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Postural Assessment Scale for Stroke: a systematic review for its 20 years old

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Postural Assessment Scale for Stroke: a systematic review for its 20 years old

THÈSE
PRÉSENTÉE POUR L'OBTENTION DU TITRE DE DOCTEUR EN MÉDECINE
DIPLOME D'ÉTAT

David Gogo
[Données à caractère personnel]

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ABSTRACT

Introduction

The PASS for Postural Assessment Scale for stroke patient is an instrument evaluating posture and balance after stroke published in *Stroke* in 1999. We propose 20 years after its creation the first systematic review concerning the use of the PASS throughout the world and summarize its psychometric properties.

Material and Methods

Results were extract from two strategies in order to be exhaustive. First all articles from Web Of Science and citing the seminal article of the PASS was analyzed since 1999 to December 2019. A complementary researches was performed in EMBASE, PUBMED with the key words 'postural, balance', 'stroke' following the COSMIN guideline for conducting systematic reviews. Study selection and quality assessment were performed by two reviewers.

Results

We analyzed 105 articles and classified them into categories of use of PASS. Among them, 36 studies analyzed psychometric properties of the PASS and enhanced scale like the SwePASS. All psychometric properties were analyzed and level of evidence of that instrument is high for the main psychometrics according to COSMIN guideline.

Conclusion

The PASS had become a gold standard throughout years because of good clinometric properties. However, enhanced versions like the SwePASS suggest some improvements that can be done especially to avoid ceiling effect.

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INTRODUCTION

According to the World Health Organization, stroke is the second largest cause of death globally in 2016. About 15 million people suffer from stroke worldwide each year. Of these, 5 million die and another 5 million are permanently disabled (1,2). In France, stroke is the first cause of handicap. Indeed, common impairments after a stroke are deficits in strength, cognition, balance, sensation, swallowing, continence, vision, language, cognition. They have a large consequence on activity daily living (3). Balance control appears as a major issue in long term functional improvement and daily life activities (4,5), playing a larger role in transfer and ambulation than strength gain (6). That is why assessing postural and balance after stroke is a major preoccupation of clinicians and researchers, leading to multiple scales developed in the literature (7–9). Besides following patients' recovery, it permits to establish prognosis on handicap of stroke patients. In this context, the PASS for Postural Assessment scale for stroke patient, was born from the balance and mobility part of Fugl-Meyer assessment and the Birgitta Lindmark Motor Assessment. That innovative instrument was first published by Benaim et al. in 1999 in *Stroke* with the will to assess posture and balance in stroke patient in their daily lives. Dynamic and static aspect were taken into account, i.e. the ability to maintain a given posture and to keep equilibrium in changes of position in the three fundamental position such as sitting, standing and lying. It should be applicable for all patients, both in best and poor postural abilities. It consists on a 4-level ordinal scale of 12 items that measure increasing difficulties to maintain or change a given lying, sitting, or standing position. Several modified scales or enhanced version like the SwePASS were born from this instrument, permitting to highlight the strong points as well as the weak points of the PASS.

We propose twenty years after first publication the first review of literature concerning the PASS and its psychometric properties.

MATERIALS AND METHODS

Sources

The Preferred Reporting Items for Systematic review and Meta-Analysis protocols (PRISMA-P) and the guideline for conducting systematic reviews of COSMIN (CONsensus-based Standards for the selection of health Measurement Instruments (10)) were followed to perform the review.

Research strategy was made by two reviewers independently and consisted on selecting articles from Web of Science data core from 1999 to December 2019 citing the seminal article introducing the PASS, published in 1999 intitled *Validation of a Standardized Assessment of Postural Control in Stroke Patients ; The Postural Assessment Scale for Stroke Patients (PASS)* developed in France (11). This research was completed for the sake of the completeness by a research by key words on MEDLINE, EMBASE, COCHRANE library, in the COSMIN database using the following keywords ‘PASS’, ‘neurological disorder’, ‘postural, balance’.

Study eligibility criteria

Records have been excluded if there were no abstract available in English or full text in English. Untitled articles, letter to the editor were excluded after reading. Selection was performed examining abstract and title from the research by key words. All articles extract from Web of Science and citing seminal article were analyzed.

Studies selected and data collection procedure

In order to have an idea of the use and success of the PASS in international scientific committee throughout years, the articles citing seminal article were read in full text and regrouped in categories classifying the different reasons of use of the PASS. This classification work was made by the two reviewers.

To assess methodological quality of selected studies, the COSMIN Risk of Bias checklist was used for the different psychometric properties of the PASS and thus ranged in four proposal

‘inadequate’, ‘doubtful’, ‘adequate’ and ‘very good’. We followed the taxonomy of COSMIN and summarized results with criteria for good measurements available in the appendix. Finally, we used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach to sum up the quality of the evidence of each psychometric properties as high, moderate, low, or very low evidence.

Clinometric properties and definitions

Content validity can be defined by the degree with which the content of an instrument is related to the construct, i.e. the variable indicator, supposed to be measured. COSMIN underlined three characteristics of content validity: relevance, comprehensiveness and comprehensibility. Indeed, all items must be relevant for the construct of interest thinking in the target population and context of use. The instrument must be comprehensive, measuring all aspects of a construct. Finally, all items must be understood without any confusion for the professionals and patients.

Structural validity refers to “the degree to which the scores of a PROM are an adequate reflection of the dimensionality of the construct to be measured” according to COSMIN. With cross cultural validity and internal consistency, these properties focus on the quality of items and the relationships between them. COSMIN insists on the fact that structural validity is relevant only for instrument with reflective model, that means that all items measure the same construct, and are correlated and interchangeable. On the contrary, in a formative model, items are not correlated necessarily but form the construct overall. Examples with a patient related outcome measuring stress is done: a formative model can regroup items like ‘job loss’, ‘death in family’ and ‘disease’ without any links between items. Different statistical tools are used to test structural validity based on two different theories: Classical test theory (CTT) or item response theory (IRT). CTT focus on the total score considered as linear to the variable indicator supposed to be measured. IRT focus on the link between response of an item and the construct supposed to

be measured without total score examination. Each method has pros and cons and it will be not developed in that work. In order to test structural validity, Rasch analysis are based on IRT and were performed to have a reflection on the items. For example, local independency is sometimes performed in a Rasch analysis, which permits to avoid dependence between items, when the probability of a response of an item is influenced by the response to another.

Internal consistency is relevant only for scale based on a reflective model, that means that all items of the instrument are the reflection of the construct measured. Internal consistency refers to the degree interrelatedness among the items and assessed usually by a Cronbach coefficient.

Measurement error refers to “the systematic and random error of an individual patient’s score that is not attributed to true changes in the construct to be measured”. Several parameters are calculated e.g. the Smallest Detectable Change (SDC); also known as the minimal detectable change or Smallest Real Change; which is a measure of the variation in a scale due to measurement error. To be considered as real and due to the ‘true’ variation, a change of score must be higher than SDC. Another important point for the interpretability of a change is the minimum important change (MIC). It is defined as the smallest measured change score that patients perceive to be important. Changes of a score which are smaller than the SDC are likely to be due to measurement error. On the contrary changes larger than the SDC can be considered as real change. Sometimes are used the limits of agreement, it is another method that gives the interval of two standard deviations of the measurement differences either side of the mean difference.

Reliability refers to ‘the proportion of the total variance in the measurements which is due to true differences between patients, where it is supposed that all observations are the addition of a true score and a measurement of error. The true score is considered as consistent and is approaching the average score if it was administrated an infinite time by the same person.

Intra rater if the instrument is administrated by the same person, inter ratter if its administration is done by another person.

Criterion validity ‘refers to the degree to which the scores of an instrument are an adequate reflection of a ‘gold standard’ ‘, that means an instrument of superior quality which serves as a point of reference. Confusion can be done with definition of other study considering criterion validity not only with a gold standard instrument.

