Original

Ambulatory Acquisition of Mentally Retarded Children as Assessed by AIC-Based Method of Discrimination —Severely Retarded Cases without Physical Impairment—

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Abstract: The study was to develop a method of discrimination to predict the ambulatory acquisition of mentally retarded children at the ages of 7, 10 and 13, by combining the Developmental Quotient (DQ) and sideways equilibrium reaction of postural reflexes (SER). Ninety-three subjects, 52 males and 41 females, participated in this study. All subjects were: 1) 10 years of age or older as of March 31, 1991, 2) 18 months of age or above and unable to walk at the first admission interview, 3) without physical impairments. By combining two DQ groups classified at a certain value line and two SER groups, the sample was categorized into four groups. Based on the cross tables of this categorization and the ambulatory capacity, the AIC was computed and the optimum value line that provided the minimum AIC was calculated. Among the SER negative with a DQ of 21 or below, the percentage of ambulatory acquisition was 0%, 1.8%, and 4.3% at ages 7, 10 and 13, respectively. The ambulatory acquisition of the two combined categories, one with a DQ of 21 or below and positive SER and another with a DQ of 22 or above and negative SER, was 42.9%, 81.0%, and 100% at ages 7, 10 and 13, respectively. In the category with a DQ of 22 or above and positive SER, 82.4% acquired ambulatory capacity at age 7 and 100% were walking at ages 10 and 13. This study demonstrated that the DQ and SER were applicable in discriminating the probability of ambulatory acquisition at ages 7, 10 and 13.

Key words: mentally retarded children, ambulatory capacity, developmental quotient, sideways equilibrium reaction of postural reflexes

Introduction

Mentally retarded children are often delayed in developing full ambulatory function compared with normal children even when their intellectual retardation is slight. This delay is a frequent source of anxiety for parents¹⁾. Predicting if and when the child will be able to

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acquire ambulatory capacity will be useful to establish the most desirable treatment and effective living plans.

There have been many studies on the ambulatory capacity of mentally retarded children with motor function delay, who also had physical impairments, especially cerebral palsy²⁻⁶⁾. Yet, there have been only a few studies on mentally retarded children without physical impairment although they are in the majority⁷⁾.

In our previous research⁸⁾, we studied children who were still unable to walk at the age of 18 months. We investigated the discriminatory factors that enabled accurate prediction regarding the possibility of the subjects' ambulatory acquisition at the age of 13. We found that the Developmental Quotient at the first admission interview and the neural reflexes were two effective discriminatory factors. In view of the present educational system in Japan which begins at about age 7, it is not sufficient simply to predict the ambulatory state the child is expected to acquire at the age of 13 to establish effective treatment plans. Development of a method is necessary to enable accurate prediction of the ambulatory state from the age of entrance into an elementary school.

In this study our objective was to develop a method of discrimination to predict ambulatory acquisition at the ages of 7, 10 and 13, combining two contributory factors—Developmental Quotient and sideways equilibrium reaction of postural reflexes—based on the algorithm for the revised program CATDAP-02⁹⁾ for “optimum cross table selection”.

Subjects and Methods

The study subjects were chosen from among the mentally retarded children who visited the Tokyo Metropolitan Rehabilitation Center for the Physically and Mentally Handicapped during and after April 1974, for parental consultation on child-rearing and developmental diagnoses. One of the authors conducted the first admission interview and selected as many as 128 children who met the following four conditions according to their medical records: 1) 10 years of age or older as of March 31, 1991, as specified as the standard date, 2) 18 months of age or above at the time of the first admission interview, 3) unable to walk at the time of the first admission interview, 4) without physical impairments based on the definition of “The Disabled Persons Welfare Law” (such as motor functional disorders including cerebral palsy and muscular dystrophy, or sensory disorders, either visual or acoustic) in addition to their present mental disorder.

