Contents lists available at ScienceDirect

Psychiatry Research

Biometric parameters of the hand as an index of schizophrenia—A preliminary study ☆

Eyal Zvi Shamir [a,b], Stanley Morris Cassan [c], Anat Levy [a,*], Tova Lifshitz [a], Ricardo Tarrasch [d]

[a] Abarbanel Psychiatric Hospital, 15 KKL Street Bat-Yam, Israel
[b] Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel
[c] Faculty of Medicine, Stanford University, Stanford, CA, United States of America
[d] School of Education and Sagol School of Neuroscience, Tel Aviv University, Tel Aviv, Israel

ARTICLE INFO

ABSTRACT

Since abnormalities in distal upper limb development are among the minor physical anomalies associated with schizophrenia we attempted to determine whether patients with schizophrenia can be identified on the basis of specific morphologic and dermatoglyphic features of the hand. Photographs and prints of the hands of 38 patients with schizophrenia and those of 42 control subjects were evaluated and graded on 13 biometric parameters. Results were statistically evaluated. A combination of three of the parameters was found to have good predicting abilities to distinguish between schizophrenics and controls. Subjects having high values in these three parameters were found to have a higher propensity to be defined as schizophrenics. In order to define a simple rule for classifying subjects we chose a criterion of having a value of 3 (in a scale from 1 to 3) in at least one of these three discriminating variables. This rule yielded an overall accuracy of 81.2%. Among controls, 85.7% of subjects did not fulfill such criteria, while 14.3% were defined as false positives. Among schizophrenics 76.3% achieved this condition while 23.7% were false negatives. The technique's objectivity and ease of application could facilitate the diagnosis of this disease.

1. Introduction

The association of morphologic and dermatoglyphic features of the distal upper limb with mental health disorders has been the subject of numerous publications (e.g. Reed and Opitz, 1981; Jelovac et al., 1998; Manning et al., 1998; Kimura and Clarke, 2001). Since the embryonic development of the central nervous system coincides with that of the distal upper limbs, in the late first and early second trimesters of pregnancy and both from the ectoderm of the fertilized ovum, associated abnormalities might be expected (O'Callaghan et al., 1995; Fatjo-Vilas et al., 2008).

It has been suggested that schizophrenia is determined by genetic factors along with intrauterine disturbances in the neurodevelopment of the brain's cortex in the embryonic stage (Kallmann, 1938; Murray and Lewis, 1987; Marenco and Weinberger, 2000; Compton and Walker, 2009). The association

of schizophrenia with anomalies of the distal upper limb as a result of an intrauterine insult has also been described (e.g. Bracha et al., 1991, 1992; Green et al., 1994; Davis and Bracha, 1996; Bramon et al., 2005; Weinberg et al., 2007; Fatjo-Vilas et al., 2008; Xu et al., 2011).

The purpose of this preliminary study is to determine whether patients with schizophrenia can be distinguished from normal control subjects on the basis of specific dermatoglyphic and morphologic features of their hands.

2. Methods

2.1. Subjects

Eighty subjects were recruited to participate in the study, 38 ambulatory patients with schizophrenia treated at a government psychiatric hospital in central Israel and 42 controls all free of recognizable mental health problems, selected randomly from hospital staff and volunteers. The diagnosis of schizophrenia was made in accord with DSM IV criteria, with the condition further defined in subcategories. Each patient had earlier been apprised of the details of this study and each subsequently signed a form of consent to participate.

Patients were examined in accord with the Helsinki committee at the hospital with medical circumstances of each patient provided by the day-patient hospital.

Both groups were similar in their age distribution; control group age ranged between 21 and 67 years (mean=41.5, S.D.=11.6), while schizophrenia group age

ranged between 21 and 60 years (mean=41.4, S.D.=12.6). Subjects were also similar in their gender distribution. The control group was comprised of 24 males and 18 females, and the schizophrenia group of 24 males and 14 females. All subjects in both groups were of Jewish heritage and of mixed Ashkenazi and Sephardi descent.

2.2. Materials

The relevant information for examination was made available in the following ways: photographs of the hands held in several given positions all taken with hand held cameras, and ink prints on regular paper of the palm and fingers of each hand. The photographs were all taken in accord with printed instructions and illustrations. Criteria included camera angle, white background, avoidance of shadows, and general composition to minimize possible inaccuracies and biases in measurements of the palms and digits.

2.3. Procedure

A total of 13 parameters of the hand were examined. These parameters were selected from among those previously suggested as having a bearing on mental health issues including schizophrenia (Holtzman, 2004, 2012) These were subsequently graded and set in an order determined by the measure of severity in each (see Table 1).

