Original Article

Handwriting difficulties: Introducing an instrument

Hadavandkhani Fatemeh[1]; Bahrami Hadi, PhD; Behnia Fatemeh,
Farahbod Mozhgan; Salehi Masood, PhD.
University of Social Welfare and Rehabilitation Sciences, Tehran, Iran

Objective: The main purpose of this study is to produce an instrument for handwriting evaluation and to execute it on mentally retarded (MR) students.

Method: This was a descriptive, cross-sectional, and relationship study. 126 MR students (53 girls and 73 boys) ranging from 9 to 19 years old (13.23±2.17) from two exceptional children schools in shahr-e-rey participated in this study. A handwriting checklist made by the researcher was executed on all students. Data were analyzed by U-Mann whitney, one-way ANOVA, and Spearman rank correlation.

Results: The test showed there isn't a significant relationship between handwriting and laterality (p=0/196), sex (p=0/487) and age (p=0/449). There is a significant relationship between handwriting and grade (r=0/448, p<0/005), but no significant difference was seen between different grades. "separate writing" caused minimum legibility (81%), and "spacing" was damaged at the least (34.9%).

Conclusion: The frequency of handwriting difficulties in MR students showed that the necessity of professional attention in exceptional schools.

Key words: handwriting evaluation; mentally retarded (MR) student; legibility components

Introduction

Some children can paint, but they are unable to write legibly and consistently, in spite of repeated admonitions. They are unable to form letters properly, they have difficulty keeping letters on the line, they may not seem to understand relative size of letters, they may space so poorly that it is almost impossible to determine where one word ends and another begins. The result is that what they have written is often difficult or almost impossible to read, even when it is spelled correctly(1). This students have handwriting difficulty (HD). HD is inability to copy letters and numbers legibly in determined time. Because of motor delay, HD in mentally retarded (MR) students is more than normal students. Evaluation of this difficulties in MR students is important, because in some cases this difficulties will be a serious barrier to learning (2).

A comprehensive evaluation of a student's handwriting includes: examining written work samples; discussing the child's performance with the teacher, parents and the other team members; reviewing the student's educational and clinical reports, observing the student's directly when he/she is writing in the natural setting; and evaluating the student's functional performance of handwriting (3).

1-Correspondence:Hadavandkhani, EMail: fhadavandkhani@gmail.com

One important aspect which must be considered in handwriting evaluation is the functional performance of handwriting, that is, what symptoms is seen during student's struggling for writing a text. For assessing the functional performance of children's handwriting, an instrument is necessary which consider important aspects of handwriting. These aspects are as follows: domains of handwriting, legibility components, writing speed, and ergonomic factors (4).

Legibility is often assessed by it's components. This components are: letter formation, alignment, spacing, size, and slant (5,6).

In the letter formation, Alston(1983) identified five features: improper letter forms, poor leading in and leading out of letters, inadequate rounding of letters, and incorrect letter ascenders and descenders(5). Alignment refer to the placement of the text on the writing guidelines. Spacing includes the dispersion of letters within words and words within sentences, along with the text organization on the entire sheet of paper. Size refer to the letter relative to the other letters. Slant refers to consistency of angle of the text.

Ergonomic factors include: pencil grip, pressure on the pencil, pressure on the paper, sitting position, kind of writing instrument, and kind of paper (6).

The speed of writing or the number of words written per minute, coupled with legibility, are the two cornerstones of handwriting (6). Graham et al. (1998) studied the speed and legibility of handwriting in 900 students and concluded that the development of handwriting's speed is slow but continuous(7). Tseng and chow (2000) compared 34 slow hand-writers with 35 students with normal handwriting speed (7-11 years old). They concluded that age can predict handwriting speed in slow hand-writers significantly (8).

Egtedari (1381) studied 28 boys and 12 girls with learning disability(LD) who were in grade two to four. She found that hyperactivity and attention deficit in children with LD can increase the handwriting problems (9). Shirazi (1375) studied children with cerebral palsy and found that perceptual disorders has an adverse effect on this students' handwriting (10).

Graham et al. (2000) proposed that handwriting can be a base for writing and remedial training in this domain which may prevent writing problems in the first grade (11).