The parameters for analysis were limited to the following: Developmental Quotient (DQ) assessment^{8,10)}, the positive or negative sideways equilibrium reaction of postural reflexes¹¹⁾ (SER) at the first admission interview, and the status of ambulatory capacity at the ages of 7 (84 months), 10 (120 months), or 13 (156 months). Other research items were described in our previous report⁸⁾.

To determine DQ at the first admission interview, the developmental age expressed in months (based on the “Intellectual Development Evaluation Table”^{8,10)} of the Tokyo Metropolitan Rehabilitation Center for the Physically and Mentally Handicapped) was divided by a revised monthly age¹²⁾ and multiplied by 100. SER response was checked according to Bleck's technique¹¹⁾. The ambulatory capacity was determined by testing the child's ability to walk five or six steps on level ground unaided. The age of acquisition of this capacity was determined according to the child's medical record, if such records were kept, or otherwise by phone interviews to the child's parents during the 3-month period from April to June 1991. The revised age¹²⁾ was used to indicate the age of ambulatory acquisition.

Of the 128 children identified as meeting the criteria, follow-up to the age of 10 or older was possible in only 93 cases (52 males, 41 females) (the follow-up group); 14 had died (the deceased group) and 21 could not be located due to address changes (the lost-contact group). No significant differences were found in the DQs of these three groups. Compared with the follow-up group, the frequency of negative SER was significantly higher in the deceased group, although no difference was observed in the lost-contact group. The deceased group and the loss-contact group were excluded from the analysis. In studying the ambulatory acquisition at the age of 13, the sample was limited to 77 cases who reached the age of 13 or older at the predetermined standard date.

The average gestation period was 40.0 ± 1.4 weeks. The average age in months at the first admission interview was 45.8 ± 14.9 , range 18–82 months, with 80.6% (75 of 93 cases) before 60 months.

The diagnostic abnormalities were determined soon after birth following close medical examinations at university hospitals, all of which were reconfirmed by the doctors of the Center. The abnormalities were roughly classified as: “unknown prenatal causes” 64 cases, the largest classification; “chromosomal abnormalities” 17 cases; “injuries or other physical causes” 5; “metabolic or nutritional disorders” 3; “infections or toxicosis” 2; “postnatal major brain injuries” 2.

For analysis the subjects were categorized into four groups by combining two DQ groups classified at a certain value line with two SER groups classified by positive-negative differentiation. Using the cross tables of this categorization and the presence or absence of ambulatory capacity at each age level, the Akaike Information Criterion (AIC) was computed based on the CATDAP-02 algorithm for “optimum cross table selection” as revised by Sakamoto⁹⁾, which was revised to process the zero frequency cell as EXP(-1). The AIC was used as it is a superior index for constructing an effective model for a given size of data with the optimum combination of explanatory variables¹³⁾. The value line for DQ classification was increased by each consecutive unit value moving from the minimum through the maximum value. Subsequently, the optimum value line that provided the minimum AIC was obtained. All calculations were done using PC-SAS software.

Results

Subject characteristics

DQ level and the positive or negative SER response are in Table 1. The mean DQ was 19.7 ± 8.4 . Of all the cases, 57.0% were severe with a DQ score of 19 or under. The percentage of ambulatory acquisition at different age levels is indicated in Table 2.

The combination of the optimum DQ classification with the positive-negative SER classification as assessed by AIC

By using AIC, we assessed the possibility of ambulatory acquisition at given ages for each combination of DQ and SER classifications. The lowest AIC was observed at all age levels in the cross table of the positive-negative ambulatory capacity and of the combined category of the two DQ groups, a score of 21 or below and 22 or above, with positive or negative SER. Ambulatory capacity according to the combined categories of DQ and SER at ages 7, 10 and 13 are shown in Tables 3, 4 and 5.

The two categories with the same or very close percentages of ambulatory acquisition at ages 7 and 10 were combined for AIC calculation: the category with DQ scores of 21 or below with positive SER and the category with DQ scores of 22 or above with negative

Table 1. DQ level and SER response of subjects (N=93).

