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Velocity of the Five Sit-to-Stand Test in Older Adults: A Systematic Review
Velocidad de la prueba sentado-de pie de cinco repeticiones en adultos mayores: Una revisión sistemática

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Abstract. The purpose of this study was to determine the reference values of the velocity of execution of the five Sit-to-Stand in older adults through a systematic review of the literature. Three databases were reviewed: Medline (PubMed), Scopus and Web of Science, with the deadline of March 2021. The search terms were: «sit to stand» OR «stand to sit» OR «chair rise» OR «chair rising» AND «kinematic» OR «velocity». The experimental studies were evaluated using the Quality Assessment of Diagnostic Accuracy Assessment (QUADAS) scale by independent reviewers. A total of seven studies were included. The velocity of execution in older adults (n=85) that presented neurological health conditions was between 0.33 m/s and 0.38 m/s. In the healthy (n=246) ones it was between 0.27 m/s and 0.94 m/s. Between 60 to 70 years (n=157) it was from 0.31 m/s and 1.59 m/s, and from 70 to 80 years (n=225) it was from 0.27 m/s and 1.04 m/s. The execution velocity of five Sit-to-Stand in older adults ranges from a minimum of 0.27 m/s to a maximum of 1.59 m/s ffor the complete cycle of standing up and sitting down. These antecedents may be useful to predict or detect functional alterations and disability.
Keywords: Aged; Geriatrics; Physical Functional Performance; Muscle Strength; Mobility Limitation.

Resumen. El propósito de este estudio fue determinar los valores de referencia de la prueba sentado-de pie de cinco repeticiones en adultos mayores a través de una revisión sistemática de la literatura. Se revisaron tres bases de datos: Medline (PubMed), Scopus y Web of Science con fecha límite Marzo del 2021. Los términos de búsqueda fueron: «sit to stand» OR «stand to sit» OR «chair rise» OR «chair rising» AND «kinematic» OR «velocity». Los estudios experimentales se evaluaron por revisores independientes mediante la escala «Quality Assessment of Diagnostic Accuracy Assessment (QUADAS)». Se incluyó un total de siete estudios. La velocidad de ejecución en adultos mayores que presentaban condiciones de salud neurológica (n=85) estuvo entre 0.33 m/s y 0.38 m/s. En sujetos sanos (n=246) estuvo entre 0.27 m/s y 0.94 m/s. En sujetos entre 60 a 70 años (n=157) fue de 0.31 m/s y 1.59 m/s, y de 70 a 80 años (n=225) fue de 0.27 m/s y 1.04 m/s. La velocidad de ejecución de la prueba sentado-de pie de cinco repeticiones en adultos mayores varía desde un mínimo de 0.27 m/s hasta un máximo de 1.59 m/s para el ciclo completo de pararse y sentarse. Estos antecedentes pueden ser útiles para predecir o detectar alteraciones funcionales y discapacidad.
Palabras clave: Adulto mayor; Geriatría; Desempeño Físico Funcional; Fuerza Muscular; Limitación de Movilidad.

Introduction

The capacity to stand up from a chair is a common form of locomotion and is considered an indicator of mobility and functional independence (Bohannon, 2015). On average, community-dwelling older adults perform the Sit-to-Stand (STS) movement at least 45 times per day (Bohannon, 2015). Aging is characterized by a series of multisystemic changes, including neuromuscular and sensorimotor systems, generally reducing functional physical capacity and muscular power (Mertz et al., 2019; Miranda et al., 2022). This situation determines that the STS movement can gradually become more demanding, becoming a highly demanding task even for the healthy population (Piano et al., 2020).

Limited STS movement promotes physical inactivity and reduced functional mobility (van Lummel et al., 2016), a predictor of falls in this population group (Zhang et al., 2013). In addition, it has recently been reported that lower STS performance is associated with reduced muscle quality in older people (Jerez-Mayorga et al., 2020). Attention is currently being paid to STS movement performance and the factors that affect it, because it is also a requirement for many activities of daily living (Pickford et al., 2019). One of the main tests to assess the sitting-biped transition is the STS test, which requires very little equipment and minimal training of the assessor (Tarrant et al., 2020). This test is being increasingly investigated in different groups of patients, older adults, orthopedics, renal and respiratory medicine (Bohannon & Crouch, 2019; Núñez-Cortés et

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al., 2021; Segura-Ortí & Martínez-Olmos, 2011).