As mentioned above, an instrument is necessary to evaluate severity of HD which includes all domains of handwriting is included (ie. ergonomic factors and legibility components). Since handwriting is a completely cultural matter, every language should have a unique assessment tool. There is some handwriting evaluation tools in other countries. For example:

- The Denver Handwriting Analysis (Anderson, 1983)
- The Diagnosis and Remediation of Handwriting Problems (Stott, Moyes & Henderson, 1985)
- The Evaluation Tool of Children's Handwriting (Amundson, 1995)
- The Minnesota Handwriting Assessment (Reisman, 2000)

The Test of Handwriting Skills (Gardner, 1998) However, there is not a Persian assessment tool for evaluating and quantifying legibility components of handwriting. The aim of this study is making a suitable handwriting tool with use of "Alston & Taylour handwriting checklist" and with regard to the shape of Persian alphabet. This tool includes demographic questions along with 12 items which measure legibility components and ergonomic factors.

To evaluate the reliability and validity of this instrument, this research tool has been carried out for the MR students.

Method:In this descriptive and cross-sectional study which is a relationship and validity assessment study, all of the MR students from first grade(third part[1]) to fifth grade who were studying in the exceptional schools of shahr-e-

---

2:Mentally retarded students in exceptional children schools are educating the first class in 3 continuous years (part 1, part 2, and part 3: since the data was collected at the end of the year, the part 3 students who were taught all letters included in the study.

rey (sheikh mohammad khiabani & danesh) has been participated.

There were 157 students in these two schools, but 31 students with anatomical, neurological, orthopedic, developmental, and behavioral difficulties were excluded. Finally, 126 educable MR students (53 girls and 73 boys) ranging from 9-19 years old participated in this research. Data was collected by:

Handwriting text. To record student's handwriting legibility and speed, a text was prepared with the first to fifth grades teachers as the research assistants. This text was a short story with four sentences which included all letters of Persian alphabet. This short story was typed with Nazanin font and then it printed on an A5 card.

Handwriting record sheet. An A5 paper which was painted 5 line on it.

Handwriting checklist. Persian handwriting checklist was prepared with the use of other references, the author's experiences, and the shape of Persian alphabet. The checklist have demographic questions and 12 items for legibility and ergonomic factors. Observation are recorded by 1,2, and 3 scores. The minimum total scores is zero and the maximum total score is 24. Content validity was 93% and alpha coronbach was 6065%

The criteria of scoring each item include:

Pencil grip. The manner in which student holds pencil in his/her hand for writing. If the student's pencil grip was dynamic tripod (the pencil is hold with palmar surface of distal phalanx of thumb and index finger and is lain on the radial surface of distal phalanx of middle finger) the score would be 2, if pencil grip was dynamic tripod but he/she holds the pencil very low or high or with a closed web-space, the score would be 1, and students who have other pencil grips would earn zero.

Pressure on the pencil. If after writing the handwriting text, pencil trace reminded on the thumb and index finger deeply, the score would be zero. If this trace were relatively superficial, the student's score would be 1 and if there was no trace, the score would be 2.

Pressure on the paper. This means that letters are richy-coloured or faint-coloured. If student's handwriting in comparison with performance of other students was normal, the score would be 2, if the text was more rich/faint, with regard to severity of richness/faintness the score would be zero or 1.

Paper position. One ergonomic factor which affects handwriting is the paper position . In the correct position the paper angle with the edge of table is 20-30 in right-handed students and 25-35 in left-handed students. Of course paper must lie in right side of midline of body in right-handed students and in the left side of midline in left-handed students. If the paper position was correct, the score would be 2, if the angle was up to 45 or down to 10, the score would be 1. If the angle was upper than 45 or lower than 10 the score would be zero.

Separate writing. Some students, repeatedly raise their pencil from the paper after each letter during writing one word and thus word looks like a puzzle. If the number of separated words was more than 3, the student's score would be zero. If they were 3 and less than 3, the score would be 1 and if all words were written correctly (not separated), the score would be 2.

Pencil movement direction during writing letters. Every letter needs to special begin, special trend and special end. Some students choose atypical direction. For example. They write " ا " from down to up, or in writing " ب ", they first put the lower line and then put the lateral lines,..... All these methods are abnormal. If the number of these mistakes in student's manuscript was more than 2, the score would be zero. If their number was two and less than two, the score would be 1. If the student wrote all letters in normal direction, the score would be 2.

