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Functional assessment in older adults: Should we use timed up and go or gait speed test?

Alexandre Kubicki [a,b,*]

[a] Institut National de la Santé et de la Recherche Médicale (INSERM), Unité 1093, Cognition Action et Plasticité sensori-motrice, BP 27877, F-21078 Dijon, France
[b] Hôpital de Jour de Champmaillot, Pôle gérontologique, CHU Dijon, 2 rue Jules Violle, 21000 Dijon, France

HIGHLIGHTS

- We tested the link between locomotors tests and arm reaching velocity in frail subjects.
- The Pearson correlation between GS and hand velocity was significant ($r = 0.495$).
- This one between TUG and hand velocity ($r = -0.139$) was not significant.
- GS seems to be more representative of the whole motricity of frail patients than the TUG.
- We propose that GS should be preferred over the TUG with these patients.

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ABSTRACT

In order to assess functional skills of older adults, both timed up and go (TUG) test and gait speed (GS) test are well validated concerning their predictive capacities. However, the question remains unclear which one of these tests represents better the whole physical performance of older adults. The aim of this study is to determine the more representative test, between TUG and GS, of the whole motor control quality. To study links between locomotion capacities and arm function, we measured, in a population of frail aged patients, the locomotion tests and the mean arm maximal velocity developed during a speed–accuracy trade-off. This arm movement consisted in reaching the hand toward a target in a virtual game scene. We plotted the different couples of variables obtained on graphs, and calculate Pearson correlation coefficients between each couple. The Pearson correlation between GS and hand maximal velocity was significant ($r = 0.495$; $p = 0.046$). Interestingly, we found a non significant Pearson correlation between timed up and go score (TUG) and hand maximal velocity ($r = -0.139$; $p = 0.243$). Our results suggest that GS score is more representative of the whole motor ability of frail patients than the TUG. We propose that the relative complexity of the TUG motor sequence could be involved in this difference. For a few patients with motor automatisms deficiencies, this motor sequence complexity could leads to a dual task perturbation. In this way, we conclude that GS should be preferred over the TUG with older adults.

1. Introduction

Pathological aging leads to physiological reserves decrease and results in falls, disability, hospitalization or even death [1]. It has been suggested that balance disorders observed during aging have a significant impact on the functional independence and quality of life of aged adults [2]. In this context, therapists are interested in the motor ability in order to maintain or improve this function as much as possible. The motor function may be assessed from different strategies. Among the functional tests, there are some that may be quickly and easily executed, being at once extremely informative about the patient's capacities. This is the case of the timed up and go (TUG) [3] as well as the gait speed (GS) tests [4].

The TUG test [3] is a clinical test that has been extensively used to assess functional stability and mobility, mainly in frail older people [5–9]. This test consists in standing up from a chair, walking a distance of 3 m, turning and walking back to the chair, and sitting down again. Older adults who are able to complete the task in less

* Corresponding author at: INSERM U1093, Cognition, Action et Plasticité Sensori-Motrice, BP 27877, Campus Universitaire, Université de Bourgogne, 21078 Dijon, France. Tel.: +33 3 80396767; fax: +33 3 80396702.
E-mail address: Alexandre.Kubicki@u-bourgogne.fr

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than 20 s are independent in transfer and have high scores on the Berg Balance Scale. In contrast, older adults requiring 30 s or longer to complete the task are more dependent in activities of daily living, require assistive devices for ambulation, and score lower on the Berg Balance Scale [8,9]. The potential of this test to predict falls is controversial: TUG test allows to predict the fall risk in several studies [7,10,11]. Shumway-Cook and colleagues measured a high sensitivity (87%) and a high specificity (87%) for the TUG test, when it is used with a cut-off value of 14 s for identifying elderly individuals who are prone to falls [8]. However, a few studies suggest that TUG test only is not able to predict falls [12,13].

The GS test consists in walking 10 m at usual speed, with a 1-m start-up before starting timing, and a stop order given after the finish line [14]. A score under 0.65 m by second reveals a frailty state [1]. The GS has been shown to predict as well the hospitalization [15,16], and the declines in function and health [4,17], as the falls [18,19]. Moreover, GS can predict a reduction in mortality in older adults [20].

