Decrease in Timed Balance Test Scores with Aging

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This study investigated whether 184 volunteers from 20 to 79 years of age could perform eight timed balance tests and examined the relationship between test performance and age. All subjects were able to balance with their feet together and eyes closed for 30 seconds. The ability to balance on the right and left legs did not differ significantly. Subjects over 60 years of age were unable to balance on one leg, particularly when their eyes were closed, for as long a period as younger subjects. The Pearson product-moment and Spearman correlations of age and duration of one-legged balance were −.65 and −.71 (eyes opened) and −.79 and −.75 (eyes closed). The findings suggest that when timed balance tests are performed as a part of a patient's neurologic examination, the results should be interpreted in light of the patient's age. Information is provided to assist in this interpretation.

Key Words: *Age factors, Kinesthesis, Leg, Physical therapy.*

Although tests of standing balance are frequently included in neurological evaluations, few objective data are available to indicate how well individuals of different ages should be able to maintain standing balance. Even balance tests, for which maximum timed end points (5–75 sec) are established, do not specifically support the clinical appropriateness of the end points or support with objective data their descriptions of changes in the capacity of older individuals to perform timed balance tests.[1-6] For example, Potvin and Tourtellotte claimed that all young adult, healthy subjects can balance on one leg for 30 seconds with eyes closed, but they offered no data to support their claim.[5] Routinely, timed balance tests require individuals to balance under one or more of the following conditions: eyes opened or closed, feet together or apart, or on one leg.[7-9] More complex tests such as quantitative Romberg tests, which use force platforms or other instruments to test the amplitude of sway of standing subjects, have objectively demonstrated a relationship between age and sway; sway increases after the age of 40 years.[7,10,11] The cost, complexity, and size of the instrumentation required for these tests, however, makes them impractical for general application. Furthermore, tests of amplitude of sway and timed tests of balance may assess a different phenomenon.

Clearly, if clinicians are to use balance tests as a part of neurological evaluations, they need tests that are objective and for which age-related data are available. The purpose of this study was twofold: 1) to establish the relationship between performance on timed balance tests and age and 2) to provide data for use in clinical assessments of patients from 20 to 79 years of age. Like sway, performance on timed balance tests was expected to be significantly correlated with age.

METHOD

Subjects

The subjects were 184 male and female volunteers who participated with informed consent in this study, which was approved by the Institutional Review Committee of the University of Illinois. The volunteers were between 20 and 79 years of age with 30 or more volunteers in each decade of age (Tab. 1). All subjects were able to follow instructions. Only individuals who reported no vertigo and no neurologic or orthopedic dysfunction of the trunk and lower extremities were allowed to participate. The volunteers consisted of employees of health-care institutions, patients with unrelated problems, members of church groups and patients' families, and residents of, and participants in, the activities of senior citizen centers.

Procedure

All balancing activities were timed with a digital stopwatch, while the subject stood without shoes on the weight-bearing lower extremities inside an 18- by 20-in* frame on a smooth, hard, and level surface (Figure). The goal of each activity was to balance for 30 seconds, an end point used by a number of previous investigators.[2-5] Each subject was permitted five

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* 1 in = 2.54 cm.

TABLE 1
Summary of Subject Data

Decade	n	Age (yr) $\bar{X} \pm s$	Men (%)
20–29	32	25.3 2.5	50.0
30–39	30	34.0 2.2	53.3
40–49	31	45.6 2.5	51.6
50–59	30	54.1 2.3	53.3
60–69	30	64.9 2.4	30.0
70–79	31	75.6 2.2	22.6

attempts to reach the 30-second goal. If the subject reached this goal, we recorded a time of 30 seconds. If the subject did not reach his goal, we recorded the best of the five timed trials. Subjects performed the following balancing activities: 1) balancing on two legs, with the feet 8 in apart and with the feet together (first with the eyes opened and then with the eyes closed) and 2) balancing on each leg (first with the eyes opened and then with the eyes closed). All subjects performed the two-legged activities before the one-legged activities. They were allowed to rest as necessary and to alternate between legs as they wished during one-legged balance. If any of the following events occurred before 30 seconds had lapsed, we stopped the timed trial and noted the time: 1) during two-legged balance, any displacement of the feet on the floor; 2) during one-legged balance, any use of the arms or the contralateral leg for support such as bracing the nonweight-bearing lower extremity against the weight-bearing lower extremity, hopping on the weight-bearing lower extremity, or moving the weight-bearing lower extremity outside the confines of the frame; and 3) opening the eyes during the eyes-closed activities.

