The Use of Predictive Factors in Stroke Rehabilitation

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Abstract

Empirical and clinical predictive factors are measures that can be used to aid in the prognosis of rehabilitation outcomes. It is important for orthoptists to be aware of the background of these factors when assessing patients for rehabilitation. An extensive review of 54 papers on the topic revealed that although predictors can aid clinical decision making, they cannot currently be used exclusively without clinical considerations. An explanation of the most common predictors is included to help clinicians make decisions about their patients' ocular health with their general prognosis in mind.

Key Words:
Prognosis, cerebro-vascular accident, incontinence, training.

Introduction

Factors ranging from continence to cognition have the potential to predict rehabilitation outcomes in stroke survivors. Good prediction of outcomes can be useful for orthoptists when setting treatment goals, calculating clinic budgets, counselling patients or in justifying treatment options. Negative predictors indicate a poor prognosis for rehabilitation, which may be reflected in a longer length of rehabilitation, worse discharge destination (institution rather than home), poor ambulatory status or low scores on functional ability tests. Positive factors indicate better outcomes.

Following the scrutiny of 54 papers concerning predictive factors in stroke rehabilitation, spanning the last 40 years, this review comments on the past and present state of these factors. Their development, limitations and uses are outlined.

Early Predictors

Although research written before the 1970s did contribute significantly to the current body of knowledge about predictors, it was usually substandard in the area of data analysis and design[1]. That literature is now mainly of historical significance, as the data is not comparable due to the anecdotal nature of the papers. Despite large group numbers and adequate information, the research often degenerated into the authors' intuitive feeling about which were the best predictors.

The historical review[2-6] found that at the end of the 1960s, the most common predictors were: bladder incontinence, age, onset-admission interval, mobility status, blood pressure and place of rehabilitation. The proceeding sections follow the fate of some of these factors to discover how they stood up to more rigorous investigation. Several new factors have emerged and they will also be examined. The predictors at the beginning of the discussion have the most support in the literature and those towards the end have the least (see Table 1.).

Bladder Incontinence

Pre 1970s literature supported bladder incontinence as a useful predictor[2,3,6] and this

review has found bladder incontinence to be the most popular predictor with 15 studies[7-21] finding it had predictive value and none disputing this value. One paper[21] revealed initial urinary incontinence to be the second most powerful predictor in the study, with a negative correlation of 0.45 with Barthel ADL (Activities of Daily Living) scores at six months after the stroke. This may have been a biased sample however, as the study lost half its original 162 subjects to death or follow up. Barer's 1989 study[9] had a more representative distribution[15,16], with only 27% of the 363 patients dying in six months and also proved incontinence to be a powerful predictor.

Similarly, Oczkowski and Barreca[19] found that continence had good predictive value for subjects being discharged home, however their use of medians as predictors made the results difficult to compare with other studies or to be used clinically. In contrast, the classification tree of Falconer and co workers[12] is impressive in its simplicity. This tree uses four variables to predict 88% of favourable outcomes, but only needs the first two, toilet management and bladder management to predict 80% of favourable outcomes and 68% of unfavourable outcomes.

Reasons cited for the good predictive ability of bladder incontinence have included non-causative factors such as association with organic medical changes, poor motivation, emotional problems and difficulties in transportation and management.[6] However, Barer[9] was unconvinced about this non-causative hypothesis and contended that lack of awareness due to apathy and urgency of micturition due to bladder instability, were the major problems in stroke patients. Borrie and co workers[11] asserted that inability to communicate the need to urinate, due to dysphasia, was the major cause.

