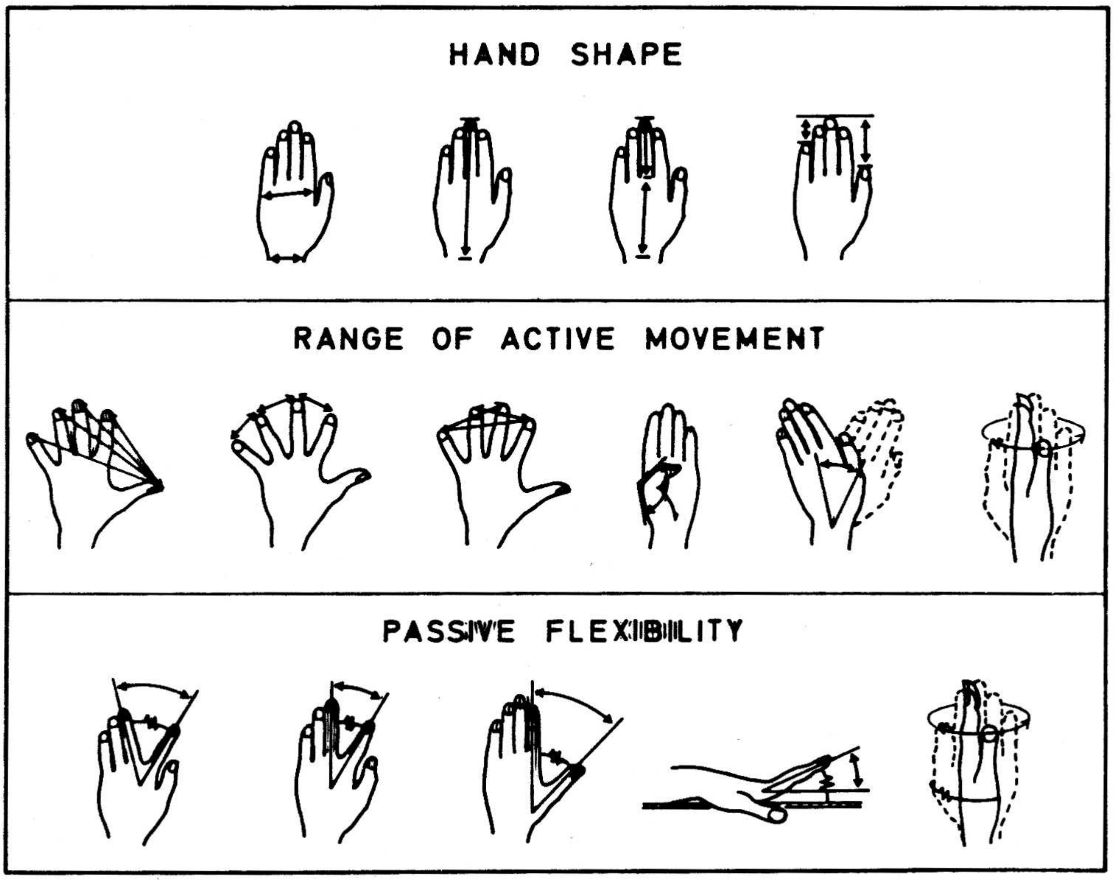

Figure 1

Characteristics of the hand which had been recorded in the investigation. The symbol — — indicates the application of an external torque when measuring passive flexibility.

amount of mechanical resistance which every individual joint offers to movement.

The combination of measurements is different for each instrument. An examination of the range of supination is of interest for playing the violin and hardly of interest for playing the cello. In the case of the piano, both hands are examined, whereas in string playing we have until now examined only the characteristics of the left hand. Apart from the strength of the muscles, some other factors of joint mobility have not been included, e.g., control of passive wrist mobility. What was decisive for the compilation of data was the time requirement necessary to carry out the tests. In its present form, the examination lasts about twenty minutes with stringed instruments and about forty minutes with pianists.

It would be going too far to describe the technique of measurement here in detail (see Wagner 1974, 1977). The shape of the hand is measured according to the rules of anthropometry. We have developed our own methods for the testing of active and passive mobility. Figure 2 provides a survey of the measurement instruments and procedures.

The reliability of the methods was tested in test-retest measurements by two independent examiners on the right and left hands of 30 test subjects. That they might provide different degrees of variability with various joints is not surprising and has been reported before (Hellenbrandt et al., 1949; Wagner and Drescher, 1984). Apart from this, the size of the external torque plays a

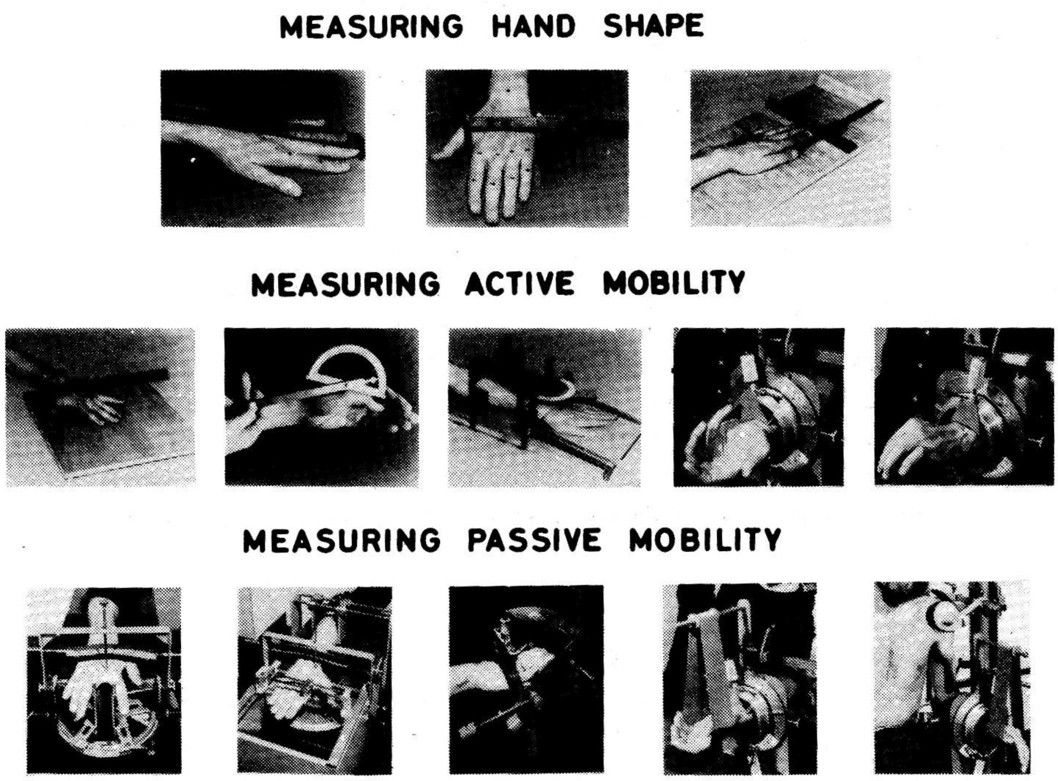

Figure 2

Measuring Equipment

role in the control of the passive mobility (Wagner, 1977). On the whole, the reliability attained seems to us to be satisfactory. Of the 79 test-retest correlations, 44 lie above .9, 66 above .8, 9 between .7 and .8, and 4 between .6 and .7. We hope to improve consistency by technical changes. However, like other investigators, we have noted that determination of joint mobility of the hand presents considerable difficulties (Hamilton and Lachenbruch, 1969; Hasselkus, et al., 1981; Wagner and Drescher, 1984).