The photographs and prints of the hands of all 80 subjects were examined by 11 individuals, three with knowledge of dermatoglyphics and hand morphology henceforth referred to as the "expert assessors" and 8 without any such previous exposure henceforth referred to as "layman assessors". Each member of the group of "layman assessors" received 30 min of instruction before receiving a collection of prints and photographs of 10 subjects wholly undifferentiated with respect to pathological and non-pathological individuals. They were asked to determine the measure of severity of each of the 13 parameters in each of the subjects. The results were then submitted for statistical evaluation.

2.4. Statistics

Data were analyzed by SPSS 21.0 software. In order to assess the correspondence between the measures performed by experts and those performed by laymen, based on photos and prints, correlations were calculated for each index. The correlation coefficients used were based on the number of possible values of each index. For indexes with two values phi was calculated, for indexes with three and four values Kendall's tau and for indexes with five values Spearman correlation coefficient. In addition Kappa indexes were calculated for evaluating differences among experts and laymen. A multivariate logistic regression was used to determine the ability of palm, digit and dermatoglyphic characteristics to predict the classification of schizophrenics/controls. Variables were entered into the model using a forward method based on Wald criteria (criteria $p < .05$ for entry and $p < .10$ for removal). Odds ratios (ORs) and 95% confidence intervals were calculated for each variable. Since the number of subjects in two out the three sub-diagnoses of schizophrenia were small (paranoid schizophrenics $n=24$, schizoaffective $n=6$ and schizophrenic other $n=8$), the logistic regression was performed using all schizophrenic subjects as a whole. In order to validate the results, a similar logistic regression was performed but using layman measurements in order to predict group membership.

3. Results

Among the thirteen indexes measured, the correlation coefficients calculated between experts and laymen assessments were significant for ten out of them at the .05 level, and for eight out of the Kappa agreement coefficients thus indicating a good correspondence between experts and laymen assessments. Table 2 summarizes these correlations.

In the logistic regression, three out of the 13 variables were included in the model (Nagelkerke R square=.575). The two groups

Table 1
List of 13 hand parameters that were examined.

Parameter	Location	Information Source	Scale
Thenar eminence	Thenar aspect	Photograph	5=Very prominent to 1=Flat
Hypothenar eminence	Hypothenar aspect	Photograph	5=Very prominent to 1=Flat
Proximal interphalangeal joint	Middle digit	Photograph	3=Poorly defined skeletal borders to 1=Well-defined skeletal borders
Lower transverse line	Proximal palmar flexion crease	Print	3=very short to 1=Terminating deep into Hypothenar Eminence, very long
Eponychium 1	Distal phalanx of index digit (nail)	Photograph	3=Growth extending over the Lunula and beyond to 1=Normal
Eponychium 2	Distal phalanx of middle digit (nail)	Photograph	3=Growth extending over the Lunula and beyond to 1=Normal
Eponychium 3	Distal phalanx of ring digit (nail)	Photograph	3=Growth extending over the Lunula and beyond to 1=Normal
Relative thickness of the digits	Digits	Photograph	3=Thickness pronounced to 1=Thinness pronounced
Conic nail phalanges	Nail phalanges	Photograph	3=Conic tips 2=Round 1=Square
Spatula nail phalanges	Nail phalanges	Photograph	1 Spatula nail phalanges 0=None
Relative thickness of the palm	Palm	Photograph	3=Thickness pronounced to 1=Thinness pronounced
Shape	Palm	Photograph	3=Square 2=No value 1=Long
Narrow to broad ridge development	Palm	Print	3=Very fine to 1=Very broad

Table 2
Correlations between experts and laymen assessments.

Parameter	Number of values of the index	Kendall's tau b	Spearman	phi	p	Kappa	p
Thenar eminence	5		.256		.022	.105	.082
Hypothenar eminence	5		.44		.001	.093	.129
Proximal interphalangeal joint	3	.59			.001	.404	.001
Lower transverse line	3	.5			.001	.353	.001
Eponychium 1	3	.626			.001	.475	.001
Eponychium 2	3	.655			.001	.465	.001
Eponychium 3	3	.531			.001	.414	.001
Relative thickness of the digits	3	.258			.012	.177	.028
Conic nail phalanges	3	.303			.008	.279	.001
Spatula nail phalanges	2			.016	.889	-.016	.889
Relative thickness of the palm	3	.374			.001	.303	.001
Shape	3	.114			.26	.106	.140
Narrow to broad ridge development	3	.129			.234	.127	.096

Table 3
Logistic regression model of Schizophrenia diagnosis based on palm, digit and dermatoglyphic characteristics.