Construct validity and hypothesis testing refer to the degree to which the score of an instrument is linked with hypotheses based on the assumption that the instrument measure the construct supposed to be measured. It can be comparisons with another instrument outcome assessing the same construct, or comparisons in the score of different subgroups. Results must be interpreted according to the excepted correlation. Correlations with instruments measuring similar construct should be superior or equal to 0.50 (e.g. Berg Balance Scale (12), Trunk Impairment scale (13)), related but dissimilar constructs should be between 0.3 and 0.5 (e.g. Barthel Index or Functional Measure Index). Correlations with instruments measuring unrelated construct should be inferior to 0.30. It is important to assure that comparisons are done with renown scales. For instance, Barthel index evaluates ten basic activities of daily living (ADL) items including feeding, transfer, grooming, toileting, bathing, ambulation, stair climbing, dressing, bowel control, and bladder control. It has been shown to be a reliable and valid measure of basic ADL (14).

Responsiveness refers to the ability of an instrument to detect a change over time in a construct. The only difference between construct validity and responsiveness is that validity refers to the validity of a single score, and responsiveness refers to the validity of a change score. Evaluation with effect sizes (mean change score / SD baseline) and standardized response mean (mean change score / SD change score) are the main tools used. Construct approach can be done with hypothesis on a score change for instance before or after an intervention, or comparison in

change with another instrument. A criterion approach can be done with a change considered as a gold standard.

RESULTS

We found 169 articles, 167 were citing the seminal article by Benaim et al., to which were added the two seminal articles published in 1999, one to valid the instrument (11), the other using the PASS as an instrument (15). Among all records, we observed a firm increase as function of time since 1999 to December 2019 (**Figure 1**), reaching 18 in 2019. These articles correspond to four categories: 64/169 (37.8%) use an information contained in the seminal article to argue in the introduction or the discussion, without proper analysis of the tool; 60/169 (35.5%) used the PASS as an assessment tool to assess postural disorders after stroke; 36/169 (21.3%) analyzed psychometric properties of the PASS in isolation or as compared to other tools (7 papers used the PASS as the gold standard), 10/169 (5.9%) corresponded to reviews analyzing the PASS with other assessment tools.

In this thesis we will analyzed the 106 papers of the three last categories. Only two articles were added with help of complementary key word research in the analyses of psychometric properties (16,17) not citing seminal article (11). The flow diagram is presented in **Figure 2**.

I. The PASS as an assessment tool of post-stroke balance disorders

Among the 60 original studies using the PASS as assessment tool of post-stroke balance disorders, 23 were interventional studies (810 patients) and 37 were observational studies (2660 patients). The PASS was the primary outcome in most interventional studies (18/23, 78%), and most of these trials reported positive results (12/18, 66%). The PASS was used as a secondary outcome in 5 other interventional studies, the results of which were always negative. In observational studies the PASS was less frequently used as a primary outcome (16/37, 43,2%),

and in such a case almost always with positive results (15/16, 93.7%). In other observational studies the PASS was just used to describe the sample size. Details are displayed in [table 1](#).

II. [Psychometrics properties of the PASS](#)

We analyzed the 36 papers investigating the psychometrics properties of the PASS, according to COSMIN guideline, i.e. in the following order: Validity (including content validity, structural validity and cross cultural validity), Reliability (including measurement error, reliability, hypotheses testing) and responsiveness with ceiling/floor effect. Quality assessment of studies was described in [table 3](#) and summarized in [table 4](#).

Validity

Content validity

At the time the PASS was designed, Delphi method did not exist to conceive ordinal scales. However efforts were made to work with a multidisciplinary team to conceive the PASS to respond to a need, emerged from the clinical experience of this team in post-stroke rehabilitation, and a literature analysis. This process involved two of the coauthors of the current paper (DP and CB), and was reported in the two seminal papers presenting and using the PASS (Pérennou 1999 (15); Benaim 1999 (11)). This team was specialized in neurorehabilitation, and was composed of three medical doctors, among whom one expert in postural control (DP) and one expert in scale construction and validation (CB), a team of physical and occupational therapists expert in post-stroke rehabilitation, a health manager, an adapted physical activity therapist, and one neuropsychologist. They constituted the panel of experts who all together conceived, constructed, tested and validated the PASS, over a period of time of 5 years. Several items such as parachute reactions of the balance subscale of the Fugl-meyer assessment scale were tested

and abandoned because of their lack of reliability (11) and the lack of enthusiasms of the physiotherapists of the team. These perturbations are examiner related and can be not suitable for an objective standardized assessment. As explained in the validation paper (11) the conception and construction of the PASS followed clear rationales. Contrary to most assessment tools proposed in the eighties, being either generic (not dedicated to a disease or a given function) or mixing in a composite score deficits and activity limitations, the PASS was designed to be a specific assessment tool of balance disorders in a well-defined population: individuals after a stroke. For that purpose, the PASS does not mix assessment of balance and gait disorders. The need to assess both the ability to maintain a given posture and the ability to change postures represented another key rationale, together with the interest to scan the three basic postures of daily life, lying, sitting and standing. The level of scoring of items were homogenous and set to 4 (not too few nor too many), an even number precluding scorings of hesitating evaluators on intermediate levels.

Others were modified and assessed on about a hundred patients, finally to reach a consensus between all the research team. Thus, the comprehensiveness and comprehensibility among professionals were evaluated and discussed throughout the two years of the development of the scale. This time of scale development lead to two publications in 1999, one assessing psychometrics published in Stroke and another as a tool to differentiate right and left hemisphere dominance in postural control.

To assess the PASS, it requires no special equipment except chronometer and a pencil. It can be performed by a physiotherapist, or junior doctor or a person with rehabilitation experience. Most of studies excluded stroke patients with aphasia, but the PASS can be assessed in clinics without any major problem. Even if methodology could be considered as inadequate according to COSMIN checklist because of absence of any specific studies, content validity of

the PASS did not suffer of any critical in literature to our knowledge. On the contrary, large number of modified scales can be the clue of robust content validity.

Moreover, at the moment of its creation, the PASS could be considered as a forward-thinking scale. And throughout years, to our knowledge, none of the existing instrument have demonstrated better properties to assess postural abilities et equilibrium in a stroke population. Therefore Criterion validity couldn't be investigated. Indeed, according to COSMIN, only comparisons with other measurement outcome considered as the gold standard of can take part of the criterion validity.

Construct validity

Structural validity

As already pointed out in the section content validity and in the seminal article Benaim and al(11), the PASS is based on a reflective model, that means that all items measure the same construct, and are correlated and interchangeable. Indeed, modifications in postural abilities of a patient are likely to have an impact on the score of all items. This was a condition required to test the structural validity of the PASS (COSMIN).Two Rasch analysis were performed in 2014 (18) and 2017 (19) respectively to assess structural validity using an advanced version, namely the Swe-PASS. The SwePASS keeps the structure of the initial version of the PASS, i.e same 12 items scored from 0 to 3. Enhancements are better instructions in the items changing posture (items 6-12), and a bigger object to pick up from the flour for this specific item.

These two studies gathering in total 400 patients tested within 7 days after stroke onset (mean confident interval) show that the scale was unidimensional. In the first study, modified version of SwePASS shows that equal capacity in postural control provides the same response to an individual item in patients with stroke, regardless of gender, age and location of stroke lesion

The second Rasch analysis published in 2017 on a larger sample size of 250 patients with an assessment within a median of two days after admission to the stroke units, including more severe patients with poor postural abilities than those of first Rasch analysis. It was found that the SwePASS covered a continuum of different levels of postural control, but had suboptimal targeting with insufficient representation of higher levels of postural control. Moreover, item response categories did not function for four items of the SwePASS and five items exhibited local dependency (19).

Cross-cultural validity

Even if no formal cross-cultural adaptation of the PASS has been performed, postural tasks tested have been chosen to target basic postural tasks of daily life important to achieve or recover in any persons who undergone a stroke, all over the world. These tasks are ideally tested at the gym otherwise in the patients room (11,20) patients remaining dressed, without need of any specific equipment other than a physio table (or bed with adjustable high), and a watch (chronometer). One may assume that tasks and instructions of the PASS are highly generalizable all over the world. This explains why the PASS is used in most continents and so many countries. On the basis of the origin of papers using the PASS, and from authors experience through several internal networks and learn societies dedicated to Neurorehabilitation, or balance and gait, we estimate that the PASS is used in all continents in at least 8 countries (France, Spain, United states, Canada, Brazil, Turkey, Taiwan, Sweden).