The STS test has several variants. The first version uses the time required to perform 10 STS (Csuka & McCarty, 1985). Other versions then time the duration of one, three and five repetitions of the maneuver or have indicated the number of repetitions that could be completed in 10 or 30 seconds (Bohannon, 1995). The time required to perform five repetitions (5STS), however, has been the most widely used (Makizako et al., 2017). The 5STS version has as its main purpose the evaluation of muscle power, being an important predictor of future functional limitations, allowing to differentiate elderly people with priority in power training (Alcazar et al., 2018). In various clinical populations, the 5STS has an intraclass correlation coefficient (ICC) between 0.64-0.95, with an adjusted mean of 0.81 (Bohannon, 2011). It has been reported that if the minimal detectable change for STS is <0.04 m/s^{-1}, is feasible to detect velocity decrements over time (Alcazar et al., 2018) through the previously validated formula for estimating the mean velocity through the STS. It also indicates reduced postural balance associated with fall risk, reduced lower extremity strength, and reduced reaction time (Ejupi et al., 2015). Thus, the research problem of the present study is to know the velocity of execution of the 5STS in older adults, due to the limited information available on this indicator (Ejupi et al., 2015; Gallardo-Meza et al., 2020; Lindemann et al., 2014; Mak & Hui-Chan, 2002, 2004, 2005). The purpose of this research was to determine the reference values of the velocity of execution of the 5STS in older adults through a systematic review of the literature.

Materials and methods

This study corresponds to a systematic review of the literature following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA) statement (Page et al., 2021). The protocol was registered in International Prospective Register of Systematic Reviews PROSPERO (CRD42020207402) on 03 October 2020.

Study Search

The search was carried out by the four authors. This search was developed through the databases: Medline (PubMed), Scopus and Web of Science, with the deadline of March 2021. The following search terms were considered: «sit to stand» OR «stand to sit» OR «chair raise» OR «Chair rising» AND «kinematic» OR «velocity».

Eligibility Criteria

The following criteria were used to select the studies for this systematic review: I) older adults >60 years of both genders; II) studies published in English or Spanish language; III) experimental studies; IV) studies performing the STS in its five-repetition version; and V) studies describing in their results the velocity of execution of the 5STS in cm/s, m/s or $m \cdot s^{-1}$. The search was not restricted by publication date and all studies published in a language other than English or Spanish, where full access to the text and presentations at conferences, letters to the editor, theses and books was not available, were excluded.

Study Selection

The studies that were deemed eligible for inclusion were entered into the Rayyan QCRI application, an app that aids in the article selection process, optimizing screening time and enabling collaborative tasks (available free of charge at http://rayyan.qcri.org) (Ouzzani M et al., 2016). Duplicate references were eliminated and four independent investigators reviewed the titles and abstracts to identify papers that met the eligibility criteria. The selected papers were then read in their entirety and the reference list was checked for relevant papers that could be included. During the review of full text articles, co-author D-JM was consulted to discuss any possible disagreements regarding inclusion/exclusion of any articles.

Assessment of risk of bias and quality of evidence

Each article included was evaluated for methodological quality and risk of bias (RoB) autonomously by four authors, using the Quality Assessment of Diagnostic Accuracy Assessment (QUADAS) scale (Thoomes-de Graaf et al., 2020), where 15 items distributed in three sections were used: (a) study sample, (b) items and (c) results. Each item was evaluated by means of a Y=yes; N=no; UC=unclear; NA=not applied. If it receives less than five «N» or «UC», the study is interpreted as having a lower RoB. In case of disagreement, the consensus method was used; if consensus could not be reached, a fifth investigator was consulted.