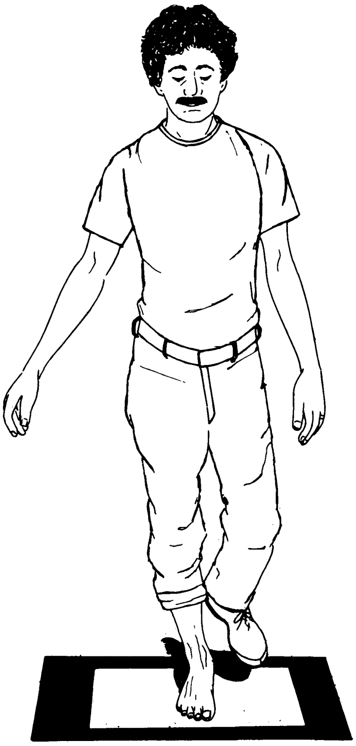

Figure. Subject undergoing one-legged balance testing with eyes closed.

Data Analysis

We recorded each subject's age, sex, and the longest times achieved for each balancing activity. Balancing activities were considered a dependent variable, and age was considered an independent variable. We grouped subjects by decade of age (from the 20s to the 70s). The data were analyzed through the Statistical Analysis System (SAS) computer package. We calculated these descriptive statistics for use in clinical assessments: minimum, first quartile, median, third quartile, maximum, number of observations, proportion of observations less than 30 seconds, mean, and standard deviation. We used a paired t test to compare the differences between left- and right-legged balance. We computed Pearson product-moment (r) and Spearman (r_s) correlation coefficients between the duration of each balance activity and age both for the entire data set and for each decade age-group to determine the relationship between timed balance and age.

RESULTS

Although a few older subjects required more than a single trial, all subjects balanced for 30 seconds, with their feet 8 in apart and with their feet together, both with their eyes opened and with their eyes closed. One-legged balance activities were not, however, accomplished for 30 seconds by all subjects. Failures to reach 30 seconds were most often the result of placing the contralateral foot on the floor. The paired t test did not show a difference in performance on the left- and right-legged activities, either with the eyes opened or with the eyes closed. Therefore, the responses from the left and right legs were averaged to increase precision. Descriptive statistics for these data are reported in Table 2. The mean duration that one-legged balance could be maintained was longer with the eyes opened than with the eyes closed. Similarly, a larger percentage of subjects failed to balance for 30 seconds with the eyes closed than with the eyes opened. The mean amount of time subjects could maintain balance on one leg and the percentage of subjects balancing for 30 seconds diminished with age. All subjects younger than 45 years of age balanced for 30 seconds on one leg with eyes opened. No subject over 70 years of age could balance for more than 13 seconds on one leg with eyes closed, whereas greater than 75 percent of the subjects 20 to 39 years of age could balance on one leg for 30 seconds with the eyes closed.

Table 3 reports the Pearson and Spearman correlation coefficients and significance for the relationship between ages and the time balanced on one leg with the eyes opened or closed. There was a significant relationship ($p = .0001$) between subjects 20 to 79 years of age and the time balanced on one leg with eyes opened or closed. The coefficient of determination (r^2) of eyes-closed data is greater than .60 when calculated from the parametric Pearson product-moment correlation. This figure indicates that greater than 50 percent capacity to balance can be attributed to the age of subjects between 20 and 79 years. A significant correlation existed not only between age and one-legged balancing ability in subjects 20 to 79 years old but among subjects from 70 to 79 years of age as well.

TABLE 2
Summary Statistics From One-Legged Timed Balance Tests of Subjects[a]

Decade[b]	Eyes	$\bar{X} \pm s$		Minimum	First Quartile	Median	Third Quartile	Maximum	<30 sec (%)
20–29	Opened	30.0	...	...	...	...	...	...	0
	Closed	28.8	2.3	22.5	28.6	...	...	...	25
30–39	Opened	30.0	...	...	...	...	...	...	0
	Closed	27.8	5.0	8.4	29.9	...	...	...	23
40–49	Opened	29.7	1.3	23.0	...	...	...	...	6
	Closed	24.2	8.4	3.5	18.9	...	...	...	24
50–59	Opened	29.4	2.9	14.3	...	...	...	...	6
	Closed	21.0	9.5	5.1	11.9	24.8	...	...	57
60–69	Opened	22.5	8.6	4.8	17.0	24.6	...	...	57
	Closed	10.2	8.6	2.1	4.5	7.1	12.5	...	90
70–79	Opened	14.2	9.3	1.2	4.9	12.2	21.6	...	90
	Closed	4.3	3.0	0.7	2.3	3.4	5.4	12.7	100

[a] Time in seconds.
[b] Number of subjects in each decade in Table 1.

