Acta Psychiatrica Scandinavica

WILEY

Acta Psychiatrica Scandinavica

ORIGINAL ARTICLE OPEN ACCESS

Motor Dexterity Deficits in Individuals With First-Episode Psychosis and Their First-Degree Relatives

Manuel Sevilla-Ramos[1] | Valentina Ladera[1] | Ricardo García-García[1] | Rosa Ayesa-Arriola[2,3,4]

[1]Faculty of Psychology, University of Salamanca, Salamanca, Spain | [2]Biomedical Research Networking Center for Mental Health (CIBERSAM), Health Institute Carlos III, Madrid, Spain | [3]Research Group on Mental Illnesses, Valdecilla Biomedical Research (IDIVAL), Santander, Spain | [4]Department of Molecular Biology, School of Medicine, University of Cantabria, Santander, Spain

Correspondence: Rosa Ayesa-Arriola (rayesa@humv.es)

Received: 25 October 2024 | **Revised:** 1 May 2025 | **Accepted:** 5 May 2025

Funding: This work was supported by the Carlos III Health Institute (PI14/00639, PI14/00918, PI17/00221, PI20/00066, and PI23/00076). In addition, Dr. Rosa Ayesa-Arriola was financed by a Miguel Servet contract from the Carlos III Health Institute (CP18/00003) and a Consolidator Grant from the Ministerio de Ciencia, Innovación y Universidades (CNS2022-136110).

Keywords: cognition | endophenotypes | first-episode psychosis | motor dexterity | relatives | schizophrenia spectrum disorders

ABSTRACT

Introduction: Motor dexterity deficits have been observed both before and during first-episode psychosis (FEP), suggesting this may be a potential endophenotype for schizophrenia spectrum disorders. We aimed to compare motor dexterity performance in FEP patients, their first-degree relatives, and controls. We also investigated whether sociodemographic, premorbid, clinical, and cognitive factors contribute to motor dexterity.

Methods: The sample included 133 FEP patients, 244 of their first-degree relatives (146 parents, 98 siblings), and 202 controls. Motor dexterity was assessed using the Grooved Pegboard Test as part of a neuropsychological battery assessing verbal and visual memory, processing speed, working memory, executive function, attention, and theory of mind. Raw scores were converted to *Z*-scores. Intelligence quotient and global cognitive function were estimated. Group comparisons were made using analysis of covariance with post hoc tests. Age, sex, and years of education were included as covariates. Multiple linear regression models examined associations between motor dexterity and other variables within each group.

Results: There was a significant group difference on the Grooved Pegboard Test ($F = 16.25$, $p < 0.001$). FEP patients ($M = -1.26$) and their parents ($M = -1.14$) scored lowest, while siblings ($M = -0.30$) and controls ($M = -0.22$) scored highest. The FEP group also scored lowest on other cognitive tests ($p < 0.001$). A positive association between global cognitive function and Grooved Pegboard performance was found in all groups ($\beta = 0.47$–0.84, $p < 0.001$). Group-specific associations with age, sex, education, intelligence, executive function, attention, and processing speed were also observed ($p < 0.05$).

Conclusions: Motor dexterity deficits were observed in FEP patients and their parents, which may reflect underlying genetic liability or result from the disorder itself. The preserved motor dexterity in unaffected siblings challenges a strict endophenotypic interpretation and suggests a potential protective effect. Motor dexterity deficits were associated with broader cognitive impairment, intelligence quotient, attention, processing speed, and executive function.

Summary

- Significant outcomes
  - Motor dexterity deficits observed in both first-episode psychosis (FEP) patients and their parents suggest a potential hereditary link and its role in psychosis vulnerability.
  - The findings challenge a strict endophenotypic model of motor dexterity, as unaffected siblings perform at control levels.
  - The distinction between parents and siblings in motor dexterity performance underscores the importance of analyzing first-degree relatives separately and suggests that genetic and environmental factors may differentially influence cognitive vulnerability to psychosis.
- Limitations
  - Differences in sex distribution across the study groups may introduce bias and limit the generalisability of the results.
  - Neuropsychological assessments were conducted at different time points: FEP patients were evaluated shortly after illness onset and relatives, in the context of a different project, some years later.

1 | Introduction

Motor dexterity is the ability to coordinate hand and finger movements with skill and precision, and includes manual dexterity, visual-motor coordination, and fine motor skills [1–4]. Motor dexterity is relevant for daily activities such as writing, using the phone, cooking, or opening a bottle [5–7]. Motor dexterity is considered a cognitive domain because of its essential intentional component [8], which distinguishes it from automatic motor functions. The inclusion of motor dexterity in cognitive assessments is useful for evaluating cognitive status and detecting early mild cognitive impairment [9–11]. Cognitive domains, such as executive functions, attention [12–14], and processing speed [15] actually have a great influence on motor dexterity. Particularly, motor dexterity is positively associated with inhibitory control, working memory, and cognitive flexibility [16]. These abilities are critical for accurate motor dexterity performance because inhibitory control regulates attention, cognitive flexibility adapts movements [4], and visual processing speed supports execution [17]. In addition, motor dexterity is related to motor skills such as muscle strength and handgrip [6, 18].

Motor dexterity deficits have been observed both before the onset of psychosis and in the early stages of schizophrenia spectrum disorders [19], suggesting their potential as an endophenotype [20]. Endophenotypes are heritable, stable traits associated with a disorder that serve as measurable behavioral markers of genetic or neurobiological factors [21]. To qualify as a valid endophenotype, a trait must be associated with the condition, be heritable, and be more prevalent in unaffected relatives than in the general population [21]. A family design study is essential to assess the potential of motor dexterity as an endophenotype for schizophrenia spectrum disorders [22].

Family studies suggest that first-degree relatives outperform patients with psychosis but underperform controls on cognitive tasks [23–27]. Research on parents and siblings of first-episode psychosis (FEP) patients has found mild deficits in processing speed, attention, working memory, executive function, and verbal memory [26, 28]. Schäppi et al. [20] reported that first-degree relatives of FEP patients showed motor dexterity performance between that of patients and controls. However, their results were inconsistent, with relatives performing worse on simple motor dexterity tasks but intact on more complex tasks [20]. Replicating these findings in a larger sample and distinguishing between siblings and parents would provide further insight.

We consider it relevant to split the sample of first-degree relatives into parents and siblings for different reasons. Genetically, parents and offspring share a fixed 50% similarity, while siblings average 50% but with greater variability [29]. Gene expression in parents and siblings may be influenced by environmental factors, with siblings sharing more developmental experiences and environmental variables with FEP patients [30]. In addition, it is uncertain whether siblings and parents have different cognitive profiles. Given these genetic and environmental differences, a more detailed examination of sociodemographic [12, 31, 32], premorbid [33], clinical [34] and cognitive factors [13, 14] is needed to better understand the cognitive profiles of parents and siblings. Inclusion of these variables in a family design study may provide valuable insights into the etiology of cognitive deficits in psychotic disorders and the role of motor dexterity.

