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Physical and cognitive capabilities among persons aged 65–79 years in Germany

Results of the German Health Interview and Examination Survey for Adults (DEGS1)

Background and objectives

In old age, the retention of physical and cognitive capabilities plays an increasingly important role in leading an independent life irrespective of prevailing chronic and acute diseases. Functional limitations impair the performance of everyday activities [1] and are associated with increased mortality [2, 3]. Age-related functional limitations have a wide range of causes. These include acute health events such as stroke, chronic health conditions like dementia, osteoarthritis or rheumatoid arthritis, lack of exercise, obesity [4], as well as age-related loss of muscle mass and muscular strength (sarcopenia) [5, 6].

By measuring capabilities relevant to daily living it is possible to identify limitations in an objective manner. Also, consequences of functional limitations such as disability in everyday living and loss of autonomy and quality of life can be assessed. The systematic and objective measurement of dysfunctions and incapacities (geriatric assessment) already play an important role for health care and rehabilitation of older persons [7].

In Germany representative data on functional capabilities and limitations of persons 65 years of age and older so far have been mainly restricted to individual performance tests [8]. A uniformly applied standard for measurement of capabilities in older age is still lacking.

To obtain valid representative data on capabilities is essential for several reasons. First, these data contribute to a better understanding of the association between limitations and medical, sociodemographic and environmental factors. Secondly, these data are necessary to assess health status, health care needs and the potential for prevention in an ageing society taking into account various health dimensions such as diseases, functional limitations and restrictions of participation [9, 10, 11]. This corresponds to the concept of the WHO's International Classification of Functioning, Disability and Health [12].

Therefore, in the German Health Interview and Examination Survey for Adults ("Studie zur Gesundheit Erwachsener in Deutschland", DEGS1) for the first time a battery of established tests for the objective measurement of capabilities relevant to daily living was included in a nationwide health survey for adults. The aim of the present paper is to describe the methodological standards and to present first results on the distribution of functional capabilities among persons 65–79 years according to age, sex and social status.

Methods

Study design and random sample

The German Health Interview and Examination Survey for Adults (DEGS) is part of the health monitoring system of the Robert Koch Institute (RKI). The concept and design of DEGS are described in detail elsewhere [13, 14, 15, 16, 17]. The first wave (DEGS1) was conducted from 2008–2011 and comprised interviews, examinations and tests [18, 19]. The target population was the residents of Germany aged 18–79 years. DEGS1 has a mixed design which permits both cross-sectional and longitudinal analyses. For this purpose, a random sample from local population registries was drawn to supplement former participants of the German National Health Interview and Examination Survey 1998 (GNHIES98). A total of 8,152 persons participated, including 4,193 first-time participants (response rate 42%) and 3,959 former participants in GNHIES98 (response rate 62%). There were 7,238 persons who attended one of the 180 examination centres, and 914 were interviewed only.

The net sample permits representative cross-sectional analyses for the age range from 18–79 (n=7,988, including 7,116 in study centres) and time trend analyses based on comparison with GNHIES98 [14]. The analysis presented here is based on 1,853 people aged 65–79 years who participated in examinations at the study centre (◘ **Fig. 1**). The performance tests presented below were carried out exclusively by people aged 65 years or older.

Participants in DEGS1
Aged 18 years and over
n = 8152

4193 first time participants 18 to 79 years

3959 former GBHIES98 participants 28 to 91 years

DEGS1 cross section
18 to 79 years
n = 7988

Visitors to study centre
(Interview and examination)
n = 7116

Interview only
(self-administered questionnaires/
by telephone)
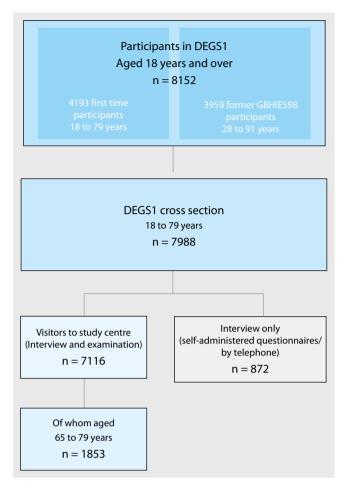n = 872

Of whom aged
65 to 79 years
n = 1853

Fig. 1 ◄ Summary of number of participants

Performance tests

To measure functional limitations, the following internationally established performance tests were used:

- Timed Up and Go test (TUG) [20, 21],
- chair rise test [22],
- balance test battery [22, 23],
- measurement of isometric[1] grip strength [8, 24, 25] and
- Digit Symbol Substitution Test [26, 27].