Item	Number of cases	Percentage of sample
DQ level		
–9	10	10.8
–14	14	15.1
–19	29	31.2
–24	19	20.4
–29	10	10.8
–34	6	6.5
–39	3	3.2
40+	2	2.2
SER response		
positive	24	25.8
negative	69	74.2

DQ, Developmental Quotient; SER, sideways equilibrium reaction of postural reflexes.

Table 2 Ambulatory capacity at ages 7, 10 and 13.

Age	Number of cases	No. with ambulatory acquisition	Percentage of sample
7	93	23	24.7
10	93	35	37.6
13	77	33	42.9

Table 3. Ambulatory capacity according to the combined categories of DQ and SER at age 7.

DQ & SER	Number of cases	No. with ambulatory acquisition	Percentage of sample
–21 & negative	55	0	0.0
–21 & positive	7	3	42.9
22+ & negative	14	6	42.9
22+ & positive	17	14	82.4

Akaike Information Criterion (AIC) = –50.12. DQ, Developmental Quotient; SER, sideways equilibrium reaction of postural reflexes.

SER. Thus we obtained even lower AIC scores of –52.12 and –85.51 at ages 7 and 10, respectively. At age 13, for the combined category of one group with positive SER having DQ scores of 21 or under and another group with DQ scores of 22 or above, all of whom are capable of walking, the AIC computation was –83.12.

Discussion

In the authors' clinical experiences, many parents with mentally retarded children have

Table 4. Ambulatory capacity according to the combined categories of DQ and SER at age 10.

DQ & SER	Number of cases	No. with ambulatory acquisition	Percentage of sample
-21 & negative	55	1	1.8
-21 & positive	7	6	85.7
22+ & negative	14	11	78.6
22+ & positive	17	17	100.0

Akaike Information Criterion (AIC) = -83.67. DQ, Developmental Quotient; SER, sideways equilibrium reaction of postural reflexes.

Table 5. Ambulatory capacity according to the combined categories of DQ and SER at age 13.

DQ & SER	Number of cases	No. with ambulatory acquisition	Percentage of sample
-21 & negative	46	2	4.3
-21 & positive	4	4	100.0
22+ & negative	11	11	100.0
22+ & positive	16	16	100.0

Akaike Information Criterion (AIC) = -74.65. DQ, Developmental Quotient; SER, sideways equilibrium reaction of postural reflexes.

requested our opinion about the possibility of ambulatory acquisition and when. This is also evident in the literature¹⁻⁷⁾. This concern is understandable in view of the fact that whether or not the child can walk unaided is a major element in the Activity of Daily Living (ADL) development, which impacts the quality of life of the child as well as the family¹⁴⁾.

The majority of mentally retarded children do not have physical impairments, such as cerebral palsy. In Japan, "The Disabled Persons Welfare Law" ("Shintai Shogaisha Fukushi Ho" in Japanese) recognizes these physical impairments. Very few studies have been done on their ambulatory capacity. One reason can be attributed to the fact that Dr. Illingworth, a noted pediatrician, once pointed out that based on his clinical experiences all mentally retarded children without cerebral palsy would grow up to be able to walk¹⁾. Later, however, many cases were found among the most severely mentally retarded children (with DQs of 20 or under) who failed to acquire ambulatory capacity⁷⁾. These findings necessitated a reexamination of the prediction of the ambulatory capacity of mentally retarded children.

In our previous report⁸⁾, we pointed out that the DQ at the first admission interview and the postural reflex were the two most effective factors in predicting ambulatory acquisition at age 13. This prediction was based on the discrimination method with the sample of mentally retarded children without physical impairments after reviewing the DQ, postural reflex, motor functions, muscular tension, and epilepsy, all of which have been recognized as important components in the study of cerebral palsy.

In the present study, we attempted to establish appropriate living plans for children early in their development. Our specific objective was to develop a simple and accurate method to

discriminate in an early infancy whether or not the child would acquire ambulatory capacity at ages 7, 10, and 13. These ages were chosen due to the age for entering elementary school. This prediction would also be very useful in assessing the effects of physical training^{8,15,16}).