Although previous research has suggested motor dexterity as a potential endophenotype for schizophrenia spectrum disorders, the evidence remains inconclusive, particularly regarding whether first-degree relatives, particularly siblings, meet the established criteria. Some studies suggest that siblings perform at control levels, raising questions about the consistency of motor dexterity as an endophenotypic marker [29, 35]. Furthermore, the potential sociodemographic, premorbid, clinical, and cognitive factors influencing motor dexterity have not been systematically investigated, leaving a critical gap in the literature.

1.1 | Aims of the Study

We aimed to investigate the potential role of motor dexterity as an endophenotype for schizophrenia spectrum disorders. We compared motor dexterity performance between FEP patients, their parents and siblings, and healthy controls. In addition, we examined the differential contribution of sociodemographic, premorbid, clinical, and cognitive factors to motor dexterity within each participant group.

2 | Materials and Methods

2.1 | Study Design

This study included FEP patients, their first-degree relatives, and controls. Patients were recruited from PAFIP (Programa de Atención a Fases Iniciales de Psicosis) [36, 37] between 2001 and 2018. PAFIP was a program providing psychiatric, nursing, psychological, and social care for individuals in the early stages of psychosis. It was implemented at the University Hospital Marqués de Valdecilla in Cantabria, Spain. Patients were referred from mental health services and healthcare facilities across the Cantabria region. Cognitive assessment was completed by 133 FEP patients (see Figure 1). Their first-degree relatives were invited to take part in a family study called PAFIP-FAMILIAS (FIS PI17/00221) from 2018 to 2022. The families were contacted by phone and completed the same neuropsychological assessment as the patients. The study involved a total of 244 relatives, members of 133 families (Figure 1). Controls (202) were recruited for the PAFIP project through local community advertisements between 2001 and 2018.

2.2 | Ethics

The PAFIP and PAFIP-FAMILIAS studies were granted ethical approval by the local institutional review board (CEIm Cantabria), following international research ethics guidelines (approval numbers NCT0235832 and 2017.247). Participants were informed about the study objectives and provided written informed consent. The PAFIP-FAMILIAS study offered financial compensation of €50 for the time and travel expenses incurred by participants' relatives.

2.3 | Inclusion Criteria

Inclusion criteria for FEP patients were: (1) ages range from 15 to 60 years; (2) they lived within the Cantabria region; (3) presenting a FEP; (4) had no prior treatment with antipsychotic medication. If they were previously treated, the total lifetime of treatment had to be less than 6 weeks; and (5) meeting DSM-IV criteria for: schizophrenia, schizophreniform disorder, brief psychotic disorder, or non-specified psychosis. An expert psychiatrist carried out the diagnosis through the Structured Clinical Interview for DSM-IV [38] within 6 months of the baseline visit. Exclusion criteria: fulfilling DSM-IV criteria for a history of neurological disorders, head injury, intellectual disability, and drug or alcohol dependence.

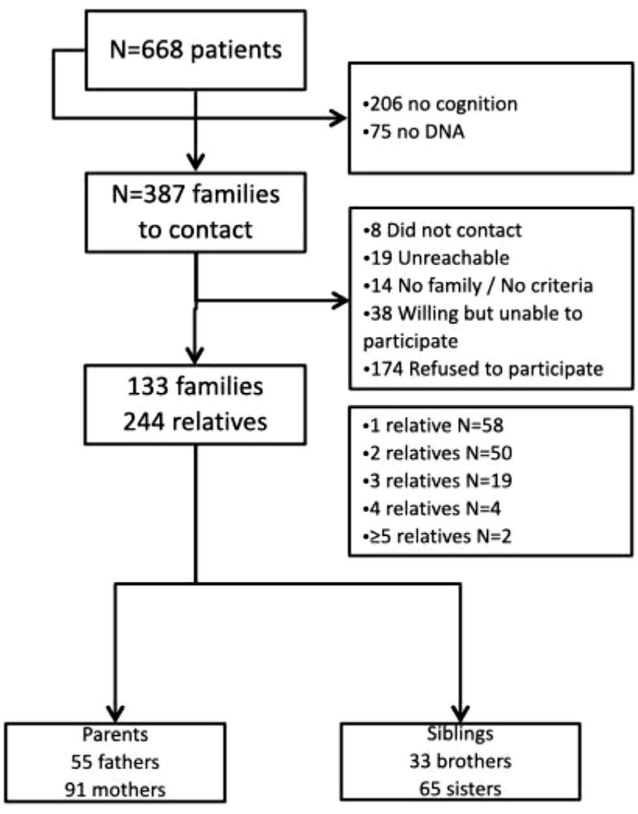

FIGURE 1 | Flow diagram of all participants.

Inclusion criteria for first-degree relatives and controls were: (1) age over 15 years; (2) Spanish as a mother tongue or great domain of the language; (3) being able to give informed consent in writing. Exclusion criteria following DSM-IV: nonexistence of a history of psychiatric disorders; absence of substance use disorders; no intellectual disability; and absence of neurological pathology. We used the abbreviated version of the Comprehensive Assessment of Symptoms and History [39], a semi-structured interview was designed to identify clinical symptoms related to depression, mania, personality disorders, anxiety, and psychosis, in order to exclude individuals with a history of psychopathology.

2.4 | Sociodemographic Variables

Sociodemographic information including sex, age, years of education, and living in an urban area was collected for all participants through interviews. For the FEP and control groups, we also recorded information about employment status, socioeconomic status of their parents, marital status, and whether they lived with their parents. The patients, siblings, and controls provided information on cannabis use.

2.5 | Premorbid and Clinical Assessment

We used the Premorbid Adjustment Scale [40] to assess the degree of achievement of developmental goals at each of several periods in the patient's life before the onset.

Expert psychiatrists employed a structured interview to collect clinical data from patients. The clinical variables gathered included the age of onset, the duration of untreated illness (defined as the period from the initial nonspecific psychotic symptom) [41], and the duration of untreated psychosis (encompassing the time from persistent psychotic symptoms to the initiation of appropriate antipsychotic medication) [42]. After randomization, patients were treated with different antipsychotic treatments, and doses in chlorpromazine equivalents were recorded [43]. The assessment of positive and negative symptoms was conducted using the validated Scale for the Assessment of Positive Symptoms [44] and the Scale for the Assessment of Negative Symptoms [45], respectively. The Spanish version of the Disability Assessment Scale [46] was utilized to assess functional status.

2.6 | Cognitive Assessment

Trained neuropsychologists, who had undergone extensive training under expert supervision, conducted a cognitive assessment of all participants. Patients completed this assessment at baseline, approximately 10.5 weeks after enrollment in the

PAFIP program, once they had achieved clinical stability. First-degree relatives and controls were assessed at the time of their inclusion in the study.

The battery included tests for estimating: motor dexterity (Grooved Pegboard Test) [47]; verbal memory (Rey Auditory Verbal Learning Test) [48]; visual memory (Rey Complex Figure Test) [49]; processing speed (Digit Symbol subtest of the WAIS-III); working memory (Digits Backward subtest of the WAIS-III) [50]; executive function (Trail Making Test, part B) [8]; attention (Continuous Performance Test) [51]; theory of mind (Reading the Mind in the Eyes Task) [52]; and intelligence quotient (IQ) (vocabulary subtest of WAIS-III) [50] as a proxy for crystallized intelligence [53]. To facilitate direct performance comparisons, T-scores from WAIS-III subtests and raw scores from other tests were converted into *Z*-scores. Raw scores were reversed when necessary before standardization to ensure all values reflected a positive direction.