The PASS was developed in parallel in French and English. All items were simultaneously written in both languages, including those from previous scales published in English (for instance Fugl Meyer et al. 1975) which were translated in French with the help of a professional translator. The final versions have been published simultaneously in both languages, English and French (15), with details on items and instructions. This dual language adaptation

had been performed by experts of the fields (see content validity) helped by a professional translator. Since 1999, the PASS has been also translated in Swedish (11), Spanish (21), Portuguese/Brazilian (22), Turk (23). Cabanas-Valdés in 2015 proposed a Spanish version (21) from French version with back-translation approved by original author. The Turkish version was born with use of back translation in English. These two version were compared by an expert committee who did cross-cultural adaptations on each item and compared with the original scale.

The SwePASS version was made from French version and back translated (24). Breistein et al (25) proposed a Norwegian version of the SwePASS following an international guideline for cross cultural adaptation and translate an English back translation of SwePASS into Swedish. These results advocate for a very good transcultural adaptation of the PASS, used today in several languages and many countries on most continents. Indeed the PASs is well refereed in all referent websites presenting assessment tools after stroke (stroke engine) or in rehabilitation (IPSEN, COFEMER) or in neurology. One may also find on the net several videos explaining in English how using the PASS (<https://www.youtube.com/watch?v=q4ulbIbyyiw>). These videos have been posted in 2016 and 2019, respectively with a cumulated number of about 10 000 views.

Hypothesis testing

The convergent validity of the PASS has been extensively investigated, in 20 studies summarized in table 3. The PASS has been found strongly correlated with many other balance scales such as the Berg Balance Scale (12), the BesTest (26), the Trunk Impairment Scale (13), the MO-STREAM (27), the Turk version of Brunel Balance Assessment (28) or the CAT-FAS (29). The PASS has also been found strongly correlated with gait (11), (30) and Dai et al. 2019.

After a stroke, PASS scores give an indication on the global balance ability in daily live (11), which requires a satisfactory control of body orientation with respect to gravity and postural stabilization with respect to the base of support. This explains that after stroke PASS scores are

related to instrumental (11) or ordinal (Dai et al., Neurology in press) measurements of body tilt with respect to gravity, and also related to instrumental or ordinal (Dai et al. 2019, Neurology in press) measurement of instability.

This first study using the PASS (15) and confirmed by others studies (31,32) published showed the right hemisphere predominance for body stabilization and body orientation. Indeed, whatever the posture analyzed : lying, sitting or standing, there is a postural disadvantage of the right brain damaged hemisphere.

For predictive validity, PASS and functional scales have been performed such as the Barthel Index or Functional Index Measure within 3 months for most of studies. Correlations were consistent and higher than we can expecting with very strong correlation between PASS assessed one month after stroke onset and functional measures at three months of stroke onset. Prediction on discharge was investigated with the PASS whether patients can go back home or placed into institution.

Reliability

Internal consistency

The internal consistency of the PASS and modified version (Koçak 2019 ((23)) have been extensively analyzed, by 3 studies (11,33,34), gathering a total of 388 patients on 29.66 days 95% CI (23.5-35.82) after stroke. All these studies reported very high Cronbach alpha coefficients, ranging mean $\alpha = 0.956$ with 95% CI (0.948-0.964) which confirms the excellent internal consistency of the PASS, already pointed out in the seminal paper (Benaim et al. 1999). Moreover Benaim et al added that both components of the PASS, maintaining and changing positions were strongly correlated ($r=0.86$, $P < 10^{-6}$).

Reliability (reproducibility)

Studies which analyzed the reliability of the PASS are summarized in table 3. Among the 3 studies which used the ICC (intra class correlation coefficient) to analyze the interrater reliability of the total PASS score, two had a sample size > 50 individuals (mean 82), a criteria required to reach robust data (Terwee et al. 2007 (35)). One examined patients at a subacute stage (34) and the other at the chronic stage (36). They found similar and high ICC: 0.97 with narrow 95%CI between 0.95-0.98 (34,36). This corroborated very high correlation coefficients ($r=0.99$) found by the seminal study (11). Three studies investigated the interrater reliability of each item, with results indicating again a very high reliability. The median kappa-coefficient for every items was 0.87 (from 0.64 to 1) and 0.86 (from 0.70 to 0.93), for Benaim et al (11) and Persson et al (24) respectively, and the median of weighted Kappa was 0.88 (0.61 to 0.96) for Mao et al (34).

Measurement error

Three studies [Chien et al. 2007 (37), Chien et al., 2007 (33), Liaw and al (23)] calculated the Minimal Detectable Change (MDC) and standard error of measurement (SEM) from interrater ICC in chronic stroke patients and results were satisfactory. In a sample of 20 chronic stroke individuals, the MDC was 2.2 at an individual level and 0.5 at group level. Chien et al. found a SEM of 2.4 in 287 chronic stroke patient. Liaw and al found on 52 patients a standard error of measurement of 1.1, interpreted as the smallest change indicating a real improvement of a group of individuals. The smallest real difference (SRD) was 3.2 and considered satisfying (<10% of highest score (38)). SRD can be interpreted as the smallest change threshold indicating a real improvement in an individual person. That means that a change of 4 points in the total scores for the PASS in the chronic stroke patients, is not likely to be attributable to chance variation or measurement error. No minimal important change was calculated to our knowledge, that mean the smallest change that an individual patient would identify as important and which would indicate a change in the patient's management.

Ceiling/ floor effects and responsiveness

Ceiling and floor effects

In total, 10 studies examined ceiling and floor effect of the PASS (11,16,27,33,39–43), 3 studies for the SwePASS and 1 for the PASS turk. A ceiling effect was found in two studies (11,39). Benaim and al (11) in 58 patients after stroke rehabilitation, 38% reached the maximal score 3 months after stroke onset. Chinsonkgram et al. (44) didn't obtain a ceiling effect with only 4.3% of the patients with the maximal score under the cut off of 20% of a maximal score, but when dealing with responsive ceiling effect (score within the 10% top of the test), 37% of patients have a score above 33/36 in a group considered as low functional abilities and 60% in a group with high functional abilities (Fugl Meyer assessment for distinguish the two groups). About the SwePASS, 2 studies found a ceiling effect at 3 months and 6 months (24,45). In the study of Kocak no floor nor ceiling effect were found (23).

Responsiveness

Summarized results of the 14 studies analyzed the responsiveness are listed in [table 3](#) in about 1700 patients in total. Only three studies have less than 50 patients, before considered as a methodologic bias by COSMIN. The number criteria was not reconducted in its next guideline in 2018 (46). High responsiveness was found within the first 3 months after a stroke with a greater responsiveness between 14 and 30 days than between 30 and 90 days after stroke onset. Lack of description about rehabilitation program between the two assessments was the main reason why quality methodology of 5 studies were doubtful. Between 14 and 30 days after stroke onset, effect size was very high ranged from 0.42 to 0.91 and slightly smaller for assessment between the 30th and 90th days after stroke. Two studies, found a larger responsiveness for sever stroke than moderate or mild stroke when classifying stroke severity with Fugl Meyer scale.

Inconsistent results can be explained by different inclusion criteria, the severity of postural abilities at admission, or the uncertainty about assessment with stroke onset. Responsiveness was also assessed with the construct method using correlation with the change in another scale, for instance the Berg Balance Scale.

