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TRUNK CONTROL TEST AS A FUNCTIONAL PREDICTOR IN STROKE PATIENTS

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The purpose of this study was to evaluate prospectively the Trunk Control Test (TCT) correlation at admission to rehabilitation with length of stay, functional independence measure (FIM), gait velocity, walking distance and balance measured at discharge in 28 hemiparetic patients. FIM and TCT were registered on admission. Outcome measures at discharge were: FIM, gait velocity, walking distance and balance assessed with the Berg Balance Scale and computerized posturography. TCT was significantly correlated with length of stay ($r = -0.722$), discharge FIM ($r = 0.738$), discharge motor FIM ($r = 0.723$), gait velocity ($r = 0.654$), walking distance ($p = 0.003$), centre of gravity symmetry ($r = 0.601$) and Berg Balance Scale ($r = 0.755$). Initial TCT predicts the 52% of the variation in length of stay and 54% in the discharge FIM. The predictive value of a compound variable (TCT and admission FIM) reaches 60% of the variation in length of stay and 66% in the FIM at discharge.

Key words: cerebrovascular accident, equilibrium, functional gain, functional independence measure, stroke assessment, rehabilitation.

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INTRODUCTION

The search for predictors of functional stroke outcome has always been a matter of research in Physical Medicine and Rehabilitation. The appropriate screening of patients in the acute stage of stroke allows the clinician to decide early the placement in which the rehabilitation programme will be most efficient (1). Even though this distribution depends on available local resources, the clinician must establish the functional prognosis as soon as possible, by identifying neurological, functional and psychosocial variables that have a demonstrated relationship with the final functional outcome in stroke patients. Functional prediction models have been developed to identify stroke patients with different functional outcomes and inpatient rehabilitation length of stay (LOS) (2, 3). Balance status has been identified as a significant predictor of LOS in previous studies (4). Sitting balance has a positive correlation with final disability in hemiparetic patients (5–7). There is a marked positive correlation between sitting balance improvement and disability measured with the Barthel Index during the hospitalization period in a rehabilitation unit (8). Sitting balance at 2 weeks after suffering a cerebrovascular accident (CVA) is also correlated significantly with walking ability at 6 months (9).

The Trunk Control Test (TCT) proposed by Colin & Wade, administered at 6 weeks post-CVA, is a predictor of walking ability at 18 weeks (10). TCT reliability and validity has been demonstrated in stroke patients, as has its positive correlation with disability at hospital discharge from inpatient rehabilitation measured with the functional independence measure (FIM) (11).

It is not well known whether the TCT correlates with other measures of static and dynamic balance which have been validated in stroke patients, such as the Berg Balance Scale (BBS) (12) and computerized Balance Master posturography (13). It also remains unknown if trunk balance at admission could correlate with outcome variables such as gait velocity and walking distance perimeter at hospital discharge.

The aim of this study was to assess the TCT predictive value at admission to inpatient rehabilitation of static and dynamic balance, gait velocity, walking distance perimeter, LOS and functional motor status achieved at hospital discharge in hemiparetic patients who have suffered a CVA.

METHODS

Patients were eligible for inclusion in this study if they met the following criteria: (1) hemiplegia secondary to a CVA in the 4 weeks preceding admission to our inpatient rehabilitation unit, (2) no previous history of motor disability and (3) absence of cognitive impairment that would prevent the patients from following the instructions required to complete the tests.

From September 14 to November 30, 2000, a total of 36 subjects were admitted to our stroke rehabilitation unit to follow a rehabilitative programme with the diagnosis of hemiplegia post-stroke; 28 of them met inclusion criteria for this study. Reasons for exclusion were: lack of collaboration and/or cognitive level to complete the tests in 4 cases, 2 patients missed after being transferred to other hospital wards because of medical complications and, finally, 2 cases of previous CVA.

Clinical characteristics of the sample were: mean age 64.5 years (SD 13.1), mean length of time from stroke onset to admission 15.33 days (SD 6). There were 24 (85.7%) ischaemic and 4 (14.3%) haemorrhagic CVA cases. Hemiplegia was right-sided in 12 (43%) and left-sided in 16 (57%) patients.