Data extraction and analysis

The following information was extracted from the

Table 1
Characteristics of the included studies

Studies	Country	Study design	Aim	N; Age (Mean±SD)	STS Test	Velocity (Mean±SD)	Conclusion
Mak et al. (2002)	China	Observational Study	To identify the kinematic and kinetic disorders that contribute to the slow execution of the STS in patients with PD.	M=7 W=8 69.0±5.6	Subjects were sitting with their torso upright and their arms folded across their chest on an adjustable armless chair that was mounted on the front force platform. After a verbal "get ready and stand up" intervention, the subjects performed the STS movement at natural velocity. Chair height=N/S	0.31±0.07 m/s	This study demonstrated that the slowness of PD patients when sitting and standing at a natural velocity could be attributed to inadequate peak hip flexion and ankle dorsiflexion torsion, prolonged torque production, as well as difficulty in shifting from the knee. direction of flexion to extension during standing position.
Mak et al. (2004)	China	Observational Study	To assess whether patients with PD can modify the velocity of the STS to the same extent as that of healthy subjects.	PD=15 CG=15 PD=65.5±7.9 CG=69.5±5.2	Participants who performed self-initiation were asked to get up when ready, without any signal, on the contrary, participants who performed a natural Velocity were given 2 clues, an auditory (verbal command) and a visual clue with the command " Get ready, get up, "with arms crossed in front of the body and the STS movement was asked to be performed as soon as possible. The STS movement was practiced three times prior to data collection to familiarize users with the STS movement. Chair height=N/S	CG: Natural velocity and self-initiation=0.40 m/s PD: Self-initiation=0.33 m/s; Natural velocity=0.39 m/s	Participants with PD, when given the signal to stand and sit, were able to perform the STS naturally as were the control subjects, therefore, over time, under this condition (indication of the signal) the probability of present a postural deterioration and perform a poor performance of the STS.
Mak et al. (2005)	China	Observational Study	To assess whether PD patients could modify the velocity of a STS task to the same extent as that of healthy subjects.	M=20 W=20 PD=20 CG=20 PD=65.8±7.2 CG=69.3±5.1	Participants with the command "get ready and stand up" had to perform the STS movement at a natural or fast velocity in a random sequence. For "natural" velocity, subjects were instructed to stand up at their own normal speed. For "fast" velocity, they were instructed to get up from the chair as fast as they could without losing their balance. Three practice trials were conducted to familiarize users with the STS movement, followed by five trial trials. Chair height=N/S	Natural velocity: CG=0.43±0.07 m/s^{-1}; PD=0.33±0.08 m/s^{-1} Fast velocity: CG=0.49±0.06 m/s^{-1}; PD=0.38±0.08 m/s^{-1}	Parkinsonian patients were significantly slower than healthy individuals during the natural velocity STS. When required to perform an STS task at a rapid velocity, these patients could increase the maximum horizontal and vertical velocities of the task, significantly increasing the hip and ankle dorsiflexion torques and the rate of torque production, just as the patients did. control subjects.
Lindemann et al. (2014)	Germany	cross-sectional	Investigate the effect of cold on physical performance in older women.	W=88 78±5.6	N/S Chair height=N/S	G15ºC=0.96 m/G25ºC=1.07 m/s	In healthy older women a moderately cold indoor environment decreased important physical performance measures necessary for independent living.
Ejupi et al. (2015)	Australia	Randomized controlled trial	Examine the feasibility of a low-cost, portable 5STS test. Investigate whether this test can be used for supervised and unsupervised clinical evaluations	M=29 W=66 F=29 NF=65 F=80.6±6.7 NF=79.3±6.3	The laboratory group was asked to stand up and sit down, as quickly as possible with their arms crossed over their chests. The home-tested group was asked to complete the 5STS unsupervised within the first 30 days after system installation. Chair height=45 cm	STS MV: F=0.78±0.20 m/s; NF=0.94±0.24 m/s Stand-to-Sit MV: F=0.65±0.20 m/s; NF=0.76±0.22 m/s	The STS MV ranked those who fail and those who do not fall well based on retrospective data from 12 months of decline. In addition, it had stronger associations with clinical tests of balance, strength, and reaction time.
Alcazar et al. (2018)	Spain	Prospective cohort study	Validate a procedure to assess muscle power.	M=16 W=26 77.6±5.4	The test was timed in a chair, the subjects started as quickly as possible from the sitting position with the glutes touching the chair to the standing position, with the arms crossed over the chest. Chair height=49 cm	0.27±0.08 m/s^{-1}	The STS is an easy, portable, and inexpensive procedure for assessing muscle power. The velocity values of the STS tests differ only by 0.02 m/s^{-1} from the velocity values obtained with a validated instrument.
Gallardo-Meza et al. (2020)	Chile	Randomized controlled trial	Execute a 4-week exergames training program applied to women.	W=72 CG=37 EG=35 CG=68.1±3.3 EG=69.2±3.7	The test consisted of standing up from a chair with the arms crossed over the chest five times as fast as possible. Chair height=50 cm	EG: Pre=0.91±0.20 m/s^{-1}; Post=1.59±0.38 m/s^{-1} CG: Pre=0.89±0.31 m/s^{-1}; Post=0.84±0.23 m/s^{-1}	Exercising training improves physical condition and therefore velocity in older women.