III. Modified versions

Enhanced version : SwePASS

That version developed by Persson et al. in 2011 was born in order to improve clinical usability of the PASS. The Swedish version, very close to the original PASS, presented in appendix underwent two Rasch Analysis and permit to show disordered thresholds and to do some adjustments. Two items were combined because of local dependency. After adjustment, modified version of SwePASS was unidimensional. It was found a good inter rater and intra rater reliability in 114 stroke patients with administration of the SwePASS on the same day. For the intrarater reliability Spearman's rank correlations were 0.88-0.98 and kappa coefficient were 0.70-0.93 for the individual items. For the interrater reliability, Spearman's rank correlations were 0.77-0.99 for individual items. Ceiling effect was encountered at 3 and 6 months and neither floor or ceiling were found in the version of 2017. That is why Persson et al. recommend to use the SwePASS within the first 3 months.

Derivative scales considered as other scale

PASS TC

Hsieh et al. took only few items of PASS (items 1, 6, 7, 8, 9) named the scale the PASS Trunk Control (47). An important ceiling effect appeared from the two weeks after stroke onset (48). Indeed 30% of patients reached maximal score and 75% at 90 and 180 days after stroke. However, this modified scale demonstrated good predictive validity between PASS-TC administrated at 14 days after stroke and comprehensive ADL function (sum of Barthel index and standardized Frenchay Activities Index scores) at 6 months after stroke (Pearson correlation $r=0.45$ (48) .

SFPASS

That short form of PASS was developed by Chien and al.(49) with 5 items of PASS of 3 levels (0-1.5-3) with a maximal score of 15. The chosen items are standing on nonparetic leg, supine to sitting up on the edge of the table, sitting on the edge of the table to supine, sitting to standing up, standing up to sitting down. This short form had a floor effect on the first and no ceiling effect. Indeed, removal of 3 lying and sitting items lead to difficulties in detecting modifications in these functions and lead to a floor effect. Moreover a 3 rating scale was not recommended because of the risk of rating the intermediate score when performance of patients were questionable (15). This scale is highly correlated with original PASS (ICC 0.98) (49).

IV. Review papers analyzing the PASS

One of the aim of these reviews is to compare psychometrics properties of different postural and balance control instruments. For instance, PASS is presented as a tool measuring trunk control in the review of Sorrentino et al (2018) reviewing all clinical measurement tools to assess trunk

performance in stroke patient. Lima et al. searched all clinical instrument available in Portuguese for stroke rehabilitation using Brazilian version. In three reviews (Miller et al., Sibley et al., Hillier et al.) PASS was presented in order to give standardized instrument to measure postural and balance control in poststroke rehabilitation.

Other reviews used PASS as an instrument to compare several physical therapies. In Li et al. review and Hugues et al., PASS was used as a primary outcome to compare several physical therapies on postural and balance control in stroke patients. Chen et al. used PASS trying to show that sling exercise therapy can improve balance in stroke patient but no significative results on PASS was found. In the review of Kegelmeyer et al (2014), description of different PASS use was made according recommendations from American Physical Therapy Association (APTA). It can be used in inpatient and outpatient rehabilitation, teach in entry-level physical therapy programs, and used in acute care.

Finally, PASS can be used in a linked domain of postural control like walking. Indeed, Geroin et al. mentioned in their review PASS as a possible tool that can be use to evaluate walking performance in stroke patient using robotic devices.

DISCUSSION

In light of results, the PASS became a gold standard in the evaluation of balance and posture after stroke because of its increasing use and number of citations throughout years in research and clinical fields. All measurement properties mentioned in the COSMIN were assessed in the different articles analyzed. We did the choice to focus our selection on English articles only (Hugues et al., (50); Dechartres et al. (51)).

The PASS has some weaknesses that is why the SwePASS was born as a constructive critic of the PASS with argue modifications. Improvements can be done to have a better distribution of the scores : items with most difficult propositions could cancel the ceiling effect.

Our review had several weaknesses : we use a guideline developed for patient related outcome measure (PROM) and not for clinician outcome measure, many adaptations particularly for content validity was made and guideline of COSMIN was not appropriate for this properties. A new version of the PASS can be suggested with determination of minimal important change, structural and content validity studies. Indeed, a modified PASS with delphi and RASCH or factorial analysis might emerge, in keeping that has been developed with the SwePASS.

CONCLUSION

The PASS had become a gold standard throughout years and an instrument more and more used. This first review permit to show that the PASS demonstrated good psychometric properties. However, enhanced versions like the SwePASS suggest some improvements that can be done especially to avoid the ceiling effect.

THÈSE SOUTENUE PAR : [Gogo David]

TITRE :

[Postural Assessment Scale for Stroke: a systematic review for its 20 years old]

CONCLUSION :

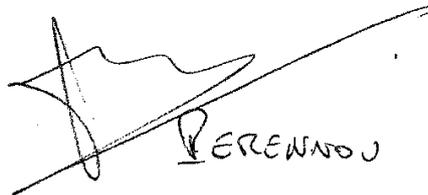
[La PASS est devenu un gold standard en 20 ans grâce à ses qualités psychométriques. Cependant des versions améliorées comme la SwePASS suggèrent qu'il est possible d'améliorer cette échelle et notamment d'éviter l'effet plafond qu'on lui connaît.]

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PERENNOU

LE DOYEN



Pr. Patrice MORAND

LE PRÉSIDENT DE LA THÈSE

Pr. [Insérer ici Prénom NOM du Président]

Pour le Président
et par délégation

—
Le Doyen de Médecine
Pr. Patrice MORAND

Table 1. Reliability and Internal Consistency of the PASS

PASS	Country and population	Reliability			Internal consistency		
		n	Meth qual	Result	n	Meth qual	Result
Benaim 1999 (11)	French subacute stroke population Included within the first month after a first unilateral hemispheric acute stroke 12 patients	12	doubtful	interrater reliability: interval < 1 day An average k-coefficient over the 12 items of 0.88 (range 0.64 to 1) Bland and Altman method illustrated the weak difference between total score (about 0,5) Correlation total score 0.99 (Pearson product moment) intra-rater reliability: interval of 3 days. Average kappa coefficient 0.72 (range 0.45 to 1) Total score 0.98 (pearson correlation product moment)	58	adequate	$\alpha=0.95$
Mao 2002 (34)	From registry of the Quality of Life After Stroke Study Taiwan university hospital. Patient with subacute stroke 52 women/ 60 men mean age of 69 years (SD=11.3)	112	adequate	interrater reliability within 24h (at 14 Days after stroke) Median of weighted Kappa for each item of the PASS was 0.88 (0.61 to 0.96), ICC (95% CI) for the total score of the PASS was 0.97 (0.95 to 0.98).	112	adequate	$\alpha=0.94$ to 0,96 at 14, 30, 90 and 180 days after stroke
Chien 2007 (37)	Taiwan university hospital. chronic stroke	20	adequate	the test-retest reliability (interval 2 weeks) ICC 0.84 (95% CI, 0.64 to .93)			
Chien 2007(49)	National Taiwan university hospital Subacute stroke patient 1 st group (n=287), Mean age 65.5, sex 174 male/113 female cross validation group (n=179) mean age 63.7, sex 133 male/ 46 female				218	adequate	$\alpha = 0,96$
Liaw 2008 (36)	Two Rehabilitation departments of Kaohsiung Medical University Hospital mild to moderate chronic stroke (more than 6 months)	52	adequate	test retest 7 days-interval ICC 0.97 (95% CI: 0.95 – 0.98). Absolute reliability was assessed by standard error of measurement.			
Pearson 2011 (20)	Subacute stroke patients tested twice within 24h, one week after stroke 114 patients for intra ratter reliability 15 patients for interrater reliability (Gender M/F : 8/7, median age 79y old, left / right lesion :8/7)	15	adequate	interrater reliability median weighted kappa 0.88 (ranged 0.61 to 0.96)			

Koçak 2019 (23)	Subacute stroke Ischemic 68%/ hemorrhagic 32% Affected side : left for 46.7% / right for 53.3% of participants	60	adequate	Cronbach alpha original PASS $\alpha=0.95$ Cronbach alpha 0.953 for the total PASS-Turk
Pooled or summary result (overall rating)		414	Adequate	Rating sufficient ICC > 0.7
		448	4*Adequate (4).	$\alpha = [0.93-0.94]$ Rating sufficient

Table 2. Construct validity and Responsiveness of PASS. TIS: trunk impairment scale, MAS: motor assessment scale, BI : Barthel index, FIM : functional instrument measure, CADL : comprehensive activity daily living (Barthel Index with Frenchay activity index; MoSTREAM : Mobility subscale of Stroke Rehabilitation Assessment of Movement instrument, BLS : Burke Lateropulsion Scale, HBSF : Hierarchical Balance Short Forms, LL-FAS Lower Limb Function Assessment Scale. CAT-5F : Computerized Adaptive Testing System for Assessing 5 Functions. BBA-T : Brunel Balance Assessment. ES : effect size. SRM : Standardized response mean.