The tests are simple to administer and provide highly reproducible results. The results of the tests are valid measures of disability in daily living and provide information on the support needs and increased risk of falls and mortality.

Prognostic relevance has been proved in longitudinal studies for all five of the individual tests used in DEGS1 [1, 28, 29].

The tests were administered by specifically trained and certified study assistants, who were continuously supervised and reassessed at 6-month intervals during the fieldwork, ensuring that they followed the standard operating procedures. Additional training was completed where necessary (see [30] in this edition).

Timed Up and Go test (TUG)

The Timed Up and Go test is used to assess mobility limitations relevant to daily living [20]. It measures the time needed to stand up from a chair, walk a distance of 3 m at normal speed, turn, return to the chair, turn and sit down again in seconds. This test requires the ability to walk. Armrests may be used while rising. Walking aids such as rollators, crutches or canes may be used if necessary. Criteria for exclusion are inability to walk even with walking aids, blindness and severe visual impairment. Results from cross-sectional and longitudinal studies underline the functional and prognostic relevance of reduced walking speed to limitations in activities of daily living and identify the need for support [1, 20, 21] and increased risk of falling [31]. Prognostically relevant threshold values vary depending on the study population and on the target variables. Persons are considered to have a mobility impairment affecting daily living [21], if the time required to perform the test is more than 20 s.

Chair rise test

The chair rise test measures the ability to rise from a sitting position to a standing position. Standing up requires strength in the legs and is a basic requirement for the ability to move about and thus to lead an independent life. It measures the time required to stand up five times from a chair and sit down again in seconds. At the beginning of the test the participants sit in an upright position on a chair with no armrests and a seat height of 43 cm without leaning on the backrest and with both arms crossed over the chest. Both feet rest stably on the ground at about hip-width. After a rehearsal (one stand), the participant stands up five times without using the arms for assistance, in an upright position with straight hips and knees. The test is to be performed as quickly and precisely as possible. At the end of the fifth repetition the participant remains standing. The study assistants give no support or encouragement during the test. The test is not carried out if the participant is unable to stand up unassisted, if during the rehearsal it emerges that it will be impossible to carry out the test, or if the participant is either wholly or partially unable to stand at all, for example in case of paresis, amputation or balance impairment. Longitudinal epidemiological studies have repeatedly reported an association between low test results and an increased risk of limitations in daily living activities, thus leading to a need for appropriate support [32, 33, 34].

Balance tests

The balance tests were carried out in accordance with the protocol of the Short Physical Performance Battery (SPPB), which is used in international epidemiological surveys [22, 35]. In DEGS1 it was complemented by the single-leg stance in

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[1] Muscular contraction during retentive or static activity when increasing muscle tension with no change in muscle length.

order to increase the degree of difficulty and to obtain a better degree of differentiation [36]. The tests assess the ability to remain in each of four positions of increasing difficulty for a period of 10 s:

1. *Romberg position*: feet are parallel and close together.
2. *Semi-tandem stance*: from the position with parallel feet, one foot is moved forward. The participant may choose which foot to move ahead. The feet are about one foot-width apart so that the heel of the front foot and the tip of the toes of the rear foot are at the same level. However, the feet do not touch.
3. *Tandem stance*: the feet are one behind the other in a line, with the heel of the forward foot touching the tip of the rear foot. A maximum space of 1 cm is tolerated between them, and a lateral space of no more than 2 cm.
4. *Single-leg stance*: standing on one leg, right and left respectively.

The tests are carried out in the middle of the room and measure the time that the participant is able to remain in the respective position without moving the feet in seconds. The tests are stopped after 10 s. Exclusion criteria include the following: not being able to stand securely with the feet at hip-width, for example in case of leg amputation without prosthetic, paresis, wheelchair use or recent surgery on the lower extremities. Subsequent tests are omitted if the position in one test level cannot be maintained for 10 s. In accordance with the FICSIT protocol scores range between 0 (Romberg stance not completed) and 5 (all positions maintained for 10 s) depending on the test level reached [36]. Reduced standing balance is a prognostic risk factor for future falls and fractures [23, 37], mobility limitations [33] and disability in activities of daily living [1].

