J Nutr Health Aging. 2019;23(6):586-594

TIME EFFECTS ON PHYSICAL PERFORMANCE IN OLDER ADULTS IN NURSING HOME: A NARRATIVE REVIEW

E. MASCIOCCHI[1,2,*], M. MALTAIS[1,*], Y. ROLLAND[1,3], B. VELLAS[1,3], P. DE SOUTO BARRETO[1,3]

1. Gérontopôle de Toulouse, Institut du Vieillissement, Centre Hospitalo-Universitaire de Toulouse, 37 allée Jules Guesdes, 31000 Toulouse, France; 2. Division of Geriatrics, University of Verona, Verona, Italy; 3. UMR INSERM, 1027 University of Toulouse III, Toulouse, France Faculté de médecine 37 allées Jules Guesde 31000 Toulouse. *The authors contributed equally to this manuscript. Corresponding author: Mathieu Maltais, PhD, Gérontopôle de Toulouse, Institut du Vieillissement, Bâtiment B, 37 Allée Jules Guesde, 31000, Toulouse France, +33 6 74 70 63 71, E-mail : mathieu.maltais@usherbrooke.ca

Abstract: *Objectives:* To gather available evidence about overtime changes on physical performance in institutionalized elderly. *Design, setting and participants:* An electronic search was performed on PubMed database on May 2018. We selected articles reporting the evolution of physical performance in older adults living in care institutions. We looked for data from observational longitudinal studies; data from clinical trials were extracted only for subjects who did not receive exercise intervention. All types of performance-based tests, for upper- and/or lower-body, were scrutinized. *Results:* Seventeen studies were reviewed; mean age varied from 78.3 to 88 years old. Fourteen studies were randomized controlled trials (RCTs), other three studies were non-randomized trials and a longitudinal observational study. Different tests assessing physical performance were examined: upper limb strength and lower limb strength, static balance, dynamic balance and mobility showed a tendency to decline over time. On average hand grip strength decreased by 2.2% per month, chair stand test by 3.5%, Berg balance scale by 2%, timed up-and-go test by 2.8%, gait speed by 2.1% and short physical performance battery by 2.8%. A minority of studies have shown an improvement in lower limb muscle strength, endurance and gait speed: in these studies, participants did not attend any kind of physical training but took part to social activities or cognitive interventions. *Conclusion:* This review shows how physical performance decreases over time in nursing home residents and quantifies their decline. However, in active controls, there was an improvement in some physical performance measures, which indicates that intervention other than exercise might prevent some loss in physical performance.

Key words: Nursing home, older adult, physical performance.

Introduction

Aging has been clearly associated with muscle strength decline and decreased physical performance (1) which aggravates the ability to perform daily tasks, increases the risk of falls, reduces quality of life and increases the risk of mortality (2–4), adverse health outcomes, common in the long-term care setting (5, 6).

The number of dependent older adults worldwide is projected to rise from 350 million in 2010 to 488 million in 2030 and 614 million in 2050 (7) and this growth will influence the number of nursing home (NH) residents (8).

Performance-based measures of physical performance are a useful tool for identifying older adults at risk for functional decline and death (9-13) and have become an important component of geriatric assessment (14, 15).

However, although many trials have focused on different types of interventions for improving physical performance in NH residents (8, 16–29), very few information is available regarding the "natural evolution" of physical performance in this particular context. Knowing this evolution in NH residents may be useful for informing the development of well-powered studies.

The aim of this review was gather the evidence on the natural evolution of physical performance (ie, changes over time) in elderly people living in NHs.

Methods

Search Strategy

One author performed the database search in PubMed on May 2018. Database searches were performed in PubMed. Keyword combinations for different categories were used. The search terms to select papers evaluating physical performance were "physical performance" OR SPPB OR "short physical performance battery" OR "performance based". For the population target we used "elder*" OR "older adults" OR "older adult". "Nursing homes" OR "nursing home" OR "institutionalized" OR "long term care facility" OR "long term care facilities" were the keywords used to select the context we wanted to assess.

MeSH terms "longitudinal study" and study protocol "randomized controlled trial" where also added to the search.

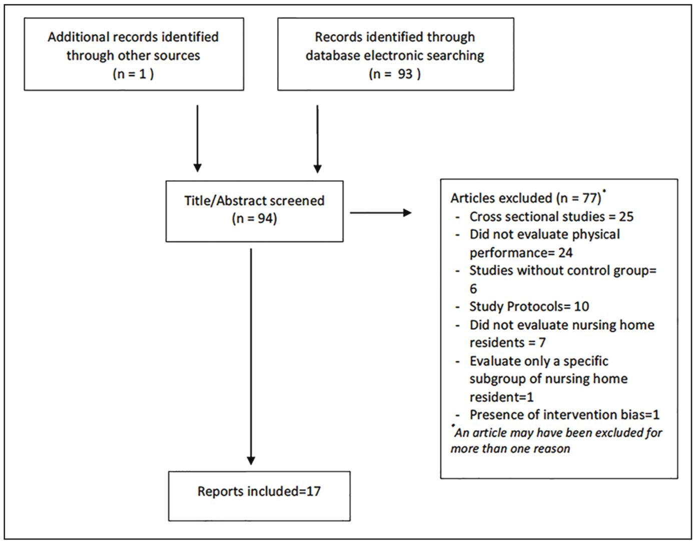
An article (24), identified through other sources, was added to the review.

A total of ninety-four articles was found. All articles identified by the search strategy were screened for eligibility. Afterwards, the full-text of potentially eligible studies were assessed for finally determining eligibility and, then, proceeded to data extraction. A flow diagram of the literature search and selection process, along with the number of the studies at each stage, is shown in figure 1.

Received February 15, 2019
Accepted for publication March 14, 2019

Published online April 26, 2019, http://dx.doi.org/10.1007/s12603-019-1199-5

Figure 1
Flowchart of literature review



Inclusion and Exclusion Criteria

We included studies performed among NH residents aged ≥ 60 years old, in which physical performance was objectively measured.

Observational longitudinal studies were eligible. For feasibility reasons (most studies retrieved in the electronic search were interventional studies), clinical trials were accepted; however, in order to avoid intervention bias and clearly evaluate the natural evolution of physical function, we only abstracted and examined data from subjects who did not received any kind of intervention aimed at improving physical performance, in particular exercise training.