Global cognitive function was calculated using performance on all neuropsychological tests. Following Reichenberg et al. [54], raw scores were converted to T-scores based on a healthy subsample and then converted to deficit scores. The global cognitive function was obtained by averaging these deficit scores and then inverted for ease of interpretation, with higher scores indicating better cognitive function.

2.7 | Motor Dexterity Assessment

Motor dexterity was assessed using the Grooved Pegboard Test, a widely used measure in the FEP population [41, 55, 56]. This test requires participants to place pegs in a 25-slot grid, first with their dominant hand and then with their non-dominant hand. Only dominant hand data were analyzed for this study. The raw score, based on completion time per trial, was converted to *Z*-scores using the controls pattern to facilitate performance comparisons. Details on the Grooved Pegboard Test administration are provided in a previous study [57].

2.8 | Data Analysis

Data were analyzed using R version 23.0 (R Core Team, 2021). Participants were divided into four groups: FEP patients, siblings, parents, and controls. Analysis of variance (ANOVA) was used to compare quantitative variables between groups, with post hoc Bonferroni corrections. Categorical variables were analyzed using chi-squared tests. Age, sex, and years of education were included as covariates in the cognitive analyses.

Four multiple linear regression models, one per group, were fitted using backward elimination to identify factors influencing motor dexterity. Correlation analyses were first performed within each group to identify independent variables that were significantly associated with motor dexterity ($p < 0.05$) (Tables S1–S4). Only the significantly correlated variables were entered into the regression models. The backward elimination process iteratively removed the least significant variable ($p \geq 0.05$) until all remaining predictors met the significance threshold ($p < 0.05$). Delta Akaike Information Criterion and Delta R^2 were estimated for each model (Tables S6, S8, S10 and S12).

3 | Results

3.1 | Sociodemographic Comparisons

As shown in Table 1, the controls and FEP groups had more men, while the parent and sibling groups had more women. Patients were the youngest, followed by controls, siblings, and parents, with siblings being significantly older than controls. Siblings had the highest educational attainment, while patients had the highest unemployment rates and cannabis use compared to controls and siblings.

3.2 | Cognitive Comparisons

Two participants were excluded due to outlying scores on the motor dexterity assessment. FEP patients had the lowest scores on the Grooved Pegboard Test, while controls and siblings had the highest scores. Parents scored significantly lower than controls and siblings, even after controlling for age, sex, and education (Figure 2).

Significant group differences were found in all cognitive measures except premorbid IQ (Table 2). Controls and siblings outperformed patients in the tests of verbal and visual memory, working memory, processing speed, attention, and theory of mind. Parents scored significantly lower on the executive function test than controls. Global cognitive function scores were highest in controls, with both parents and patients showing lower performance.

3.3 | Linear Models by Groups

See the (Tables S5, S7, S9 and S11) for the backward elimination progression for each group.

3.3.1 | FEP Patients

Three significant predictors of motor dexterity were identified in FEP patients (Table 3). Premorbid IQ was negatively associated with motor dexterity performance ($p = 0.015$). In contrast, more years of education ($p = 0.006$) and higher global cognitive function ($p < 0.001$) are associated with higher scores on the Grooved Pegboard Test.

3.3.2 | Parents

In the parent group (Table 4), higher executive functioning scores were associated with lower Grooved Pegboard Test scores ($p = 0.026$), whereas higher global cognitive functioning scores were associated with higher Grooved Pegboard Test scores ($p < 0.001$).

TABLE 1 | Between-group comparisons in sociodemographic, premorbid, and clinical variables.

	FEP patients			Parents			Siblings			Controls					
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	F/χ^2	*p*	Posthoc comparisons*
Sex (male %)	133	82 (61.70%)		146	55 (37.70%)		98	33 (33.70%)		202	123 (60.90%)		36.05	< 0.001	Controls > siblings***, parents*** FEP > siblings***, parents***
Age	133	26.79	8.40	146	61.66	7.73	98	40.29	13.16	202	29.71	8.16	446.82	< 0.001	FEP < controls ***, siblings, parents. Parents > controls, siblings. Siblings > controls.
Years of education	132	10.60	3.38	145	10.26	3.54	98	12.56	3.62	201	10.84	2.72	10.75	< 0.001	Siblings > controls, parents, FEP.
Unemployed (yes%)	132	50 (37.90%)			—			—		156	33 (21.20%)		9.75	0.002	—
PAS General	128	3.44	2.25		—			—			—		—		—
Age at psychosis onset	131	26.01	8.24		—			—			—		—		—
DUI (months)	130	19.66	31.59		—			—			—		—		—
DUP (months)	132	12.72	28.42		—			—			—		—		—
SAPS	132	14.62	4.87		—			—			—		—		—
SANS	131	6.57	6.24		—			—			—		—		—
Equivalent doses of chlorpromazine at baseline	122	205.00	67.47		—			—			—		—		—
DAS	123	1.65	1.58		—			—			—		—		—
GAF	101	51.97	30.44		—			—			—		—		—
Cannabis consumption (yes%)	133	61 (45.90%)			—		97	5 (5.20%)		191	26 (13.60%)		74.73	< 0.001	FEP > controls* FEP > siblings*

Note: *All posthoc comparisons are ≤ 0.001 unless otherwise indicated. **≤ 0.01; ***≤ 0.05.
Abbreviations: DAS, disability assessment score; DUI, duration of untreated illness; DUP, duration of untreated psychosis; GAF, global functioning assessment; PAS, premorbid adjustment scale; SANS, scale for the assessment of negative symptoms; SAPS, scale for the assessment of positive symptoms.

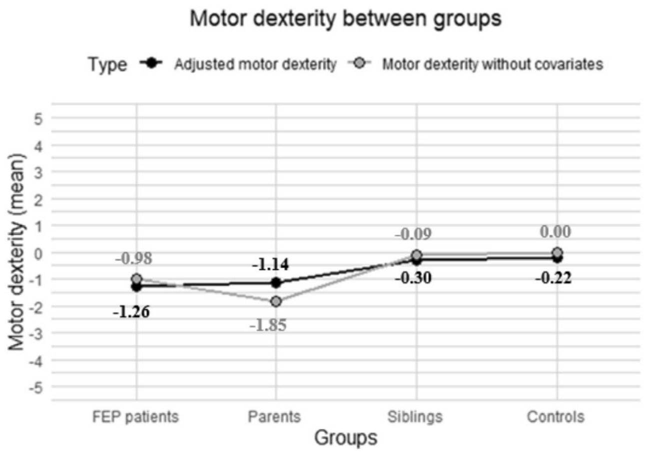

FIGURE 2 | Plot of motor dexterity performance between groups. When we compared motor dexterity between groups, including age, sex, and years of education as covariates, we obtained (see Table 2) that FEP patients differed significantly from siblings and controls. Parents performed significantly worse than siblings and controls.

3.3.3 | Siblings

Scores on the Grooved Pegboard Test were negatively associated with age ($p<0.001$) and with performance in executive function ($p<0.001$) and attention ($p<0.001$) (Table 4). Conversely, scores on the Grooved Pegboard Test were positively associated with performance on processing speed ($p<0.001$) and global cognitive function ($p<0.001$).