All patients were studied prospectively during their inpatient rehabilitation stay. Disability was measured with the FIM (14) by a trained rater. Trunk control was assessed with the TCT (10) in the first 72 hours after admission to our stroke rehabilitation unit. The FIM was divided into two subscales: motor (motFIM) and cognitive FIM (15).

Outcome measurements at hospital discharge from rehabilitation

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Fig. 1. Static and dynamic balance was assessed with computerized posturography (Neurocom® Balance Master System 6.1) at hospital discharge. Weight bearing symmetry, centre of gravity, sway standing with open/closed eyes and a walking test were registered.

were: LOS, FIM and the motFIM, FIM and motFIM gain (difference between admission and discharge of the same values), efficiency (FIM gain related to LOS) and motor efficiency (motFIM gain related to LOS).

Gait velocity was assessed in a 10 m straight walkway. Patients were asked to walk at their comfortable speed and then at their maximal safe speed (with technical devices and/or standby supervision when necessary) (16). Walking distance was categorized in three levels: none, less than 50 m and more than 50 m.

Static and dynamic walking balance was assessed with computerized posturography (Neurocom® Balance Master System 6.1) (Fig. 1). Variables collected were: weight-bearing symmetry, centre of gravity (COG), sway standing with open and closed eyes. Step length, step width, walk speed and COG end sway are registered in the walking test on a short 1.53 m platform from a position of still standing (Fig. 2). It must be noted that gait testing using this method is only partially representative of gait in a real environment, but it provides functionally important values such as step width and the end-walk sway. Reliability and validity of this system has been demonstrated to test static and overall dynamic balance in stroke patients (13). Balance was also clinically assessed with the BBS whose validity, reliability and sensitivity to change have been also demonstrated in stroke patients (12, 17).

The same team conducted all tests: two rehabilitation specialists evaluated patients without knowledge of admission scores.

Statistics

Normality of the quantitative variables was checked both graphically and with the Shapiro-Wilks test. Student's *t*-test was used to assess the relationship between groups in dichotomous variables and Scheffe's multiple comparison procedure in variables with more than 2 categories. Relationship between the quantitative variables was assessed using Pearson's correlation coefficient (*r*). To predict the value of the FIM at discharge and the LOS in rehabilitation on the basis of the values of the TCT and the FIM at admission, two stepwise multivariate regression analyses were performed with LOS and discharge FIM as dependent variables and TCT and admission FIM as explanatory variables. But collinearity was observed (eigenvalue = 0.028, condition index = 10.2) thus, a principal component analysis was done with the two explanatory variables, and a new compound variable was created multiplying by 0.561 the sum of standardized values for TCT and admission FIM, i.e.:

$$\text{compound} = \left(\frac{\text{TCT} - 76.4}{24.03} + \frac{\text{admission FIM} - 84.0}{22.38}\right) * 0.561.$$

Results were considered statistically significant at *p*-values ≤ 0.05.

RESULTS

Twenty-eight patients were assessed in the first 72 hours following their hospital admission to our inpatient rehabilitation unit: mean time after stroke onset was 15.3 days (SD 6). Mean initial disability measured with the FIM and the motFIM was 84 (SD 22.4) and 52.7 (SD 19.2). Mean TCT score was 76.4 (SD 24). Of note are the lower scores observed in the "rolling to the sound side" performance (18.6 (SD 8.1)) in comparison with the "rolling to the weak side" performance (23.1 (SD 4.6)).

The mean LOS in rehabilitation was 19.2 days (SD 7.6). The mean FIM and motFIM scores reached 109.5 (SD 11.5) and 76.8 (SD 10.9), respectively, at hospital discharge. The mean motFIM gain during inpatient stay was 24.1 (SD 13.7) and the mean FIM gain was 25.4 (SD 16.3). Efficiency related to the FIM and the motFIM was 1.3 (SD 0.7) and 1.29 (SD 0.6), respectively.

Within the 48 hours preceding hospital discharge, the length of time required to walk a distance of 10 m at a comfortable walking velocity was 26 seconds (SD 17.4). At maximal safe walking velocity, the mean time to cover the same distance was 19 seconds (SD 13.5).