PASS	Country and population	Hypotheses testing			Responsiveness		
		n	Meth qual	Result	population (n)	Methodological quality	Result
Benaim 1999 (11)	French stroke subacute stroke patients Included within the first month after a first unilateral hemispheric acute stroke	58	Very good	<ul style="list-style-type: none"> ❖ PASS vs FIM score $r=0.75$, the transfer FIM items $r=0.74$, and the locomotion FIM items $r=0.71$, motricity (upper limb $r=0.63$ and lower limb $r=0.78$), sensitivity (upper limb $r=-0.42$, lower limb $r=-0.45$) and spatial neglect score ($r=-0.53$) ❖ PASS vs postural stabilization ($r=0.48$) and postural orientation with respect to gravity ($r=0.36$) <p>r= Pearson correlation coefficient</p>	-	-	-
Mao 2002(34)	National Taiwan university hospital stroke patient Sex M/F : 66/55 Age 69.3 +/- 11.2 y	123	Very good	<ul style="list-style-type: none"> ❖ PASS (D14,30,90,180) vs BBS (D14,30,90,180) $p > 0.92$ ❖ PASS vs FM-B (D14,30,90,180) $p > 0.95$ ❖ PASS vs BI (at D14, 30, 90 and 180), $p > 0.88$ ❖ PASS (D14, 30 90) vs MAS (D180), $p > 0.86$ <p>p= Spearman correlation coefficient</p>	14-30 (n=110) 30-90 (n=93) 90-180 (n=80) 14-90 (n=93) 14-180 (n=80)	Doubtful	Effect size: 0.89 (days 14-30), 0.64 (day 30-90), 0.31 (90-180). Global 1.12 (14-180). Each time, better responsiveness when severe stroke than mild-moderate, with ES (14-180) = 1,54 against 0,85 and 1,20 to mild and moderate respectively.

Wang 2004(52)	National Taiwan university hospital stroke patient Male/ female : 123/103 Mean age 68 range [33-95]. Infarction 72% For convergent/concurrent validity 77 subjects For predictive and responsiveness 226 subjects	77	Very good	<ul style="list-style-type: none"> ❖ Concurrent and convergent: PASS vs BBS, $p=0.94$ PASS vs PASS 3P $p=0.94$ PASS vs BI $p=0.84$ ❖ Predictive PASS (D14, D30) vs BI (3 months) $p>0.78$ PASS 3P (D14, D30) vs BI (3 months) $p>0.78$ Spearman correlation coefficient 	14-30 (n=202) 30-90 (n=167) 14-90 (n=167) Mild (n=67) Moderate (n=50) Severe (n=85)	Doubtful	SRM (standardized response mean) between days 14-30: SMR= 0,84 between days 14-90: SMR= 1,02 between days 30-90: SMR= 0,65 Subgroups analysis (FM): Severe; Moderate; mild stroke D14-90 ES 1.35; 1.12; 0.78 D14-30 ES 1.02; 0.93; 0.59 D30-90 ES 0.92; 0.52; 0.43
Chien 2007(37)	National Taiwan university hospital stroke patient For predictive validity n=32, mean age 60 +/- 11.5 y, 16 infarction/ 16 hemorrhage, male/ female : 23/9, side of hemiplegia (right 22/ left 10) For Responsiveness n=40, mean age 58.6 +/- 12, infarction 21/ hemorrhage 19, right hemiplegia 25/ left 15.	32	Very good	<ul style="list-style-type: none"> ❖ PASS (within 3 month) vs comprehensive ADL functions (1 year) $r^2=0.24$. Pearson correlation coefficient 	40	Very Good	Between 2 weeks within 3 months of stroke onset (mean dean of first evaluation 41) Small ES =0.41
Chien 2007(49)	National Taiwan university hospital Subacute stroke patient Calibration and validation group (n=287), Mean age 65.5, sex 174 male/113 female cross validation (n=179) groups mean age 63.7, sex 133 male/ 46 female	287	Very good	<ul style="list-style-type: none"> Convergent validity ❖ PASS vs BI : correlation of 0.87 ❖ PASS vs Fugl Meyer : correlation of 0.75 Predictive validity ❖ PASS (D14) vs BI (D90) produit moment correlation $r=0.49$ on calibration group ❖ PASS (admission to rehabilitation) vs BI (discharge) $r=0.83$ on validation group product-moment correlation 	262 179	Doubtful	Between 14 and 30 days ES=0.42 for first group ES=0.43 for second group
Di Monaco 2012(53)	Italia Torino rehabilitation hospital Subacute stroke patient Mean age 68 y Sex M/F : 62/38 Right/Left hemiplegia : 50/50 Time from stroke to first assessment: mean 21 days	60	Very good	<ul style="list-style-type: none"> Spearman rank test (correlation coefficient ρ) and multiple regression (correlation coefficient β) ❖ TIS vs PASS (admission) $p=0.85$ ❖ PASS (admission) vs FIM (discharge) $p=0.69$ and after adjustment $\beta=0.37$ ❖ PASS vs change in FIM after ajustement on FIM (admission) and BI (before stroke) $\beta=0.55$ ❖ PASS vs destination at discharge (home/institution) Odss ratio 0.75 (95% CI: 0.58-0.98) 	Ad - 4w (n=34) Ad - 8 w (n=17)	Doubtful	From admission to 4 weeks SRM 1.76; mean change score 10 From admission to 8 weeks : SRM 1.87

Yu 2012 (54)	National Taiwan university hospital subacute stroke patient Mean age 65.5 Infarction/ hemorrhage : 56/29 Side of hemiplegia Right/left/bilateral : 37/47/1 Period of onset to initial evaluation median of 19 days ranged (5-79)	85	Very good	❖ PASS (admission) vs BI (discharge) $r^2=0.39$ (+) ❖ PASS (admission vs MO-STREAM) $r^2=0.63$ (+)	85	Very Good	Admission – discharge: ES 0.87 (high) Period from onset to first evaluation: median 19d Days of rehabilitation median 34d. Change in BI r^2 : 0.20 Change in MO-STREAM 0.59 Considered as moderate and sufficient if $0.25 < r^2 < 0.64$
Clarck 2012(55)	Acute stroke (21 female, 22 male; 72 ± 6.7 y old) with lateropulsion within the Northern Health Rehabilitation Units and Geriatric Units across 2 sites in Melbourne, Australia. Mean time from stroke to 1rst assessment: 21 + 7.1	43	Very good	❖ BLS vs PASS correlation at each time point (0, 2, and 4wk) using a Spearman correlation Baseline $\rho=0.61$ Week 2: $\rho=0.72$ Week 4: $\rho=0.76$	43	Very good	Admission-discharge SRM=1.46
O'Dell 2013(56)	subjects with stroke in inpatient rehabilitation unit (IRU) mean age of 71.5 ± 13.8 years, admission functional independence measures (FIM) of 57.2 ± 17.2 points, and IRU length of stay of 17.3 ± 9.7 days 60% men, and 80% with an ischemic stroke.	55	Very good	❖ BBS vs PASS $r=0.9$ Spearman coefficient ❖ Correlations between the PASS at admission and discharge gait velocity $r=0.28$ ❖ Both subscores were associated with both toileting and transfers of FIM ($r=[0.43-0.56]$) ❖ Admission PASS-MP vs discharge GV $r=0.35$ ❖ Admission PASS-CP vs discharge GV $r=0.23$			
Hsueh 2013(57)	Population from Mao and al study Exclusion if PASS 36/36. Right/Left Lesion 101/150 Mean age 68				251	Doubtful	Between 14 and 30 days after stroke onset Individual level SRM 53% of patients had significant improvement, 37.8% non-significant, 9.2% no change or worsening Group level SRM=0.91 Significant if change > MDC (1.8)
Yu et al 2013 (40)	inpatient rehabilitation at the National Taiwan University sex M/F : 40/26 age 63.1 y side hemiplegia right/left/bilateral : 33/31/2 Days between onset and initial evaluation : 18 ranged 6-79	66	Very good	PASS admission vs MOSTREAM at discharge $r=0.80$ PASS admission vs BI at discharge $r=0.69$	66	Very good	Changes in the BI $r=0.42$ Changes in MOSTREAM $r=0.73$ PASS admission discharge ES : 0.86, SRM 1.23
Allart 2014 (58)	30 patients (85.7%) had suffered from an ischemic stroke, which was most frequently located in the right hemisphere (n = 18, 51.4%) Assesment within 12 weeks after stroke	35	Very good	Correlation between LL-FAS and PASS Questionnaire part vs PASS correlation $r=0.74$ Test part vs PASS $r=0.80$			