Variability of the Musician's Hand

Up to the present time we have examined approximately 600 professional musicians and 130 adult non-musicians according to the methods described. In addition we have examined 160 young people as well as 130 children with and without instrumental training. The majority of pianists were enrolled as students in the piano classes of six German State Colleges of Music. Music teachers at the high school and college levels and free-lance pianists also took part in the study. The majority of string performers were intentionally drawn from professional orchestras ranging from smaller provincial orchestras to large well-known orchestras.

First I would like to show those results which are important from a methodologic point of view, namely the question of variability of the musician's hand. I will show an investigation of 91 male pianists aged 16-33 years. The variability of the left hand of the 31 characteristics investigated is shown in Figure 3. (At the suggestion of B. Scheider, 1981, instead of the coefficient of variation, I use a non-parametric coefficient which provides a ratio of the interdecile range to the median. This is done because we cannot make any assumptions about the form of distribution of the various characteristics or, alternatively, we have indications that in some cases the distribution may not be normal).

Shape

Shape factors as a group show considerably more limited variability than the factors of active and passive mobility. It is interesting that the relative length of the fifth finger is apparently the least consistent characteristic.

Active Mobility

In assessing the pianist's hand one often thinks first about the 1-5 span. As the data show, it is precisely this span which shows the least variability among the ten spans studied; the 3-4 span almost doubles this variation.

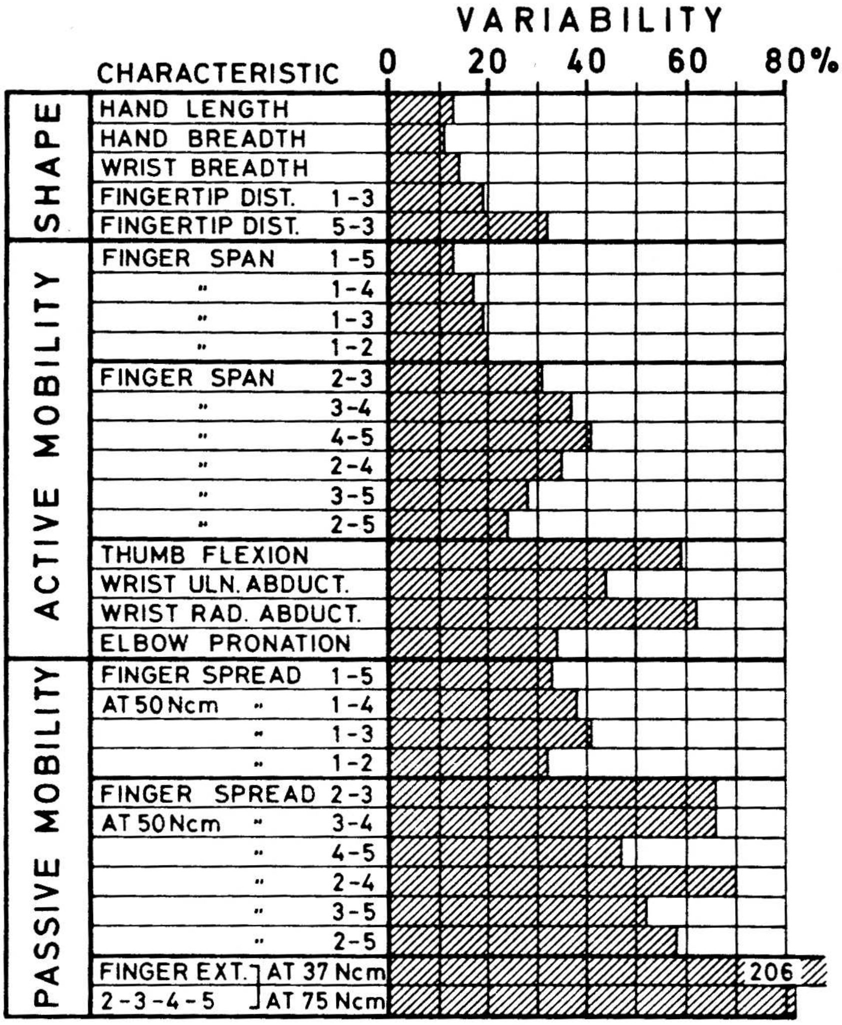

Figure 3

Variability of the pianist's hand. Decile coefficients (Interdecile Range x 100/Median) of characteristics of shape and mobility of the left hands of 91 male pianists, 16-33 years.

Much greater differences are also found in the active flexion mobility of the basal joint of the thumb and in the active lateral mobility of the wrist.

Passive Mobility

A graded picture, one similar to active mobility, is also found with passive mobility in that the level of variability as a whole is considerable. The decile coefficient of the active span 2-3 is 31%; the coefficient of the passive spread 2-3 is in contrast, 66%. This means that only with measurements of *passive* mobility does the actual extent of difference in the biomechanical pre-requirements become clear. Finally, gross variability is found in the *passive* extension mobility of the basal joints of fingers 2-5.

Knowledge of this graded variability is also of interest for instrumental training as well. From this it is possible to derive a type of ranking order in respect to the teachers' observing manual characteristics with their students. As you see it is precisely the shape of the hand which tells us least of all.

Quite apart from the *inter*individual variability, the *intra*individual variability is also of interest. If at least some of the characteristics measured here were in close relationship to one another, then the number of factors to be examined could be reduced. For example, to what extent can we draw conclusions from the size of the hand on the hand spans, or from span 1-5 on other hand spans? In the practice of instrumental training such conclusions are constantly drawn unconsciously.

The calculation of correlations provides a number of surprises in this connection (see Table 1). In the test series with 91 pianists there was, at most, a correlation of .49 between the length of the left hand and its spans. The breadth of the hand has a correlation of .32 with the span 2-5. Several spans have a closer relationship if a common finger is involved. Between spans 1-2 and 3-4 there is a correlation of only .23. In the matrix which considers thirty characteristics of the left hand of this pianist group, there are 435 rank correlation coefficients. Of these, 319 are below .5, 407 below .8, with only 27 values over .8. Even a correlation of .8 is an unsatisfactory basis when we are considering the assessment of individual preconditions for piano performance. The correlation between spans 1-2 and 1-4 amounts to .84. As Figure 4 shows, we must nevertheless reckon with the fact that, for example, with a span 1-2 of 220mm, spans 1-4 can differ by 35mm. That corresponds to a distance of a third on the piano! It hardly needs to be pointed out that, under such circumstances, general statements about manual preconditions for piano performance should not be made.

At this point it is worth recalling the investigations concerning the problem of generalization of dexterity which were carried out by Henry (1958) and Fleishman (1958) which essentially speak in favor of the *specificity* of motor skills. The question seems to be whether the non-generalized biomechanical characteristics of the hand could not also, perhaps, be part of the cause of these findings. I am reminded of J.P. Guilford who wrote in 1958, "The properties of bones and muscles, and the manner in which they are put together, should have much explanatory significance in accounting for many psychomotor abilities."