3.3.4 | Controls

Female sex ($p=0.002$) and global cognitive functioning ($p<0.001$) were positively associated with Grooved Pegboard Test scores (see Table 5).

The higher scores in the motor dexterity test observed in women may be due to differences in education. A secondary analysis showed that women in the control group had completed significantly more years of education than their male counterparts (Table S13).

4 | Discussion

We compared motor dexterity performance between FEP patients, their parents, siblings, and controls. The main finding was that patients and parents showed the lowest motor dexterity scores, while siblings and controls obtained the highest scores. Furthermore, we found a positive association between global cognitive function and motor dexterity across the four groups. We identified distinct group-specific associations between motor dexterity and age, sex, years of education, IQ, processing speed, attention, and executive functions.

Endophenotypes should be more common in unaffected first-degree relatives than in the general population. However, our results show a different pattern: while both FEP patients and their parents showed motor dexterity deficits, siblings performed similarly to controls [28, 58, 59]. This suggests that motor dexterity may not fit the classical endophenotype model and instead raises the possibility that preserved motor dexterity in individuals at genetic risk, such as siblings, may serve as a protective factor, in line with research on resilience in psychosis [60, 61].

The distinction between parents and siblings highlights the importance of analyzing first-degree relatives separately when considering motor dexterity as a potential endophenotype. The observed motor dexterity deficit in parents supports previous evidence suggesting some heritability in this cognitive domain [62]. The results highlight two distinct patterns of performance: FEP patients and their parents exhibited motor dexterity deficits, while siblings performed comparably to controls, consistent with studies showing that unaffected siblings perform at control levels on cognitive tasks [29, 35]. Despite sharing genetic risk for schizophrenia with FEP patients, siblings did not show motor dexterity impairment, reinforcing the idea that better motor dexterity may act as a protective factor [63–65]. Similar trends were observed across other cognitive domains, with no significant differences between controls and siblings. In addition, motor dexterity was significantly associated with global cognitive function in all four groups, supporting previous evidence of an intrinsic relationship between motor dexterity and cognitive function [12–15].

Siblings had more years of education than FEP patients, their parents, and controls. A key factor affecting educational attainment is the participants' age, which may partly explain the differences in education. Since FEP patients were evaluated at a younger age than their siblings, they had less time to complete higher levels of education. The higher educational attainment of unaffected siblings may contribute to a better cognitive reserve, which may act as a protective factor against psychosis. Cognitive reserve also encompasses factors such as life experiences, occupational complexity (the cognitive demands of a job or occupation), social engagement [66, 67], substance use, physical health conditions [68], and genetic predispositions [69]. These protective factors may help preserve cognitive function, even in individuals at risk of psychosis.

We also analyzed the possible differential contributions of sociodemographic, premorbid, clinical, and cognitive factors to motor dexterity within each group of participants. An unexpected finding was that motor dexterity and IQ were negatively associated in FEP patients. We estimated crystallized intelligence, so our results suggest a potential negative relation between verbal abilities and motor dexterity in FEP. Previous studies of children with autism spectrum disorders have shown that those with significantly higher verbal IQ perform worse on fine motor dexterity tasks [70, 71]. Future research in the population with psychosis is needed to confirm whether such a pattern is similar. To understand the nature of this relationship, it would be necessary to assess non-verbal IQ and global IQ. This association was only observed in FEP patients and not in other groups of participants. Previous research has shown that FEP patients have a higher prevalence of low IQ compared to the general population [72, 73]. Thus, the negative association between motor dexterity and IQ could be due to lower IQ scores in the group of FEP patients than in first-degree relatives or controls. Similarly, we

TABLE 2 | Between-group comparisons in cognitive assessment.

	FEP patients			Parents			Siblings			Controls					
	n	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***n***	**Mean**	**SD**	***F***	***p***	**Posthoc comparisons***
Motor dexterity without covariates	130	−0.98	1.60	143	−1.85	2.41	98	−0.09	1.32	201	0.00	1.00	42.70	< 0.001	FEP < controls, siblings. Parents < FEP, controls, siblings.
Motor dexterity	130	−1.26	1.60	143	−1.14	2.41	98	−0.30	1.32	201	−0.22	1.00	16.25	< 0.001	FEP < controls, siblings. Parents < controls **, siblings**
Premorbid IQ	132	100.28	13.13	145	105.09	11.65	98	103.72	11.47	200	101.52	10.77	2.18	0.08	NS.
Verbal memory	132	−0.65	1.00	145	−0.29	0.99	98	−0.29	0.99	201	−0.13	0.99	8.95	< 0.001	FEP < controls, siblings***.
Visual memory	131	−0.71	0.99	143	−0.33	1.24	98	−0.08	0.86	200	−0.25	1.00	7.99	< 0.001	FEP < controls, siblings.
Processing speed	132	−1.12	1.13	145	−0.18	0.95	98	0.02	0.99	201	0.24	1.00	61.89	< 0.001	FEP < controls, siblings, parents.
Working memory	132	−0.54	0.80	145	−0.09	0.91	98	−0.08	0.90	200	−0.16	1.00	6.20	< 0.001	FEP < controls, siblings.
Executive functions	130	−1.15	1.67	141	−1.27	2.68	97	−0.76	1.36	201	−0.20	1.00	11.11	< 0.001	FEP < controls. Parents < controls**.
Attention	128	−2.74	4.11	139	−1.25	4.08	98	−1.11	2.92	182	−0.39	1.00	14.46	< 0.001	FEP < controls, siblings**.
Theory of mind	105	−0.64	0.93	144	−0.24	1.00	98	−0.11	0.95	179	−0.07	1.00	8.69	< 0.001	FEP < controls, siblings**.
Global cognitive function	124	−1.10	0.86	135	−0.79	0.86	97	−0.51	0.55	181	−0.37	0.43	35.19	< 0.001	FEP < controls, siblings. Parents < controls**.

Note: Using age, sex, and years of education as covariates for all cognitive domains except the one indicated otherwise. *All posthoc comparisons are ≤ 0.001 unless otherwise indicated. **≤ 0.01; ***≤ 0.05.

TABLE 3 | Regression model to predict motor dexterity in FEP patients.

Predictors	Beta coefficient standardized (SE)	*T*	*p*
Premorbid IQ	−0.20 (0.01)	−2.46	0.015
Years of education	0.21 (0.03)	2.79	0.006
Global cognitive function	0.60 (0.14)	7.45	< 0.001

Note: The adjusted R^2 of the overall model is 0.38. Motor dexterity was used as the dependent variable.

TABLE 4 | Regression model to predict motor dexterity in first-degree relatives.

Predictors	Beta coefficient standardized (SE)	*T*	*p*
Parents*			
Executive functions	−0.20 (0.08)	−2.24	0.026
Global cognitive function	0.77 (0.23)	8.39	< 0.001
Siblings**			
Age	−0.35 (0.01)	−4.47	< 0.001
Executive functions	−0.44 (0.09)	−4.65	< 0.001
Attention	−0.33 (0.04)	−3.80	< 0.001
Processing speed	0.27 (0.10)	3.41	< 0.001
Global cognitive function	0.84 (0.28)	7.20	< 0.001

Note: *The adjusted R^2 of the overall model is 0.41. **The adjusted R^2 of the overall model is 0.52. Motor dexterity was used as the dependent variable.