To observe changes in time, participants must have received at least one post-baseline assessment and the measures or their overtime change had to have been reported in the original articles. We did not require a limit in the follow-up length.

Data Extraction

One author extracted the main demographic characteristics (sample size, age of participants, gender) of each study, time of further assessments, and information on the performance-based physical measures.

Outcome Measures

The main outcomes considered for physical performance were upper and lower limb strength, balance (static and dynamic), endurance, locomotion, and flexibility. Also, we included studies that assessed physical performance with battery tests, such as Short Physical Performance Battery (SPPB), Physical disability Index (PDI) or Physical Performance Test (PPT). The outcomes were evaluated over time through the difference of each battery test result at baseline and follow-up as percentage per month.

Results

A total of seventeen studies were eligible for review according to the inclusion/exclusion criteria. All the studies were published in the last 15 years, except for one study, published in 1994 (17). Seventy-seven of the ninety-four articles retrieved were excluded for the following reasons: cross-sectional study without follow-up, no control groups, study protocols, did not evaluate physical performance, were not directed to nursing home people or only to a specific subpopulation of nursing home residents suffering an acute event (eg, NH residents with hip fractures) or received intervention that had been proven to affect the results.

Study Characteristics

An overview of the study characteristics is provided in Table 1. The mean age varied from 78.3 to 88 years old across studies. Most of the subjects were female with a percentage variable from 49% to 100% and sample size ranged between 9 and 123. The follow-up period varied from 3 to 18 months.

Fourteen studies were randomized controlled trials (RCTs), other three studies were non-randomized trials (18, 30) and a longitudinal observational study (2).

Intervention Characteristics

In nine RCTs (8, 19–25, 28), two non-randomized control trials (18, 30) and one longitudinal observational study with an 18 months follow-up (2), subjects received ordinary care and continued to participate to the usual activities offered by the nursing home. In two RCTs (19, 25) and in one non-randomized study design (18), control group activity was not specified; we assumed these studies used a usual care approach. In the other RCT studies, individuals in the control group did not participate to physical activities but took part to social activities (such as therapeutic music meditation or arts and crafts) (16) or received friendly visit (17) or participated to activities including cognitive tasks (such as memory training) and coordinative tasks (such as manual dexterity) (29), or recreational activities (drawing, painting, doing puzzles, playing cards) (26). In one randomized double-blind, placebo-controlled, dose response study (27), control group received a placebo (containing dextrin, cellulose, sucrose fatty acid esters, shellac, caramel, L-arginine, glycerin).

Upper limb strength

Upper limb strength was assessed in nine studies (2, 8, 18, 20, 21, 25, 27-29) (Table 3). The most used test to assess upper limb strength was hand grip strength (HGS) (2, 8, 18, 20, 21, 25, 27-29). Other tests used were pinch strength (18), arm curl strength (8, 21, 29). Upper limb strength declined in eleven tests (2, 8, 18, 20, 21, 27–29), on average by 3.4% per month (range 0.1%-4.8%), and six (8, 18, 20, 21, 29) of these were statistically significant.

Table 1
Characteristics of the studies included in the review considering the population that did not receive interventions aimed at improving physical performance and the considered outcomes of each study

	Design	Country	Sample	Age	Duration	Outcomes	Results*
Chiu SC et al. 2018	Non random. study design	Taiwan	34 (21 M/13 F)	Age 80.2 (7.4)	3 mo	Total[1] Hand Grip Strength[2]; Total[1] Pinch Strength (PS)	Total[1] HGS[2] and PS ↓
Arrieta H. et al. 2018	RCT	Spain	55 (18M/37F) (Low PFS3=30, Intermediate/ High PFS3=17)	Age 84.7 (6.1)	3 mo	CST[4]; ACT[5]; 8-ft TUG[6]; 6Mwt[7]; CSRT[8]; BST[9]; SPPB[10]; 4m-GS[11]; Dominant HGS[2]; Non dominant HGS[2];4m-FGS[12]; BBS[13]	Total: CST[4], ACT[5], 8-ft TUG[6], SPPB[7], 4mGS[11], BBS[13]↓ Low PFS: CST[4],ACT[5],8-ft TUG[6], SPPB[10], BBS[13] ↓ Intermediate/high PFS:SPPB[10]↓
Reid N. et al. 2017	CSS+FU¡	Australia	58 (17M/41F)	Age 85.6 (8.2)	18 mo	HGS[2],GS[11]; SPPB[10]; Standing balance;5 timed-CST[4]	
Lauzé M et al. 2017	RCT	Québec	T1 11, T2 10 (1M/10F)	(1M/10F)	T_1 3 mo. 6 mo (T_2)	Dyapenia Index[14]; 3m-TUG[6]; GS[11]; CST[4]; SPPB[10];	From T[1] to T[2]: GS[11]↑ From T[2] to T[3]: TUG6,GS11,SPPB[10]↓
De Souto Barreto P. et al. 2017	RCT	France	47(11M/36F)	Age 86.9(5.8)	4 mo.	4m-GS[11]; SPPB[10].	
Frändin K. et al. 2016	RCT	Scandinavian countries	T1 123; T2 112 (24 M/88 F)	Age 84.5 (7.3)	6 mo. (T_2) T_1 3 mo.	BBS[13]; W/W speed[15]; W/W max speed[16]; Timed-CST[4].	BBS[13] ↓
Grönstedt H. et al. 2013	RCT	Scandinavian countries	123 (39 M/76 F)	Age 84.9 (7.6)	3 mo.	BBS[13];10m-GS[11];10m-max GS[11] ; CST[4], Dominant-HGS[2], Non dominant-HGS[2].	BBS[13] ↓
Benavent-Caballer V. et al. 2014	RCT	Spain	23 (8M/15F)	Age 83.6(5.6)	4 mo.	TUG[6] ; BBS[13] ; 6mWT[7]; Dominant HGS[2].	TUG[6], Dominant HGS[2], BBS[13] ↓
Mulrow CD. Et al. 1994	RCT	USA	97 (28M/69F)	Age 81.4(7.9)	4 mo.	PDI[17]: range of motion, strength, balance, mobility.	
Mouton A. et al. 2017	Quasi-experimental longitudinal study	Belgium	11 (3M,8F)	Age 89.9 (87-91)	3 mo. (T2) T1 at 1 mo.	SPPB10, TUG6, Muscular isometric strength of six lower limb muscle	T[1] hip flexors, ankle flexors ↑ T[2] ankle flexors ↓
Meng G. et al. 2017	RCT	China	Total sample:194(99M/95F) Control group: 51	Age 78.3 (76.5-79.6)	12 mo.	HGS[2], 6mWT[4], TUG[3], Standing one leg with eyes closed (right and left).	
Oesen S. et al. 2015	RCT	Austria	40 (5M/35F) (T_1 29 ;T2 26)	Age 83.4 (5.6)	6mo (T_2) T_1 3 mo.	Muscle strength of the lower extremities (Isokinetic Peak Torque); HGS[2]; Arm-lifting test; CST[4]; 6mWT[7]; GS[11]; Functional Reach Test.	T[1]: Arm lifting test ↓, CST[8]↔, Peak Torque[18] 60°/s Q[19] rel.[19] ; Peak Torque 120°/s Q[19] rel.[20], Peak Torque 120°/s H[21] rel.[19] ↑. T[2]: Arm lifting test ↓ 6mWT[7], GS[11] ↑ CST[8] ↔. Peak Torque 60°/s H[21] rel.[20] , Peak Torque18 120°/s Q[19] rel.[20], Peak Torque 120°/s H[21] rel.[20]↑
Baum EE. et al. 2003	RCT	USA	9 (3M/6F)	Age 88 (78-99)	6 mo.	TUG[3], Physical Performance Test, BBS[12].	
Cebrià I Iranzo MÀ. et al. 2018	RCT	Spain	17 (5M,12F)	81.2 (5.4)	3 mo.	QFS[22], BiBS[23], Dominant-HGS[2], GS[8].	QFS[22], BiBS[23] ↓
Tak EC. et al. 2012	RCT	Netherlands	70 (F)	Age 84.6 (6.5)	6 mo.	Physical Performance Test (PPT)	
Holmerová I. et al 2010	RCT	Czech Republic	25 (4M,21F)	Age 82.8	3 mo.	CST[4], 2min.Step Test, CSRT[8], TUG[6]	
Rolland Y. et al . 2007	RCT	France	67 (19M/48F)	82.8 (7.8)	12 mo.	6mWT[7], Get-up-and-go test, One leg balance t.	T[2] Walk speed ↑