Table 1

Matrix of rank correlation coefficients for shape and active spans of the right hand of 91 male pianists, 16-33 years.

	Hand Length	Hand Breadth	Fingertip dist. 1-3	5-3	Active span of fingers 1-5	1-4	1-3	1-2	2-3	3-4	4-5	2-4	3-5
Hand breadth	.56+	—											
Fingertip distance 1-3	.52+	.33+	—										
Fingertip distance 5-3	.36+	.27+	.05	—									
Finger span 1-5	.49+	.42+	.41+	.13	—								
Finger span 1-4	.40+	.25+	.48+	.16	.86+	—							
Finger span 1-3	.38+	.08	.50+	.22.	.76+	.89+	—						
Finger span 1-2	.26+	.04	.32+	.26+	.74+	.84+	.92+	—					
Finger span 2-3	.34+	.16	.49+	.01	.47+	.60+	.58+	.40+	—				
Finger span 3-4	.19	.34+	.24+	.07	.40+	.47+	.28+	.23+	.56+	—			
Finger span 4-5	.14	.35+	.14	-.14	.49+	.33+	.16	.14	.35	.50+	—		
Finger span 2-4	.21	.18	.37+	-.11	.66+	.73+	.54+	.43+	.81+	.93+	.54+	—	
Finger span 3-5	.30	.27	.35+	-.20	.72+	.61+	.43+	.40+	.63+	.85+	.78+	.87+	—
Finger span 2-5	.36+	.32	.32	-.15	.80+	.65+	.50+	.48+	.65+	.80+	.66+	.86+	.91+

+p <.05

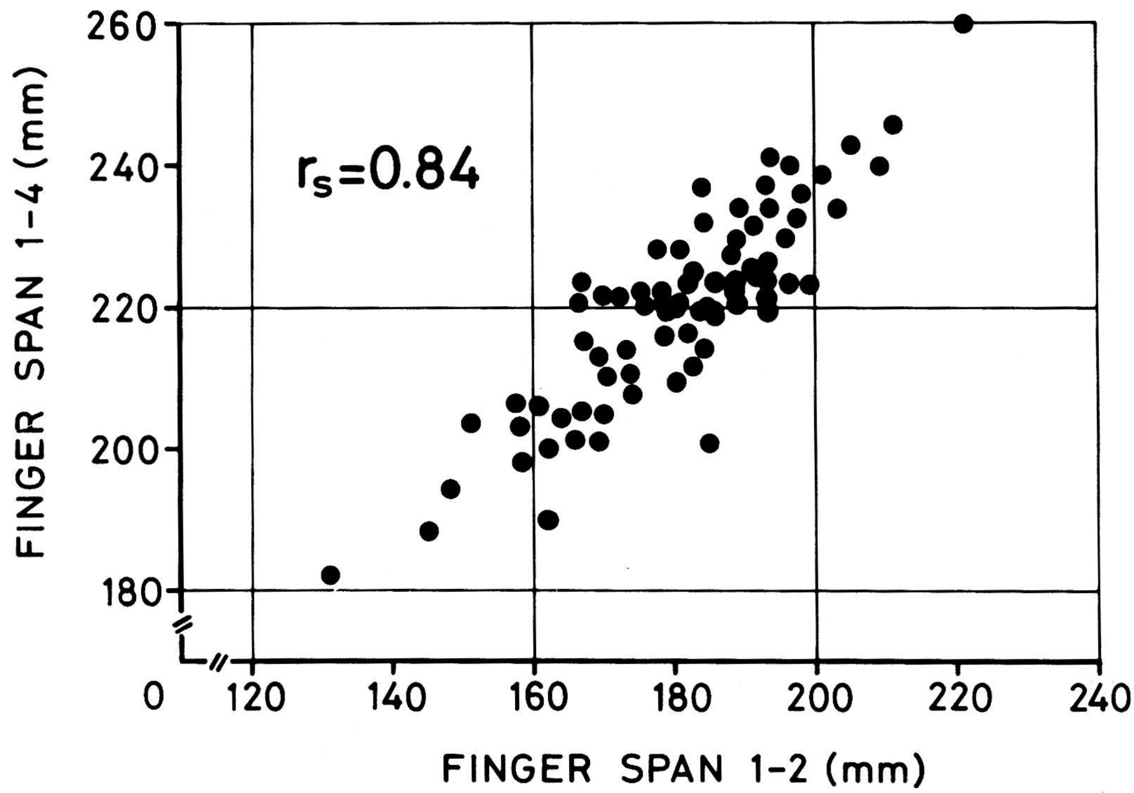

Figure 4

Correlation between active span of fingers 1-2 and 1-4 of the left hand; male pianists, 16-33 years.

Success and Failure Criteria: Comparing Two Groups

In the search for essential biomechanical factors for instrumental performance one could first of all compare musicians with non-musicians. We did this in an earlier investigation with violinists (Wagner, 1975), where we were able to show with a range of characteristics the biomechanical advantages of the violinists' hands. It seems even more instructive to contrast very successful instrumentalists with a group of players who have had serious difficulties with the instrument during or after training. The implementation of such investigations is, however, problematic. For example, the grouping of successful and problem cases for statistical purposes must be done carefully. One depends on successful people who, in spite of their success, have enough time and interest to undergo a biomechanical examination. Also needed is the cooperation of musicians who can recognize their technical difficulties and speak openly about them. For these reasons only a relatively small amount of data are available for contrasting both groups.

It would be desirable to select well-known soloists and winners of international competitions for the "Successful Performers" group (Group S). This restriction would, however, have failed because of the considerable time and effort required. Moreover, I don't consider rigorous limitations to be required. Our investigations are, after all, looking only for biomechanical causes of *technical* success or failure — not causes for a performer's *musical* success as a whole!

For acceptance of an instrumentalist into Group S it was sufficient that they meet one of the following criteria:

- mastery of major works from the virtuoso literature
- participation in international competitions
- membership in a top orchestra
- regular concertizing activity

It would be inappropriate to designate the other group as a failure group for also here it is a matter of professional musicians who have reached a corresponding level of technical achievement.

The group of Problem Cases (Group P) included:

- instrumentalists who had to struggle with selected technical problems over a long period of time, e.g., lack of speed, lack of manual security, lack of endurance, and difficulties with grip and spacing
- instrumentalists with acute functional or organic disorders related to the locomotor system in connection with instrumental performance, e.g., tendinitis, epicondylitis, neuritis, and coordination disorders of the fingers.

We were able to contrast a total of 110 "successful" instrumentalists and 46 "problem" cases. We further divided the subjects according to instrument, sex, and age.

I would like to report on two of these comparisons — other comparisons have yielded similar results. The null hypothesis that both samples (successful and problem cases) originate from one and the same population was tested within each characteristic using the U Test of Mann and Whitney (Sachs, 1969). This means the comparison does not take into account the intraindividual combination and weighting of the factors being examined. We should, therefore, neither over-value the presence of statistically significant differences with particular characteristics nor the lack of significant differences with other characteristics. The analysis serves to describe the present status of results and to call attention to specific tendencies. Later we will want to apply other statistical methods which do justice to the intraindividual combination of the factors. At this time we are not recording a number of biomechanical factors which will be of undoubted importance.