Both tests are interesting in their predictive capacity about the general health and falls, and seem to be of similar efficiency, even if a recent study suggests that GS presents a better predictive capacity than TUG test [21]. However, if clinical tests aim to assess the whole functional abilities of patient in order to predict its outcomes, one of their objectives is also to inform therapists about the patients physical performance at the present moment, and to guide them in establishment of the "care plan". Systemic tests have been developed to respond to this objective [22,23]. However, even if they are very interesting, these approaches need a relatively long time, and are difficult to integrate in clinical practice. In this way, in order to propose an intermediate solution, it could be very helpful to identify which test, GS or TUG, is the most indicative of the patient motor control efficiency. Indeed, motor control allows to manage – whole body – global tasks, such as those assessed during GS and TUG, and fine motor tasks, usually performed by upper limbs in the activities of daily living. Is it a locomotor test, as GS or TUG test, that is linked with the fine motor control ability of upper limbs? To answer this question, and achieve our goal, we propose to test the relationship between both tests and the patients speed–accuracy tradeoff ability during a reaching arm movement using a virtual interface.

2. Material and methods

2.1. Patients

A total of 37 patients participated in the present study after giving their written consent. The French Committee for the protection of persons (CPP) approved the experimental protocol, which was carried out in agreement with legal and international requirements (Declaration of Helsinki, 1964). The participants were patients in the short-term rehabilitation service of the Benigne Joly Clinic, Burgundy, France. One inclusion criterion was to present a balance disorder, but also to be able to remain standing without any mechanical or human help. The patients all presented multiple causes of hospitalization, but all patients with pyramidal or extra-pyramidal syndrome or peripheral neuropathy were excluded. Nevertheless, inclusion required a conscientious examination, and the diagnosis of frailty was made by a geriatrician according to the clinical features of the syndrome. Frailty was defined as a clinical syndrome in which three or more of the following criteria were present: unintentional weight loss, self-reported exhaustion, weakness, slow walking speed, and low physical activity [1]. Moreover, patients were excluded if there was a suspicion of dementia (Mini Mental State Examination was performed, and dementia was considered for MMSE < 24). All of the patients were right-handed.

Table 1
Patients characteristics.

Parameter	Mean ± standard deviation
Age (years)	82.25 ± 6.01
Height (cm)	162.87 ± 8.04
Weight (kg)	68.57 ± 17.37
Body mass index (BMI)	26 ± 6.91
Timed up and go (s)	21.12 ± 7.05
Gait speed ($m\,s^{-1}$)	0.64 ± 0.2
Gait speed in dual task ($m\,s^{-1}$)	0.56 ± 0.19

Patients characteristics and functional abilities are presented in Table 1.

2.2. Experimental device

The set-up used is an active motion-capture system based on vision technology manufactured by Fovea Interactive®. This system is able to track the marker held by the patient in his right hand. The camera is positioned in front of the participant at a standard distance (d) depending on the patient's height ($d = 1.2 \times$ patient's height). The experimental device is placed underneath a large screen (200 cm × 130 cm, screen diagonal: 238 cm), onto which a marker position is projected. In this way, the right-hand movements are represented on the screen, with a short delay of 33 ms (i.e. the hand movement displays 33 ms late on the screen). The right index finger is represented on the screen by a white hand. In the lower part of the virtual scene, there is a half circle with many needles. Patients are asked to put their hand on this circle to pick up a needle (automatic pick-up). In this way, this half circle placed in the lower part of the screen is the starting point of the reaching movement. When the patient put his right hand on this half-circle, a yellow ball appears somewhere on the screen (the radius of the yellow ball was 10 cm), after a short variable delay (0.2–2 s) and in a random position (eight standard positions: four in the right half of the screen and four in the left half). This is repeated over 10 trials per sequence. For each target, the peak velocity is recorded. At the end of the 10 trials, the mean of this parameter is calculated and communicated to the patients (see Fig. 1 for experimental device).

