■ ORIGINAL ARTICLE

Fall-predictive factors and calculation of probability of falls based on 'Assessment Score Sheet of Falls'

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ABSTRACT: We investigated the calculation of probability of falls by identifying the fall-associated items in the 'Assessment Score Sheet of Falls' and the weight level of each fall-predictive factor in the prediction. Regarding the data of 1153 subjects evaluated employing the Assessment Score Sheet of Falls as input variables and the presence or absence of falls as a target variable, a 'Neural Network' was constructed (SET software Neuralworks Predict ver. 3.23), and fall-predictive factors were identified. The weights and transfer functions of the predictive factors were derived from the constructed Neural Network, and equations to calculate the probability of falls were established. Eight of the items of the Assessment Score Sheet of Falls were found to be fall-predictive factors: 'paralysis and numbness', 'bone and joint abnormalities (contracture and deformity)', 'necessity of assistance to movement', 'light-headedness', 'disorientation, clouding of consciousness, and confusion', 'restless behavior', 'use of sleep stabilizer', and 'necessity of toilet assistance'. We prepared equations to predict the probability of falls from the weight and transfer function of each predictive factor employing the Neural Network.
Key words: Fall-predictive factors, calculation of probability, Assessment Score Sheet of Falls

INTRODUCTION

To prevent fall accidents, it is important to identify risks beforehand. Our hospital periodically assesses fall risks of inpatients employing the Assessment Score Sheet of Falls established by the Japanese Nursing Association (Fig. 1)[1)]. However, the assessment results suggested that rough detection of fall risks by simple calculation of the score by this method only clarifies a tendency of falls, and the risk assessment is not fully utilized.

We investigated the calculation of probability of falls by identifying the fall-associated items in the Assessment Score Sheet of Falls and the weight level of each fall-predictive factor in the prediction.

Assessment Score Sheet of Falls

Classification	Characteristics	Score	Patient's evaluation		
			／	／	／
A. Age	Over 70 years or under 9 years	2			
B. Gender	Male	1			
C. Past medical history	Experience of fall Experience of syncope	2			
D. Sensation	Visual disorder	1			
E. Functional disorder	Paralysis or numbness Bone or joint abnormality (contracture, deformity)	3			
F. Activity	Leg and muscle weakness Use of a wheelchair, cane, or walker Necessity of assistance for movement Light headedness Bedridden condition	3			
G. Cognitive function	Disorientation, clouded consciousness, or confusion Dementia Reduced ability to make a judgment and understand Restless behavior Reduced memorizing ability and difficulty in learning	4			
H. Drugs	☐ Analgesic ☐ Narcotic ☐ Sleep stabilizer ☐ Antiparkinsonism ☐ Hypotensive diuretic ☐ Enema/laxative ☐ Chemotherapy	1 each			
I. Excretion	☐ Urinary or fecal incontinence ☐ Frequent urination ☐ Necessity of toilet assistance ☐ Urethral catheter placement ☐ Use of toilet at night ☐ Distant location of toilet	2 each			
Note		Total			
		Risk level			

* Scores by category are given to A to G, and by the number of checked items to H and I.

Risk level and total score

Risk level I (0-5 points): Falls may occur.

Risk level II (6-15 points): Falls are likely to occur.

Risk level III (16 or higher points): Falls frequently occur.

Fig. 1 Assessment Score Sheet of Falls

SUBJECTS

The subjects were 1,153 inpatients of our hospital between June 2007 and March 2009. There were 509 males and 644 females aged 36-103 years (mean ± standard deviation: 80.5±9.1 years).

METHODS

Regarding the data of the 1,153 patients on the Assessment Score Sheet of Falls as input variables and the presence or absence of falls as a target variable, a 'Neural Network' was constructed (SET software Neuralworks

Predict ver. 3.23), and fall-predictive factors were identified. The weights and transfer functions of the predictive factors were derived from the constructed Neural Network, and equations to calculate the probability of falls were established.

Consent to this study was obtained from the subjects, and the study was approved by the Research Ethics Committee of Shibata Hospital.

RESULTS

Eight of the items of the Assessment Score Sheet of Falls were identified as fall-predictive factors by the Neural Network constructed regarding the results of the assessment sheet as input variables and the presence or absence of falls as a target variable: 'paralysis and numbness', 'bone and joint abnormalities (contracture and deformity)', 'necessity of assistance to movement', 'light-headedness', 'disorientation, clouding of consciousness, and confusion', 'restless behavior', 'use of sleep stabilizer', and 'necessity of toilet assistance'. The correlation coefficient and coefficient of determination between these items and the prediction of falls were 0.88 and 0.77, respectively.

The weights and transfer functions of the fall-predictive factors in the prediction of falls on the Neural Network are shown in Table 1. Based on these, the following equations to calculate the probability of falls were prepared:

h1= -0.18 + 0.14 x (paralysis and numbness) + 0.37 x (bone and joint abnormalities (contracture and deformity)) + 0.51 x (necessity of assistance to movement) + 0.98 x (light-headedness) + 0.12 x (disorientation, clouding of consciousness, and confusion) + 0.03 x (restless behavior) + 0.13 x (use of sleep stabilizer) + 0.19 x (necessity of toilet assistance)

h2= 0.07 + 0.16 x (paralysis and numbness) + 0.08 x (bone and joint abnormalities (contracture and deformity)) + 0.26 x (necessity of assistance to movement) + 0.54 x (light-headedness) + 0.14 x (disorientation, clouding of consciousness, and confusion) + 0.03 x (restless behavior) + 0.04 x (use of sleep stabilizer) + 0.03 x (necessity of toilet assistance)