Variable	B	Wald	OR (95% CI)	P
Proximal interphalangeal joint	1.922	18.572	6.833 (2.851–16.377)	.028
Lower transverse line	.943	4.836	2.567 (1.108–5.947)	.001
Eponychium of the middle digit	1.944	10.336	6.990 (2.136–22.871)	< .001

Table 4
Distribution of the variables entering the discriminant function among controls and schizophrenics.

	Controls (%)	Schizophrenics (%)
Proximal interphalangeal joint		
1	64	21
2	31	21
3	5	58
Lower transverse line		
1	71	47
2	21	16
3	7	37
Eponychium of the middle digit		
1	86	76
2	10	13
3	5	11

Table 5
Distribution of subjects based on the criteria of having a value of 3 in at least one of the four discriminative variables.

	Non risk	At risk
Controls	85.7%	14.3%
Schizophrenics	23.7%	76.3%

differed significantly on their palm, digit and dermatoglyphic characteristics, with schizophrenics exhibiting higher values than controls in proximal interphalangeal joint, eponychium of the middle digit and lower transverse line (Table 3). It is of interest to mention that eponychium of the ring digit did not enter the logistic regression because of its high correlation to eponychium of the middle digit (r Spearman$=.76$, $p < .001$).

The classification of subjects into controls or schizophrenics resulted in overall 81% correct classifications, with a sensitivity of 81.6% (correct schizophrenic prediction) and specificity of 80.5% (correct control prediction). Table 4 presents the distribution of the discriminating variables among schizophrenics and controls. As can be seen, schizophrenics exhibited higher values than controls in all three indexes.

In order to apply a simple rule for future distinction between schizophrenics and non-schizophrenics, a new variable was calculated. Subjects having a value of 3 (high) in at least one of the three predicting indicators were defined as "at risk". Table 5 presents the distribution of controls and schizophrenics applying this criterion. As can be seen, 81.2% of subjects are correctly classified among controls as well as among schizophrenics.

The logistic regression based on layman measurements resulted in a 70.5% overall correct classifications, 70.7% in the control group and 70.3% in the schizophrenic group (Nagelkerke R square $=.279$). Only two indicators were selected by this model to enter the predicting equation, and they were proximal interphalangeal joint and eponychium of the middle digit. Both indicators appear among the three indicators selected by the model using expert's evaluations, thus validating the results obtained.

In order to negate a possible explanation of the results, stemming from the option that the treatment received by schizophrenics affects in a manner their palm, digit and dermatoglyphic structures, correlations between the predicting variables that entered the equation and age were calculated among schizophrenics. No significant correlations were obtained between age and proximal interphalangeal joint, eponychium of the middle digit and lower transverse line ($r=.118$, .019 and .032 respectively).

4. Discussion

The high correlations obtained between experts measurements and those of laymen revealed that the quantification of palm, digit and dermatoglyphic characteristics can be performed in an objective manner that does not require long training. The logistic regression results indicate that palms, digit and dermatoglyphic features of individuals can be reliably used for predicting schizophrenia.

Among the thirteen indicators measured, only the combination of three of them was found to have good predicting abilities to distinguish between schizophrenics and controls. As such, subjects having high values in these three indicators, namely a poorly defined skeletal border of the proximal interphalangeal joint (Fig.1), a high eponychium of the middle digit distal phalanx (Fig. 2), and a short lower transverse line (Fig. 3), were found to have a higher propensity to be defined as schizophrenics. In order to define a simple rule for classifying subjects we chose a criterion of having a value of 3 (in a scale from 1 to 3) in at least one of these three discriminating variables. This rule yielded an overall accuracy of 80%. Among controls, 85.7% of subjects did not fulfill such criteria, while 14.3% were defined as false positives. Among schizophrenics, 76.3% achieved this condition while 23.7% were found to be false negatives.

The embryonic origin of distal upper extremity features associated with schizophrenia may be the result of genetic or intrauterine events impacting the simultaneous development of the central nervous system and distal upper extremity from the oval ectoderm. While the temporal proximity or cellular juxtaposition of the two may be the determining factor, some evidence suggests there is a dynamic interaction between both central nervous system and distal upper extremities so that abnormalities in the development of either one may affect changes in the other (Bracha et al., 1991). In the current study the concurrence of several features of the hand were needed as an index of schizophrenia. How any one of these may be reflected in alterations of the central nervous system remains unclear.