*Only the outcomes that are statistically significant have been included in the results column. Even results whose statistical value has not been analyzed have not been inserted; 1.Total=Dominand +Non dominant; 2. HGS=Hand grip strength(kg), if not specified, maximum result obtained from both measures, left and right; 3. PFS=physical function score; 4. CST=Chair Stand Test(n° or s) ; 5 . ACT=Arm-curl test(n) ; 6. TUG=Timed up-and-go(m/s); 7. 6mWT=6-min Walk Test(m); 8. CSRT=Chair sit-and-reach test (cm); 9. BST=Back scratch test (cm); 10. SPPB=Short Physical Performance Battery score; 11. GS=Gait speed (m/s); 12. FGS=Fast Gait Speed (m/s); 13. BBS=Berg Balance scale (pts); 14. Dyapenia Index=handgrip(kg)/BW(Kg); 15. W/W speed=Walking/Wheelchair propulsion speed(m/s); 16. W/W max speed=Walking/Wheelchair Propulsion Maximum speed (m/s); 17. PDI=Physical Disability Index; 18. PT=Peak Torque(Nm/kg); 19. Q=Quadriceps, knee extension; 20. rel.= relative to body mass; 21. H=hamstrings, knee flexion; 22. QFS=Quadriceps femoris strength; 23. BiBS=Biceps brachii strength. ¡ CSS+FU=cross-sectional study with 18-month follow-up

Table 2
Values relative to each performance test obtained at the baseline and to the follow-ups in which the statistical significance was revealed