Comparison I: Successful Pianists to Problematic Pianists

(Males, 18-30 years old, right hand. See Table 2)

Table 2 shows both the median and decile coefficient for each of the characteristics examined. Also shown is the indication as to whether a significant difference is or is not present at the .05 level. A two-tailed test was applied to the characteristics of shape of the hand so that arguments for a difference in either direction might be put to rest. We can see that in the selected characteristics of hand shape there were no significant differences.

Characteristics of mobility, however, are quite another matter. All ten active spans are larger among the successful group when compared to the problem group. The same is also true with the active range of flexion in the basal joint of the thumb. There were no differences in the active lateral mobility of the wrist and in the active angle of pronation. With passive mobility we find no differences in the angles of spread in which the thumb is involved. In contrast, higher mobility is seen among successful performers in the six angles of spread without the thumb. The passive extension mobility of the basal joints of fingers 2-5 is also higher among the successful performers.

Comparison II: Successful Violinists to Problem Violinists

(Females, 18-30 years old, left hand. See Table 3)

Included in the Successful Violinists group were 11 female violinists appearing at an international music competition. Quite by chance, the Problem Violinists group also included 11 female subjects. The two-tailed test was applied to the characteristics of the shape of the hand, and the one-tailed test was applied to the characteristics of mobility. This procedure is similar to that used in Comparison I.

In contrast to the comparison of pianists, here we found differences in the shape of the hand — although not those we might have expected. The hands of the Success group were on an average shorter and the wrist narrower when compared to the Problem group. There was, however, no difference in the relative length of the fifth finger, even though it is precisely here that an

Table 2a

Comparison of the samples of "Successful Pianists" (Group S) and "Problem Pianists" (Group P) with respect to shape and active mobility of the right hands. (Males, 17-33 years)

Characteristic		Group	N	Median	Decile Coeff.%	U-Test α=0.05
HAND SHAPE						
Hand length	(mm)	S	37	192	11.5	—
		P	10	189	18.7	
Hand breadth	(mm)	S	37	86	9.3	—
		P	10	83	8.4	
Wrist breadth	(mm)	S	37	57	10.9	—
		P	10	58	21.2	
Fingertip distance 1-3	(mm)	S	37	74	19.7	—
		P	10	72.5	20.3	
Fingertip distance 5-3	(mm)	S	37	36	29.4	—
		P	10	39.5	33.9	
ACTIVE MOBILITY						
Finger span 1-5	(mm)	S	26	233.5	11.6	sig.
		P	10	220	27.3	
Finger span 1-4	(mm)	S	26	228	13.5	sig.
		P	10	213	32.1	
Finger span 1-3	(mm)	S	26	217	13.8	sig.
		P	10	202	36.0	
Finger span 1-2	(mm)	S	26	184.5	18.8	sig
		P	10	167.5	47.4	
Finger span 2-3	(mm)	S	26	97	20.2	sig.
		P	10	90	48.6	
Finger span 3-4	(mm)	S	26	82	32.0	sig.
		P	10	72	37.1	
Finger span 4-5	(mm)	S	26	93	33.4	sig.
		P	10	83	50.6	
Finger span 2-4	(mm)	S	8	131.5	28.8	sig.
		P	6	119	34.6	
Finger span 3-5	(mm)	S	8	134	19.7	sig.
		P	6	124	26.2	
Finger span 2-5	(mm)	S	8	174.5	14.2	sig.
		P	6	155	34.6	
Thumb flexion	(°)	S	36	55	59.8	—
		P	10	44	103.0	
Wrist ulnar abduction	(°)	S	26	34.5	49.0	—
		P	9	35	77.1	
Wrist radial abduction	(°)	S	26	25	48.8	—
		P	9	23	56.5	
Elbow pronation	(°)	S	21	82	29.0	—
		P	5	81	31.9	

Table 2b

Comparison of the samples of "Successful Pianists" (Group S) and "Problem Pianists" (Group P) with respect to passive mobility of the right hands. (Males, 17-33 years)

Characteristic	Group	N	Median	Decile Coeff.%	U-Test $\alpha=0.05$
PASSIVE MOBILITY					
Finger spread 1-5 at 50 Ncm (°)	S P	10 6	97 87.5	41.3 42.6	—
Finger spread 1-4 " (°)	S P	10 6	83 75.5	42.8 45.2	—
Finger spread 1-3 " (°)	S P	10 6	90 81	41.4 50.9	—
Finger spread 1-2 " (°)	S P	11 6	57 56	43.2 45.7	—
Finger spread 2-3 " (°)	S P	37 10	40 34.5	62.0 60.3	sig.
Finger spread 3-4 " (o)	S P	37 10	27 23	73.3 87.4	sig.
Finger spread 4-5 " (°)	S P	37 6	42 37	48.1 58.7	sig.
Finger spread 2-4 " (°)	S P	10 6	52.5 38.5	92.6 91.2	sig.
Finger spread 3-5 " (°)	S P	10 6	55 45.5	59.5 43.1	sig.
Finger spread 2-5 " (°)	S P	10 6	65.5 53	57.4 43.4	sig.
Finger extension 2-3-4-5 at 37 Ncm (°)	S P	8 6	20.5 12.5	134.6 127.2	sig.
Finger extension 2-3-4-5 at 75 Ncm (°)	S P	37 10	35 25.5	105.1 138.4	sig.

Table 3

Comparison of the samples of "Successful Violinists" (Group S) and "Problem Violinists" (Group P) with respect to shape, active and passive mobility of the left hands. (Females, 18-30 years)

Characteristic	Group	N	Median	Decile Coeff.%	U-Test α=0.05
HAND SHAPE					
Hand length (mm)	S	11	172	11.9	sig.
	P	11	184	17.3	
Hand breadth (mm)	S	11	74	13.5	—
	P	11	77	15.1	
Wrist breadth (mm)	S	11	50	10.8	sig.
	P	11	53	15.5	
Fingertip distance 5-3 (mm)	S	11	37	26.5	—
	P	11	38	23.2	
ACTIVE MOBILITY					
Elbow supination (°)	S	11	109	35.6	sig.
	P	11	100	28.2	
PASSIVE MOBILITY					
Elbow supination at 16 Ncm (°)	S	11	103	34.8	sig.
	P	11	59	111.5	
Elbow supination at 32 Ncm (°)	S	11	108	28.0	sig.
	P	11	80	71.0	
Elbow supination at 64 Ncm (°)	S	11	120	26.7	sig.
	P	8	91.5	40.3	
Finger extension 2-3-4-5- at 75 Ncm (°)	S	11	58	72.1	sig.
	P	11	43	74.8	
Finger spread 1-2 at 50 Ncm (°)	S	11	60	49.3	—
	P	11	61	25.6	
Finger spread 2-3 " (°)	S	11	50	67.2	sig.
	P	11	38	83.2	
Finger spread 3-4 " (°)	S	11	37	89.2	sig.
	P	11	28	85.7	
Finger spread 4-5 " (°)	S	11	56	45.0	sig
	P	11	42	69.1	
Finger spread 2-4 " (°)	S	11	67	81.5	sig.
	P	11	49	82.5	
Finger spread 3-5 " (o)	S	11	73	47.7	sig.
	P	11	58	63.1	
Finger spread 2-5 " (°)	S	11	82	44.2	sig.
	P	11	66	69.4	

anatomic difference would be plausible. The data also show that except for the passive range of abduction of the thumb, the Success group is on average at an advantage with regard to active and passive mobility.