Chinsongkram 2014(44)	Subacute stroke patient Assessment with mean 1.1 months after stroke Male/female : 38/32 Affected side Right/Left : 39/31 Ischemic/hemorrhagic : 54/16	70	Very good	❖ PASS vs BesTEST $r=0,96$ Spearman rank order correlations		
Lin 2016 (59)	Subacute Stroke patient 76 ischemic/38 hemorrhage 56 (49%) left hemiplegia Median delay between evaluation and stroke onset (18 days) and discharge evaluation (29 days after stroke onset)	114	Very good	Predictive validity of Five digit test between admission -discharge Selective attention index vs PASS $r=-0.42$ Alternating attention index vs PASS $r=-0.38$		
Chinsongkram 2016(60)	Thailand. Assessment stroke Mean age 58 years (range 28-82) Men / Women : 29/20 Time since stroke : mean of 38 days (range 2-120) Affected side right/left : 27/22				49	Very Good Admission and discharge (mean time between assessments 14 days range 5-44) SRM 1.1 high AUC 0.78 with cutoff score PASS 4 points, reference of a change of 7 BBS. Sensibility 81% Spe 71%
Huang 2016 (61)	341 patients (209 men and 132 women) Mean age 63 ambulatory group Mean age 69 non ambulatory group Admission with mean 34 days. Discharge mean length of hospitalization was 18 days.	341	Very good	ROC Curve determine most appropriate cut off of 12.5 points in PASS total score with sensitivity 78.9%, specificity 83.7% to predict walking ambulation. Results still significant after logistic regression.		
Huang 2016 (62)	Subacute stroke patient Mean age 63.5 Infarction/hemorrhage 22/15 Side hemiplegia left/right/ both : 21/13/7 Days after onset median 19 days (1 st -3 rd quartile : 12-24)	50	adequate	❖ The Brief-BESTest total scores correlations with PASS scores $r = 0.91$	41	Very Good Admission – discharge (median of 19 day after stroke onset and 50days of length of stay) ES 0.90 SRM 1.32
Lin et al 2017 (63)	Subacute stroke population Mâle 60.8% Age 67 (+/- 10 y) 75% infarction Left Hemiplegia 58.3%	301 (14 th days) 262 (30 th days)		On CAT FAS vs PASS on 292 patients $r=0.95$	258	Very good Between 14 and 30 days after stroke, SRM= 0.60

Lee 2017 (64)	Chronic stroke patient Male/ female infarction/hemorrhage : 44 (80%)/11 (20%) Affected side (left/right) 31 (56.4%)/24 (43.6%)	55	Very good	PASS-TC vs mTIS r=0.55		
Huang 2017 (65)	Chronic stroke Mean age (SD) : 59.2 (+/- 7.2) years Left/right hemiplegia : 25/25 Infarct/hemorrhage : 30/20 Post stroke duration 9y (3-13.5)	50	Very good	PASS vs brief BESTest : correlation (rs = 0.911)		
Huang 2018 (66)	Subacute stroke of Taiwan university rehabilitation center Group level N=212 Mean age 68y 60% of male 74% of ischemic stroke Assessment between 14 and 30 th days				212	Very Good Between 14 and 30 days after stroke: - group level SRM: 0.58 indicate moderate group change. Mean change 7.2 (t test significant) - Individual responsiveness level : 46.2% of patients have an improvement considered as significant if superior to MDC (MDC 3.2 points)
Lin 2019 (29)	Hemorrhage/infarction : 87/212 Side hemiplegia right/left/bilateral : 76 /63/16	309	Very good	CAT-5F vs PASS admission (person correlation moment r=0.96 CAT-5F vs PASS at discharge (r=0.93-0.94)		
Arslan 2019 (28)	105 stroke patients (49 female, 56 male) with a mean age of 65.45 ± 11.33 y Acute/subacute/chronic stroke : 55/7/43 Affected side right/left : 53/52	105	Very good	BBA-T vs PASS r=0.847		
Huang 2019 (17)	Subacute stroke Taiwan university Mean age 69.8 y Sex male/female 27/22 Ischemic/hemorrhage : 37/12 Left / Right hemiplegia : 30/19				49	Very good Between day 14-30 At the group level, SRM = 0.79 At the individual level, the PASS showed that 43% of patients had clinically significant improvements
Pooled or summary result (overall rating)		2316	Very good	Same construct (BBS, Brief Best Test, TIS, MO STREAM, MAS, Best TEST) Correlation between 0.63 – 0.94 Predictive validity with functional assessment at discharge (CADL, BI, FIM) correlation between	1702	Doubtful (5), Very good (9) 14-30days : ES between 0.42-0.90; SRM 0.84-1.32 30-60/90 days : ES 0.41-0.91 Global 14-90/180 : ES 1.02-1.12; SMR 1.87 Responsiveness better for severe than small or moderate stroke MDC 1.8 – 3.2

Table 3. Quality assessment

Quality Assessment	Benaim et al. 1999	Hsieh et al. 2002	Mao et al. 2002	Wang et al. 2004	Wang et al. 2005	Chien et al. 2007	Chien et al. 2007	Liaw et al. 2008	Di Monaco et al. 2010	Lin et al. 2010	Persson et al. 2011	Clark et al. 2012	Liaw et al. 2012	Yu et al. 2012	O'dell et al. 2013	Hsueh 2013	Persson et al. 2013	Yu et al. 2013	Allart et al. 2014	Chinongkram et al. 2014	Persson et al. 2014	Cabanas-Valdes. 2015	Chinongkram et al. 2016	Huang et al. 2016 Valida.	Huang et al. 2006 Responsi.	Lin et al. 2016	Huang et Pang 2017	Lin et al. 2017	Persson et al. 2017	Huang et al. 2018	Lee et al. 2018	Lin et al. 2019	Bergkvist et al. 2019	Huang et al. 2019	Kocak et al. 2019	Arsilan et al. 2019						
Content validity	+																																									
structural validity																					+								+													
cross cultural validity																						?																	+			
hypothesis testing	+	+	+		+	+		+			+		+	+				+	+	+		?	+	+	+	+		+											+			
internal consistency	+		+			+																																		+		
reliability	?		+			+					+		+																													
measurement error						+	+	+																																		
responsiveness			+	+		+	+		?			+		+									+		+																	

Table 4. Summarized quality assessment of studies and level of evidence according to COSMIN

	Summary or pooled result	Overall rating	Quality of evidence
Structural validity	2 studies adequate (SwePASS)	Sufficient	high
Internal consistency	4 studies adequate methodology	Sufficient	high
Cross-cultural validity	1 study adequate methodology	Indeterminate	moderate
Reliability	5 studies (4 adequate, 1 doubtful)	Sufficient	high
Measurement error	2 studies	Indeterminate	moderate
Hypotheses testing	20 studies	sufficient	high
Responsiveness	14 studies	sufficient	high