h3= -2.03 + 0.78 x (paralysis and numbness) + 0.95 x (bone and joint abnormalities (contracture and deformity)) + 0.50 x (necessity of assistance to movement) + 0.43 x (light-headedness) + 2.98 x (disorientation, clouding of consciousness, and confusion) + 1.98 x (restless behavior) + 3.40 x (use of sleep stabilizer) + 0.12 x (necessity of toilet assistance) + 2.98 x tanh"h1" + 0.14 x tanh"h2"

h4= 0.49 + 0.18 x (paralysis and numbness) + 0.11 x (bone and joint abnormalities (contracture and deformity)) + 0.04 x (necessity of assistance to movement) + 0.31 x (light-headedness) + 0.99 x (disorientation, clouding of consciousness, and confusion) + 0.31 x (restless behavior) + 1.00 x (use of sleep stabilizer) + 0.16 x (necessity of toilet assistance) + 1.03 x tanh"h1" + 2.38 x tanh"h2"

out= -0.85 + 0.13 x (paralysis and numbness) + 1.08 x (bone and joint abnormalities (contracture and deformity)) + 0.26 x (necessity of assistance to movement) + 0.38 x (light-headedness) + 0.36 x (disorientation, clouding of consciousness, and confusion) + 0.70 x (restless behavior) + 0.43 x (use of sleep stabilizer) + 0.43 x (necessity of toilet assistance) + 0.54 x tanh"h1" + 0.84 x tanh"h2" - 0.55 x tanh"3" + 0.87 x tanh"h4"

One and 0 were given to 'yes' and 'no' of each fall-predictive factor in the equations, respectively.

Table 1　Weights and transfer functions of fall-predictive factors

		Correction	Paralysis or numbness	Bone or joint abnormality (contracture, deformity)	Necessity of assistance for movement	Light headedness	Disorientation, clouded consciousness, or confusion	Restless behavior	Use of sleep stabilizer	Necessity of toilet assistance	h1	h2	h3	h4
h1	Weight	-0.18	0.14	0.37	0.51	0.98	0.12	0.03	0.13	0.19	—	—	—	—
	Transfer function	linear	linear	linear	linear	linear	linear	linear	linear	linear	—	—	—	—
h2	Weight	0.07	0.16	0.08	0.26	0.54	0.14	0.03	0.04	0.03	—	—	—	—
	Transfer function	linear	linear	linear	linear	linear	linear	linear	linear	linear	—	—	—	—
h3	Weight	-2.03	0.78	0.95	0.50	0.43	2.98	1.98	3.40	0.12	2.98	0.14	—	—
	Transfer function	linear	linear	linear	linear	linear	linear	linear	linear	linear	tanh	tanh	—	—
h4	Weight	0.49	0.18	0.11	0.04	0.31	0.99	0.31	1.00	0.16	1.03	2.38	—	—
	Transfer function	linear	linear	linear	linear	linear	linear	linear	linear	linear	tanh	tanh	—	—
out	Weight	-0.85	0.13	1.08	0.26	0.38	0.36	0.70	0.43	0.43	0.54	0.84	0.55	0.87
	Transfer function	linear	linear	linear	linear	linear	linear	linear	linear	linear	tanh	tanh	tanh	tanh

Revised Assessment Score Sheet of Falls

Classification	Characteristics	Score	Patient's evaluation			
			／	／	／	／
Functional disorder	Paralysis or numbness	1				
	Bone or joint abnormality (contracture, deformity)	1				
Activity	Necessity of assistance for movement	1				
	Light headedness	1				
Cognitive function	Disorientation, clouded consciousness, or confusion	1				
	Restless behavior	1				
Drugs	Sleep stabilizer	1				
Excretion	Necessity of toilet assistance	1				
Note		Total				
		Probability of falls				

Fig. 2　Revised Assessment Score Sheet of Falls

DISCUSSION

When one or more of the 8 fall-predictive factors were met, the risk of falls corresponding to the positive factors was calculated as a percentage. The percentage may change depending on the combination of the factors. A contradiction was found in the Assessment Score Sheet of Falls: the risk increases as the number of items met increases, even if the item is not included in the identified fall-predictive factors, and the determined risk level is very rough, as shown in Fig. 1. In contrast, the prepared equations calculate probability of falls by adopting the results of the 8 items as fall-predictive factors and adding the weights of the factors. Since the probability of falls is presented as a numerical value, the risk level can be clearly understood. In addition, we revised the Assessment Score Sheet of Falls reflecting the fall-predictive factors and equations (Fig. 2) on spreadsheet software, which facilitated storing assessment results, instantly performing the probability calculation, and tracing changes with time, leading to timely identification of risks and raising caution.

Fall accidents may cause fracture and subsequently reduce movement ability, change lifestyles and places of living activities, markedly reduce their quality of life, and in the worst case, it may be fatal. Thus, concrete measures to prevent falls are necessary[2-5]. Fall accidents occur in a state in which factors, such as physical diseases, drug treatment, and aging, as well as the environment, are associated in a complex way. Effects of muscle and balance training provided by therapists and physical environment improvement have been reported[6,7], showing the importance of rehabilitation to prevent falls. Greater involvement of rehabilitation medicine in the fall-preventive measures and plan is needed.

The equations to calculate the fall probability and the revised Assessment Score Sheet of Falls reflecting the equations cannot be verified until fall accidents occur because comparison of the predicted values with actual incidences is necessary. Since the equations and the revised sheet were prepared to prevent falls, it is necessary to take sufficient prevent p ive measures based on the rediction. When fall accidents occur despite measures being taken, we will compare their data with the outcomes of the equations and the revised sheet for their verification.

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