We will repeat these comparisons at some future date when a larger amount of data have been collected. Current data show greater variability in the Problem groups than in the Success groups. Even so, present results confirm and explain a number of things that students and teachers experience in an attempt to overcome performance difficulties.

The Individual Behind the Data

I would like to speak about certain basic connections which from a physiological and pedagogical point of view, perhaps also from a medical point of view, seem of interest. In the test series with 91 pianists we noticed that the greatest variability occurred in factors of passive mobility (Figure 3). Passive mobility factors were also seen as having the largest relative difference of medians in the comparison of Success and Problem groups (Tables 2 and 3).

It is important to keep in mind what *individual* differences lie behind these data, and what the data suggest in terms of instrumental performance. Particularly striking are the data related to passive mobility, especially the passive extension mobility of the basal joint of the finger. In the case of hand shape factors, the 9th decile exceeds the 1st decile by at most 30%. (Figure 5) In the case of passive mobility the 9th decile exceeds the 1st decile by 200%, 300%, sometimes 500%, 700%, and even more. This means that in an unfavorable case the joint must be moved against two or three times the resistance, sometimes even against five or ten times the resistance, than might be moved by a person with favorable manual preconditions.

What can an individual affected by five or ten times higher joint resistance do? He can try to reduce the disadvantage by assuming individually favorable postures and movements — something which is seldom done because of a belief that there is only one correct playing posture. Typically, the performer will try to compensate for higher joint resistance by using a correspondingly higher muscular effort, which causes an increase in the basic tension of the affected muscles. Muscle tension is a component of joint resistance which, according to Barnett and Cobbold (1969), comprises an average of 50% of the total resistance when the joint is moved in its middle range. This is the range which is used above all for rapid and precise movements. When muscle tension increases, the affected joint is harder to move — a phenomenon known to many musicians suffering performance anxiety. The increased muscular effort

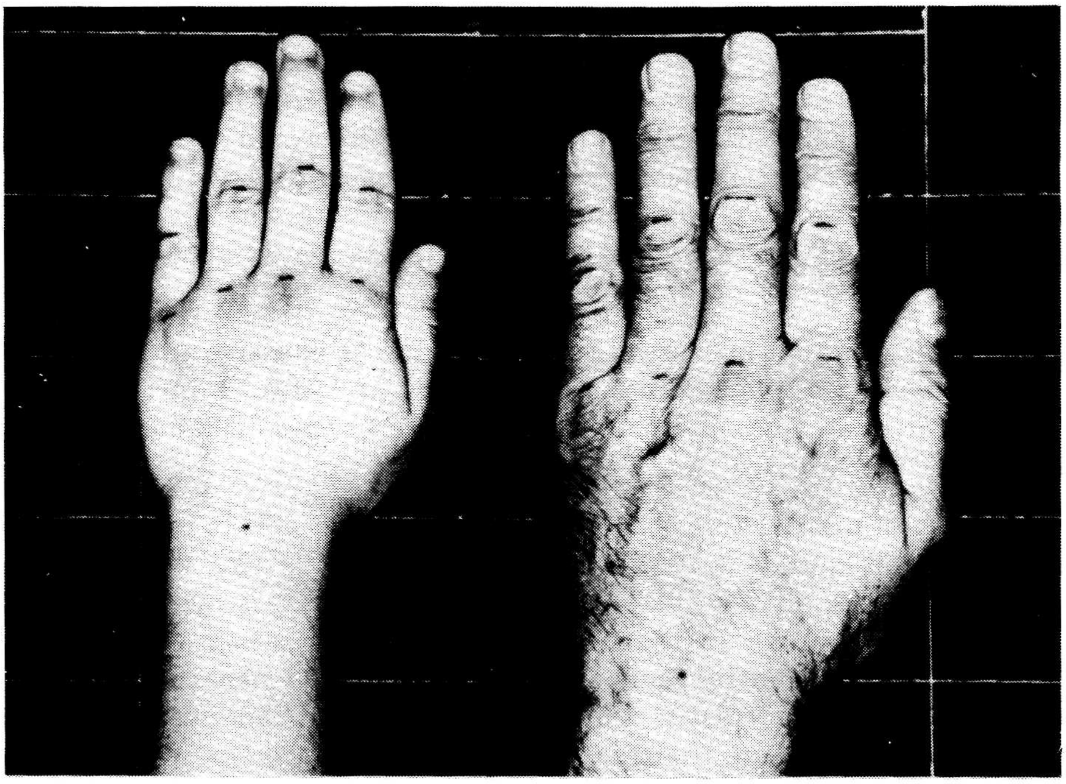

Figure 5

A "large" hand as compared to a "small" hand of two successful pianists. In regard to hand length, the large hand exceeds the small hand by 28%, in regard to hand breadth, by 30%.

needed to move the joint requires a correspondingly higher central nervous control to overcome these unfavorable conditions (Bernstein, 1975). Perhaps the most important effect of biomechanical disadvantages of the hand lies in the increased load on the central nervous system.

Problems of Performance

Once one becomes conscious of these connections, some negative aspects of musical practice are more easily seen. There is, for example, a considerable amount of work needed to acquire such technical skills as trills, ornaments, and repetitions which rely primarily on quickness of execution. For some players, the development of these skills is achieved relatively quickly; for others the process is laborious and time-consuming. For years I have observed that players who have difficulty in attaining speed of execution show high extension resistance in the basal joints of the fingers. This is completely understandable from a physiological point of view. It is known that the speed of contraction is dependent on the loading of the muscle. Differences in the range of 1:5 or 1:10 must make themselves noticeable! No one would expect the same performance from two 100-meter runners where one is dressed in racing attire while the other wears hiking boots, heavy clothing, and carries a backpack. Long hours of practice would be of little use to the weighted-down runner.

It is not surprising that in cases of particularly limited passive mobility, complaints are heard and injuries occur in the hand and arm. Injuries may include tendinitis and epicondylitis resulting from excessive demands of performance.

Despite the best preparation, some musicians are never able to rely completely on their technique. It is understandable that they develop anxiety. I am convinced that this anxiety, more often than we suspect, is biomechanically based. It may originate in the barely conscious realization that one has reached the limits of central compensation for peripheral weaknesses. Therefore, before anxiety is treated with beta-blockers and tendinitis with cortisone, one should be sure that the primary cause of such troubles is not an unfavorable biomechanical condition.

I would like to finish this comment on the topic of failure with an earlier finding because in this, something of the "safety interval" becomes visible. It is a matter of the measurement of the passive supination flexibility of the left elbow joint with non-musicians, non-selected orchestral violinists and participants in an international violin competion (see Figure 6). The noticeable difference between the medians is not found between violinists and non-musicians but between non-musicians *and* orchestral violinists as compared with competition participants. (By the way, the lower variability of the active mobility can once more be read here.) Biomechanical advantages such as we see here are naturally not the reason for success but are a part of the background for the success.

Training or Talent?

