Validity and Reliability of Gait Assessment with Benesh Movement Notation

— for analysis of the walking of adult hemiplegic patients —

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Abstract We studied the validity and the reliablity, as well as the indications and limitations of Benesh Movement Notation gait assessment with adult hemiplegic patients. We described the use of BMN for analysis of the walking of 20 adult hemiplegic patients, and analyzed the number of BMN deviational signs which we divided into five classifications of walking factors, in addition to factor for limb and trunk.

It was thereby found that:

1. The twenty subjects represented 366 deviational signs that we summarize the performance in terms of standing posture and walking. The Brunnstrom recovery stage (BS) was low with higher numbers of deviational signs, although a significant difference was not observed.
2. For walking factors, the numbers of deviational signs with position/angle factors were significantly higher than many the numbers of deviational signs associated with the other four factor classifications.
3. For walking factors, the numbers of deviation signs increased with low BS, and significant differences were idetified the position/angle and orthosis factor classificatione.

The BMN methods consist mainly of the evaluation of gait deviations from visual assessment of position/angle factors and limb and trunk variables. Our results indicate that the BMN method can be used reliably. It should be possible to develop BMN systems with higher reliability levels so that observational gait assessments can be generally recognized as an objective clinical gait evaluation tool.

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Key Words : Benesh Movement Notation, Observation gait analysis, adult hemiplegic patients, Brunnstrom recovery stage.

Introduction

The purposes of gait assessment are 1) evaluation of pathological deviations and functional disorders, 2) determining appropriate physical therapy programs, 3) verification of the suitability orthosis, and 4) recording the walking state[1].

Recently, the development of tools for measuring gait has preceded consensus on how to best undertake this complicated task. However, these tools are expensive and can not easily incorporated into routine evaluation. Observational gait analysis describes the qualitative approach of gait analysis used by physical thrapists. This approach identifies gait deviations in adult hemiplegic patients from visual observations, and both the identification and the grading of gait deviations depend on the observer's judgments[2),3)]. Although visual assessment of gait is practiced almost daily by many clinicians, no standardized observational gait analysis system is yet in universal use. While specific and systematic gait evaluation forms and scoring systems have been described, clinicians in general use a more individualistic approach. Visual gait assessment is appealing for clinicians given the ease, rapidity, simplicity, and low cost of its use in comparison with instrumental gait analysis systems[3),4),5),6)].

We introduced Benesh Movement Notation(BMN), a method of obser vational gait analysis, and currently use it for gait assessment at our clinic. Ashford reported the use of BMN in clinical work with handicapped children[7)], Atokinson described a

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BMN distance learning package for clinicians[8], and Scott explained the relation between movement study and BMN[9]. However no data on the validity or reliability of BMN has been reported. Many questions have arisen concerning the validity and reliability of the measurements derived from this method.

Consequently, we have been studying the validity and the reliablity, as well as the indications and limitations of BMN gait assessment with adult hemiplegic patients.

Subjects and Methods

Subjects

The subjects in this study were 20 adult hemiplegic patients who were all able to walk. There were 13 males and seven females, aged 37 to 73 years with a mean age of 58.5±11.4 years, four with right hemiplegia and 16 with left hemiplegia. By Brunnstrom recovery Stage (BS), three subjects were in stage Ⅲ, 13 subjects were in stage Ⅳ, and four subjects were in stage Ⅴ.

Methods

We carefully observed the walking of subjects before we represented a number of gait deviational signs by means of BMN. For example, Figure 1 shows representive signs of a normal adult person and a typical subject. This subject exhibited 24 deviation signs. We have designed a gait assessment for adult hemiplegic patients which gives numbers of deviation signs summarizing the performance of standing posture and walking.

We analyzed the numbers of the representive deviational signs using BMN for walking factors categorized as: 1) position / angle factors, 2) temporal factors (% time of swing phase, % time of stance phase, cadence, and speed), 3) distance factors (step length, stride width, and foot

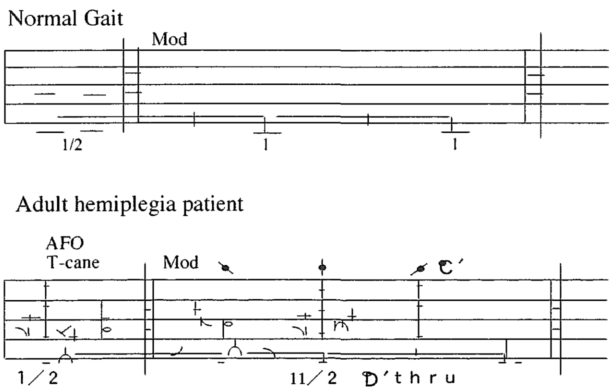

Fig. 1 Subject of deviation signs

deviation), 4) characteristic pattern factors, 5) orthosis and/or cane factor. In addition, the total numbers of deviational signs included analysis of the upper limb factor, the lower limb factor, the trunk factor and a few others.