The subjects were chosen from those visiting the Tokyo Metropolitan Rehabilitation Center for the Physically and Mentally Handicapped for parental child-rearing consultations and developmental diagnosis. More than 80% of the sample visited the Center before the age of 5. The average DQ at the first admission interview was 19.7 and the majority were severely mentally retarded children with a DQ score of below 20¹⁷). Most of the previous studies on mentally retarded children have reported that many of the severely mentally retarded children have walking difficulties while those with lesser degrees of intellectual retardation are likely to obtain ambulatory capacity^{1,7,18}). Based on these previous reports it follows that those with lower degrees of intellectual retardation would be the appropriate target for the prediction of ambulatory capacity.

In the present study the analysis was based on the algorithm for the CATDAP-02 program⁹). The AIC computation is done through the following procedures. The DQ scores are classified into two groups at each consecutive division value which is increased by each unit value from the minimum to maximum values. Each child is categorized according to the combination of the individual classified group with the positive or negative SER. The AIC is computed by the cross table of this categorization and the positive-negative ambulatory capacity at each age level. This probing-type analysis led to the optimum classification of the sample at the age levels of 7, 10 and 13 into two groups: one with a DQ of 21 or under and another with a DQ of 22 or over. The combination of these groups and the positive-negative SER response enabled us to discriminate quite accurately the ambulatory capacity at each age level. In other words, a method was developed for the first time to make practical predictions concerning the probability of ambulatory acquisition which is commonly applicable to any age level as a discrimination method of ambulatory acquisition.

Among the negative SER with a DQ score of 21 or below, the percentages of ambulatory acquisition were as small as 0%, 1.8%, and 4.3% at ages 7, 10 and 13, respectively. The ambulatory acquisition of two combined categories, one with a DQ of 21 or below and positive reflex and another with a DQ of 22 or above and negative reflex, was 42.9% and 81.0% at ages 7 and 10, respectively. Thus the percentages of ambulatory acquisition increased in accordance with the increasing age reaching a 100% acquisition rate at age 13. Furthermore, in the category with a DQ of 22 or above and positive reflex, as many as 82.4% acquired the ambulatory capacity as early as the age of 7 and 100% were walking at ages 10 and 13.

Previous studies have pointed out that the age of 13 was the upper limit for ambulatory acquisition⁷). We took this into consideration in proposing the following discrimination method. The method is based on the DQ and SER discrimination by the assessment system adopted in the present study for mentally retarded children without physical impairments who are unable to walk in infancy.

1. For the children with a DQ of 22 or above and positive SER, about 80% will acquire ambulatory capacity at age 7, and nearly 100% will be able to walk by age 10.
2. For the children with a DQ 21 or below and negative SER, there is little or no possibility of ambulatory acquisition in the future.
3. For the children with either a DQ of 22 or above and negative SER or a DQ of 21 or below and positive SER, ambulatory capacity will be acquired in about 40% at age

7, in nearly 80% at age 10 and nearly 100% at age 13.

Dr. Illingworth has previously pointed out that through his clinical experience the level of DQ is an effective predictor of the ambulatory acquisition in mentally retarded children¹⁾. However, we were the first to indicate in our previous report the importance of closely observing the SER. The present study confirms that the SER has much to do with discriminating the probability of ambulatory acquisition. SER is a postural reflex which is indispensable in maintaining the standing position and which develops prior to ambulatory functions. It has been pointed out that the SER is a potential characteristic for ambulatory acquisition¹⁹⁾. The findings of the present study will add much to the clarification of the biological significance of SER in this regard.

Among disabled children with motor development delay, there are not only the mentally retarded or those with cerebral palsy, but also those with visual²⁰⁾ or auditory difficulties. In view of this, the development of a practical method of ambulatory prediction applicable to all types of disabilities is needed. Regarding the algorithm for AIC calculation, two-group divisions were used for DQ differentiation as the number of subjects was limited in this study. With an increasing number of cases, more precise divisions of DQ scores would be possible which, we hope, would enable the development of a discrimination method of increased accuracy.