Circular letters. If circular letters (س ،خ ،ح ،چ،ج ، ل ،ق ،غ ،ع ،ض ،ص ،ش) were angulated or there was incomplete closure of circular letters, the shape would be abnormal. If the number of atypical circular letters was three or more than three, the score would be 1. If the student wrote all circular letters typically, the score would be 2.

Size of letters. Size of letters follows rules in comparison with others. For example, ک، "فـلا" "ل، must have the same height; " ژ ، ر ، ز " must have the same size and shape; final " ب " must be bigger than the first ب " ". If the number of words in which letters don't have suitable size was more than three, the score would be zero, if they were three or less than three, the score would be 1. If all letters had relative proper size, the score would be 2.

 Slant. It means that, in spite of existence of guidelines, the manuscript is slanted up/down. If the slant was more than 10 mm, the score would be zero. If the slant was up to 10 mm, the score would be 1, and if the manuscript had no slant the score would be 2.

Spacing. The space between letters usually must be less than the space between words. If improper spacing was repeated up to three times in total text, the score was 1. If the number of them was more than 3, the score would be zero, and if the spacing was correct, the score would be 2.

 Size of whole manuscript. It means that student's manuscript is large-written or little-written. If the student has written the whole text in three lines, the score would be 2, if there were four lines, the score would be 1, and more than four lines would earn zero.

Writing on the guideline. Each Persian alphabets have a special place relative to guideline. For example, the place of "فـلا " is above the guideline, the place of "ب، پ ، ت ، ث، ف is on the guideline and the place of "....ی، ن ، ل " is under the guideline. If all letters were written on the own place, the score would be 2. If the number of letters which weren't in own place was up to 3, the score would be 1. If they were more than 3, the score would be zero.

Method: After consent of students and their parents, the student sat on a chair which was suitable for his/her height (the chair and the table was two size for controlling ergonomic factors). Then the student was asked to read the handwriting text.
If the student had problem in reading the text, he/she is helped to read the text correctly and completely. Then the examiner placed the record sheet and a sharpened pencil on the midline of the table in front of the student, for determining student's dominant hand and paper positioning. The student wasn't given a writing-pad.

The time was calculated by a digital chronometer. The student was being observed precisely during writing, so that the researcher could score the manuscript on the basis of criteria which was considered for 12 items. Using eraser is not permissible and wrong spelling wasn't a criterion for scoring.

The data were analyzed with u-mann Whitney, one-way ANOVA and Spearman rank correlation coefficient.

Results: 126 mentally retarded students (53 girls and 73 boys) ranging from 9-19 years old (13.23 ± 2.17) participated in this study.

Table1: prevalence of handwriting items

items	prevalence
Separate writing	81%
Pencil movement direction	80.2%
Size of letters	77.8%
Pressure on the pencil	77.8%
Size of whole manuscript	74.6%
Pressure on the paper	61.9%
Circular letters	61.2%
Pencil grip	48.5%
Writing on the line	46%
Paper position	35.7%
Spacing	34.9%

Table 1 shows the frequencies of 12 handwriting items in the sample. The most prevalent item in MR students of Shahr-e-Rey was 'separate writing' (81%) and the least prevalent item was 'spacing' (34.9%). The prevalence of 7 items was more than 50%.

Table 2: handwriting correlation with variables

variables	handwriting	p-value	sample
Suffering from Down's syndrome	0.066	0.465	126
Laterality	-0.116	0.196	126
Gender	-0.063	0.487	126
Age	0.068	0.449	126
Use from glass	-0.152	0.089	126
Use from hearing aid	0.057	0.527	126
Grade	0.248	0.005	126
Pencil grip	0.381	0.0001	126
Pressure on the pencil	0.262	0.003	126
Pressure on the paper	0.517	0.0001	126
Paper position	0.323	0.0001	126
Separate writing	0.519	0.0001	126
Pencil movement direction	0.536	0.0001	126
Circular letters	0.469	0.0001	126
Size of letters	0.559	0.0001	126
Slant	-	-	126

In table 2, the relationship between handwriting and some variables was shown. Handwriting and suffering from Down's syndrome (p=0.465), using hearing aid (p=0.527), and age (p=0.449) hadn't significant relationship. Also handwriting and handedness (p=0.196), gender (p=0.487), and using glass (p=0.089) had a negative relationship but they were not meaningful. However handwriting and