Statistical analysis used the Wilcoxon test, the Kruskal-Wallis test, and the chi-square test for goodness of fit. The statistical significance level was set at $P<0.05$.

Results

1. The twenty subjects represented 366 deviational signs that summarize their performance during standing posture and walking. When BS compared was to representive deviation signs for each subject, BS was low as deviational signs increased, althougt a significant difference was not observed (Figure 2).

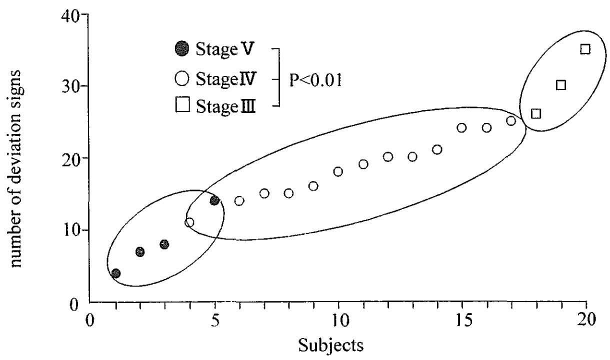

Fig. 2 Total number of deviation signs

2. The order of occurence in the walking factors was position/angle factor (214 signs, 58.5%), temporal factor (46 signs, 12.6%), distance factor (43 signs, 11.7%), characterstic pattern factor (41 signs, 11.2%), and orthosis/ cane factor (22 signs, 6.0%). For factors of limb and trunk, the order was upper limb (158 signs, 43.2%), lower limb (137 signs, 37.2%), trunk (63 signs, 17.2%), and others (8 signs, 2.2%) (Figure 3).

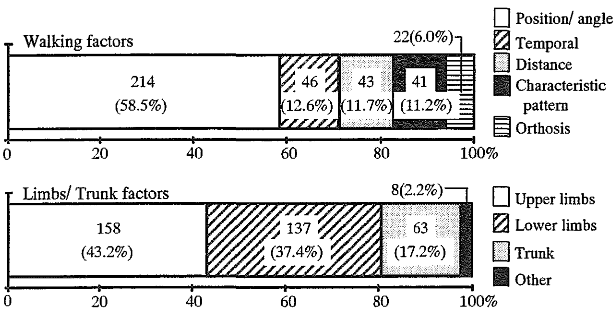

Fig. 3 Content of deviation signs

3. For walking factors, the numbers of deviational signs involving position / angle factors were significantly greater than the numbers of deviational signs for the other classifications. In the limb / trunk factors, there was no significant difference between the numbers of the deviational signs involving the upper and lower limb, but these factors were significant in comparison with other factors (Figure 4).

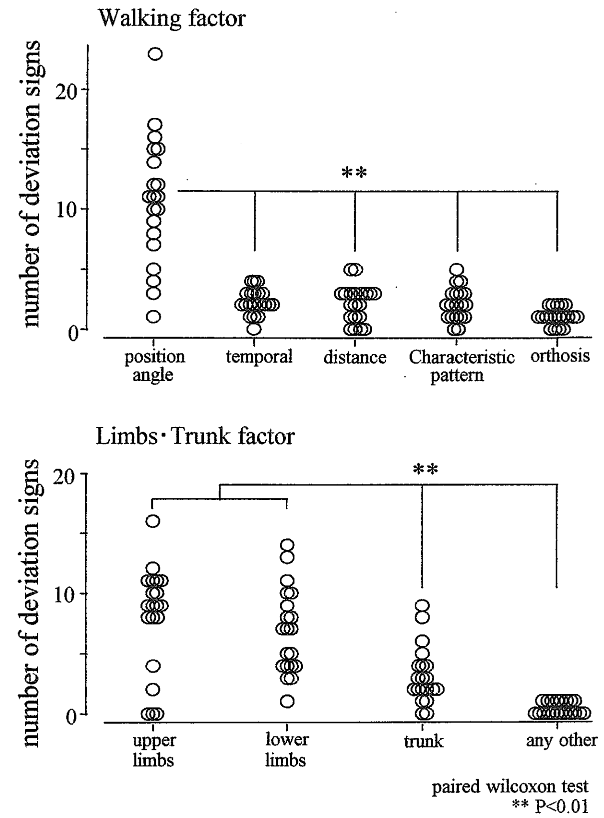

Fig. 4 Compare to signs.