2.3. Experimental procedure

Patients participated in only one evaluation session, in which they performed clinical tests and hand movements with the experimental device. This evaluation session was always conducted before any classical rehabilitation session. Initially, patients performed the following functional tests: timed up and go test (TUG) and gait speed (GS), as described in the introduction section. After this first clinical assessment, the therapist explained the game task to the patient, and showed a short demonstration of the game. The patient used the device first in a familiarisation sequence: the instruction was to burst the yellow ball with the right hand. Patients were asked to react as soon as possible and to reach the ball as fast as possible. After this first familiarization sequence (10 balls), patients were asked to perform 3 sequences with the same instruction. The experimental device recorded the hand positions during these 3 sequences.

2.4. Data recording of hand maximal velocity and statistical analysis

During the 3 maximal speed sequences of the session, right hand displacements were recorded using the experimental device (sampling rate: 60 Hz). The onsets of hand movement were calculated from a 5% threshold of the maximal speed of each velocity

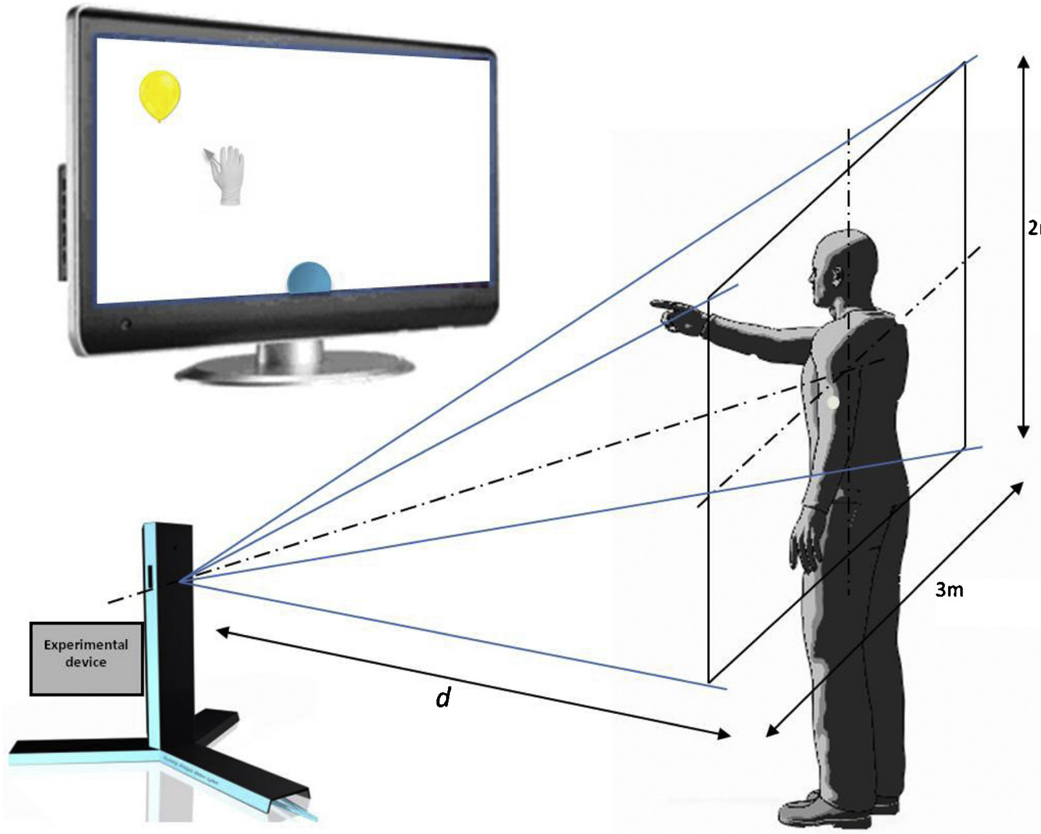

Fig. 1. Schematization of the experimental device.

signal. Hand kinematics signals were filtered (fourth-order Butterworth with a 7 Hz low-pass cut-off frequency).

To start our statistical analysis, we tested the distributions normality of gait speed, timed up and go, and hand maximal velocity with Kolmogorov–Smirnov tests (Statistica software, Statsoft). As all of the analyzed distributions were normally distributed, we plotted in 2 graphs the following couples of data: (1) gait speed and hand maximal velocity and (2) timed up and go and hand maximal velocity. As all of these data are normally distributed (see Fig. 2), we performed a Pearson correlation analysis for each of these 3 between variables associations. The significant level of this Pearson coefficient (r) was 0.324. It was established for an alpha level of 0.05 and for a subject numbers of 37 ($n-1=36$) from the Pearson table.