If successful and less successful performers can be shown to be different in respect to certain biomechanical characteristics of the hand, one then may ask how these differences came to exist. It is, indeed, difficult to imagine that the left hand of the female violinist becomes shorter by playing the violin (compare Table 3), but that the spans of the pianist increase in the course of training. It is the opinion of most musicians and instrumental teachers that

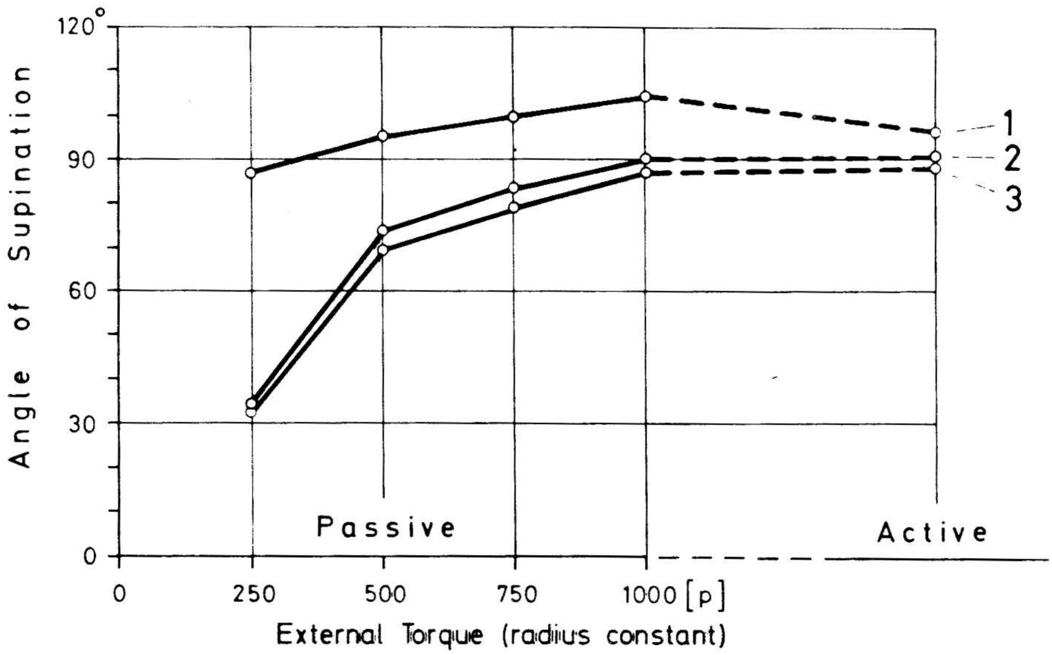

Figure 6

Passive and active supination of the left elbow joint (medians) examined with different groups:

1. 11 violinists, participants in an international music competition (19-29 years)

2: 19 violinists, members of orchester (24-35 years)

3. 13 non-musicians (18-30 years)

mobility can be taught. Our investigation, however, gives no definite answer whether and to what extent selected characteristics are teachable. An initial review of present data indicates no general tendency of increasing mobility in the case of any of the mobility factors. Regarding the average value in relation to time, we can see either no shifting at all (compare Figure 7) or a more or less decreasing tendency in general (compare Figure 8).

In order to complete the survey about development of age we have presented in Figure 9, apart from data on professional musicians as far as was available, also data on children and young people. This example should remind us of the following points:

1. The amount of joint mobility of the hand at early childhood can obviously not be maintained at the same level in any case, even under the condition of daily training.

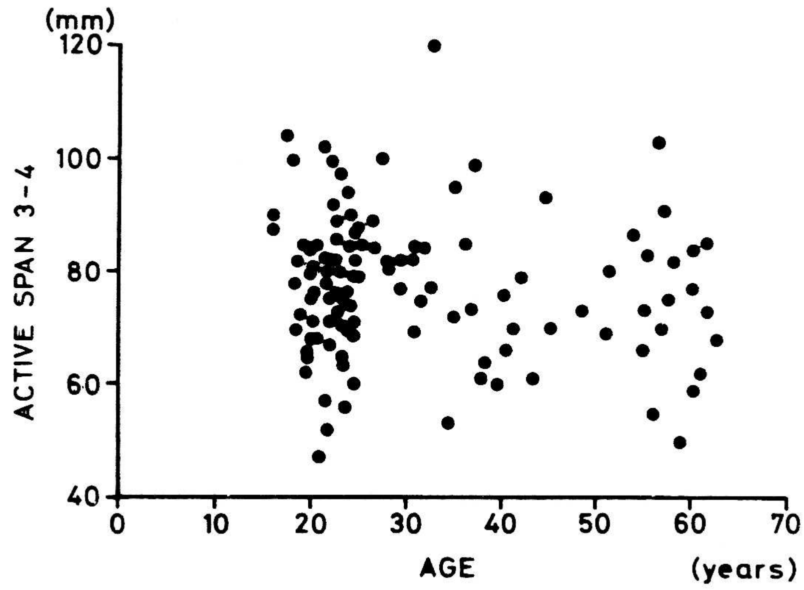

Figure 7

Active span of fingers 3-4 in relation to age; male pianists, 16-33 years, left hand

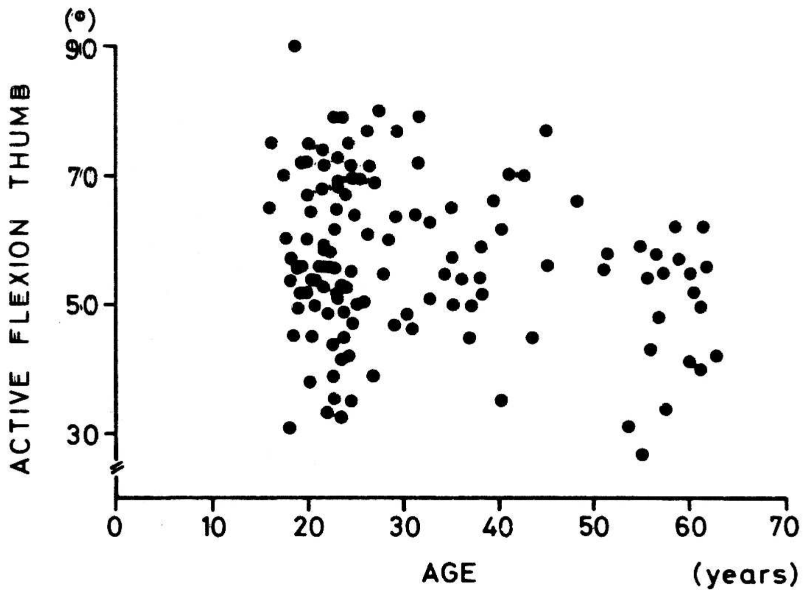

Figure 8

Range of active flexion of the basal joint of the thumb in relation to age; male pianists, 16-33 years, left hand.