Motor Function

The early work of Bourestom[3] and others[2] first sparked interest in the analysis of motor function as a predictor. As this area is not as clearly defined as age or urinary incontinence, there have been a variety of measures of motor function cited in the literature, creating confusion as to which actually work as predictors. The most obvious sign of motor dysfunction in stroke survivors is the degree of hemiparesis.[22] Feigenson and co workers[13] discovered that although only 74% of subjects with severe hemiparesis on admission were discharged home, 86% of those with mild or moderate weakness returned home. Hemiparesis combined with the presence of homonymous hemianopia has proved to be a strong predictor,[13,23-25] possibly because it infers a larger lesion.[25] Olsen[26] found Barthel

Predictor	For	Against
bladder incontinence	15 [7-21]	0
motor function	8 [10,13,22-27]	0
age	11 [10,15,16,19,21,23,25,28-31]	3 [7,8,32]
ADL score	6 [19,20,29,35-37]	2 [15,29]
perceptual disorder	7 [7,10,13,16,22,29,43]	1 [19]
cognition	5 [13,38-41]	1 [19]
cortical damage	4 [47-50]	1 [51]
onset admission interval	5 [7,13]	3 [19,21,31]
social factors	3 [15,29,30]	2 [15,52]

Table 1. *Most popular predictors and the number of research papers supporting them.*

ADL scores were slightly better predictors of rehabilitation outcome, but the ease of measurement of hemiparesis favoured its use. Upper limb mobility has also been found to have predictive value,[10,27] as has postural control on admission.[19,27]

Although mobility has strong support as a predictor, and few detractors, its value is limited by the varied methods of measurement.

Age

Age was a popular predictor in early literature,[4,5] although not all agreed.[2] More recent studies[21,28] have found that older patients were less likely to have a high Barthel ADL score on completion of rehabilitation. Further studies, using place of discharge as an outcome measure, found older people less likely to be discharged home than younger people1.[9,28,29] However, Lehmann and co workers[29] did find this related to the availability of family support. Age has also been a useful multivariate factor in predictive equations[10,23,30] and further support for age as a predictor has come from Haerer[25] and others.[15,16,31]

Not all studies, found age had predictive value[7,8,32] although Anderson and associates[7] suggested that age may have been excluded from their study due to its high correlation with a stronger predictor, as it was in Bourestom's study.[3]

Regarding the reason for its predictive ability, Oczkowski and Barreca[19] asserted that age was linked to co morbidity, which resulted in worse outcomes, however they provided no evidence. In contrast, Kalra[28] went to great lengths to determine whether it was co morbidity or another factor that made age a negative predictor. He found that although subjects over 75 years old had a higher incidence of degenerative disabilities, deficits due to the present stroke and the initial Barthel ADL scores were comparable with their younger counterparts. Shah et al[30] similarly found that the effect of age on outcome was independent of other factors.

ADL Scores

Activities of daily living (ADL) indices score the ability of patients to care for themselves physically.[33] These scores are used in rehabilitation fields to diagnose, gauge improvement and predict outcomes. Most commonly used is the Barthel ADL Index, a taxonomy of functional activities in the areas of self care, bowel and bladder sphincter control and mobility.[34] This score therefore encompasses many of the predictive factors that have been previously studied and gives them equal weighting.

Wade and co workers[21] claim to have been the first to relate ADL ability after rehabilitation with initial data, however this was investigated 16 years earlier by Bourestom.[3] Their research[21] showed high correlation ($r = 0.48$) between Barthel ADL scores on initial assessment and six months after stroke. Granger et al[35] found that a Barthel score of 60 was pivotal in predicting independence. Initial Barthel scores have also been found to be the most powerful factors in several predictive equations.[30,36] Another commonly used ADL score the Functional Independence Measure, was found by Oczkowski and Barreca[19] to be the most powerful of the factors they used to predict location of discharge after stroke rehabilitation, and others[37] have also found it had good predictive ability. In contrast, neither Lehmann and associates,[29] nor Jimenez and Morgan[15] found predictive value in ADL scores at admission.

Associated Neurological Deficits

In 1977, Feigenson and co workers[13] found perceptual function (neglect, denial, apraxia), cognitive function and motivation to be such strong predictors that they concluded that these were the "only" predictors and that all others were superfluous. Unfortunately, although this was a large, well-implemented study, percentages were used to compare outcomes and the researchers used personal judgement in deciding whether these factors were clinically significant, with no account of statistical significance. Although not making such presumptuous statements, other more reliable studies[38-41] have agreed that cognition is a well correlated predictor, although this has been disputed.[19] Problems in comparing studies or using these factors clinically arise because cognition must be measured in different ways to accommodate its various components.