Table3: U-mann whitney in items on the basis of gender

variables	mean		Standard deviation		p-value
	girl	boy	girl	boy	
Pencil grip	1.11	1.28	0.91	0.85	0.290
Pressure on the pencil	0.83	0.75	0.82	0.75	0.650
Pressure on the paper	1.05	0.98	0.88	0.85	0.650
Paper position	1.77	1.28	0.54	0.80	0.0001
Separate writing	0.71	0.60	0.79	0.77	0.384
Pencil movement direction	0.92	0.50	0.80	0.72	0.002
Circular letters	0.98	1.38	0.77	0.63	0.003
Size of letters	0.75	1.82	0.78	0.78	0.629
spacing	1.29	1.65	0.76	0.58	0.052
Size of whole manuscript	0.71	0.82	0.81	0.82	0.484
Writing on the line	1.45	1.23	0.72	0.85	0.181

Table 3 shows the difference between scores of handwriting items in two gender. Girls acquired the most mean scores in 'paper position' and the least mean scores in 'separate writing'. Boys acquired the most mean scores in 'spacing' and the least mean scores in 'pencil movement direction'. In this table u-mann Whitney showed there was meaningful difference between boys and girls in the 'paper position' ($p<0.0001$), and in 'pencil movement direction' ($p<0.002$), so that the girls performance was better than boys. Also there was significant difference between girls and boys in 'circular letters' ($p<0.003$), so that boys performed better than girls. However, there wasn't meaningful difference between two gender in other items. grade ($p<0.005$) and handwriting items was related significantly.

Table4: handwriting scores in grades

grade	Handwriting checklist					
	girls		boys		all	
	mean	Standard deviation	mean	Standard deviation	mean	Standard deviation
First grade	13.22	6.05	12.14	4.67	12.57	5.15
Second grade	11.17	2.71	12.35	3.45	12.08	3.28
Third grade	13.50	2.90	13.71	4.53	13.62	3.79
Forth grade	14.31	2.89	14.29	3.15	14.30	2.98
Fifth grade	14.70	5.05	15.13	4.08	14.89	4.52
p-value	0.484		0.267		0.083	

One-way ANOVA(table 4) showed that there was not significant difference between grades($p=0.083$).

Discussion: In this study girls and boys performed equally in handwriting checklist($p=0.487$). Egtedari(1381) found that there is not significant relationship between handwriting and gender in students with LD too(9). Although MR students (in our study) and LD students(in egtedari's study) differ, the equal results shows that intelligence probably doesn't impact on handwriting, thus MR and LD students may have legible handwriting. Of course legibility differ from nicely writing which is a step beyond the legibility, and in this research only legibility is evaluated. That is, although there may a little chance for nicely writing in MR students, but they can write legible.

Also in this study handwriting scores wasn't correlated with suffering from Down's syndrome (DS) who were 7.9%. Their scores in handwriting checklist doesn't differ from other MR students. Probably DS students can compensate hypotonus and motor delay by more attention and relaxation which is their characteristic. Thus they can write as legible as other MR students.

In this study, Spearman's rank correlation showed that handwriting is related to handedness negatively, but it wasn't significant. So left-handedness was not an effective factor on the handwriting. The prevalence of left-handedness in MR students of Shahr-e-Rey was 23%. Levin (1991) said that the prevalence of left-handedness in general population is 10%. He believes left-handedness doesn't cause HD, but the number of left-handed students with HD is more than right-handed students with HD. Because most of left-handed students originally were right-handed, but due to clumsiness in right hand, they preferred left hand for writing (12). In this study the prevalence of left-handed MR students was more than that of

typical students. Since the sample of research was from MR population who often have motor delay in fine motor and clumsiness, probably clumsiness in their right hand resulted in preference of left hand for writing, thus the prevalence of left-handed students was more than normal population. So levin's hypothesis is confirmed. Also, Levin hypothesized that left-handedness is not an effective factor on handwriting (12). This study showed that mean scores of handwriting in left-handed students doesn't differ from that of right-handed students. So the levin's second hypothesis is confirmed too. In this research, Spearman rank correlation coefficient showed that there is a significant relationship between handwriting scores and grade.