Authors	Results					
	Measures	**Baseline**	**Follow-up**		**Statistically significant (P<0.05)**	
Chiu SC et al. 2018	Total Grip Strength (kg)	24.56(3.20)	20.40(3.08)		YES	
	Total Pinch Strength (kg)	4.88(0.71)	3.54(0.55)		YES	
Arrieta H. et al. 2018		Total	Total			
	CST[2] (n of stands)	7.40 (4.10)	5.90(4.20)		YES	
	ACT[3] (n of repetitions)	11.90(4,10)	10.20(4.70)		YES	
	8-ft TUG[4] (m/s)	0.38(0.16)	0.33(0.17)		YES	
	6mWT[5] (m)	217.00(93.80)	188.80 (83.50)		NO	
	CSRT[6] (cm)	-12.70(10,90)	-10.30(12.20)		NO	
	BST[7] (cm)	-19.60(11.90)	-21.30(12.70)		NO	
	SPPB[8] score	5.90(2.70)	5.10(2.80)		YES	
	Gait speed 4m (m/s)	0.64(0.24)	0.59(0.26)		YES	
	Hand grip dominant (kg)	21.60(8.60)	18.10(7.90)		NO	
	Hand grip non dominant (kg)	18.60(7.60)	15.60(7.60)		NO	
	Fast Gait Speed 4 m(m/s)	0.85(0.34)	0.79(0.36)		NO	
	BBS[9]	45.50 (6.80)	41.70(11.40)		YES	
		Low PF[1] (SPPB 0-6)				
	CST[2] (n of stands)	5.70(3.70)	4.10(3.20)		YES	
	ACT[3] (n of repetitions)	10.70(3.80)	8.40(3.70)		YES	
	8-ft TUG[4] (m/s)	0.30(0.10)	0.24(0.12)		YES	
	6mWT[5] (m)	174.20(73.80)	151.00(66.80)		NO	
	CSRT[6] (cm)	-13.90(9.90)	-12.30(11.30)		NO	
	BST[7] (cm)	-21.40(12.30)	-24.20(12.50)		NO	
	SPPB[8] score	4.20(1.40)	3.60(1.60)		YES	
	Gait speed 4m (m/s)	0.53(0.18)	0.47(0.17)		NO	
	Hand grip dominant (kg)	19.90(7.40)	16.50(6.60)		NO	
	Hand grip non dominant (kg)	17.20(6.50)	13.90(6.30)		NO	
	Fast Gait Speed 4 m(m/s)	0.69(0.25)	0.63(0.24)		NO	
	BBS[9]	42.30(6.30)	37.00(11.50)		YES	
		Intermediate/High PF1 (SPPB 7-12)				
	CST[2] (n of stands)	10.50(2.70)	9.30(3.70)		NO	
	ACT[3] (n of repetitions)	14.00(3.90)	13.40(4.70)		NO	
	8-ft TUG[4] (m/s)	0.54(0.13)	0.48(0.15)		NO	
	6mWT[5] (m)	294.40(79.10)	256.30(70.40)		NO	
	CSRT[6] (cm)	-10.70(12.40)	-6.90(13.40)		NO	
	BST[7] (cm)	-16.90(11.20)	-16.80(12.10)		NO	
	SPPB[8] score	9.00(1.50)	7.90(2.40)		YES	
	Gait speed 4m (m/s)	0.85(0.19)	0.81(0.27)		NO	
	Hand grip dominant (kg)	25.00(10.10)	21.30(9.60)		NO	
	Hand grip non dominant (kg)	21.50(8.80)	18.80(8.90)		NO	
	Fast Gait Speed 4 m(m/s)	1.15(0.28)	1.09(0.37)		NO	
	BBS[9]	51.30(2.80)	50.30(2.90)		NO	
Reid N. et al. 2017	Hand Grip Strength (kg)	16.50(7.70)	12.70(7.60)		The statistical significance of these results is unclear	
	SPPB[8] score	3.50(2.40)	2.50(2.20)			
	Standing Balance (s)	13.90(10.00)	6.90(10.20)			
	Gait speed (m/s)	0.40(0.20)	0.20(0.20)			
	5 timed-chair stand test (s)	20.90(5.40)	23.20(12.46)			
Lauzé M et al. 2017¡			T_1	T_2	T_1	T_2
	Dyapenia Index (Kg/BW)	0.28(0.11)	0.00(0.05)	0.00(0.06)	NO	NO
	TUG[4] 3m (s)	13.70(4.30)	-0.20(2.80)	0.60(1.50)	NO	YES
	Walking speed (m/s)	0.74(0.20)	0.02(0.15)	-0.04(0.16)	YES	YES
	5 repetitions-Chair test (s)	16.00(3.00)	0.30(3.60)	-0.10 (3.00)	NO	NO
	SPPB[8] score	7.50(1.40)	0.46(1.80)	-0.40(1.60)	NO	YES
De Souto Barreto P. et al. 2017¡	SPPB[8]	4.50(2.30)	-0.80(0.34)		NO	
	4-m gait speed	0.48(0.18)	0.03(0.03)		NO	

Table 2 (continued)

Values relative to each performance test obtained at the baseline and to the follow-ups in which the statistical significance was revealed

Authors	Results: Measures	Baseline	Follow-up		Statistically significant (P<0.05)	
Frändin K. et al. 2016	BBS[9]	21.00 (0.00-54.00)	17.00 (0.00-52.00)		YES	
	W/W[10]Self-selected speed(m/s)	0.44 (0.06-1.15)	0.40 (0.07-1.67)		NO	
	W/W[10] Maximum speed (m/s)	0.63 (0.06-1.43)	0.56(0.10-1.43)		NO	
	Timed Chair stand test (s)	24.15 (8.00-187.00)	25(8.00-73.00)		NO	
Mulrow CD. Et al. 1994	Physical Disability Index:	58.30 (11.30)	55.00 (13.30)		The statistical significance of these results is unclear	
	• Range of motion	76.80 (10.30)	74.50 (11.50)			
	• Strength	45.40 (19.10)	39.20 (23.60)			
	• Balance	60.00 (25.30)	60.70 (26.30)			
	• Mobility	51.20 (25.60)	45.80 (26.70)			
Mouton A. et al. 2017¡			T1	T2	T1	T2
	SPPB[8]	6.60 (2.30)	-0.10 (2.92)	-0.55 (2.01)	NO	NO
	TUG[4] (s)	22.70 (13.90-23.60)	+0.46(-8.70 to +2.90)	+0.55(-7.30 to 3.40)	NO	NO
	Strength of knee extensors (N)	110.70 (38.60)	+10.27 (20.5)	+13.62 (25.06)	NO	NO
	Strength of knee flexors (N)	117.80 (28.60)	+4.83 (22.78)	-0.81 (20.72)	NO	NO
	Strength of hip extensors (N)	88.20 (36.90)	+6.26 (22.73)	-4.91 (27.14)	NO	NO
	Strength of hip flexors (N)	60.20 (16.50)	+17.57 (8.9)	+13.63 (13.94)	YES	NO
	Strength of ankle extensors (N)	89.90 (29.90)	+11.56 (27.72)	+10.98 (22.32)	NO	NO
	Strength of ankle flexors (N)	82.40 (20.50)	+12.4 (17.5)	-13.23 (16.67)	YES	YES
Meng G. et al. 2017	Hand grip strength (kg)	22.30 (20.00-24.60)	22.00 (19.20-24.70)		NO	
	6mWT[5] (m)	341.00 (308.00-373.70)	335.50 (300.30-370.70)		NO	
	TUG[4] (s)	10.60 (9.10-12.10)	12.00(9.70-14.40)		NO	
	Standing one leg (right) (s)	4.08 (2.51-5.65)	3.31 (2.48-4.14)		NO	
	Standing one leg (left) (s)	3.72 (2.91-4.53)	4.35 (3.05-5.65)		NO	
Oesen S. et al. 2015			T1	T2	T1	T2
	Hand grip strength (kg)	17.00 (6.60)	17.30 (8.20)	16.60 (7.60)	NO	NO
	Arm lifting test (rep)	24.00 (10.00)	23.00 (9.00)	23.00 (10.00)	YES	YES
	Chair stand test (rep)	11.00 (5.00)	11.00 (5.00)	11.00 (5.00)	YES	YES
	6mWT5 (m)	369.00 (111.00)	380.00 (119.00)	389.00 (113.00)	NO	YES
	Gait speed (m/s)	1.48 (0.57)	1.62 (0.75)	1.62 (0.67)	NO	YES
	Functional reach test (cm)	27.30 (5.30)	27.90 (6.00)	27.50 (6.50)	NO	NO
	Peak Torque[11] 60°/s Q[12] rel [Nm/kg]	1.03 (0.29)	1.09 (0.34)	0.97 (0.38)	YES	NO
	Peak Torque[11] 60°/s H[13] rel. [Nm/kg]	0.55 (0.17)	0.61 (0.15)	0.56 (0.21)	NO	YES
	Peak Torque[11] 120°/s Q[12] rel. [Nm/kg]	0.82 (0.27)	1.00 (0.25)	0.84 (0.31)	YES	YES
	Peak Torque[11] 120°/s H[13] rel. [Nm/kg]	0.48 (0.16)	0.63 (0.15)	0.56 (0.23)	YES	YES
Baum EE. et al. 2003¡	TUG[4] (s)	49.00 (12.00-141.00)	+5.50		The statistical significance of these results is unclear	
	Physical Performance Test (PPT)	9.70 (5.00-15.00)	-1.60			
	BBS[9]	32.00 (5.00-52.00)	-5.90			
Cebrià I Iranzo MÀ. et al. 2018	Quadriceps Femmoris Strength (Kg)	6.10 (1.90)	5.30 (1.10)		YES	
	Biceps Brachii Strength (Kg)	6.30 (2.20)	4.80 (1.10)		YES	
	Handgrip dominant strength (Kg)	17.10(7.80)	17.40 (8.70)		NO	
	Gait speed (m/s)	0.60 (0.20)	0.70 (0.20)		NO	
Tak EC. et al. 2012	Physical Performance Test	15.80 (5.60)	14.70 (4.27)			
Holmerová I. et al 2010	Chair stand test (rep)	8.40 (3.60)	7.20 (3.50)		The statistical significance of these results is unclear	
	2-minute step test (rep)	30.00 (25.40)	21.80 (21.20)			
	Chair sit-and-reach test (cm)¡¡	7.60 (13.60)	8.50 (11.00)			
	TUG4 (s)	20.20 (13.60)	23.40 (14.50)			
Rolland Y. et al . 2007			T1	T2	T1	T2
	Walk speed (m/s)	0.33 (0.14)	0.37 (0.17)	0.36 (0.19)	NO	YES
	Get-up-and-go test score	2.70 (0.80)	3.0 (1.0)	3.20 (1.20)	NO	NO
	Abnormal 1 leg balance test (n)	62.00	53.00	51.00	NO	NO