Perceptual disorders also have support as predictors, however whether they have a causative role or are merely an indication of severity of function is contentious.[42] Stern et al[43] showed that hemisensory losses were found predominantly in patients with poor functional outcomes but used three unrepresentative tests. Anderson and co workers[7] included perceptual disorders in their list of predictors but did not indicate which perceptual disorders they assessed. Kaplan and Hier[22] found a significant correlation between perceptual tasks scores and self care status on discharge. Lehmann and co workers[29] and Lincoln and co workers,[16] used the Weschler neuropsychological tests to analyse perceptual factors as predictors and found good correlation, although Lehmann and co workers[29] did not state follow-up times. This is relevant as Barer and Mitchell[10] found perceptual factors had predictive value three months after hospital admission, but not after six months. Oczowski and Barecca,[19] did not find perceptual factors to be predictors at any time.

Amount of Cortical Damage

The relationship between the extent of cortical damage secondary to stroke, and the functional losses related to that damage was previously thought to be very strong,[44] however the work of Vygotsky and Luria have shown that this is not necessarily the case.[44-46] Recent technological advances have allowed this area to be more thoroughly investigated, in particular with computerised tomography. This was first used in attempting to predict rehabilitation outcomes in stroke patients by Miller and Miyamoto in 1979,[47] who found that those with large superficial lesions had a 50% chance of a good outcome, whereas those with deep lesions, showed a 25% chance of a good outcome. They did not find any outcome changes when the damage was in different areas. Consequently, others[48,49] have investigated the prognostic value of cortical damage by comparing it with Barthel ADL scores in patients undergoing stroke rehabilitation. They found that although size of lesion had predictive value it was not as powerful as initial Barthel ADL scores. Using a four point scale to categorise cortical damage due to stroke, a 1988 study[50] found that those with less damage had a greater chance of going home, although all groups, except those with bihemispheric damage, improved after rehabilitation.

Research by Henley, Petit, Todd-Pokropek and Tupper[51] disputed these claims, finding no significant correlation between outcome and size of the lesion.

Onset Admission Interval

This was one of the first factors advocated for its predictive ability[3-5], and it continues to be investigated, possibly because it is nearly always an easily calculated variable. However, although some researchers[7,13] contend that an increased time

interval between stroke onset and rehabilitation initiation is a negative predictor of good outcome, others[19,21,31] have found no correlation, possibly because what is actually happening is natural recovery.[18]

Social Factors

This is an area where results vary depending on the definition of successful outcome. Although research has shown[15,29,30] that subjects with maximal family involvement were more likely to be discharged home, others[15,52] have found that those with more family involvement had less functional improvement. This is possibly because those returning home need family help if they are not totally independent,[29] but the patients feel overprotected and lose motivation in their rehabilitation when they have too much family involvement.[52]

How are Predictors Devised and Implemented?

Methods for calculating and implementing predictors have varied widely, from simple correlations to clinical decision trees and even quadratic equations.

In the search for an objective method of prediction, Bruell and Simon[5] chose three factors that they as clinicians thought might be useful predictors and then divided those patients with good and bad rehabilitation outcomes. They found, using averages, that the three factors had a statistically significant correlation with rehabilitation outcome, making them useful as predictors. The original measures were then reduced with T-score transformations to a common scale with a mean of 50 and a standard deviation of 10. By adding and averaging these T -scores, three two-factor measures and one three-factor measure were obtained.

Instead of fractions of T-scores, Bourestom[3] used correlation coefficients which form the basis of many later attempts to calculate predictors.[7,22,26,36] These predictors were then used to estimate improvement in ADL scores. The study took a multivariate approach similar to that of Bruell and Simon,[5] but they also did a regression analysis in order to find the most powerful predictors from a field of twelve. Their criterion was that the factor not only had a high correlation coefficient but that it also did not correlate strongly with more powerful factors. Therefore, although age and locomotion status had high correlations, they were excluded as they correlated well with the more powerful ADL scores.