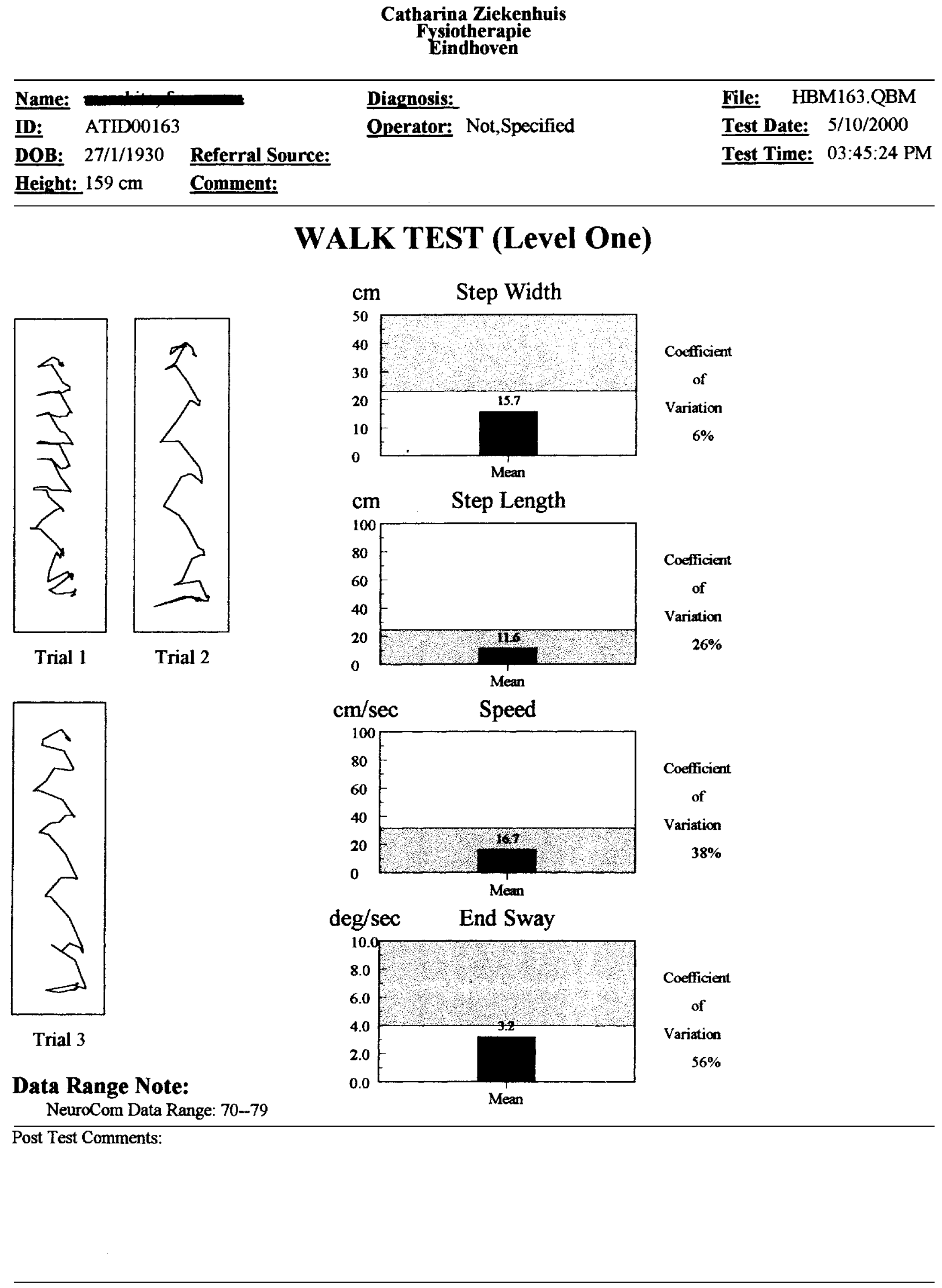
As to walking distance, all patients were ambulant at hospital discharge, but only 15 of them (53.6%) were able to cover distances futher than 50 m.