1. Physical Performance ; 2. Chair stand test; 3. arm curl test; 4. timed up-and-go test; 5. 6-minutes walking test; 6. chair sit-and-reach test;7. back scratch test; 8. Short Physical Performance Battery; 10. Walking/wheelchair propulsion; 11. Nm/kg; 12. quadriceps, knee extension; 13. hamstrings, knee flexion. ¡Results showed as delta changes in time; ¡¡lower number, better performance

Table 3
Grouping of studies based on the analyzed test performance and the result obtained

Physical Performance Tests	Declined (p<0.05)	Declined (not SS or unclear)	Improved (p<0.05)	Improved (not SS or unclear)	Did not change (p<0.05)	Did not change (not SS or unclear)
Upper Limb strenght	HGS	Chiu SC et al.2018, Benavent-Caballer V . et al.2014 (dominant HGS)	Arrieta H. et al.2018, Reid N. et al. 2017, Grönstedt H. et al.2013 (dominant HGS), Meng G. et al.2017, Oesen S. et al. 2015		Grönstedt H. et al. 2013 (non-dominant HGS), Cebrià I Iranzo MÀ. et al. 2018 (dominant)	Lauzé M et al. 2017
	Pinch strength	Chiu SC et al.2018				
	Arm Curl Test	Arrieta H et al.2018				
	Arm lifting Test	Oesen S. et al.2015				
	Biceps Brachii strength	Cebrià I Iranzo MÀ. et al.2018				
Lower Limb strenght	Chair stand test	Arrieta H. et al. 2018	Reid N. et al .2017, Frändin K. et al.2016, Holmerova I. et al. 2010		Lauzé M et al.2017, Grönstedt H. et al. 2013,	Oesen S. et al.2015.
	Muscolar isometric strength of 6 lower limb muscles	Mouton A. et al. 2017(ankle flexors)	Mouton A. et al. 2017 (knee flexors, hip extensors)		Mouton A. et al. 2017 (Knee extensors, hip flexors, ankle extensor)	
	Muscle strength of the lower extremities with isokinetic peak torque		Oesen S. et al.2015 (Peak Torque 60°/s Q rel)	Oesen S. et al.2015 (Peak Torque 60°/s H rel, Peak Torque 120°/s H rel, Peak Torque 120°/s Q rel)	.	
	Quadriceps Femoris strength	Cebrià I Iranzo MÀ. et al.2018				
Static Balance	BBS	Arrieta H. et al.2018, Frändin K. et al.2016, Grönstedt H. et al.2013, Benavent-Caballer V. et al.2014	Baum EE. et al. 2003			
	Standing one leg		Meng G.et al.2017 (right)		Meng G.et al.2017 (left)	
	Abnormal 1 leg balance test				Rolland Y. et al. 2007	
	Standing balance		Reid N. et al. 2017			
Dynamic Balance	TUG	Arrieta H. et al.2018, Lauzé M. et al.2017, Benavent-Caballer V. et al. 2014	Mouton A. et al.2017, Meng G. et al.2017, Baum EE. et al. 2003, Holmerovà I. et al.2010			
	Get up-and-go test				Rolland Y. et al. 2007	
Endurance	6 m WT		Arrieta H. et al.2018, Benavent-Caballer V. et al.2014, Meng G. et al.2017	Oesen S. et al.,		
	2 minute step test		Holmerovà I. et al. 2010			
Flexibility	Chair sit-and-reach test		Holmerovà I. et al. 2010		Arrieta H. et al.2018	
	Functional reach test				Oesen S. et al.2015	
	Back Scratch Test		Arrieta H. et al. 2018			
Mobility	Gait speed	Arrieta H. et al.2018, Lauzè M. et al. 2017.	Reid N. et al.2017	Oesen S. et al.2015, Rolland Y. et al.2017	De Souto Barreto P. et al.2017, Cebrià I Iranzo MÀ. et al.2018	
	Fast Gait speed		Arrieta H. et al.2018			
	Walking/Wheelchair propulsion selected speed		Frändin K. et al.2016, Grönstedt H. et al.2013			
	Walking/Wheelchair Propulsion Maximum speed		Frändin K. et al.2016		Grönstedt H. et al.2013	
Battery Test	SPPB	Arrieta H. et al.2018, Lauzè M. et al. 2017.	Reid N. et al.2017, De Souto Barreto P. et al.2017, Mouton A. et al.2017			
	Physical Disability Index		Mulrow CD et al.1994 (Total score)			
	Physical Performance Test		Baum EE. Et al.2003, Tak EC et al. 2012			