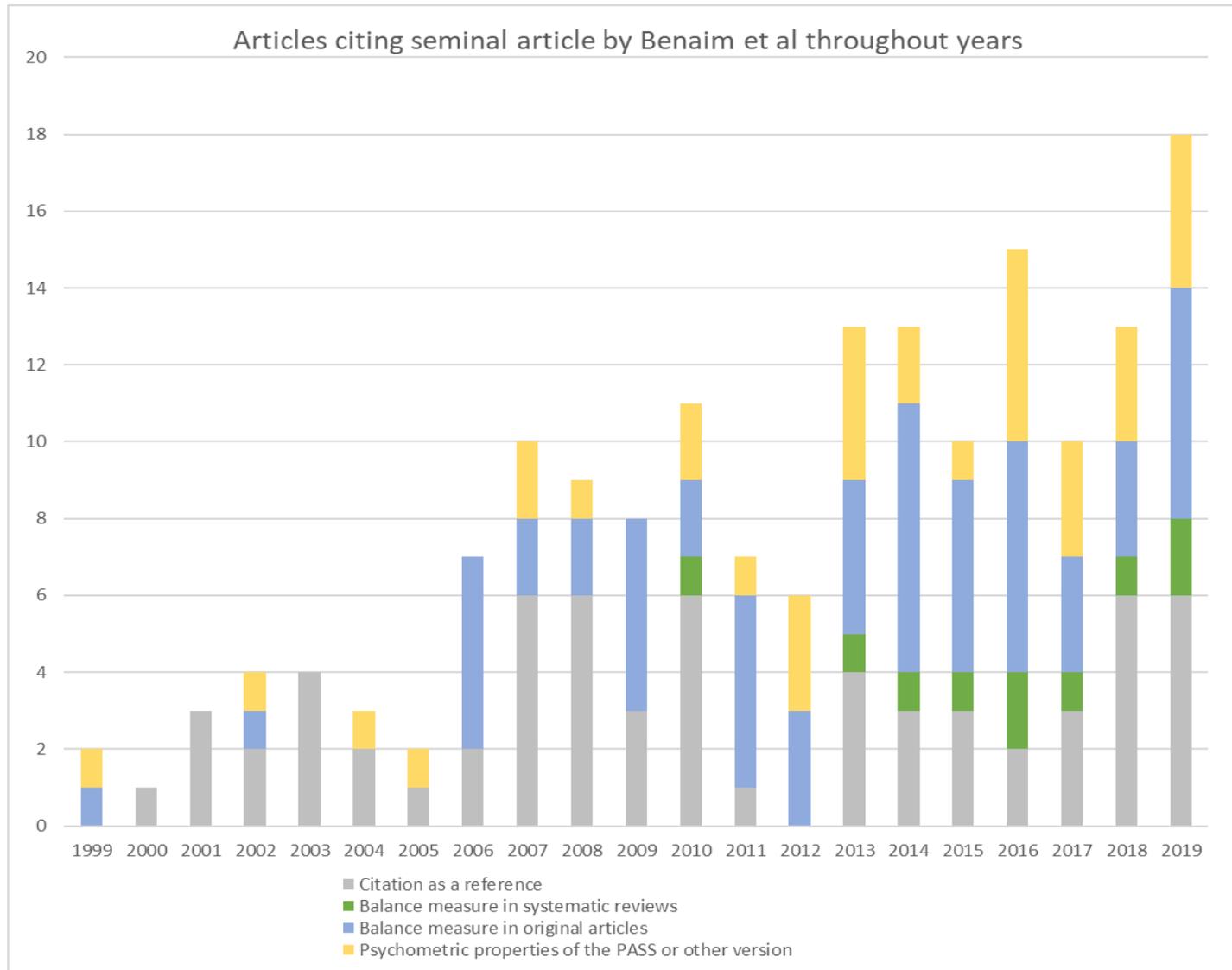


Figure 1. Articles citing seminal article by Benaim et al. throughout years

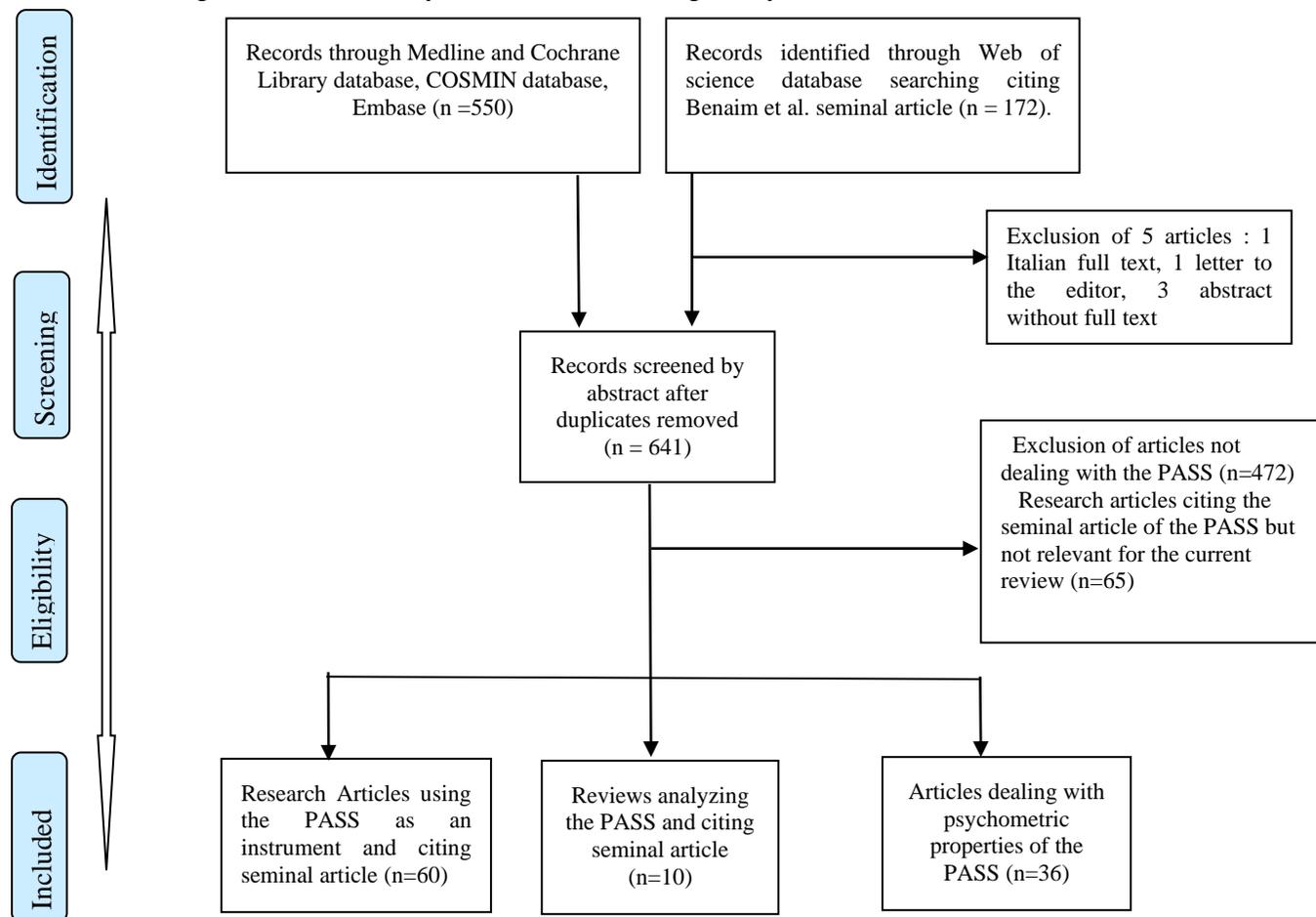


Figure 2. Flow chart. Double narrow indicating part of research done by the two reviewers