In the computerized posturography evaluation, when static standing, the COG was displaced to the sound side: the strong limb sustained 54.3% of body weight. The 12 patients unable to roll independently towards the sound side ($\text{TCT2} \leq 12$) presented more asymmetric loading on the platform (61% of the weight sustained by the sound limb) in contrast with the 16 patients with $\text{TCT2} > 12$ (49.4% of the weight sustained by the sound limb) ($p = 0.006$).

The mean COG sway was 0.4°/sec (SD 0.2) with open eyes and 0.6°/sec (SD 0.4) with closed eyes. In the walking test, the step length was 21.1 cm (SD 7.6), the step width was 17.8 cm (SD 2.5), mean velocity was 23.5 cm/sec (SD 11.4) and final COG sway when patients were asked to stop walking was 2.65°/sec (SD 0.9).

Mean total score in BBS at hospital discharge was 42.7 (SD 13.3) over a theoretical maximum of 56.

When the relation between the TCT and the measured variables was analysed, we found the following results: the



Catharina Ziekenhuis
Fysiotherapie
Eindhoven

Name: [redacted]	**Diagnosis:**	**File:** HBM163.QBM
ID: ATID00163	**Operator:** Not,Specified	**Test Date:** 5/10/2000
DOB: 27/1/1930 **Referral Source:**		**Test Time:** 03:45:24 PM
Height: 159 cm **Comment:**		

WALK TEST (Level One)

Data Range Note:
NeuroCom Data Range: 70--79

Post Test Comments:

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Fig. 2. Walk test assessed with computerized posturography (Neurocom®Balance Master System 6.1). The figure represents the walking test tracing: patients walk on a short 1.53 m platform: step length and gait speed are only partially representative of gait in a real environment, but it provides functionally important values such as step width and the end-walk sway. Three trials of the same test are done for each patient and mean values are registered: drawings to the left represent the centre of gravity progression of the three walk trials.