3. Results

We checked the distributions normality following the Kolmogorov–Smirnov test. Fig. 2 shows that, except one subject which was clearly faster than the others both in walking and reaching, these three plots exhibit a normal distribution (see on Fig. 2).

We plotted 2 couples of variables to determine the potential link between each of them: (1) gait speed and hand maximal velocity and (2) timed up and go and hand maximal velocity.

For the gait speed and hand maximal velocity, the correlation was significant ($r=0.495$; $p=0.046$). There is a significant link between gait speed and the speed–accuracy trade-off represented by the arm reaching movement.

As we can see on Fig. 3, the equation of the linear tendency curve was "gait speed" = 0.138 × "hand maximal velocity" + 0.433. This equation shows that an increase of only 0.1 m s^{-1} in gait speed was equivalent to an increase of 1 m s^{-1} in hand maximal velocity.

For the second couple of variables: timed up and go and hand maximal velocity, the correlation was not significant ($r=-0.139$; $p=0.243$). The Pearson coefficient was under the significant threshold (0.324), there is no statistical link between these two variables (see graph in Fig. 4).

4. Discussion

The aim of this study was to determine the more representative test, between TUG and GS, of the whole motor control quality. The first relationship tested, involving GS test, was significant, whereas the second, involving TUG test, was not. This result strongly suggests that GS score is able to reflect the fine motor control ability of frail older adult, contrary to TUG score.

We noted that TUG scores are not correlated with hand maximal velocity (i.e. arm movement control). This could be explained by the relative complexity of the motor sequence involved in the TUG, during which patients have to understand the correct flow of actions, keep it in their short-term memory, and do it without breaks. In the case of motor automatisms deficiencies, the ability to program the correct motor sequence without involved attentional processes, could be challenged [24,25]. These patients have to focus "cognitively" on the motor sequence: which may involve a waste of time and affect the test result.

Interestingly, recent works have highlighted that TUG might be as reliable and accurate as GS in aged patients with cognitive disorders [26]. However, cognitive integrity does not involve efficient motor automatisms, and inversely: cognitive disorders, as dementia, do not systematically involve a loss of motor automatisms, that seems to be better linked with impairments in frontal–subcortical systems [27]. Moreover, in a population of frail older adults who are prone to fall, patients with motor automatisms deficiencies, as whom that "stop walking when talking", present the same