W Women; M Men; N/S Not specify; PD Parkinson's disease; CG Control group; EG Experimental group; F Falling; NF Not falling; Pre-T Pre-training; Post-T Post-training; MV Mean velocity; STS Sit-to-Stand.

included studies: I) author; II) study objective; III) sample size; IV) age; V) health condition; VI) test description (chair height, procedure, score); VII) velocity of execution; and VIII) main conclusions of the study. Authors JP-D, BR-M, FS-R and RZ-A used an Excel template to extract the relevant information from each article.

Results

Study selection

A total of 1.560 records were identified through the data search; subsequently, duplicate records were eliminated, leaving 700 records. Titles and abstracts were examined, 10 were selected according to inclusion criteria and 690 were eliminated according to exclusion criteria by title and abstract screening. The main reasons for exclusion were: age < 60 years, type of STS other than five repetitions, results of velocity of execution other than cm/s, m/s or m·s^{-1}, studies published in a language other than English or Spanish, where full access to the text was not available. Finally, a total of seven studies were included (Figure 1).

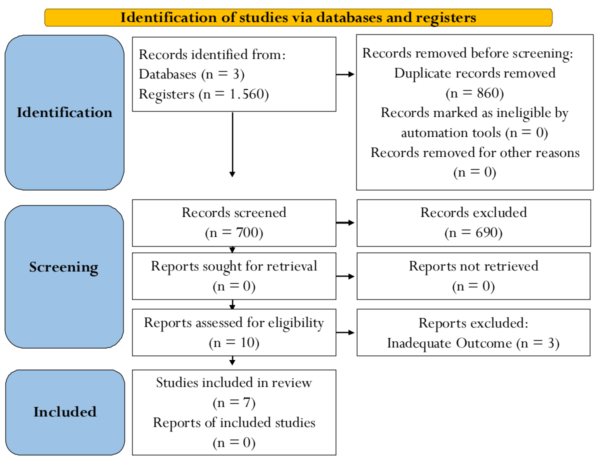

Figure 1. *Flowchart of the article selection process*

Characteristics of the study

Individuals were presented in two main contexts; I) according to a specific health condition as a control group to compare with people with neurological damage, such as Parkinson's disease (PD) (Mak & Hui-Chan, 2004, 2005), and II) STS performance across different conditions and age ranges, e.g., subjects subjected to different temperatures (Lindemann et al., 2014), auditory and visual cues (Mak & Hui-Chan, 2004), verbal intervention (Mak & Hui-Chan, 2002, 2005) and different velocities (Alcazar et al., 2018; Ejupi et al., 2015) (Table 1).