TABLE 5 | Regression model to predict motor dexterity in controls.

Predictors	Beta coefficient standardized (SE)	*T*	*p*
Sex (female)	0.19 (0.12)	2.98	0.003
Global cognitive function	0.47 (0.14)	7.32	< 0.001

Note: The adjusted R^2 of the overall model is 0.26. Motor dexterity was used as the dependent variable.

found a positive association between motor dexterity and years of education only in patients with FEP. This relationship has previously been shown in the general population [74], but we have not been able to replicate these findings in our controls. This discrepancy may be due to methodological limitations or the small sample size. Despite the cognitive deficits often observed in FEP patients, it appears that they may still benefit from increased education. This relationship may have important implications for therapeutic interventions. Incorporating programs that stimulate motor dexterity, along with educational attainment and general cognitive function, may contribute to improved long-term outcomes and prognosis.

Our analysis of siblings revealed a negative association between motor dexterity and age, which partially aligns with expectations, as advancing age is generally linked to a decline in general motor performance [74]. However, this association may be more expected in parents than in siblings, suggesting the need for additional research. Siblings may be particularly sensitive to the effects of aging on motor dexterity, suggesting that a high risk of psychosis could be associated with more pronounced age-related cognitive decline. It is relevant to study cognition over the long term in family designs to compare whether patterns of cognitive trajectories are differentially influenced by the level of risk for schizophrenia spectrum disorders [35, 75–77].

Our results indicate that in the group of siblings, motor dexterity is significantly influenced by processing speed. This suggests that processing speed is a key component in achieving optimal performance in motor dexterity [15, 78, 79]. Motor dexterity appears to be preserved when processing speed is intact, as observed in unaffected siblings, whereas impairments in processing speed, as seen in FEP patients, are associated with reduced motor dexterity [80]. Furthermore, the strong association between these two cognitive traits indicates that the Grooved Pegboard Test used for motor dexterity testing is a neuropsychological tool highly sensitive to such deficits, similar to the Digit Symbol subtest. Thus, the motor dexterity assessment could be a valuable addition to brief neuropsychological batteries for detecting subtle cognitive deficits in individuals at risk of psychosis.

Better executive function performance was associated with lower motor dexterity performance in both siblings and parents, while greater attention was negatively related to motor dexterity scores in siblings. These findings suggest that better cognitive control does not necessarily translate into better motor dexterity performance. This contrasts with previous research, which has reported a significant influence of both cognitive domains on motor dexterity [12–14]. This discrepancy may be due to the specific characteristics of the Grooved Pegboard Test. Future research should include different motor dexterity measures to determine whether different components are differentially associated with executive function and attention.

Analysis of the controls group revealed that women showed a positive association with motor dexterity. This finding supports the results of other studies in which women outperformed men in motor dexterity tasks in the general population [81, 82]. However, our data showed that control women had completed significantly higher educational attainment than men, which may explain their difference in motor dexterity performance. These findings correspond with previous evidence on the role of education regarding sex differences in motor dexterity [83, 84].

4.1 | Strenghts and Limitations

A major strength of this study is the use of the same neuropsychological battery in all participants, allowing direct comparisons of cognitive performance between groups. Relatives were further subdivided into siblings and parents to control for the type of familial relationship to the FEP patient. However, there are several limitations. First, there was a statistically significant difference in the sex distribution between the groups, which may affect the generalizability of the results. Secondly, the neuropsychological assessments were carried out at different time points: FEP patients were assessed a few months after the onset of psychosis, while their relatives completed the assessment several years later. This difference in timing could explain differences in certain variables, such as the higher level of education observed in the siblings. Thirdly, we could not collect information on some variables for all participants, such as unemployment and cannabis use.

5 | Conclusion

This study identifies motor dexterity deficits in FEP patients and their parents, consistent with the possibility that this deficit reflects either a consequence of the disorder or a manifestation of genetic liability to psychosis. In contrast, the intact motor dexterity performance observed in unaffected siblings challenges a strict endophenotypic interpretation and raises the possibility that preserved motor dexterity may act as a protective factor against psychotic disorders. Motor dexterity deficits in FEP patients and their parents are linked to broader cognitive impairment, while in siblings, motor dexterity performance is associated with processing speed and inversely related to age, executive function, and attention. These findings underscore motor dexterity's complexity as a cognitive marker and its potential role in early identification and intervention.

Acknowledgments

The authors would like to thank the entire PAFIP research team and all the patients and family members who participated in the study. The PAFIP cohort projects were carried out at the University Hospital Marqués de Valdecilla and the Valdecilla Research Institute, and were supported by the Carlos III Health Institute (PI14/00639, PI14/00918, PI17/00221, PI20/00066, and PI23/00076). In addition, Dr. Rosa Ayesa-Arriola was financed by a Miguel Servet contract from the Carlos III Health Institute (CP18/00003) and a Consolidator Grant from the Ministerio de Ciencia, Innovación y Universidades (CNS2022-136110).

Ethics Statement

The PAFIP and PAFIP-FAMILIAS were granted ethical approval by the local institutional review board. International research ethics guidelines were followed in the studies.

Consent

All participants were comprehensively informed about the study objectives and provided written informed consent.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Peer Review

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/acps.13821.

References

1. A. D. Barber, P. Srinivasan, S. E. Joel, B. S. Caffo, J. J. Pekar, and S. H. Mostofsky, "Motor "Dexterity"?: Evidence That Left Hemisphere Lateralization of Motor Circuit Connectivity Is Associated With Better Motor Performance in Children," *Cerebral Cortex* 22, no. 1 (2012): 51–59.

2. R. Kanj, P. Zeinoun, C. Roukoz, and R. Mashmoushi, "Factors Associated With Motor Dexterity on the Grooved Pegboard Test in a Lebanese Sample," *Applied Neuropsychology: Child* 11, no. 2 (2022): 178–183.

3. Y. Kimoto, T. Oku, and S. Furuya, "Neuromuscular and Biomechanical Functions Subserving Finger Dexterity in Musicians," *Scientific Reports* 9, no. 1 (2019): 12224.

4. P. Rinne, M. Hassan, C. Fernandes, et al., "Motor Dexterity and Strength Depend Upon Integrity of the Attention-Control System," *Proceedings of the National Academy of Sciences of the United States of America* 115, no. 3 (2018): E536–E545.

5. C. Seer, H. Z. Adab, J. Sidlauskaite, et al., "Bridging Cognition and Action: Executive Functioning Mediates the Relationship Between White Matter Fiber Density and Complex Motor Abilities in Older Adults," *Aging* 14, no. 18 (2022): 7263–7281.

6. K. E. Kobayashi-Cuya, R. Sakurai, N. Sakuma, et al., "Hand Dexterity, Not Handgrip Strength, Is Associated With Executive Function in Japanese Community-Dwelling Older Adults: A Cross-Sectional Study," *BMC Geriatrics* 18, no. 1 (2018): 192.