DISCUSSION

This study presents objective information regarding standing balance. Such objective documentation should allow the clinician to make better judgments than are possible from general summary statements such as that by Potvin and Tourtellotte.[5] Our findings suggest that an inability to maintain balance for 30 seconds while the feet are together is abnormal, whether the eyes are opened or closed, in individuals from 20 to 79 years of age. This finding is consistent with the report of Potvin and Tourtellotte.[5] Romberg's sign, the tendency to sway and fall when the eyes are closed and the feet approximated, can legitimately be considered demonstrative of an abnormal state in patients younger than 79 years of age.[12]

The mean times reported for one-legged balance in this study are somewhat lower, at least in the younger age group, than they would have been if an upper limit of 30 seconds had not been established. The use of the 2.0 standard deviation criteria for normal limits provides an estimate of a rather absolute minimum duration for "normal one-legged balance." Therefore, a "normal" subject from 60 to 69 years of age should be able to balance for at least five seconds on one leg with the eyes opened. The 10-second standard used by Fugl-Meyer and associates[6] in assessing stroke patients or the 5-second standard of Ashburn[3] may not be representative of normalcy in individuals 20 to 50 years of age or 70 to 79 years of age. The failure to demonstrate a significant difference between balancing ability on the left and right lower extremities indicates that substantial differences between balancing ability on each lower extremity must demonstrate an abnormality of one of the lower extremities or the more proximal components controlling balance on the extremity.

TABLE 3
Correlations of Averaged Data (One-Legged Timed Balance) with Age

Age	Correlation Statistics	Eyes Opened		Eyes Closed	
		r/r_s	p	r/r_s	p
20–29	Pearson	0	NS	−.09	NS
	Spearman	0	NS	−.16	NS
30–39	Pearson	0	NS	−.07	NS
	Spearman	0	NS	−.15	NS
40–49	Pearson	−.10	NS	−.04	NS
	Spearman	−.02	NS	−.29	NS
50–59	Pearson	−.24	NS	−.29	NS
	Spearman	−.26	NS	−.30	NS
60–69	Pearson	−.14	NS	−.37	NS
	Spearman	−.24	NS	−.16	NS
70–79	Pearson	−.62	.0002	−.46	.009
	Spearman	−.58	.0007	−.45	.01
20–79	Pearson	−.65	.0001	−.79	.0001
	Spearman	−.71	.0001	−.75	.0001

Because the distribution of balance test scores was skewed, we calculated both parametric and nonparametric correlation coefficients. The values of the correlation coefficients and of the coefficient of determination for the entire data set support the presence of an inverse relationship between age and balance. In the oldest age group (70 to 79 years), the significant correlation between age and balancing ability suggests that a finer grouping, perhaps 5 years, may be appropriate if normative data are to be obtained.

Observations revealed that younger subjects went to greater lengths to maintain their balance on one leg. This observation raises the possibility that at least some limitations in balance may have been the consequence of the older subjects' unwillingness or inability to do what was necessary to maintain their balance.

The limited number of subjects in this study prevents the use of these results as true "normative" values for balance, as does the nature of the sample (ie, volunteers rather than randomly selected subjects and fewer men in the older age groups). The information does, nonetheless, indicate the level of balance for subjects of different ages. The quartiles calculated in this study, like those calculated by other investigators studying balance,[7,10] identify further how an individual's performance is typical. Different methods of balance testing (testing with shoes on the weight-bearing leg, without a boundary frame, or using fewer trials) might have resulted in a different outcome.

Whether the ability to balance as tested is related to functional capacity awaits further testing. Although assessment of our patients has demonstrated increases in balance to accompany increases in functional capacity, a direct relationship is difficult to confirm. This relationship and testing of the benefits of balance exercises, which have been advocated for increasing postural control, increasing confidence, and preventing falls,[13] are areas worthy of future research.

Clinical Implications

This study provides objective documentation that the ability to balance on one leg diminishes with age in much the same way as sway increases with age.[7,10,11] The practical implication of this information in patient assessment is that performance in timed tests is age specific and that the clinician's expectations for patients should be based on the patient's age.

CONCLUSION

The duration that individuals are able to maintain standing balance on one leg is highly related to age. This age-related information should assist the clinician in gaining some perspective on the performance that should be expected of unimpaired individuals. This perspective should, in turn, give more relevance to the data obtained during patient evaluation.

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