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APPENDIX

PASS Items and Criteria for Scoring

Maintaining a Posture

1. Sitting without support (sitting on the edge of an 50-cm-high examination table [a Bobath plane, for instance] with the feet touching the floor)

0 = cannot sit

1 = can sit with slight support, for example, by 1 hand

2 = can sit for more than 10 seconds without support

3 = can sit for 5 minutes without support

2. Standing with support (feet position free, no other constraints)

0 = cannot stand, even with support

1 = can stand with strong support of 2 people

2 = can stand with moderate support of 1 person

3 = can stand with support of only 1 hand

3. Standing without support (feet position free, no other constraints)

0 = cannot stand without support

1 = can stand without support for 10 seconds or leans heavily on 1 leg

2 = can stand without support for 1 minute or stands slightly asymmetrically

3 = can stand without support for more than 1 minute and at the same time perform arm movements above the shoulder level

4. Standing on nonparetic leg (no other constraints)

0 = cannot stand on nonparetic leg

1 = can stand on nonparetic leg for a few seconds

2 = can stand on nonparetic leg for more than 5 seconds

3 = can stand on nonparetic leg for more than 10 seconds

5. Standing on paretic leg (no other constraints)

Same scoring as item 4

Changing Posture

Scoring of items 6 to 12 is as follows (items 6 to 11 are to be performed with a 50-cm-high examination table, like a Bobath plane; items 10 to 12 are to be performed without any support; no other constraints):

0 = cannot perform the activity

1 = can perform the activity with much help

2 = can perform the activity with little help

3 = can perform the activity without help

6. Supine to affected side lateral

7. Supine to non-affected side lateral

8. Supine to sitting up on the edge of the table

9. Sitting on the edge of the table to supine

10. Sitting to standing up

11. Standing up to sitting down

12. Standing, picking up a pencil from the floor

Table of update criteria for good measurements properties

Measurement property	Rating	Criteria
Structural validity	+	CTT: CFA: CFI or TLI or comparable measure >0.95 OR RMSEA <0.06 OR SRMR <0.082 IRT/Rasch: No violation of unidimensionality ³ : CFI or TLI or comparable measure >0.95 OR RMSEA <0.06 OR SRMR <0.08 AND no violation of local independence: residual correlations among the items after controlling for the dominant factor < 0.20 OR Q3's < 0.37 AND no violation of monotonicity: adequate looking graphs OR item scalability >0.30 AND adequate model fit: IRT: $\chi^2 > 0.01$ Rasch: infit and outfit mean squares ≥ 0.5 and ≤ 1.5 OR Zstandardized values > -2 and < 2
	?	CTT: Not all information for '+' reported IRT/Rasch: Model fit not reported
	-	- Criteria for '+' not met
Internal Consistency	+	At least low evidence ⁴ for sufficient structural validity ⁵ AND Cronbach's alpha(s) ≥ 0.70 for each unidimensional scale or subscale ⁶
	?	Criteria for "At least low evidence ⁴ for sufficient structural validity ⁵ " not met
	-	At least low evidence ⁴ for sufficient structural validity ⁵ AND Cronbach's alpha(s) < 0.70 for each unidimensional scale or subscale ⁶
Reliability	+	ICC or weighted Kappa ≥ 0.70
	?	ICC or weighted Kappa not reported
	-	ICC or weighted Kappa < 0.70
Measurement error	+	SDC or LoA < MIC ⁵
	?	MIC not defined
	-	SDC or LoA > MIC ⁵
Hypotheses testing for construct validity	+	The result is in accordance with the hypothesis ⁷
	?	No hypothesis defined (by the review team)
	-	The result is not in accordance with the hypothesis ⁷
Cross-cultural validity/measurement invariance	+	No important differences found between group factors (such as age, gender, language) in multiple group factor analysis OR no important DIF for group factors (McFadden's R ² < 0.02)
	?	No multiple group factor analysis OR DIF analysis performed
	-	Important differences between group factors OR DIF was found
Criterion validity	+	Correlation with gold standard ≥ 0.70 OR AUC ≥ 0.70
	?	Not all information for '+' reported
	-	Correlation with gold standard < 0.70 OR AUC < 0.70
Responsiveness	+	The result is in accordance with the hypothesis ⁷ OR AUC ≥ 0.70
	?	No hypothesis defined (by the review team)
	-	The result is not in accordance with the hypothesis ⁷ OR AUC < 0.70

Table 3 criteria for good measurements

AUC = area under the curve, CFA = confirmatory factor analysis, CFI = comparative fit index, CTT = classical test theory, DIF = differential item functioning, ICC = intraclass correlation coefficient, IRT = item response theory, LoA = limits of agreement, MIC = minimal important change, RMSEA: Root Mean Square Error of Approximation, SEM = Standard Error of Measurement, SDC = smallest detectable change, SRMR: Standardized Root Mean Residuals, TLI = Tucker-Lewis index

1 "+" = sufficient, "-" = insufficient, "?" = indeterminate

2 To rate the quality of the summary score, the factor structures should be equal across studies

3 unidimensionality refers to a factor analysis per subscale, while structural validity refers to a factor analysis of a (multidimensional) patient-reported outcome measure

4 As defined by grading the evidence according to the GRADE approach

5 This evidence may come from different studies

6 The criteria 'Cronbach alpha < 0.95' was deleted, as this is relevant in the development phase of a PROM and not when evaluating an existing PROM.

7 The results of all studies should be taken together and it should then be decided if 75% of the results are in accordance with the hypotheses

The modified version of PASS - SwePASS

Item	Scale	Item	Scale
1. Supine to affected side lateral Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3	7. Standing without support Cannot stand without support Can stand without support for 10 s or leans heavily on 1 leg Can stand without support for 1 minute or stands slightly asymmetrically Can stand symmetrically without support for more than 1 minute and at the same time draw hand/s from forehead to neck (like pulling your fingers through your hair) alternating with arm/s hanging parallel to the trunk to avoid tiredness	0 1 2 3
2. Supine to non-affected side lateral Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3	8. Standing on non-affected leg Cannot stand on the non-paretic leg Can stand on the non-paretic leg up to 5 seconds Can stand on the non-paretic leg for more than 5 seconds Can stand on the non-paretic leg for more than 10 seconds	0 1 2 3
3. Supine to sitting up on edge of bed towards the non-affected side Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3	9. Standing on affected leg Cannot stand on the paretic leg Can stand on the paretic leg up to 5 seconds Can stand on the paretic leg for more than 5 seconds Can stand on the paretic leg for more than 10 seconds	0 1 2 3
4. Bedside sitting with feet supported on the floor and hands in the lap Cannot sit Can sit with slight support, for example with the help of their own hand Can sit for more than 10 s without support Can sit for 5 min without support	0 1 2 3	10. Standing, picking up a shoe from the floor Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3
5. Sitting to standing up Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3	11. Sitting down from standing up Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3
6. Standing with support Cannot stand, even with support Can stand with support from 2 persons Can stand with support from 1 person Can stand with only slightly support of 1 hand	0 1 2 3	12. Sitting on edge of bed to supine Cannot perform the activity Can perform the activity with support from 2 persons Can perform the activity with support from 1 person Can perform the activity without any help	0 1 2 3

Corrected version 2013-11-29.

Equipment: a stopwatch and a shoe/slipper.

The test is performed with the patient barefoot. Only one attempt per item is allowed. Ensure that the patient meets the criteria for the scores below, as well as the criterion for the registered score. A stopwatch is used in items 4 and 7-9, where the patient should maintain a position within a specific time. In items 1-3, 5-6 and 10-12, the patient's postural balance/control should be scored according to different degrees of support (verbal, tactile or supervision). The SwePASS, developed by Carina U Persson, Maria Edvinsson, Katharina Stibrant Sunnerhagen and Ulla Svantesson, published in *J Rehab Med* 2011; 43:348-53, is a synthesis of the original French version and the published English version of the Postural Assessment Scale for Stroke Patients by Benaim C, Pérennou DA, Villy J, Rousseaux M, Pelissier JP. *Stroke* 1999; 30: 1862-1868.

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