4. For walking factors, the numbers of the deviationl signs increased with low BS and significant differences existed with position / angle and orthosis factors. In the limb/trunk factors, there was a significant difference between the upper limb and trunk factors. Here too, subjects with low BS had higher numbers of deviation signs (Figure 5).
5. When the numbers of the deviational signs were compared to BS, we found that BS was high as position/angle factors decreased, although other factors did not appear to result in substantial change. On the other hand, for the position/ angle factor, the upper limb deviational signs decreased with BS V, and a significant relation with BS was recognized (Table 1).

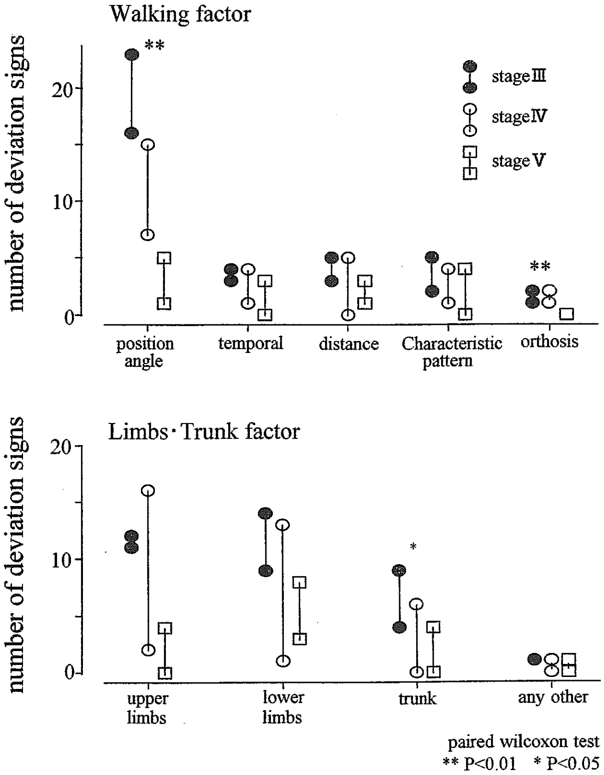

Fig. 5 Compare to Brunnstrom stage.

Table 1 Significant relation and Brunnstrom Stage

Walking factor

Stage	position angle	temporal	distance	Characteristic pattern	orthosis
Ⅲ	56	10	11	9	5
Ⅳ	145	30	24	26	17
Ⅴ	13	6	8	6	0

χ^2=12.4 df=8 not significant

Limbs・Trunk factor

Stage	Upper limbs	Lower limbs	Trunk	Any other
Ⅲ	34	33	21	3
Ⅳ	120	84	34	4
Ⅴ	4	20	8	1

χ^2=20.7 df=6 P<0.01

Discussion

We studied the validity and reliability of gait assessment based on the numbers of BMN deviational signs, expressing the gait of adult hemiplegics able to walk. We obtained a large number of total deviational signs for adult hemiplegic patients after carefully observing their overall walking, including gait pattern, deviational posture of limb and trunk and pathological movement.

Nelson's Functional Ambulation Profile assesses skills from standing balance to independent ambulation[10]. Reimer used a weighting of items determined from experience during a trial period in which the point values were changed to meet practical needs[11]. Wolf gives a functional score corresponding to the time needed to walk over different surfaces, taking into consideration the amount of assistance required[12]. The reliability of these ambulation profiles exemplifies how locomotor skills can be objectively evaluated; they also demonstrate that well standardized procedures can give reproducible measurements[13),14),15),16]. These evaluations provide a global score summing the subject's performance for a series of tests each graded on an ordinal scale, whereas others use variables such as time and distance that provide a measure of the subject's performance on an interval scale[17),18),19].