5. Conclusion

The current study demonstrates that it is possible to distinguish patients with schizophrenia from control subjects based on a set of defined biometric parameters of the hands. These parameters include the proximal interphalangeal joint, the lower transverse line, and the eponychium of the middle finger. The objectivity of this technique, as well as its ease of application could facilitate the diagnosis of this psychiatric disorder. The mechanism
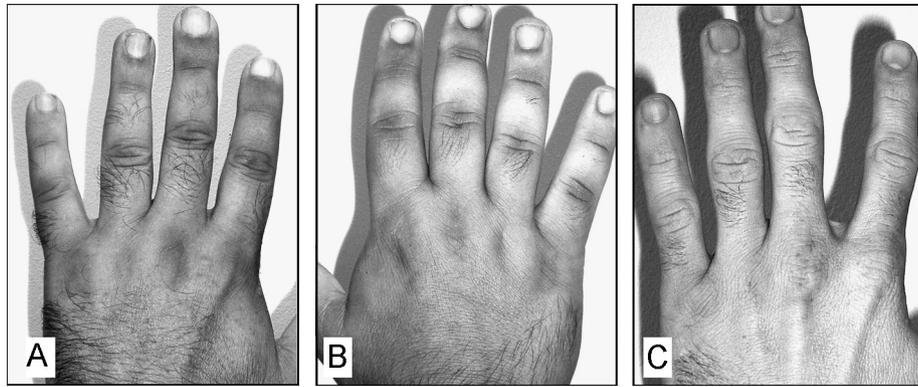
Fig. 1. (A, B) Examples of poorly defined skeletal borders of the proximal interphalangeal joint of the middle digit. (C) Normally well-defined borders of the same joint.
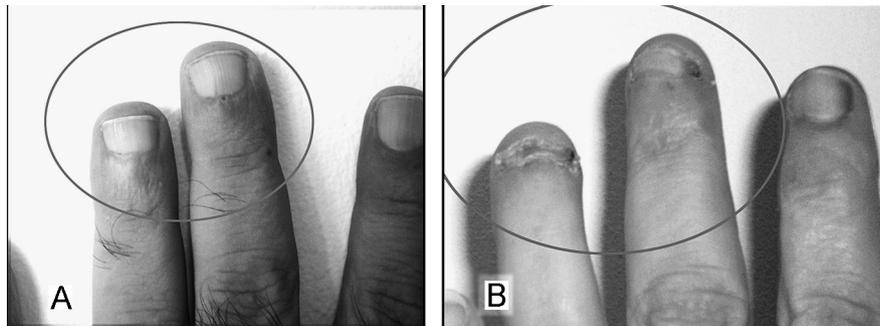
Fig. 2. (A, B) Examples of the extension of the eponychium over the nail in the distal phalanges of both middle and ring digits. See normally placed eponychium in the index digit of the same hands.
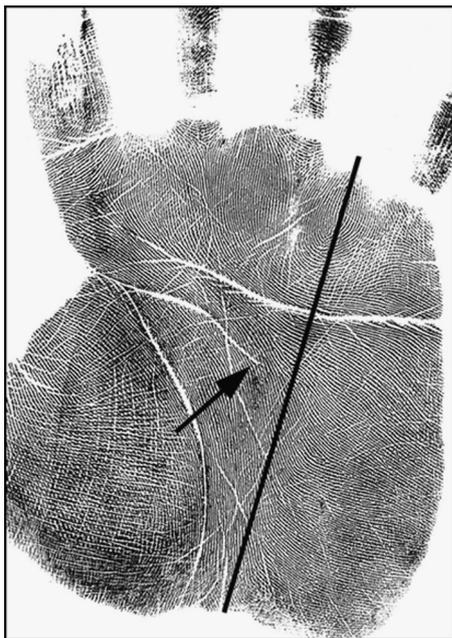
Fig. 3. A short lower transverse line that does not extend beyond an imaginary line from the web space between the ring and little digits and the midpoint of the base of the palm.

accounting for the relationship of this psychiatric disorder with its associated morphologic and dermatoglyphic features remains obscure.

As this is a preliminary study the usage of a multimodal approach combining several markers for predicting schizophrenia may be recommended. Further studies of these three parameters would be needed to establish an accurate sensitivity factor and to determine whether the specificity is exclusive to schizophrenia but no other maladies.

Author contributions

Conceived and designed the study: EZS, RT, TL, AL. Organized examinations and established ratings: TL, AL. Statistical analysis: RT. Writing the paper: EZS, SMC, RT, TL, AL.