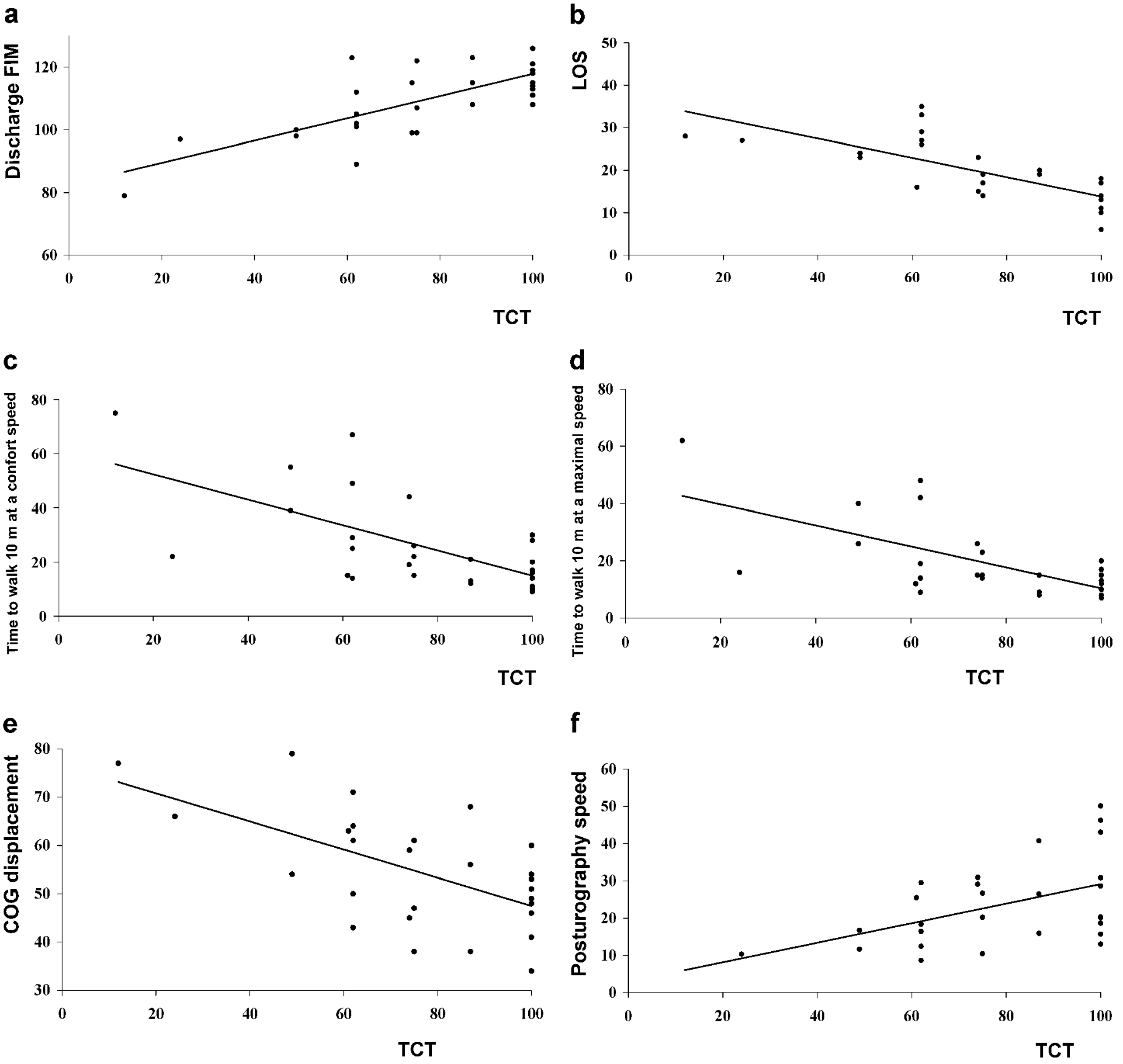

Fig. 3. Correlations between Trunk control test and (a) discharge FIM ($r = 0.738$), (b) length of stay (LOS) ($r = -0.722$), (c) time required to walk a 10 m straight walkway at a comfortable speed ($r = -0.644$) and (d) at maximal safe speed ($r = -0.654$), (e) centre of gravity (COG) displacement ($r = -0.601$), and (f) posturography gait speed ($r = 0.482$). All p-values < 0.05.

TCT showed a positive correlation with the motFIM and the FIM at admission ($r = 0.648$ and 0.587, respectively). No statistical differences between these positive correlations were found: in other words, the TCT correlated equally with the motFIM and the FIM at admission to rehabilitation.

Admission TCT value showed correlation with the motFIM and the FIM at hospital discharge ($r = 0.723$ and $r = 0.738$, respectively). Correlation was inversely significant between the TCT and the LOS ($r = -0.722$) (all p-values ≤ 0.05) (see Fig. 3). The TCT did not correlate with the motFIM/FIM gain and efficiency.

The TCT showed a statistically significant difference ($p = 0.003$) between patients whose walking distance at discharge was longer than 50 m (mean TCT 88.9 (SD 14.3)) and patients whose walking distance was shorter than 50 m (mean TCT 61.9 (SD 25.2)).

Correlations were also statistically significant between the TCT and the time required to walk a 10 m straight walkway at a comfortable and at maximal safe pace ($r = -0.644$ and $r = -0.654$, respectively): the better initial TCT was, the higher gait velocities at discharge were (Fig. 3).

Correlations with results measured by computerized posturography were significant as well, so that the higher TCT at admission was, the less displacement ($r = -0.601$) and the better