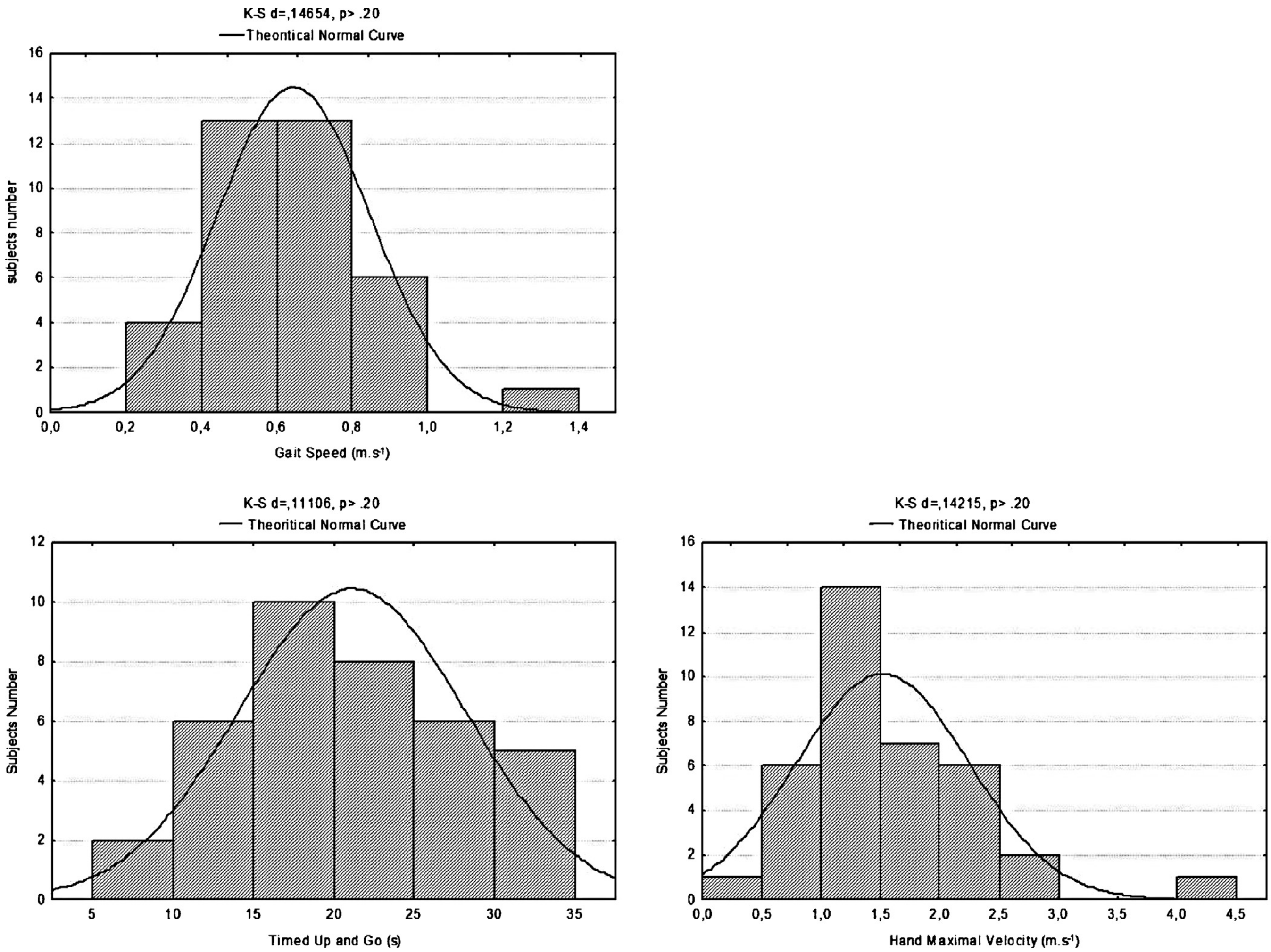

Fig. 2. Distributions of analyzed variables (K–S: Kolmogorov–Smirnov).

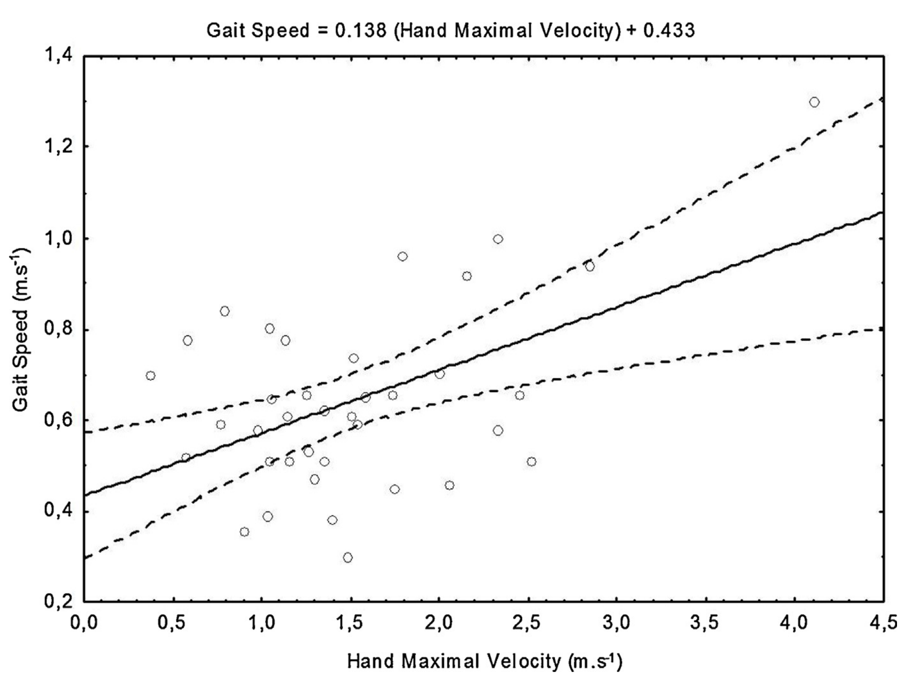

Fig. 3. Relationship between gait speed and hand maximal velocity.