References

Bracha, H.S., Torrey, E.F., Gottesman, I.I., Bigelow, L.B., Cunniff, C., 1992. Second-trimester markers of fetal size in schizophrenia: a study of monozygotic twins. American Journal of Psychiatry 149, 1355–1361.

Bracha, H.S., Torrey, E.F., Bigelow, L.B., Lohr, J.B., Linington, B.B., 1991. Subtle signs of prenatal maldevelopment of the hand ectoderm in schizophrenia: a preliminary monozygotic twin study. Biological Psychiatry 30, 719–725.

Bramon, A., Walshe, M., McDonald, C., Martı́n, B., Toulopouloua, T., Wickhama, H., van Osc, J., Fearon, P., Shama, P.C., Fananas, L., Murraya, R.M., 2005. Dermatoglyphics and Schizophrenia: a meta-analysis and investigation of the impact of obstetric complications upon a–b ridge count. Schizophrenia Research 75, 399–404.

Compton, M.T., Walker, E.F., 2009. Physical manifestations of neurodevelopmental disruption: are minor physical anomalies part of the syndrome of schizophrenia? Schizophrenia Bulletin 35, 425–436.

Davis, J.O., Bracha, H.S., 1996. Prenatal growth markers in schizophrenia: a monozygotic co-twin control study. American Journal of Psychiatry 153, 1166–1172.

Fatjo-Vilas, M., Gourion, D., Campanula, S., Mouaffak, F., Levy-Rueff, M., Navarro, M.
   E., Chayet, M., Miret, S., Krebs, M.O., Fananas, L., 2008. New evidences of gene
   and environment interactions affecting prenatal neurodevelopment in
   schizophrenia-spectrum disorders: a family dermatoglyphic study. Schizophre-
   nia Research 103, 209–217.
Green, M.F., Bracha, S.H., Satz, P., Christenson, C.D., 1994. Preliminary evidence for
   an association between minor physical anomalies and second trimester
   neurodevelopment in schizophrenia. Psychiatry Research 53, 119–127.
Holtzman, A., 2004. The Illustrated Textbook of Psychodiagnostic Chirology
   in Analysis and Therapy. The Greenwood-Chase Press, Toronto. (pp. 84–85,
   126–133, 386.).
Holtzman, A., 2012. Addendum The Illustrated Textbook of Psychodiagnostic
   Chirology in Analysis and Therapy. Self Published, Tel Aviv. (pp. 15–16, 17–19,
   20, 33–34).
Jelovac, N., Milicić, J., Milas, M., Dodig, G., Turek, S., Ugrenović, Z., 1998. Derma-
   toglyphic analysis in borderline personality disorder and schizophrenia: results
   of a Croatian study. Collegium Antropologicum 22, 141–148.
Kallmann, F.J., 1938. The Genetics of Schizophrenia. J.J. Augustin, Oxford p. 291.
Kimura, D., Clarke, P.G., 2001. Cognitive pattern and dermatoglyphic asymmetry.
   Personality and Individual Differences 30, 579–586.
Manning, J.T., Scutt, D., Wilson, J., Lewis-Jones, D.I., 1998. The ratio of 2nd to 4th
   digit length: a predictor of sperm numbers and concentrations of testosterone,
   luteinizing hormone and estrogen. Human Reproduction 13, 3000–3004.

Marenco, S., Weinberger, D.R., 2000. The neurodevelopmental hypothesis of
   schizophrenia: following a trail of evidence from cradle to grave. Development
   and Psychopathology 12, 501–527.
Murray, R.M., Lewis, S.W., 1987. Is schizophrenia a neurodevelopmental disorder?
   British Medical Journal 295, 681.
O'Callaghan, E., Buckley, P., Madigan, C., Redmond, O., Stack, J.P., Kinsella, A., Larkin,
   C., Ennis, J.T., Waddington, J.L., 1995. The relationship of minor physical
   anomalies and other putative indices of developmental disturbance in schizo-
   phrenia to abnormalities of cerebral structure on magnetic resonance imaging.
   Biological Psychiatry 38, 516–524.
Reed, T., Opitz, J.M., 1981. Dermatoglyphics in medicine—problems and use in
   suspected chromosome abnormalities. American Journal of Medical Genetics 8,
   411–429.
Weinberg, S.M., Jenkins, E.A., Marazita, M.L., Maher, B.S., 2007. Minor physical
   anomalies in schizophrenia: a meta-analysis. Schizophrenia Research 89,
   72–85.
Xu, T., Chan, R.C.K., Compton, M.T., 2011. Minor physical anomalies in patients with
   schizophrenia, unaffected first-degree relatives, and healthy controls: a meta-
   analysis. Plus One 6, 24129.