7. A. R. Sobinov and S. J. Bensmaia, "The Neural Mechanisms of Manual Dexterity," *Nature Reviews Neuroscience* 22, no. 12 (2021): 741–757.

8. M. D. Lezak, *Neuropsychological Assessment* (Oxford University Press, 2004).

9. O. Vasylenko, M. M. Gorecka, and C. Rodríguez-Aranda, "Manual Dexterity in Young and Healthy Older Adults. 2. Association With Cognitive Abilities," *Developmental Psychobiology* 60, no. 4 (2018): 428–439.

10. O. Vasylenko, M. M. Gorecka, K. Waterloo, and C. Rodríguez-Aranda, "Reduction in Manual Asymmetry and Decline in Fine Manual Dexterity in Right-Handed Older Adults With Mild Cognitive Impairment," *Laterality* 27, no. 6 (2022): 581–604.

11. J. J. de Paula, M. R. Albuquerque, G. M. Lage, M. A. Bicalho, M. A. Romano-Silva, and L. F. Malloy-Diniz, "Impairment of Fine Motor Dexterity in Mild Cognitive Impairment and Alzheimer's Disease Dementia: Association With Activities of Daily Living," *Brazilian Journal of Psychiatry* 38 (2016): 235–238.

12. K. E. Kobayashi-Cuya, R. Sakurai, H. Suzuki, S. Ogawa, T. Takebayashi, and Y. Fujiwara, "Observational Evidence of the Association Between Handgrip Strength, Hand Dexterity, and Cognitive Performance in Community-Dwelling Older Adults: A Systematic Review," *Journal of Epidemiology* 28, no. 9 (2018): 373–381.

13. C. Rodríguez-Aranda, M. Mittner, and O. Vasylenko, "Association Between Executive Functions, Working Memory, and Manual Dexterity in Young and Healthy Older Adults: An Exploratory Study," *Perceptual and Motor Skills* 122, no. 1 (2016): 165–192.

14. K. A. Tolle, A. M. Rahman-Filipiak, A. C. Hale, K. A. Kitchen Andren, and R. J. Spencer, "Grooved Pegboard Test as a Measure of Executive Functioning," *Applied Neuropsychology Adult* 27, no. 5 (2020): 414–420.

15. E. Low, S. G. Crewther, B. Ong, D. Perre, and T. Wijeratne, "Compromised Motor Dexterity Confounds Processing Speed Task Outcomes in Stroke Patients [Internet]," *Frontiers in Neurology* 8 (2017): 484, accessed April 6, 2024, https://www.frontiersin.org/journals/neurology/articles/10.3389/fneur.2017.00484/full.

16. J. Seol, N. Lim, K. Nagata, and T. Okura, "Effects of Home-Based Manual Dexterity Training on Cognitive Function Among Older Adults: A Randomized Controlled Trial," *European Review of Aging and Physical Activity* 20, no. 1 (2023): 9.

17. S. Nobusako, A. Sakai, T. Tsujimoto, et al., "Manual Dexterity Is a Strong Predictor of Visuo-Motor Temporal Integration in Children [Internet]," *Frontiers in Psychology* 9 (2018): 948, https://doi.org/10.3389/fpsyg.2018.00948/full.

18. J. Firth, J. A. Firth, B. Stubbs, et al., "Association Between Muscular Strength and Cognition in People With Major Depression or Bipolar Disorder and Healthy Controls," *JAMA Psychiatry* 75, no. 7 (2018): 740–746.

19. P. Rakhshan, H. Sørensen, J. DeVylder, et al., "Childhood Pegboard Task Predicts Adult-Onset Psychosis-Spectrum Disorder Among a Genetic High-Risk Sample," *Schizophrenia Research* 178, no. 1–3 (2016): 68–73.

20. L. Schäppi, K. Stegmayer, P. V. Viher, and S. Walther, "Distinct Associations of Motor Domains in Relatives of Schizophrenia Patients—Different Pathways to Motor Abnormalities in Schizophrenia? [Internet]," *Frontiers in Psychiatry* 9 (2018): 129, https://doi.org/10.3389/fpsyt.2018.00129/full.

21. I. I. Gottesman and T. D. Gould, "The Endophenotype Concept in Psychiatry: Etymology and Strategic Intentions," *American Journal of Psychiatry* 160, no. 4 (2003): 636–645.

22. I. J. Chou, C. F. Kuo, Y. S. Huang, et al., "Familial Aggregation and Heritability of Schizophrenia and co-Aggregation of Psychiatric Illnesses in Affected Families," *Schizophrenia Bulletin* 43, no. 5 (2017): 1070–1078.

23. L. Krabbendam, M. Marcelis, P. Delespaul, J. Jolles, and J. van Os, "Single or Multiple Familial Cognitive Risk Factors in Schizophrenia?," *American Journal of Medical Genetics* 105, no. 2 (2001): 183–188.

24. A. L. Hoff, C. Svetina, A. M. Maurizio, T. J. Crow, K. Spokes, and L. E. DeLisi, "Familial Cognitive Deficits in Schizophrenia," *American Journal of Medical Genetics Part B, Neuropsychiatric Genetics* 33B, no. 1 (2005): 43–49.

25. E. I. Ivleva, D. W. Morris, J. Osuji, et al., "Cognitive Endophenotypes of Psychosis Within Dimension and Diagnosis," *Psychiatry Research* 196, no. 1 (2012): 38–44.

26. C. L. Hou, Y. T. Xiang, Z. L. Wang, et al., "Cognitive Functioning in Individuals at Ultra-High Risk for Psychosis, First-Degree Relatives of Patients With Psychosis and Patients With First-Episode Schizophrenia," *Schizophrenia Research* 174, no. 1 (2016): 71–76.

27. E. Bora and C. Pantelis, "Theory of Mind Impairments in First-Episode Psychosis, Individuals at Ultra-High Risk for Psychosis and in First-Degree Relatives of Schizophrenia: Systematic Review and Meta-Analysis," *Schizophrenia Research* 144, no. 1 (2013): 31–36.

28. N. Murillo-García, A. Díaz-Pons, L. M. Fernández-Cacho, et al., "A Family Study on First Episode of Psychosis Patients: Exploring Neuropsychological Performance as an Endophenotype," *Acta Psychiatrica Scandinavica* 145, no. 4 (2022): 384–396.

29. C. Hughes, V. Kumari, M. Das, et al., "Cognitive Functioning in Siblings Discordant for Schizophrenia," *Acta Psychiatrica Scandinavica* 111, no. 3 (2005): 185–192.

30. J. K. Haukka, J. Suvisaari, and J. Lönnqvist, "Family Structure and Risk Factors for Schizophrenia: Case-Sibling Study," *BMC Psychiatry* 4, no. 1 (2004): 41.

31. R. K. Heaton, L. Ryan, and I. Grant, *Demographic Influences and Use of Demographically Corrected Norms in Neuropsychological Assessment*, ed. I. Grant and K. M. Adams (Oxford University Press, 2009).

32. A. Aleman, R. S. Kahn, and J. P. Selten, "Sex Differences in the Risk of Schizophrenia: Evidence From Meta-Analysis," *Archives of General Psychiatry* 60, no. 6 (2003): 565–571.