In our study, for the walking factors, the position/angle factor generated 214 (58.5%) deviation signs. This was the highest number of deviational signs, and was significant compared to the number of deviational signs for other factors. Furthermore, there was not a significant difference in the numbers of deviation signs between upper limb (158, 43.2%), and lower limb (137, 37.4%) in the factors for limb and trunk. We suggest that the deviational signs of position/angle represent an abnormal posture and pathological movement of the upper limb, lower limb, and trunk, which appears to be due to associated movement, with spasticity shown as a spatial position/angle change. BMN is a potentially excellent method for the expression of changed position/angle, and can be used to address quantitative problems given numbers of deviational signs.

When we compared the number of deviational signs to BS, we found that deviational signs of the position/angle factor increased with lower BS, and a significant difference existed in comparison with other walking factors. The same phenomenon was observed in relation to deviational signs the upper limb and trunk. In addition, This is aslo reflected in the total numbers of deviational signs. These results indicate that spatial position/angle deviation of in the upper limb and trunk were often represented when BS was low, as summing that this decreases quantitatively with functional improvement. However, there were no significant relations between other numbers of walking factor deviational signs and BS. Without a significant difference being observed by BS, it is conceivable that other walking factors have the same problem, i,e, supported activity of the lower limb on the affected side and other gait patterns. On the other hand, when numbers of limb/trunk factor were compared to BS, the number of deviational signs for upper limb decreased remarkably with higher BS and there was a significant relation.

The ease with which gait deviations can be detected depends on the degree of impairment and resulting level of disability. Gait deviations may be more obvious and easier to detect and to grade in a spastic adult hemiplegic patient with a circumduction-like gait pattern of spatial position/angle deviation in the upper limb and trunk than with other factors.

Accordingly, the number of lower limb deviational signs with position/angle factors increased relatively, and the corresponding number for upper limb decreased. It is conceivable that the lower limb can have various problems even if BS is high, reflecting various walking factors. When a characteristic phenomenon is not obviously demonstrated in the upper limb, it is difficult to observe upper limb deviational signs with the BMN method. The degree of attention of the observer can easily affect the results. Perry suggested that the evaluator place more emphasis on learning to observe the ankle, knee, and hip, since most significant motions occur at these joints[3]. The findings were interpreted as total limb function by summing the gait deviations that occur in each gait phase.

As reported above, discussion of gait assessment variables in BMN has often been based on the adult hemiplegic patients studied or methodological concerns. The selection of variables is one of the many aspects that needs to be addressed for the standardization of BMN for universal use.

The BMN methods consist mainly of the evaluation of gait deviations from the visual assessment of position/angle factors and limb and trunk variables. Most importantly, clinicians must be aware that there is a discrepancy between their self-assessment of gait analysis capabilities and their actual ability. The results of our study clearly indicate that to be recognized as a useful method of evaluation, the reliability level of BMN assessments must be improved. If we consider the overall reliability of BMN, current visual assessment of gait is at best moderately reliable.

Among the many factors with the potential of improving the reproducibility of visual assessments are standardization of rater training, better knowledge of normal, well-developed operational definitions, and a simple scoring system. The establishment of better standards for data collection and analysis should also improve the reliability of the observational process. Validity studies designed to determine a reasonable threshold of visual detection of gait deviations are needed in order to develop more appropriate BMN systems and scoring methods. It should be possible to develop BMN systems with high reliability levels so that observational gait assessments can be recognized as an objective clinical gait evaluation tool.

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ベーネッシュ運動記載法を用いた歩行評価

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要　旨　本研究の目的は，ベーネシュ運動記載法を用いた成人片麻痺患者の歩行分析評価の妥当性と信頼性ついての検討である．20例の脳卒中片麻痺患者の歩行を記載し，５つの歩行因子，及び四肢・体幹の要素の記号数を求め，分析した．その結果，歩行因子では位置・角度因子の記号数が他の因子の記号数に比べ有意に多く，四肢・体幹の要素では上肢と下肢の記号数に有意差はなかった．また，Brunnstrom stage が低いほど位置・角度因子や上肢，体幹の記号数が有意に多く，それを反映し記号総数も多かった．以上の結果からＢＭＮの歩行評価の適応とその妥当性と信頼性が認められた．このように観察歩行評価としてのＢＭＮは，有効な客観的臨床歩行評価の方法と認められる．

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