Table 4
Results

Upper Limb Strength	HGS (Kg)
	Pinch strength (kg)
	ACT n°
	ALT n°
	BBS (Kg)
Lower limb Strength	CST (s)
	CST (n°)
	Muscle isometric strength 6 lower limb (N)
	Lower extremities strength with peak torque (N/kg)
	Quadriceps femoris strength (kg)
Static Balance	BBS
	Standing one leg

Lower limb strength

The chair stand test was the most common test used in all of the studies. In four studies it declined (2, 8, 19, 23), on average by 3.5% per month (0.6%-6.7%), of which one (8) was statistically significant. In two studies (21, 25, 28), chair stand test seemed to increase but results were not statistically significant.

Other tests used in the studies evaluated muscular isometric lower limb strength (21, 30) and one study assessed muscle strength with isokinetic peak torque (29). In two of these studies, strength of some lower extremities muscular groups seemed to improve at follow-up and, being statistically significant in one study (29).

Static balance

The most used tool to assess balance was the Berg Balance Scale (BBS) which declined in all studies (8, 19, 20, 26, 28). Studies using other tests to measure balance (Standing Balance Test, One Leg Standing Balance, Abnormal One Leg Balance) mostly tended to decline but no one of these were statistically significant (2, 24, 27). The average decline of BBS was 2% per month (0.3%-6.3%).

Dynamic balance

The most used test was timed up-and-go test (TUG) which has been adopted in seven studies (8, 20, 23, 25-27, 30). In all the studies it tended to decline and three of these results where statistically significant (8, 20, 25). The average decline of TUG was 2.8% (0.7%-6.2%).

In one study (24), the get up-and-go test was used and showed a tendency for improvement.

Endurance

Four studies measured endurance with the 6-minute walking test. In three of these it tended to decline (8, 20, 27) but no results where statistically significant. The decline of 6-minute walking test was on average 1.8% (0.1%-4.3%).

Mobility

Mobility was mostly assessed by gait speed (2, 8, 16, 21, 24, 25, 29). Three studies showed a tendency to decline (2, 8, 25) and two of these results were statistically significant (8, 25). The average decline was 2.1% (0.9%-2.8%). In other four studies gait speed improved (16, 21, 24, 29) but only two studies (24, 29) showed results statistically significant. Other studies evaluated mobility also by fast gait speed (8), walking/wheelchair propulsion (19, 28), walking/wheelchair propulsion maximum speed (19, 28). All tests showed a tendency to decline except in one study (28) where walking/wheelchair propulsion improved but it was not statistically significant.

Battery of tests

The most used tool of overall evaluation of physical performance was SPPB. In all the five studies who adopted SPPB (2, 8, 16, 25, 30), it tended to decrease. In two studies (8, 25) this worsening was statistically significant. The average decline of SPPB over time was 2.8% (0.8%-4.2%). Other batteries of test performed to assess physical performance were the Physical Performance Test (22, 26) and the Physical Disability Index (17). Both tended to decline over time.

Discussion

In this review of seventeen studies, we showed that performance-based physical tests declined over time, in particular for gait speed, upper limb strength, chair stand-and-sit test, static and dynamic balance.

These are expected results since it is known that older adults are one of the least physically active (31) and most sedentary (32, 33) population groups (34) and residents in long-term care facilities are even more sedentary than community-dwelling older adults (34, 35). In addition, the prevalence of comorbidity, frailty and sarcopenia is greater in nursing homes (36, 37); all of them constituting conditions that can impair physical function. Despite this logic finding, this review was the first to have quantified objectively measured (using several different tests) physical declines in the NH population. This information is useful for better planning interventions targeting physical function in the very old and vulnerable population of NH residents.

However, apparently controversial results of increases in physical performance tests in some studies (8, 16, 21, 24, 25, 27–30) were observed. In fact, most of studies had, as an inclusion criterion, the ability to stand up and walk for at least a few meters independently and to perform the required physical performance tests, which, in some cases, led to the exclusion of subjects with severe cognitive impairment and advanced cardio-pulmonary comorbidities (an important portion of the NH population). Excluding the most vulnerable subjects may have impacted our findings, constituting a possible explanation for the discrepancy in some results of some studies (21, 24, 27-30).

Another reason for this discrepancy could be the higher prevalence of women in the studies; it has been found that women have lower insulin-stimulated muscle protein synthesis which could partly explain a slower decline of muscle mass compared to men (29, 38). It is also noteworthy to mention that some studies with an active control had implemented new activities that were not the ordinary activities offered by the NHs. For example, new social activities (16), friendly visits (17), cognitive and coordinative activities (29) and recreational activities (26). These changes of the daily habits may have indirectly improved physical performance, which has been shown in a recent study (16).

Several studies have shown that cognitive activities, for example, can lead to global physical improvements (39-41).

The strength of this paper is to focus on the change of physical performance over time in institutionalized people while previous studies mostly focused on interventions aimed to improve physical performance more than examine its "natural trend".

However, this review has also some limits. First of all, the population considered in most of the studies in our review do not exactly reflect the population present in nursing homes, which includes people with many comorbidities, not considered in the studies. Moreover, as already previously explained, there are active controls who received different activities which could interfere with the results.