Methodological quality and risk of bias

According to the seven included studies, it was observed that all determined an appropriate sample (# item 1). Only one study (Mak & Hui-Chan, 2002) does not specify the gender of the sample (# item 2), and the seven studies indicated the age of the sample (# item 2), in addition, three (Ejupi et al., 2015; Mak & Hui-Chan, 2004, 2005) studies presented the health condition of the participants (# item 2). The seven studies had described the selection criteria of the sample (# item 3). Regarding the size of the sample two studies (Ejupi et al., 2015; Lindemann et al., 2014) presented an appropriate size, in two of the studies (Alcazar et al., 2018; Mak & Hui-Chan, 2004) it was unclear, and in three (Gallardo-Meza et al., 2020; Mak & Hui-Chan, 2002, 2005) it was not determined whether it had an adequate sample size (#ítem 4). Regarding the procedure of the test performed, the seven studies did not describe the experience of the evaluator (#item 5). In the seven studies a description of the device used to measure the data was presented (#item 6). Regarding the validity of the instruments used, only two studies described it (Alcazar et al., 2018; Gallardo-Meza et al., 2020) (#ítem 7). Only one study (Lindemann et al., 2014), did not comply with the description of the position, movement performed or stabilization of the test performed (#item 8). In the seven studies, the commands or instructions given to the participants to perform the test were described (#item 9). In two of the studies (Mak & Hui-Chan, 2004, 2005) were performed randomly (#item 10). In all studies the measures of velocity results were clearly described (#item 11). In only one study (Lindemann et al., 2014) the direction (horizontal or vertical) in which the STS velocity was evaluated was not described, however, a specific environment (15ºC/25ºC) was described for the performance of the test (#item 12). In five studies (Ejupi et al., 2015; Gallardo-Meza et al., 2020; Lindemann et al., 2014; Mak & Hui-Chan, 2004, 2005), did not apply to present a measure of reliability, such as the ICC or some reference of reliability in similar studies (#ítem 13). Regarding the presentation of the results, all seven studies clearly described the velocity results obtained and the comparison between different types of health conditions that performed the test (#item 14), furthermore all seven studies presented appropriate inferential statistics (#item 15). Finally, all studies presented a low RoB (Table 2).

Difference between health conditions

Two studies (Mak & Hui-Chan, 2004, 2005) compared the velocity between participants with some type of neurological damage mainly with PD and participants without neurological alteration. In the study of Mak & Hui-Chan (2004), the experimental group (EG) performed the 5STS at a natural velocity (mean velocity (MV) = 0.39 m/s) and in self-initiation (MV = 0.33 m/s), while the control group (CG) presented a MV of 0.4 m/s, so the difference between the velocity in the autoinitiation of the CG and EG was 0.07 m/s, and in the natural velocity there is a difference of 0.01 m/s. In other study (Mak & Hui-Chan, 2005), the EG was divided into I) those who performed a natural velocity, and II) those who performed at a fast velocity, both groups presented participants without neurological damage and with some damage. The results indicated that the participants who performed a natural velocity with

Table 2
Assessment of risk of bias using the QUADAS scale

Studies	Items															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total RoB
Alcazar et al. (2018)	Y	Y	Y	UC	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Low
Mak et al. (2002)	Y	Y	Y	N	N	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Low
Mak et al. (2004)	Y	Y	Y	UC	N	Y	N	Y	Y	Y	Y	Y	NA	Y	Y	Low
Mak et al. (2005)	Y	Y	Y	N	N	Y	N	Y	Y	Y	Y	Y	NA	Y	Y	Low
Lindemann et al. (2014)	Y	Y	Y	Y	N	Y	N	N	Y	N	Y	N	NA	Y	Y	Low
Ejupi et al. (2015)	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	NA	Y	Y	Low
Gallardo-Meza et al. (2020)	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	NA	Y	Y	Low