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References

- 1) Illingworth RS: Delayed motor development. *Pediatr Clin North Am*, **15**: 569–580 (1968)
- 2) Perlstein MA and Hood PN: Infantile spastic hemiplegia. *Am J Ment Defic*, **61**: 534–543 (1957)
- 3) Bleck EE: Locomotor prognosis in cerebral palsy. *Dev Med Child Neurol*, **17**: 18–25 (1975)
- 4) Molnor GE and Gordon SU: Cerebral palsy: predictive value of selected clinical signs for early prognostication of motor function. *Arch Phys Ther*, **57**: 153–158 (1976)
- 5) Badell-Rebera A: Cerebral palsy: Postural-locomotor prognosis in spastic diplegia. *Arch Phys Med Rehabil*, **66**: 614–619 (1985)
- 6) Watt JM, Robertson CMT and Grace MGA: Early prognosis for ambulation of neonatal intensive care survivors with cerebral palsy. *Dev Med Child Neurol*, **31**: 766–773 (1989)
- 7) Donoghue EC, Kirman BH, Bullmore GHL, Laban D and Abbas KA: Some factors affecting age of walking in a mentally retarded population. *Dev Med Child Neurol*, **12**: 781–792 (1970)
- 8) Nakajima K and Nekoda Y: Prediction of ambulation in mentally retarded children without physical impairments. *J Showa Med Assoc*, **52**: 287–298 (1992) (in Japanese)
- 9) Sakamoto Y: Optimum cross table selection by AIC. In: Data Analysis using a Personal Computer, Murakami M and Tamura Y (Eds), Asakura Shoten, Tokyo, Japan, pp 155–166 (1989) (in Japanese)
- 10) Nakajima K and Mori H: Computer application programs concerning predictions of intelligence and adaptive behavioral status of biologically impaired infants. *Bull Tokyo Metro Rehabil Cent Phys Ment Hand*: 1–26 (1987)
- 11) Bleck EE: Orthopaedic Management of Cerebral Palsy. WB Saunders Company, Philadelphia, pp 45–46 (1979)
- 12) Knobloch H and Pasamanick B: Gesell and Amatruda's Developmental Diagnosis. Harper and Row, New York, pp 255–256 (1974)
- 13) Akaike H: Information theory and an extension of the maximum likelihood principle. In: 2nd International Symposium on Information Theory, Petrov BN and Csaki F (Eds), Akademiai Kiado, Budapest, Hungary, pp 267–281 (1973)

- 14) Patric DL and Erickson P: Evaluation of health-related quality of life in clinical judgement. In: Quality of Life Assessment and Application, Walker SR and Rosser RM (Eds), Maruzen Planet Corp, Tokyo, pp 8-42 (1993) (in Japanese) 83
- 15) Simeonsson RJ, Cooper DH and Scheiner AP: A review and analysis of the effectiveness of early intervention programs. *Pediatrics*, **69**: 635-641 (1982)
- 16) Parette HP and Hourcade JJ: How effective are physiotherapeutic programmes with young mentally retarded children who have cerebral palsy? *J Ment Defic Res*, **28**: 167-175 (1984)
- 17) Nakajima K: Intelligence prognosis in profoundly mentally retarded children. *Bull Tokyo Metro Rehabil Cent Phys Ment Hand*: 19-32 (1988)
- 18) Shapiro BK, Accardo PJ and Capute AJ: Factors affecting walking in a profoundly retarded population. *Dev Med Child Neurol*, **21**: 369-373 (1979)
- 19) Molnor GE: Analysis of motor disorder in retarded infants and young children. *Am J Ment Defic*, **83**: 213-222 (1978)
- 20) Adelson E and Friberg S: Gross motor development in infants blind from birth. *Child Dev*, **45**: 114-126 (1974)

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