 Marr and Cermak (2002) found that the handwriting quality is consistent from preschool to first grade in 60% of children (13). However in this research it was seen student·s handwriting is improving during grades consistently, but there is not significant difference between grades. That is, the relationship between handwriting and grade couldn't make difference between grades. So students with HD can't prevail over HD because this problems is seen in higher grades as much as lower grades. This controversy is because of the study of Marr & Cermak evaluated the handwriting consistency from preschool to first grade only, but in this research all grades were considered. There is a short period from preschool to first grade which may not be established considerable changes in student's handwriting. But regarding the age of students in study (9-19 years old), there is the chance of handwriting improvement with growing. Also the study of Marr & Cermak was an longitudinal study which assessed a fixed number of students, but this research was a cross-sectional study. So MR students need to aid and treatment to prevail over HD.

In this study was seen positive correlation between handwriting with 'spacing', and with 'writing on the line'. Graham et al. (1998) found that there is a significant difference between good and poor hand-writer in 'spacing' and 'writing on the line' (7). This results are controversial. Since: first,

Graham et al. studied typical students, but our sample are MR students, second, Spatial analysis (SA) is one item in intelligence tests, third, IQ in MR students is lower than normal students, thus the chance of spatial analysis difficulties is high in MR and SA difficulties is related to HD. Another result of Graham's research is that poor hand-writers have difficulties in size of letters (7). In our research was seen there is power positive relationship between handwriting scores with 'size of whole manuscript' too.

In this study, the least prevalent item was 'spacing' (34.9%) and one of the most prevalent item was 'size of whole manuscript' (77.8%). Graham et al. found that writing little letters is seen repeatedly in poor hand-writer, but they didn't find significant difference between good and poor hand-writer in 'spacing' and ' writing on the guideline' (7). So there is the same results in two studies. The problem with spacing is relatively low in students but keeping normal size in writing is their usual problem.

Conclusion: This research shows that HD is serious in MR students and improvement on them needs to treatment planning.

Proposals. Preparation an suitable instrument is necessary for evaluating student's handwriting. Professionals must do some efforts in this domain. This checklist is a preliminary effort. Finally, to increasing this instrument application, it must be standardized on normal students. A good instrument can enable the therapist to implementation a suitable intervention which is due to exact assessment. Also the therapist can follow up the student's improvement quantitatively by a suitable instrument.

Innovation a computerized instrument for some items is noticeable because the assessment will be more exact. For example, innovation a pencil which shows 'pressure on the pencil' digitally, or an screen which shows 'pressure on the paper' digitally and quantitatively.

References:

http://www.childdevelopmentinfo.com/learning/handwriting.shtml

Tseng, M. H., Cermak, S. A. The Influence of Ergonomic Factors and Perceptual Motor Abilities on Handwriting Performance. American Journal of Occupational Therapy 1993 ; 47: 919-926.

Amundson S. J. Prewriting and Handwriting Skills. In: Case-Smith, J. Occupational therapy for children. Forth edition. USA: Mosby, 2001;545-565.

Amundson, S.J. Handwriting: Evaluation and intervention in school settings. In J. Case-smith & C. Pehoski (Eds). Development of hand skills in the child. Rockville, MD 1992 : American Occupational therapy association.

Alston, J. A legibility index: Can handwriting be measured? Educational Review 1983; 35, 237-242.

Amundson, S.J. Evaluation tool of children's handwriting. Homer, AK 1995; O.T.KIDS, Inc.

Graham, S., Berninger, V., Weintraub, N., Schafer. Development of Handwriting Speed and Legibility in Grades 1-9. The Journal of Educational Research 1998; 92(1): 42-52.

Tseng, M. H., Chow, S. M. Perceptual-Motor Function of School-Age Children With Slow Handwriting Speed. American Journal of Occupational Therapy 2000; 54(1): 83-88.

Egtedari, Z., Investigation of relationship between visual perception skills and handwriting in children with learning disabilities. Thesis for occupational therapy master degree, university of Iran Medical Science, Tehran, 1381.

Seyed mohammad shirazi, R., Investigation of handwriting difficulty and it's relationship with perceptual motor skills in cerebral palsied children who are in preschool and first grade. Thesis for occupational therapy master degree, university of Iran Medical Science, Tehran, 1375.

Graham, S., Harris, K.R. Fink, B. Is handwriting causally related to learning to write? Treatment of handwriting problems in beginning writers. Journal of Educational Psychology 2000; 92: 620-633.

Levine, Kristin Johnson. Fine motor dysfunction. Tucson: Therapy skill builders 1991.

Marr, D., & Cermak, S. Consistency of handwriting in early elementary students. American Journal of occupational therapy 2002; 57: 161-167.