Items considered: 1. Was the study population adequately described (i.e., sex, age, body mass, body height, kind of physical activity/lifestyle (sedentary, athlete, level of physical activity))?; 2. Was the description of selection criteria presented?; 3. Was there justification of appropriate sample size (through calculation or guidelines)?; 4. Were warm-ups and a familiarization protocol performed?; 5. Were type of muscle action (i.e., concentric and eccentric), sequence of action (i.e., concentric–concentric, concentric–eccentric, eccentric–eccentric), and velocity of movement described?; 6. Was the order of tests randomized or counterbalanced?; 7. Was the lower limb dominance considered?; 8. Was the standardization of positions, movements and stabilization performed and properly described?; 9. Did participants receive the same encouragement during the test?; 10. Was gravity correction considered?; 11. Were the outcome measures clearly described?; 12. Were data extracted from the STS test?; 13. Were measures of reliability (e.g., Intraclass correlation coefficients (ICC), Standard error of the mean (SEM)) presented?; 14. Were results clearly described?; 15. Were appropriate inferential statistics presented?; N no; Y yes; UC unclear; NA not applied; RoB risk of bias.

neurological damage presented a decrease in velocity, with results of 0.33 versus 0.43 m/s^{-1}, a difference of 0.1 m/s^{-1}, while the participants who performed at a fast velocity the 5STS showed a greater variation between the execution velocities, resulting in 0.11 m/s^{-1} difference. Those with neurological damage have a velocity of 0.38 m/s^{-1} and those without neurological damage have a velocity of 0.49 m/s^{-1}. Also, Ejupi et al. (2015) valued the velocity at the falling (F) and non-falling (NF) older adults, the F showed a 5STS velocity of 0.78 ± 0.20 m/s and a Stand-to-Sit velocity of 0.65 ± 0.20 m/s. The NF group performed the 5STS at 0.94 ± 0.24 m/s, and the Stand-to-Sit at 0.76 ± 0.22 m/s.

Difference between the age range 60-70 versus 70-80

Regarding the velocity difference between the age range of 60-70 versus 70-80, the study by Gallardo-Meza et al. (2020), the EG (69.2 ± 3.3 years) who underwent training through exergames, was faster than the CG (68.1 ± 3.3 years) in terms of the velocity of execution of the 5STS, since prior to the training they obtained 0.91 ± 0.20 m/s^{-1} and after training 1.59 ± 0.38 m/s^{-1}, while the CG before training 0.89 ± 0.31 m/s^{-1} and after training 0.84 ± 0.23 m/s^{-1}. Mak & Hui-Chan (2002), evaluated older adults (69.0 ± 6.6 years) and its result in terms of velocity was 0.31 ± 0.07m/s, comparing it with the study by Mak & Hui-Chan (2004), the participants (65.5 ± 7.9 years), where the natural velocity and self-initiation were analyzed, which resulted in 0.4 m/s each. Regarding the study of Mak & Hui-Chan (2005) the CG (69.3 ± 5.1 years) had an average natural velocity of 0.43 ± 0.07 m/s^{-1} and a fast velocity of 0.49 ± 0.06 m/s^{-1}. In the Alcazar's et al. (2018) the participants (77.6 ± 5.4 years), when performing the 5STS movement, obtained a velocity of 0.27 ± 0.08 m/s^{-1}. In the study of Ejupi et al. (2015) which evaluated NF (79.3 ± 6.3 years), the velocity of the 5STS was 0.94 ± 0.24 m/s^{-1}, and the Stand-to-Sit was 0.76 ± 0.22 m/s^{-1}. On the other hand, in Lindemann's et al. (2014), the participants (78 ± 5.6 years) who performed the 5STS at two temperatures, first at 15°C where a MV of 0.96 m/s was obtained and then at 25°C resulting in a MV of 1.07 m/s. As described, the older adults evaluated (Gallardo-Meza et al., 2020; Mak & Hui-Chan, 2002, 2004, 2005) with ages from 60 to 70 years, presented a velocity of execution of the STS between 0.4 to 0.91 m/s^{-1}. Regarding the studies (Alcazar et al., 2018; Ejupi et al., 2015; Lindemann et al., 2014) that present a sample with an age range of 70 to 80 years, the velocity ranges from 0.27 to 1.07 m/s^{-1}.