33. C. González-Blanch, B. Crespo-Facorro, M. Álvarez-Jiménez, et al., "Pretreatment Predictors of Cognitive Deficits in Early Psychosis," *Psychological Medicine* 38, no. 5 (2008): 737–746.

34. P. Byrial, L. Nyboe, P. H. Thomsen, and L. Clausen, "Motor Impairments in Early Onset Schizophrenia," *Early Intervention in Psychiatry* 16, no. 5 (2022): 481–491.

35. M. J. Cuesta, L. Moreno-Izco, M. Ribeiro, et al., "Motor Abnormalities and Cognitive Impairment in First-Episode Psychosis Patients, Their Unaffected Siblings and Healthy Controls," *Schizophrenia Research* 200 (2018): 50–55.

36. B. Crespo-Facorro, C. Gonzalez-Blanch, J. Pelayo-Teran, et al., "Programa asistencial para las fases iniciales de psicosis de Cantabria (PAFIP). Fases Iniciales Las Enfermedades Ment Psicosis Barc Masson, 133–42," (2005).

37. J. M. Pelayo-Terán, R. Pérez-Iglesias, M. Ramírez-Bonilla, et al., "Epidemiological Factors Associated With Treated Incidence of First-Episode Non-Affective Psychosis in Cantabria: Insights From the Clinical Programme on Early Phases of Psychosis," *Early Intervention in Psychiatry* 2, no. 3 (2008): 178–187.

38. R. L. Spitzer, J. B. W. Williams, M. Gibbon, and M. B. First, "The Structured Clinical Interview for DSM-III-R (SCID): I: History, Rationale, and Description," *Archives of General Psychiatry* 49, no. 8 (1992): 624–629.

39. N. C. Andreasen, *Comprehensive Assessment of Symptoms and History (CASH)* (Department of Psychiatry, University of Iowa College of Medicine, 1987).

40. N. Brill, A. Reichenberg, J. Rabinowitz, et al., "Accuracy of Self-Reported Premorbid Functioning in Schizophrenia," *Schizophrenia Research* 97, no. 1 (2007): 103–108.

41. R. Ayesa-Arriola, J. M. Rodríguez-Sánchez, E. S. Suero, L. E. Reeves, R. Tabarés-Seisdedos, and B. Crespo-Facorro, "Diagnosis and Neurocognitive Profiles in First-Episode Non-Affective Psychosis Patients," *European Archives of Psychiatry and Clinical Neuroscience* 266, no. 7 (2016): 619–628.

42. N. Murillo-García, E. Setién-Suero, G. Pardo-de-Santayana, et al., "Entire Duration of Active Psychosis and Neurocognitive Performance in First-Episode Non-Affective Psychosis," *Early Intervention in Psychiatry* 15, no. 5 (2021): 1266–1275.

43. M. Gómez-Revuelta, J. M. Pelayo-Terán, M. Juncal-Ruiz, et al., "Antipsychotic Treatment Effectiveness in First Episode of Psychosis: PAFIP 3-Year Follow-Up Randomized Clinical Trials Comparing Haloperidol, Olanzapine, Risperidone, Aripiprazole, Quetiapine, and Ziprasidone," *International Journal of Neuropsychopharmacology* 23, no. 4 (2020): 217–229.

44. N. C. Andreasen, *Scale for the Assessment of Positive Symptoms (SAPS)* (University of Iowa, 1984).

45. N. C. Andreasen, "The Scale for the Assessment of Negative Symptoms (SANS): Conceptual and Theoretical Foundations," *British Journal of Psychiatry* noviembre de 1989; 155, no. S7 (1989): 49–52, https://doi.org/10.1192/S0007125000291496.

46. S. Mañá, J. Ivorra, and M. Girón, "Adaptación y fiabilidad de la entrevista para la evaluación de la discapacidad social en pacientes psiquiátricos (OMS). [Adaptation and reliability of the interview for social incapacity assessment in psychiatric patients (WHO).]," *Revista de psiquiatría de la Facultad de Medicina de Barcelona* 25, no. 2 (1998): 43–48.

47. H. Kløve, *Grooved Pegboard* (Lafayette Instrum, 1963).

48. A. Rey, *L'examen clinique en psychologie* (Presses Universitaires de France, 1964).

49. P. Osterrieth, "The Test of Copying a Complex Figure: A Contribution to the Study of Perception and Memory," *Archiv für Psychologie* 30 (1944): 206–356.

50. D. Wechsler, *Wechsler Adult Intelligence Scale*, 3rd ed. (Psychological Corporation, 1997).

51. J. Cegalis and J. Bowlin, *Vigil: Software for the Assessment of Attention* (Forthought, 1991).

52. S. Baron-Cohen, S. Wheelwright, and T. Jolliffe, "Is There a «Language of the Eyes»? Evidence From Normal Adults, and Adults With Autism or Asperger Syndrome," *Visual Cognition* 4, no. 3 (1997): 311–331.

53. W. K. Ringe, K. C. Saine, L. H. Lacritz, L. S. Hynan, and C. M. Cullum, "Dyadic Short Forms of the Wechsler Adult Intelligence Scale–III," *Assessment* 9, no. 3 (2002): 254–260.

54. A. Reichenberg, P. D. Harvey, C. R. Bowie, et al., "Neuropsychological Function and Dysfunction in Schizophrenia and Psychotic Affective Disorders," *Schizophrenia Bulletin* 35, no. 5 (2009): 1022–1029.

55. L. M. Ellman, S. Vinogradov, W. S. Kremen, et al., "Low Maternal Hemoglobin During Pregnancy and Diminished Neuromotor and Neurocognitive Performance in Offspring With Schizophrenia," *Schizophrenia Research* 138, no. 1 (2012): 81–87, https://doi.org/10.1016/j.schres.2012.04.008.

56. H. Song and S. K. Min, "Aggressive Behavior Model in Schizophrenic Patients," *Psychiatry Research* 167, no. 1–2 (2009): 58–65.

57. M. Sevilla-Ramos, V. Ladera, R. García-García, B. Crespo-Facorro, and R. Ayesa-Arriola, "Exploring the Longitudinal Course of Motor Dexterity in First-Episode Psychosis: A 10-Year Follow-Up [Internet]," *European Archives of Psychiatry and Clinical Neuroscience* (2024), https://doi.org/10.1007/s00406-024-01937-2.

58. Á. Yorca-Ruiz, N. Murillo-García, R. Magdaleno Herrero, et al., "Processing Speed in First Episode of Psychosis and First-Degree Relatives: A Candidate Endophenotype of Spectrum Schizophrenia Disorders," *Neuropsychology* 38, no. 4 (2024): 357–367, https://doi.org/10.1037/neu0000931.

59. G. Abreu-Fernández, N. Murillo-García, V. de la Ortiz-García Foz, R. Magdaleno Herrero, Á. Yorca-Ruiz, and R. Ayesa-Arriola, "Theory of Mind as an Endophenotype for Schizophrenia Spectrum Disorder: Study in First Episode of Psychosis Patients and First-Degree Relatives [Internet]," *Spanish Journal of Psychiatry and Mental Health* (2023), accessed February 7, 2025, https://www.sciencedirect.com/science/article/pii/S295028532300039X.