This novel review brings new data and information about the "natural history" of physical performance. A decline has been observed in the main tests and we can have quantitative data about their decrease. However, the observation took place in a variable period of time in the various studies and relatively short (most of it lasted 3-6 months). Obtaining data from large-scale observational study with long follow-up and several time-point waves of data collection would allow us to better know the natural evolution of several physical components. This can lead to planning better and more targeted interventions and, moreover, some evidence points out that new and engaging social activities could indirectly improve some aspects of physical performance. Further research is needed to determine exercise recommendations in this population.

Acknowledgements: I would like to thank Mathieu Maltais and Philipe de Souto Barreto for their help and their work. A special thanks to Professor Yves Rolland and Professor Bruno Vellas for giving me the chance to work on his team.

Ethical Standards: This article complies with the current laws. Research involving Human Participants and/or Animals: This article does not contain any studies with human participants performed by any of the authors.

Informed consent: For this type of study formal consent is not required.

Conflicts of interest: The authors declare that they have no conflict of interest.

References

1. Tabue-Teguo M, Dartigues J-F, Simo N, Kuate-Tegueu C, Vellas B, Cesari M. Physical status and frailty index in nursing home residents: Results from the INCUR study. Arch Gerontol Geriatr 2018;74:72–76 . doi: 10.1016/j.archger.2017.10.005
2. Reid N, Keogh JW, Swinton P, Gardiner PA, Henwood TR. The Association of Sitting Time With Sarcopenia Status and Physical Performance at Baseline and 18-Month Follow-Up in the Residential Aged Care Setting. J Aging Phys Act 2018;1–6 . doi: 10.1123/japa.2017-0204
3. Bradley C, Australian Institute of Health and Welfare. Hospitalisations due to falls by older people, Australia, 2009-10. Australian Institute of Health and Welfare, Canberra
4. Wolinsky FD, Miller DK, Andresen EM, Malmstrom TK, Miller JP, Miller TR. Effect of subclinical status in functional limitation and disability on adverse health outcomes 3 years later. J Gerontol A Biol Sci Med Sci 2007;62:101–106
5. Wisniowska-Szurlej A, Cwirlej-Sozanska A, Wilmowska-Pietruszynska A, Milewska N, Sozanski B. The influence of 3 months of physical exercises and verbal stimulation on functional efficiency and use of free time in an older population under institutional care: study protocol for a randomized controlled trial. Trials 2017;18:376 . doi: 10.1186/s13063-017-2114-1
6. Williams SW, Williams CS, Zimmerman S, Sloane PD, Preisser JS, Boustani M, Reed PS. Characteristics associated with mobility limitation in long-term care residents with dementia. Gerontologist 2005;45 Spec No 1:62–67
7. World Alzheimer Report 2013 - Journey of Caring: An analysis of long-term care for dementia. 92
8. Arrieta H, Rezola-Pardo C, Zarrazquin I, Echeverria I, Yanguas JJ, Iturburu M, Gil SM, Rodriguez-Larrad A, Irazusta J. A multicomponent exercise program improves physical function in long-term nursing home residents: A randomized controlled trial. Exp Gerontol 2018;103:94–100 . doi: 10.1016/j.exger.2018.01.008
9. Binder EF, Miller JP, Ball LJ. Development of a test of physical performance for the nursing home setting. Gerontologist 2001;41:671–679
10. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. N Engl J Med 1995;332:556–561 . doi: 10.1056/NEJM199503023320902
11. Ferrucci L, Guralnik JM, Salive ME, Fried LP, Bandeen-Roche K, Brock DB, Simonsick EM, Corti MC, Zeger SL. Effect of age and severity of disability on short-term variation in walking speed: the Women's Health and Aging Study. J Clin Epidemiol 1996;49:1089–1096
12. Reuben DB, Rubenstein LV, Hirsch SH, Hays RD. Value of functional status as a predictor of mortality: results of a prospective study. Am J Med 1992;93:663–669
13. Reuben DB, Siu AL, Kimpau S. The predictive validity of self-report and performance-based measures of function and health. J Gerontol 1992;47:M106-110
14. Applegate WB, Blass JP, Williams TF. Instruments for the functional assessment of older patients. N Engl J Med 1990;322:1207–1214 . doi: 10.1056/NEJM199004263221707
15. Branch LG, Meyers AR. Assessing physical function in the elderly. Clin Geriatr Med 1987;3:29–51
16. de Souto Barreto P, Cesari M, Denormandie P, Armaingaud D, Vellas B, Rolland Y. Exercise or Social Intervention for Nursing Home Residents with Dementia: A Pilot Randomized, Controlled Trial. J Am Geriatr Soc 2017;65:E123–E129 . doi: 10.1111/jgs.14947
17. Mulrow CD, Gerety MB, Kanten D, Cornell JE, DeNino LA, Chiodo L, Aguilar C, O'Neil MB, Rosenberg J, Solis RM. A randomized trial of physical rehabilitation for very frail nursing home residents. JAMA 1994;271:519–524
18. Chiu S-C, Yang R-S, Yang R-J, Chang S-F. Effects of resistance training on body composition and functional capacity among sarcopenic obese residents in long-term care facilities: a preliminary study. BMC Geriatr 2018;18:21 . doi: 10.1186/s12877-018-0714-6
19. Frandin K, Gronstedt H, Helbostad JL, Bergland A, Andresen M, Puggaard L, Harms-Ringdahl K, Granbo R, Hellstrom K. Long-Term Effects of Individually Tailored Physical Training and Activity on Physical Function, Well-Being and Cognition in Scandinavian Nursing Home Residents: A Randomized Controlled Trial. Gerontology 2016;62:571–580 . doi: 10.1159/000443611
20. Benavent-Caballer V, Rosado-Calatayud P, Segura-Orti E, Amer-Cuenca JJ, Lison JF. Effects of three different low-intensity exercise interventions on physical performance, muscle CSA and activities of daily living: a randomized controlled trial. Exp Gerontol 2014;58:159–165 . doi: 10.1016/j.exger.2014.08.004
21. Cebria I Iranzo MA, I Bernat MB, Tortosa-Chulia MA, Balasch-Parisi S. Effects of Resistance Training of Peripheral Muscles versus Respiratory Muscles in Institutionalized Older Adults with Sarcopenia: A Randomized Controlled Trial. J Aging Phys Act 2018;1–32 . doi: 10.1123/japa.2017-0268
22. Tak ECPM, van Hespen A, van Dommelen P, Hopman-Rock M. Does improved functional performance help to reduce urinary incontinence in institutionalized older women? A multicenter randomized clinical trial. BMC Geriatr 2012;12:51 . doi: 10.1186/1471-2318-12-51
23. Holmerova I, Machacova K, Vankova H, Veleta P, Juraskova B, Hrnciarikova D, Volicer L, Andel R. Effect of the Exercise Dance for Seniors (EXDASE) program on lower-body functioning among institutionalized older adults. J Aging Health 2010;22:106–119 . doi: 10.1177/0898264309351738
24. Rolland Y, Pillard F, Klapouszczak A, Reynish E, Thomas D, Andrieu S, Riviere D, Vellas B. Exercise program for nursing home residents with Alzheimer's disease: a 1-year randomized, controlled trial. J Am Geriatr Soc 2007;55:158–165 . doi:

10.1111/j.1532-5415.2007.01035.x
25. Lauze M, Martel DD, Aubertin-Leheudre M. Feasibility and Effects of a Physical Activity Program Using Gerontechnology in Assisted Living Communities for Older Adults. J Am Med Dir Assoc 2017;18:1069–1075 . doi: 10.1016/j.jamda.2017.06.030
26. Baum EE, Jarjoura D, Polen AE, Faur D, Rutecki G. Effectiveness of a group exercise program in a long-term care facility: a randomized pilot trial. J Am Med Dir Assoc 2003;4:74–80 . doi: 10.1097/01.JAM.0000053513.24044.6C
27. Meng G, Wang H, Pei Y, Li Y, Wu H, Song Y, Guo Q, Guo H, Fukushima S, Tatefuji T, Wang J, Du H, Su Q, Zhang W, Shen S, Wang X, Dong R, Han P, Okazaki T, Nagatomi R, Wang J, Huang G, Sun Z, Song K, Niu K. Effects of protease-treated royal jelly on muscle strength in elderly nursing home residents: A randomized, double-blind, placebo-controlled, dose-response study. Sci Rep 2017;7:11416 . doi: 10.1038/s41598-017-11415-6
28. Gronstedt H, Frandin K, Bergland A, Helbostad JL, Granbo R, Puggaard L, Andresen M, Hellstrom K. Effects of individually tailored physical and daily activities in nursing home residents on activities of daily living, physical performance and physical activity level: a randomized controlled trial. Gerontology 2013;59:220–229 . doi: 10.1159/000345416
29. Oesen S, Halper B, Hofmann M, Jandrasits W, Franzke B, Strasser E-M, Graf A, Tschan H, Bachl N, Quittan M, Wagner KH, Wessner B. Effects of elastic band resistance training and nutritional supplementation on physical performance of institutionalised elderly--A randomized controlled trial. Exp Gerontol 2015;72:99–108. doi: 10.1016/j.exger.2015.08.013
30. Mouton A, Gillet N, Mouton F, Van Kann D, Bruyere O, Cloes M, Buckinx F. Effects of a giant exercising board game intervention on ambulatory physical activity among nursing home residents: a preliminary study. Clin Interv Aging 2017;12:847–858 . doi: 10.2147/CIA.S134760
31. Leavitt MO. Physical Activity Guidelines for Americans. 2008;76
32. Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, Troiano RP. Amount of Time Spent in Sedentary Behaviors in the United States, 2003-2004. American Journal of Epidemiology 2008;167:875–881 . doi: 10.1093/aje/kwm390
33. Healy GN, Clark BK, Winkler EAH, Gardiner PA, Brown WJ, Matthews CE. Measurement of Adults' Sedentary Time in Population-Based Studies. American Journal of Preventive Medicine 2011;41:216–227 . doi: 10.1016/j.amepre.2011.05.005
34. Reid N, Eakin E, Henwood T, Keogh JWL, Senior HE, Gardiner PA, Winkler E, Healy GN. Objectively measured activity patterns among adults in residential aged care. Int J Environ Res Public Health 2013;10:6783–6798 . doi: 10.3390/ijerph10126783
35. Harvey JA, Chastin SFM, Skelton DA. How Sedentary are Older People? A Systematic Review of the Amount of Sedentary Behavior. J Aging Phys Act 2015;23:471–487 . doi: 10.1123/japa.2014-0164
36. Kojima G. Prevalence of Frailty in Nursing Homes: A Systematic Review and Meta-Analysis. J Am Med Dir Assoc 2015;16:940–945 . doi: 10.1016/j.jamda.2015.06.025
37. Collard RM, Boter H, Schoevers RA, Oude Voshaar RC. Prevalence of Frailty in Community-Dwelling Older Persons: A Systematic Review. Journal of the American Geriatrics Society 2012;60:1487–1492 . doi: 10.1111/j.1532-5415.2012.04054.x
38. Smith GI, Atherton P, Villareal DT, Frimel TN, Rankin D, Rennie MJ, Mittendorfer B. Differences in muscle protein synthesis and anabolic signaling in the postabsorptive state and in response to food in 65-80 year old men and women. PLoS One 2008;3:e1875 . doi: 10.1371/journal.pone.0001875
39. Pothier K, Gagnon C, Fraser SA, Lussier M, Desjardins-Crepeau L, Berryman N, Kergoat M-J, Vu TTM, Li KZH, Bosquet L, Bherer L. A comparison of the impact of physical exercise, cognitive training and combined intervention on spontaneous walking speed in older adults. Aging Clin Exp Res 2017. doi: 10.1007/s40520-017-0878-5
40. Azadian E, Torbati HRT, Kakhki ARS, Farahpour N. The effect of dual task and executive training on pattern of gait in older adults with balance impairment: A Randomized controlled trial. Arch Gerontol Geriatr 2016;62:83–89 . doi: 10.1016/j.archger.2015.10.001
41. Li KZH, Roudaia E, Lussier M, Bherer L, Leroux A, McKinley PA. Benefits of cognitive dual-task training on balance performance in healthy older adults. J Gerontol A Biol Sci Med Sci 2010;65:1344–1352 . doi: 10.1093/gerona/glq151