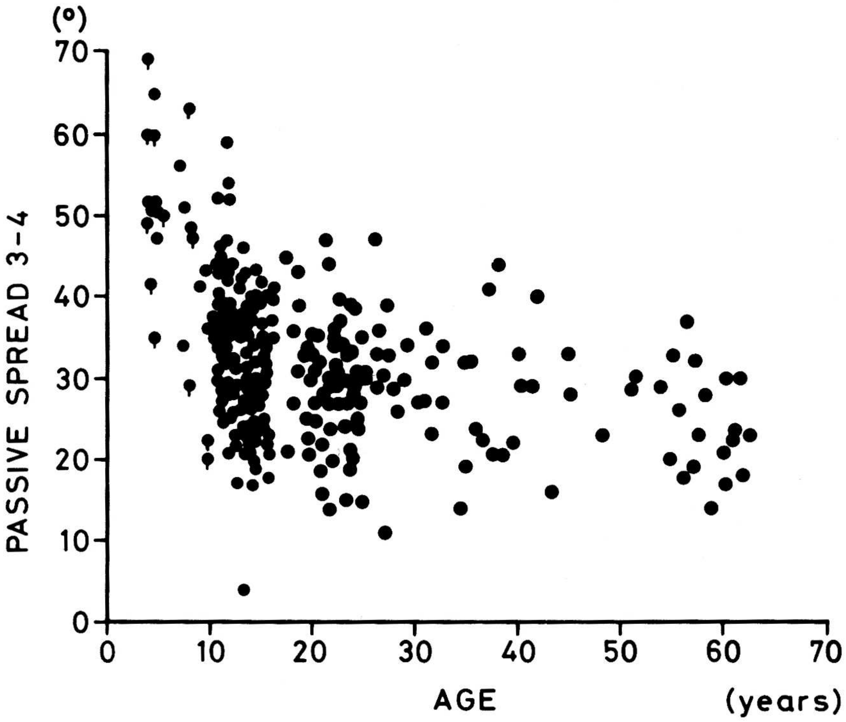

Figure 9

Range of passive spread of fingers 3-4 in relation to age (pre-set load 50 Ncm). Male pianists ( ) 16-63 years; boys ( ) ; girls ( ) 4-16 years, left hand.

2. The variability with children and young people, seen in absolute terms, is already very high, sometimes just as high as with adults.

3. On the basis of high variability of joint mobility, it can happen even with a decreasing tendency in general that a 60-year-old has a considerably higher mobility than a 20-year-old or even a 10-year-old.

In view of these facts I once again think about Artur Rubinstein, remembering his marvelous performances at age 80. Perhaps his remark about his hands was more than just a joke.

Summary and Conclusion

We have considered (1) the variability of biomechanical characteristics of the hand; (2) the lack of uniformity within one and the same hand; (3) genetic determination as probably the more relevant influence upon joint mobility than the effect of training; and (4) the dependence of the level of technique on certain biomechanical preconditions. There is one conclusion I would draw, namely that instrumental training should be based on knowledge about the actual manual preconditions of the individual. To this end an examination at the very beginning of training is recommended. It is hoped that such a strategy would also contribute to the prevention of some occupational diseases to which musicians are prone.

At the State College of Music and Theater in Hannover we provide those who wish to be informed about their manual preconditions with a "Hand Profile." (Figure 10) It shows an individual's constellation of measured values as compared to the decile values of a reference group. The central column corresponds to the 5th deciles, i.e., the average values of the reference group. To the right are the higher, more favorable values; to the left the lower, less favorable values.

In the given example one can see a frequently found irregularity. It is obvious that the student should try to compensate for the extremely small range of flexion of the thumb (Figure 10, line 16) by moving the arm in advance when the thumb passes under in scales and arpeggios.

Two further examples are given in Figures 11 and 12. The former is of a violinist who won prizes at national and international competitions; the latter is of a student who came to us because of pain in the forearm after doing finger isolation exercises. For years his teacher had admonished him to relax. The student's comment: "I just can't hear that word anymore!" — and with good reason.