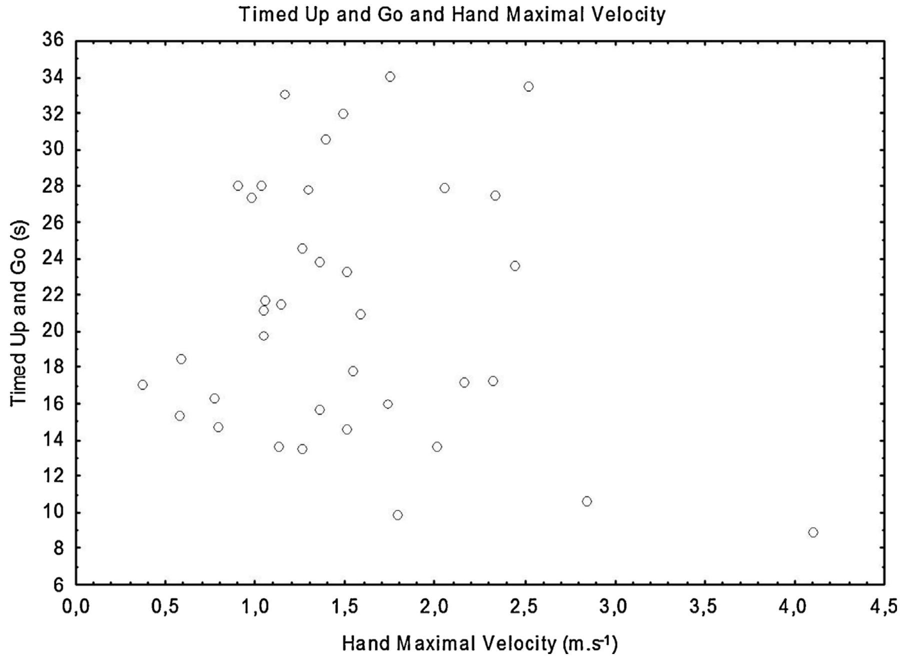

Fig. 4. Relationship between timed up and go and hand maximal velocity.

cognitive performances that the non-stoppers [28,29]. Thus, if TUG is as efficient as GS with patients in the case of cognitive impairments, we suggest that it is less adapted to motor automatisms deficiencies. Consequently, it could explain its poor relationship with the fine arm motor control. A study from Shumway-Cook and colleagues proposed that TUG is sensitive and specific measure for identifying community-dwelling adults who are at risk for falls [8]. However, they explained that the ability to predict falls is not enhanced by adding a secondary task, even cognitive, when performing the TUG. Maybe this result could be explained by the relative cognitive involvement needed by the "normal TUG" for certain older adults.

Moreover, the GS test could be done in a covert form, since there is no consigns to give, contrary to the TUG. As in our experiment, the consign given to the patient could be: 'please, walk on toward the end of the corridor". In this way, the patient does not know that he is timed, and so its mobility may be considered as usual. Indeed, researches about non-specific effects showed that the simple knowledge of being observed could affect the behavior. The existence of change due to the awareness of being studied, known as the Hawthorne effect, should be taken into account during clinical tests [30]. Then GS should probably be measured in a covert form, asking the patient to go toward the refectory, for instance, starting and stopping the timers without informing him. Further researches are required to confirm, or not, this blind condition advantage.

In our study, one may wonder that the link between the two motor behaviors is more conditioning by the virtual immersion capacity of patients. The speed–accuracy trade-off (arm reaching toward the yellow ball) was leaded by the game displayed on the screen. However, we point out that patients who were not able to reach quite rapidly toward the target (hand maximal velocity < 0.3 m s^{-1}), for several reasons (shoulder impairment, lack of immersion, comprehension deficiency), were excluded from the study.

To conclude, from a clinical point of view, we support that GS test should be preferred over the TUG one in order to assess functional capacities, because the result will be representative of a more global motor control quality.

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