Another popular method has involved using ADL scores themselves as predictors. Shah et al[30] used the Barthel ADL index to develop a quadratic equation that explained 8% more variance than a simple regression equation. Oczkowski and Barreca[19] used the Functional Independence Measure, in a study of 113 stroke survivors and developed a table of likelihood ratios that predicted the probability of discharge home which was based on the average probability of discharge home being 73%.

In 1994, Falconer and co workers,[12] designed a classification tree for simple clinical use. To generate it, they first identified 51 possible predictor variables and measured them in 225 stroke survivors, plus whether the subjects had good or poor rehabilitation outcomes. Computer analysis then identified the predictor that best separated favourable and unfavourable outcomes into two subgroups. These subgroups were also split until a large tree was grown that included all the predictor variables. The tree was then reduced so that it included only the best predictors, because too many predictors increased the chance of error. To determine outcomes, the clinician follows different branches of the tree, based on the patient's characteristics, until the end of a branch is reached and a favourable or unfavourable result is forecast. This tree correctly predicted 88% of the cases with an 18% error rate.

Uses of Predictors

After 40 years of studying predictors, it appears odd that even the most powerful ones are not in common usage. The problem appears to have occurred due to poor statistical analysis, use of different outcome measures and lack of cross validation.[18,53] Researchers are still stressing the same point that was made 30 years ago,[3] that more objective criteria are needed to predict rehabilitation outcomes.[54] In addition, some researchers have contended that predictive factors are not powerful enough to determine an individual's progress and are only useful in large group analyses.[8,10,15,17] Nevertheless, the use of predictors is becoming increasingly popular and proposed uses are numerous.

The most common suggestions for using predictors usually concern efficient use of resources, including the evaluation of the effectiveness and the cost of rehabilitation.[12,30] This is important due to financial constraints and long waiting lists.[19,27] Osberg and co workers,[32]

investigated this area in 1990, when they used retrospective data on stroke patients to determine which groups used the most resources with the least improvements. They found that a small group of patients who do not improve with rehabilitation consume a disproportionate share of inpatient rehabilitation resources. However, as Wade[55] discussed, data collection itself takes resources.

Predictors have been advocated as an aid in the planning of services and in identifying those who will most benefit from rehabilitation.[4,28,30,37,39,40] In selecting appropriate patients for referral, Boyle & Schalzitti[4] suggested only providing rehabilitation to those patients under 60 years old for the first month and then to the one month survivors in the older group. However, the study by Feigenson and co workers,[56] found that excluding negative predictors did not result in better rehabilitation outcomes, partly because their exclusion methods were not good enough. Barer and Mitchell[10] compared multiple and single variable predictors, and found that although multivariate formulas did predict significantly better, this difference was irrelevant clinically. They advocated the use of a few clinical signs such as consciousness level, arm function and continence to make clinical judgements.

A less dramatic form of rehabilitation program planning may involve using the prediction of a patient's discharge destination to direct the focus of their training.[37] This strategy would be particularly relevant for assessment of ocular function and subsequent visual rehabilitation. Patients predicted to be discharged to a nursing home for example, would have visual rehabilitation as a low priority compared to transfers and bladder control. In contrast, a patient discharged to their home, may have a need for an intensive period of visual rehabilitation, especially if treatment after discharge is inconvenient.

Predictors may also have a psycho-social use. They can be used to help allocate support and counselling for those patients and their families with unfavourable prognoses.[57] They also allow clinicians to gauge the risk associated with any proposed treatment.[21] Additionally, predictors suggest direction for research, with strong negative predictors often targeted for extra treatment or further study.[17]

Conclusion

Although they have not been developed to the stage where they are useful as the sole guide for determining rehabilitation potential, predictive factors can be a valuable tool for the orthoptist working with patients who have survived stroke. They allow estimation of a rehabilitation time frame to help set goals and assist the orthoptist in catering to the visual needs of their patients. Experienced clinicians would already employ these judgements informally, however this is not a readily transferable skill, and clinicians inexperienced in this area should particularly benefit from some basic guidelines based on solid research.

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