Measuring devices used

Four assessment device were used: I) The sensor (Microsoft Kinect-based) was used to measure the velocity of the 5STS and together with the software (Kinect Development Kit for Windows) they recorded the anatomical reference points of the study subjects (Ejupi et al., 2015); II) The linear position transducer (T-Force Dynamic Measurement system: Ergotech, Murcia, Spain), was used to measure the velocity of the 5STS, this was fixed through a belt on the hips of the subjects (Gallardo-Meza et al., 2020); III) The linear position transducer (MuscleLab, Power model MLPRO, Ergotest Technology, Langesund, Noruega) was used to measure the velocity of the 5STS, this was fixed on the hips of the subjects (Lindemann et al., 2014); and IV) 2 force platforms (Model BEDAS-2; AMTI, Watertown, MA) and a motion analysis system (Model PEAK 5, Peak Performance Technologies, Englewood, CO), was used during the measurement of the STS. Two force platforms «A» and «B» placing under the feet of the subjects (A), and another under the chair (B). In addition, reflective markers were placed on the left lateral side in 5 body segments (foot, leg, thigh, trunk, arm, and head) (Mak & Hui-Chan, 2002, 2004, 2005).

Discussion

The aim of this study was to determine the reference values of the velocity of execution of the 5STS, in older adults through a systematic review of the literature. The main findings found in the studies were; I) The execution velocity of the 5STS in older adults that presented neurological health conditions was between 0.33 m/s and 0.38 m/s; II) The healthy older adults (CG) presented a execution velocity between 0.27 m/s and 0.94 m/s; III) The older adults between 60-70 years the 5STS executed it between 0.31 m/s and 1.59 m/s, and the older adults between 70 and 80 years the velocity was 0.27 m/s and 1.04 m/s; and IV) The methodological quality of the seven selected studies had a low RoB. The main conclusion of this study is that the execution velocity of the 5STS varies between a minimum velocity of 0.27 m/s and a maximum of 1.59 m/s.

The STS has been shown to be a tool of great contribution in the clinic, both for the detection and prediction of alterations in physical and cognitive function and sarcopenia (Alcazar et al., 2018, 2020), which are risk factors for developing some type of disability (Tarrant et al., 2020). This is why the importance of greater muscle power and velocity of execution of the test, which would indicate a lower index of clinical frailty and limitations in activities of daily living (Glenn, Gray, & Binns, 2017; Losa-Reyna et al., 2020) and therefore a better quality of life and mortality (Alcazar et al., 2018; Puhan et al., 2013). Specifically, the 5STS is a validated, practical, and economical field test for the assessment of muscle power (Alcazar et al., 2018), which is also better tolerated by older people as it is considered less tiring, compared to the original 10STS version.

Taking into account the above, the presence of different health conditions affects variations in the velocity of the STS, such as PD (Mak & Hui-Chan, 2004, 2005), where there is a variability between 0.33 m/s to 0.38 m/s compared to the population that does not present any health condition, where the highest velocity value was 1.59 m/s (Gallardo-Meza et al., 2020), demonstrating that, in PD conditions, the onset of movements tends to be slow, prolonging the time of its performance and decreasing its velocity values. Another study indicates that in sarcopenic conditions, MV has a value of 0.5 m/s (Glenn, Gray, Vincenzo, et al., 2017). Under conditions of fragility, population F presents a MV of 0.78 m/s (Ejupi et al., 2015), in addition, another study identifies a MV of 0.41 m/s and peak velocity of 0.64 m/s in this population (Vincenzo et al., 2018). In clinical conditions, maximum velocity values of 0.52 m/s prior to training and a velocity of 0.61 m/s post strength training are indicated (Regterschot et al., 2014). Although few studies indicate the velocity of 5STS in different health conditions, a clear decrease in velocity is observed in populations suffering from health conditions associated with neurological and musculoskeletal conditions.