60. J. S. DeLuca, P. Rakhshan Rouhakhtar, M. J. Klaunig, et al., "Psychosis-Like Experiences and Resilience: A Systematic and Critical Review of the Literature," *Psychological Services* 19, no. Suppl 1 (2022): 120–138, https://doi.org/10.1037/ser0000585.

61. A. Cojocaru, A. Braha, C. M. Anastasescu, et al., "A Systematic Review of Resilience in at-Risk Youth for Psychotic Disorders: An Analysis of Protective and Risk Factors From Recent Literature," *Behavioral Science* 14, no. 10 (2024): 898.

62. M. Térémetz, L. Carment, L. Brénugat-Herne, et al., "Manual Dexterity in Schizophrenia—A Neglected Clinical Marker? [Internet]," *Frontiers in Psychiatry* 8 (2017): 120, https://doi.org/10.3389/fpsyt.2017.00120/full.

63. U. Gschwandtner, M. Pflüger, J. Aston, et al., "Fine Motor Function and Neuropsychological Deficits in Individuals at Risk for Schizophrenia," *European Archives of Psychiatry and Clinical Neuroscience* 256, no. 4 (2006): 201–206.

64. E. Studerus, M. Papmeyer, and A. Riecher-Rössler, "Neurocognition and Motor Functioning in the Prediction of Psychosis," in *Early Detection and Intervention in Psychosis: State of the Art and Future Perspectives*, eds. A. Riecher-Rössler and P. D. McGorry (Karger, 2016), 116–132, https://doi.org/10.1159/000440919.

65. Q. Le Boterff, A. Rabah, L. Carment, et al., "A Tablet-Based Quantitative Assessment of Manual Dexterity for Detection of Early Psychosis [Internet]," *Frontiers in Psychiatry* 14 (2023): 1200864, https://doi.org/10.3389/fpsyt.2023.1200864/full.

66. C. Pappalettera, C. Carrarini, F. Miraglia, F. Vecchio, and P. M. Rossini, "Cognitive Resilience/Reserve: Myth or Reality? A Review of Definitions and Measurement Methods," *Alzheimer's & Dementia* 20, no. 5 (2024): 3567–3586.

67. F. Conte, L. Rinaldi, T. Gerosa, S. Mondini, G. Costantini, and L. Girelli, "Cognitive Reserve Potential: Capturing Cognitive Resilience Capability in Adolescence," *Assessment* 31, no. 4 (2023): 812–826.

68. J. L. Zijlmans, S. Lamballais, M. W. Vernooij, M. A. Ikram, and A. I. Luik, "Sociodemographic, Lifestyle, Physical, and Psychosocial Determinants of Cognitive Reserve," *Journal of Alzheimer's Disease* 85, no. 2 (2022): 701–713.

69. A. Sidenkova, "Cerebral-Cognitive Reserve: Concept and Functions of the Cerebral-Cognitive Reserve," *European Psychiatry* 67, no. S1 (2024): S681–S682.

70. T. Y. Yu, W. Chou, J. C. Chow, C. H. Lin, L. C. Tung, and K. L. Chen, "IQ Discrepancy Differentiates Levels of Fine Motor Skills and Their Relationship in Children With Autism Spectrum Disorders," *Neuropsychiatric Disease and Treatment* 14 (2018): 597–605.

71. T. Y. Yu, K. L. Chen, W. Chou, et al., "Intelligence Quotient Discrepancy Indicates Levels of Motor Competence in Preschool Children at Risk for Developmental Delays," *Neuropsychiatric Disease and Treatment* 12 (2016): 501–510.

72. D. Clougher, M. F. Forte, G. Mezquida, et al., "Emotional Intelligence and Neurocognition Profiles in First-Episode Psychosis: A Two-Year Follow-Up Study," *European Neuropsychopharmacology* 85 (2024): 66–77.

73. G. M. Khandaker, J. H. Barnett, I. R. White, and P. B. Jones, "A Quantitative Meta-Analysis of Population-Based Studies of Premorbid Intelligence and Schizophrenia," *Schizophrenia Research* 132, no. 2 (2011): 220–227.

74. A. Heaton, A. Gooding, M. Cherner, et al., "Demographically-Adjusted Norms for the Grooved Pegboard and Finger Tapping Tests in Spanish-Speaking Adults: Results From the Neuropsychological Norms for the U.S.-Mexico Border Region in Spanish (NP-NUMBRS) Project," *Clinical Neuropsychologist* 35, no. 2 (2021): 396–418.

75. S. R. Mathias, E. E. M. Knowles, J. Barrett, et al., "The Processing-Speed Impairment in Psychosis Is More Than Just Accelerated Aging," *Schizophrenia Bulletin* 43, no. 4 (2017): 814–823.

76. N. M. Haddad, L. Hortêncio, J. C. Andrade, et al., "Cognitive Patterns and Conversion in a Representative Sample of Individuals at Risk for Psychosis," *Journal of Nervous and Mental Disease* 210, no. 5 (2022): 335.

77. J. P. Koning, R. S. Kahn, D. E. Tenback, L. J. van Schelven, and P. N. van Harten, "Movement Disorders in Nonpsychotic Siblings of Patients With Nonaffective Psychosis," *Psychiatry Research* 188, no. 1 (2011): 133–137.

78. P. Bachman, T. A. Niendam, M. Jalbrzikowkski, et al., "Processing Speed and Neurodevelopment in Adolescent-Onset Psychosis: Cognitive Slowing Predicts Social Function," *Journal of Abnormal Child Psychology* 40, no. 4 (2012): 645–654.

79. D. Ebaid, S. G. Crewther, K. MacCalman, A. Brown, and D. P. Crewther, "Cognitive Processing Speed Across the Lifespan: Beyond the Influence of Motor Speed [Internet]," *Frontiers in Aging Neuroscience* 9 (2017): 1–11, https://doi.org/10.3389/fnagi.2017.00062/full.

80. K. E. Kobayashi-Cuya, R. Sakurai, N. Sakuma, et al., "Bidirectional Associations of High-Level Cognitive Domains With Hand Motor

Function and Gait Speed in High-Functioning Older Adults: A 7-Year Study," *Archives of Gerontology and Geriatrics* 117 (2024): 105232.

81. F. N. Da Silva, F. Irani, J. Richard, et al., "More Than Just Tapping: Index Finger-Tapping Measures Procedural Learning in Schizophrenia," *Schizophrenia Research* 137, no. 1 (2012): 234–240.

82. Y. C. Wang, R. W. Bohannon, J. Kapellusch, A. Garg, and R. C. Gershon, "Dexterity as Measured With the 9-Hole Peg Test (9-HPT) Across the Age Span," *Journal of Hand Therapy* 28, no. 1 (2015): 53–60.

83. H. L. Ferrett, K. G. F. Thomas, S. F. Tapert, et al., "The Cross-Cultural Utility of Foreign- and Locally-Derived Normative Data for Three WHO-Endorsed Neuropsychological Tests for South African Adolescents," *Metabolic Brain Disease* 29, no. 2 (2014): 395–408.

84. C. H. van Wijk and W. Meintjes, "Grooved Pegboard for Adult Employed South Africans: Normative Data and Human Immunodeficiency Virus Associations," *South Africa Journal of Psychology* 45, no. 4 (2015): 521–535.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.