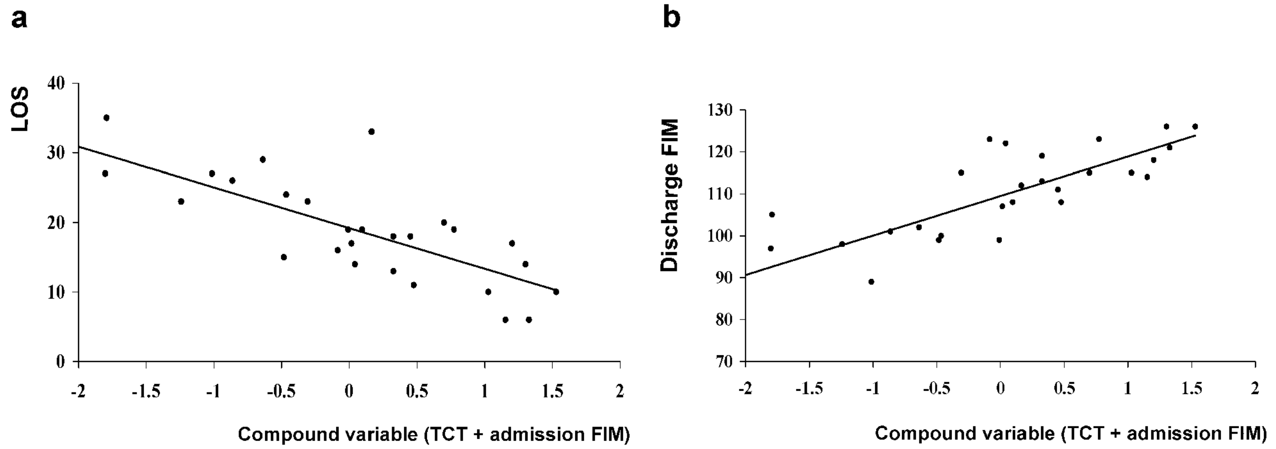

Fig. 4. Correlation between the compound variable $\left(\frac{\mathrm{TCT}-76.4}{24.03}+\frac{\text{admission FIM}-84.0}{22.38}\right)*0.561$ and (a) length of stay (LOS) ($r = 0.771$, $p < 0.001$) and (b) discharge FIM ($r = 0.815$, $p < 0.001$).

posturography gait speed ($r = 0.482$) were (all p-values ≤ 0.05) (see Fig. 3). No significant correlations between the TCT and the standing COG sway (with open and closed eyes, $r = -0.207$ and $r = 0.272$ respectively), step length ($r = 0.328$) and step width ($r = 0.024$) were found. The BBS presented a positive correlation either with the motFIM and the FIM at admission ($r = 0.630$ and $r = 0.578$) and the motFIM and the FIM at discharge ($r = 0.838$ and $r = 0.809$). Correlation was also significant between the initial TCT and the BBS ($r = 0.755$) (all p-values ≤ 0.05). No statistically significant differences between these correlations were observed; in other words, we cannot consider that the TCT correlates better than the FIM at admission with the FIM at discharge. In the same way, we cannot consider that the TCT correlates better than the FIM at admission with the BBS at discharge.

Two multivariate regression analyses were performed with LOS and FIM at discharge as dependent variables and TCT + FIM at admission as explanatory. Although in both regressions the R^2 increase significantly when the second variable (admission FIM) was included: 0.521 vs. 0.60 for LOS ($p = 0.036$) and 0.545 vs. 0.665 for discharge FIM ($p = 0.006$), collinearity was observed. A new compound variable was created using a principal component analysis. This compound was highly correlated with LOS ($r = 0771$, $p < 0.001$) and discharge FIM ($r = 0.815$, $p < 0.001$) (Fig. 4).

DISCUSSION

Trunk balance in the acute stage of stroke is a functional outcome predictor (5–7). Clinical examination of balance is done in daily practice when stroke patients are assessed in rehabilitation units, but it is not usually done in a standardized and objective way.

When analysing TCT results, we found in most of the patients that rolling to the weak side (TCT1) was easier than rolling to the sound side (TCT2). This observation might be explained by the existing difficulty in mobilizing hemiplegic limbs, as has also been reported by other authors in previous TCT studies (10, 11). Most of the patients (89.3%) achieve sitting in a balanced position on the edge of the bed without assistance for a duration of 30 seconds. This suggests that discriminative ability of the TCT4 is lower than the remaining TCT movements (11).