Regarding age, it can be seen that between 60-79 years, the MV of the STS begins to decrease from 17-20% compared to young adults (Glenn, Gray, & Binns, 2017). In a recent review, it was found that the execution velocity of the STS in ages between 60-79 years, varies between 0.27 to 1.59 m/s. In a similar study, where a linear encoder was validated to determine STS muscle power in older adults, the STS execution velocity ranged from 0.55 to 1.64 m/s, results similar to ours. In addition, it has been shown that at an older age, the speed of STS execution decreases (Alcazar et al., 2018; Lindemann et al., 2014; Mak & Hui-Chan, 2004; Smith et al., 2020). In healthy older adults, between 70-84 years, the maximum velocity performed in a normal velocity execution of the STS is 0.52 m/s while, the maximum velocity to perform the STS quickly is 0.70 m/s (Regterschot et al., 2014). In an average age of 77.8 years, when performing the 5STS with a rest of 60 seconds, in NF participants, the MV is 0.50 m/s and the maximum velocity is 0.74 m/s (Vincenzo et al., 2018). In contrast, healthy adults (53.1 years), when performing 3 repetitions of the STS, the MV is 0.79 m/s, and the average peak velocity is 0.85 m/s (Sherwood et al., 2020). Another study also indicates that older adults of ages between 60-95 years, the execution velocity of the STS is 0.38 m/s for women and 0.39 m/s for men (Sherwood et al., 2020). In this context, there are different types of STS and for different evaluations, for example, in institutionalized older adults, the 30STS is an excellent alternative to predict risk of falls (Roongbenjawan & Siriphorn, 2020). The 5STS is able to predict future disabilities (Makizako et al., 2017) and the one-minute STS is an indicator to assess cardiorespiratory function and performance (Reychler et al., 2018, 2019). Therefore, the STS is an easy-to-use, inexpensive and portable test to determine the functional capacity of older adults.

Regarding the devices used, the linear position transducer (T-Force System, Ergotech, Spain) reports an ICC of 0.99 (Courel-Ibáñez et al., 2019) to measure the velocity of the bar during muscle strength exercises. Moreover, the linear encoder (MuscleLab Power model MLPRO, Ergotest Technology, Langesund, Norway) presents an association of $r = 0.646$ with muscle power measured through the Nottingham Power Rig (Lindemann et al., 2015). In addition, the formula used by Alcazar et al. (2018), which consists in calculating the MV of the STS based on the distance (in meters), traveled by the center of mass, divided by the time (in seconds) that elapses in performing a repetition of STS presents a high reliability (ICC = 0.97).

The main limitations of this study were: I) the low number of studies that provide information on the velocity of execution of the STS; II) among the selected studies only three presented a value on the height of the chair, which gives understand that there is no standard height of this for the execution of the STS (Alcazar et al., 2018; Ejupi et al., 2015; Gallardo-Meza et al., 2020), III) Using the Microsoft Kinect System to evaluate 5STS in older adults with high risk of frailty at home without supervision may not be feasible to perform (Ejupi et al., 2015), IV) the scarcity of validated or reliable instruments to measure the velocity of execution of the STS, which is important to consider for future research. Among the strengths of the systematic review is the characterization of a range of velocity of execution of the STS, in addition, the description of a formula to determine the velocity of the STS, which is economical, fast, and easy to apply, being very useful for the clinic. Future research should be aimed at evaluating the effect of various physical training programs to favor the velocity of execution of the movement of standing and sitting (Gallardo-Meza et al., 2020).

Conclusions

In conclusion, the execution velocity of the 5STS in older adults oscillates between a minimum of 0.27 m/s and a maximum of 1.59 m/s, within these ranges we find populations that present some neurological condition such as PD that varies from 0.33 m/s at 0.38 m/s. On the other hand, in healthy older adults, their execution velocity is between 0.27 m/s and 0.94 m/s, in those over 70 years the velocity is between 0.27 m/s up to 1.04 m/s, being slower compared to those with a lower age range (<70 years) that fluctuate 0.31 m/s and 1.59 m/s. It should be noted that the 5STS is a useful tool to predict or detect functional alterations and disability, hence the importance of making known the kinematic characteristics of the 5STS through the velocity of execution. Through the average velocity of the 5STS, reference values could be obtained that can be used in the clinic to identify elderly people with a history of frailty, thus favoring the diagnosis and the need to intervene through muscle training in these patients.

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