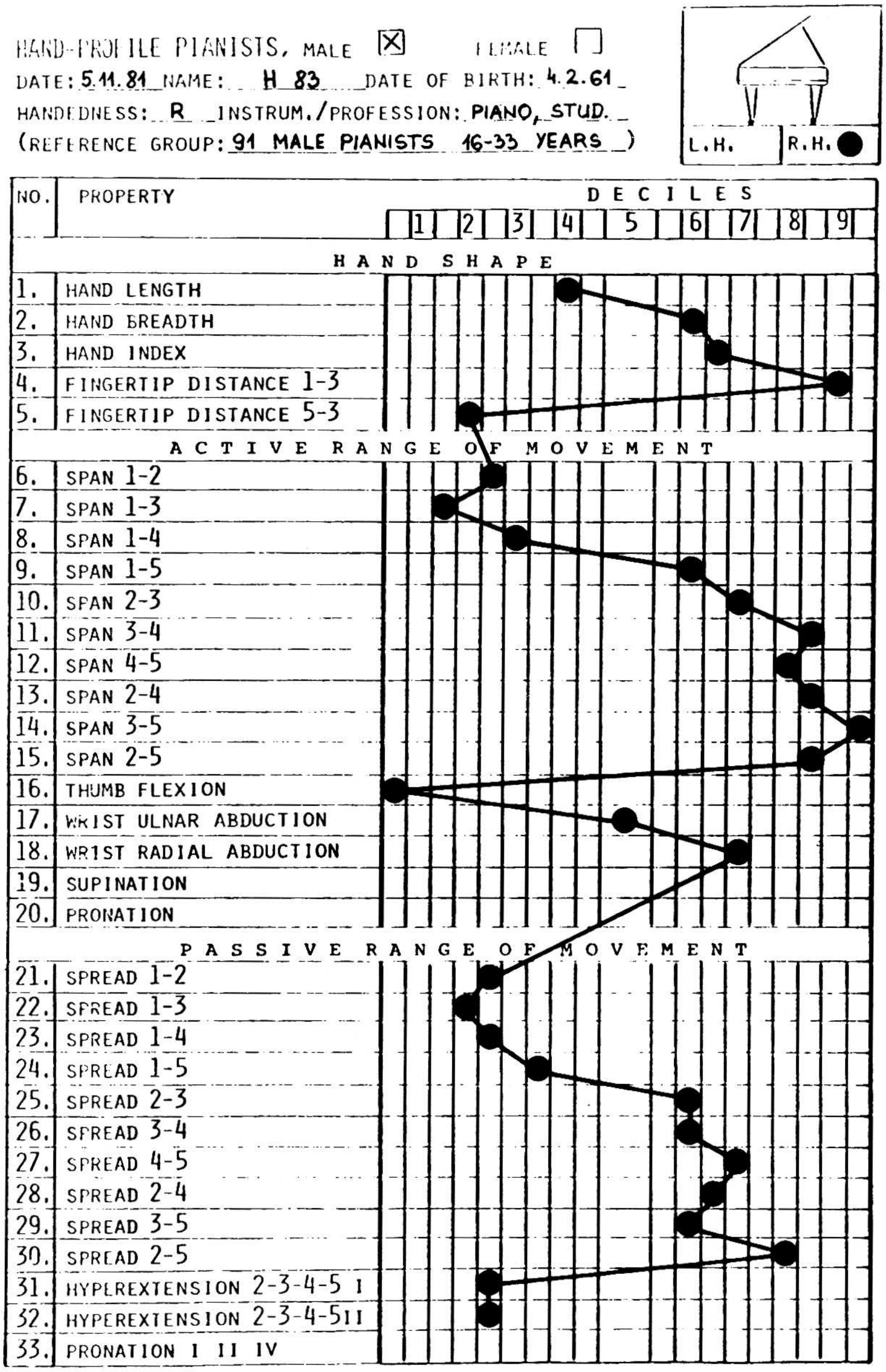

Figure 10

Hand profile of a piano student. Description in text

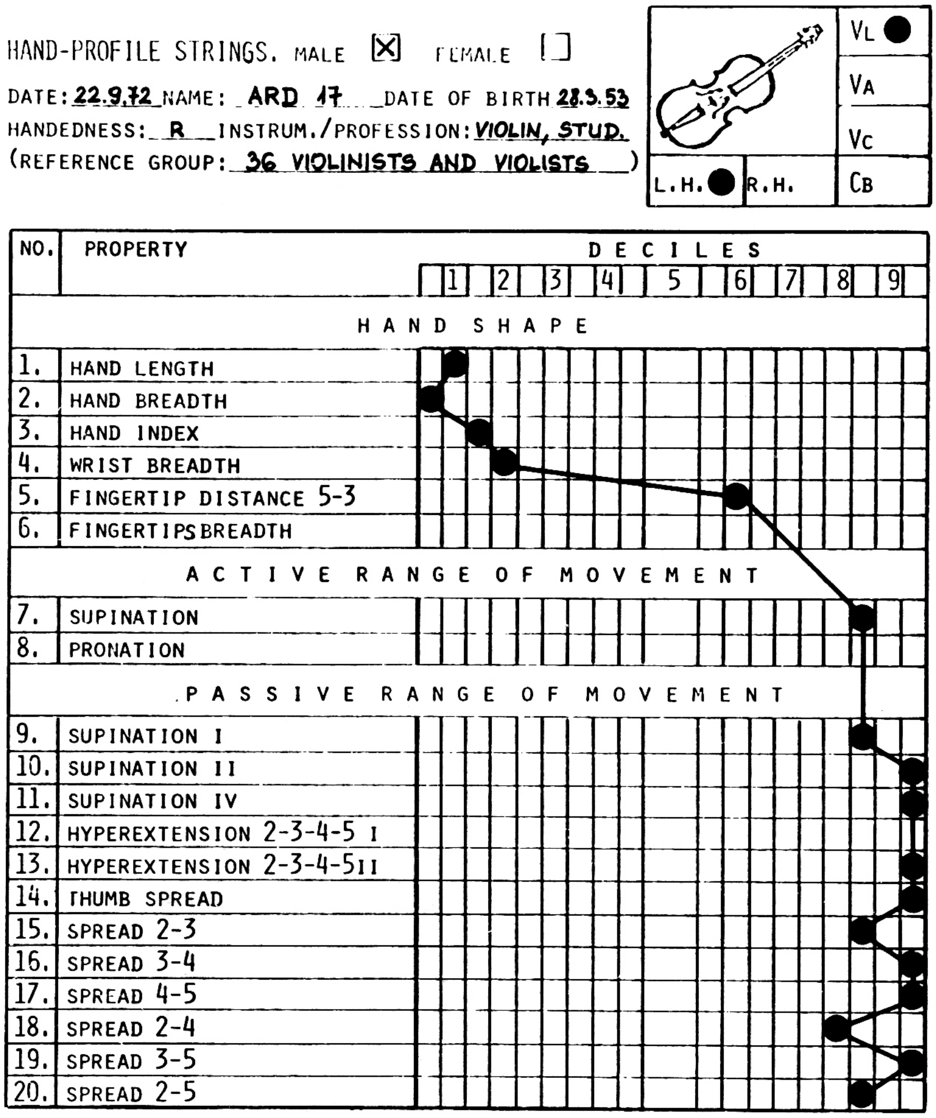

Figure 11

Hand profile of a violin student. Description in text.

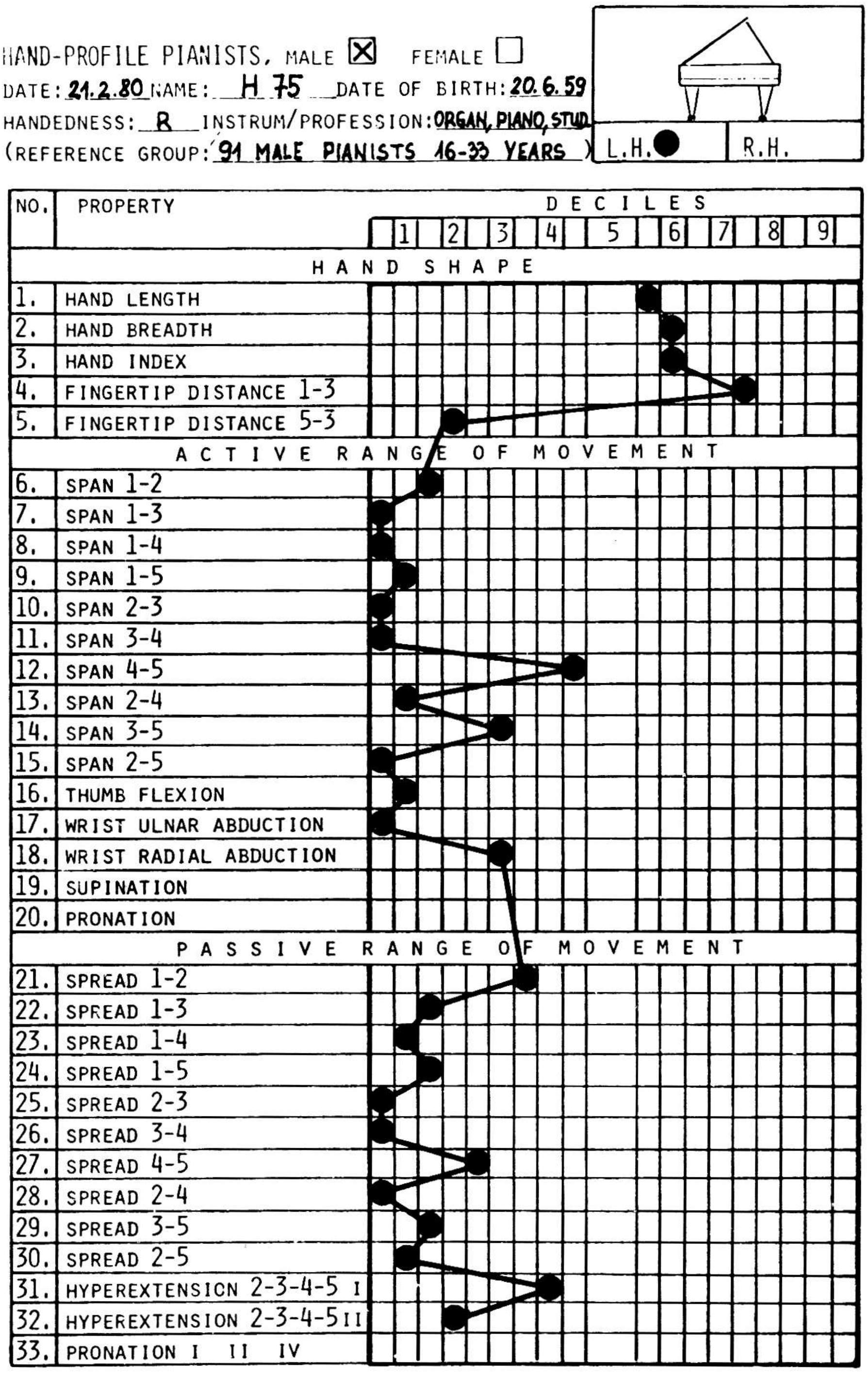

Figure 12

Hand profile of a piano student. Description in text.

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