In our study, the TCT correlates with the FIM at admission and at discharge (both FIM and motFIM). Franchignoni et al. (11) observed that the correlation of the TCT at admission with the motFIM at discharge is even higher than correlation of the motFIM at admission with the motFIM at discharge. In our case, correlation between the TCT at admission and the FIM at discharge is not significantly higher than correlation between the FIM at admission and the FIM at discharge. The four patients excluded for not being able to complete TCT at admission for cognitive impairment reported lower mean FIM admission and discharge scores: 57.3 (SD 32.1) and 83.6 (SD 24.5), respectively.

We have found a significantly negative correlation between the TCT and the LOS: hemiparetic patients with worse trunk control at admission stay longer in a rehabilitation ward. However, we have not found correlation between the initial TCT and FIM gain during the hospitalization period. This might be explained by the fact that patients with better TCT scores present higher FIM scores at admission and, therefore, their gain potential is lower. This fact would also explain why we have not found a correlation with efficiency measured with the motFIM and the FIM.

As reported in a recent study, Suzuki et al. point out that balance and muscle strength in the acute stage post-CVA are predictors of walking speed in stroke patients (18). In our study, there is also a positive correlation between the TCT score at admission and the walking speed (comfortable and fast) at discharge. Walking distance difference is also significant: hemiparetic patients whose walking distance at discharge is >50 m present higher TCT scores on admission than those whose walking distance is <50 m. In other words, the better initial trunk control patients have, the longer walking distance and the faster speed they achieve at hospital discharge.

We have not found studies that correlate trunk balance with static or dynamic balance assessed with computerized posturography. Besides, our study reflects a positive correlation between the TCT score at admission and standing COG symmetry. Furthermore, patients with less ability to roll towards the sound side showed more COG displacement at discharge.

Juneja et al. show that the BBS correlates with disability measured with the FIM in stroke patients (19). We have found a positive correlation of the BBS at discharge with the TCT at admission and the motFIM/FIM at either admission or discharge. We have also compared these correlations and have not found significant differences between them.

LOS in rehabilitation is conditioned by clinical, functional and sociodemographic characteristics of stroke patients, though local resources and local health economic policy should be considered simultaneously. Different LOS prediction models have been assessed using available admission information. Brosseau et al. explain 43.6% of the variation in LOS with a model consisting of age, functional status at 1 week post-rehabilitation admission, perceptual status and balance status (4). The model proposed by Stineman & Williams includes age and modified Barthel index: rehabilitation LOS prediction reaches 30% (2). The FIM Function Related Groups system explains 31.5% of the variance in rehabilitation LOS (3). We have not found studies including TCT in their prediction models. In our study admission TCT becomes a significant predictor reaching large prediction values: 52% of the variation in LOS and 60% in discharge FIM (model 1). Adding the admission FIM to the TCT (model 2), the prediction value increases only to 60%, whereas the discharge FIM prediction is still better: 67%. However our sample size is very small, so the high predictive values achieved could be sample dependent. Our results suggest that TCT should be included in future prediction studies of LOS and functional stroke outcomes.

Other limitations of the present study should be noted. First, as usually happens in rehabilitation units, there is an initial bias due to the fact that our patients are pre-selected on the basis of their potential to follow an intensive rehabilitation programme. Information about remaining stroke patients, whose TCT scores could be different from those of our sample, is not available. Second, the sample size did not allow us to determine a cut-off TCT threshold in our predictive model to be used in daily practice. Initial design of this study considered TCT as an early predictor and not an outcome variable. It would have been interesting to repeat TCT at discharge to provide further evidence of correlation with the other outcome variables. Further research is needed to correct design drawbacks.

To summarize, we would like to point out that the TCT is a short and simple test that can be used to predict functional outcome in stroke patients. Its correlation with the FIM and the LOS is significantly positive, though it does not correlate with FIM gain or treatment efficiency. Likewise we can conclude that the TCT correlates well with some specific motor results such as walking speed, distance walking perimeter and balance, measured with computerized systems such as posturography or with clinical scales such as the BBS. The prediction power of the TCT in our sample, as a single test, accounts for 52% of the variation in LOS in rehabilitation and 54% in the FIM at discharge. The predictive value of a compound variable (TCT + admission FIM) reaches 60% of the variation in LOS and 66% in the FIM at discharge.

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