Grip strength test

In DEGS1 isometric grip strength was measured using a handheld dynamometer (Smedley, Scandidact, Denmark, 100 kg). The dynamometer is adjusted to the particular hand size. Grip strength is measured while the participant is standing upright if possible. The upper arm rests against the upper part of the body

Physical and cognitive capabilities among persons aged 65–79 years in Germany. Results of the German Health Interview and Examination Survey for Adults (DEGS1)

Abstract

In older age, physical and cognitive capabilities play an important role for independent living. For this reason, the German Health Interview and Examination Survey for Adults (DEGS1) included the Timed Up and Go test (TUG) and a chair-rise test, balance tests, a measurement of hand grip strength and the Digit Symbol Substitution Test (DSST) in order to representatively describe physical and cognitive performance of older people in Germany. Among 1,853 persons 65–79 years of age who came to the study centre more than 90% participated in the performance tests. The average time needed to complete the TUG and chair-rise tests were 10.7 and 11.8 s, respectively. On average, participants reached 3.9 of a maximum of 5 points in the balance tests (FICSIT4 protocol). Mean maximum grip strength was 32.3 kg. The mean number of correctly assigned symbols in the DSST was 43.8. In all functional capacity areas tested, performance declined with increasing age. There were differences by sex in the chair-rise test, hand grip strength and DSST. The objective measurement of physical and cognitive capabilities in DEGS1 contributes to describe the health status of older people with implications for health promotion and prevention.

Keywords

Physical performance · Physical and cognitive capabilities · Limitations · Aging · Health survey

Körperliche und geistige Funktionsfähigkeit bei Personen im Alter von 65 bis 79 Jahren in Deutschland. Ergebnisse der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1)

Zusammenfassung

Die Funktionsfähigkeit spielt im Alter eine wichtige Rolle für ein selbstständiges Leben. In der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1) wurden daher Timed-up and Go-Test (TUG), Chair-Rise-Test, Balance-Tests, Greifkraft-Test und Zahlen-Symbol-Test (ZST) eingesetzt, um die körperliche und kognitive Funktionsfähigkeit von 65- bis 79-Jährigen in Deutschland bevölkerungsrepräsentativ zu beschreiben. Von den 1853 Personen zwischen 65 und 79 Jahren, die ins Untersuchungszentrum kamen, nahmen über 90% an den Funktionstests teil. Für den TUG wurden im Mittel 10,7 s benötigt, für den Chair-Rise-Test 11,8 s. Von den möglichen 5 Punkten im Balance-Test (nach FICSIT4-Protokoll) wurden im Mittel 3,9 Punkte erreicht. Die mittlere maximale Greifkraft lag bei 32,3 kg. Im ZST wurden 43,8 Zeichen richtig zugeordnet. In allen Fähigkeitsbereichen wurde eine Leistungsabnahme mit zunehmendem Alter deutlich; geschlechtsspezifische Unterschiede zeigen sich beim Chair-Rise-Test, Greifkraft-Test und ZST. Die objektive Erfassung körperlicher und kognitiver Funktionseinschränkungen in DEGS1 trägt zur Charakterisierung des Gesundheitszustandes Älterer bei und ist relevant für die Prävention und Gesundheitsförderung im höheren Lebensalter.

Schlüsselwörter

Funktionstests · Funktionsfähigkeit · Funktionseinschränkungen · Ältere · Gesundheitssurvey

with the elbow raised at 90°. Two values were recorded for each hand. The dynamometer is squeezed with maximum strength for approximately 5 s. The results are recorded with a precision of 0.5 kg. Exclusion criteria are severe pain, operations or injuries to fingers, hands or arms within the previous six months, amputations or paresis, or the presence of acute swelling, inflammation or injury. If just one side is affected, measurements are made for the unaffected hand only. For analyses the maximum grip strength attained is used, regardless of side, measurement sequence and body position. In numerous studies hand grip strength has proved to be an easily assessed objective indicator of

Tab. 1 Characteristics of the survey population 65–79 years of age eligible for the performance tests (n=1,853)

	Age group			Overall
	65–69	**70–74**	**75–79**	
Women				
Overall	33.6%	42.4%	24.0%	53.9%
95% CI	30.2–37.7%	38.5–46.4%	20.5–27.7%	51.5–56.4%
$n_{unweighted}$	373	371	185	929
Social status[a]				
Low	22.0%	29.5%	36.9%	28.7%
95% CI	16.8–28.3%	23.4–36.4%	28.6–46.0%	24.5–33.2%
$n_{unweighted}$	64	81	56	201
Middle	65.7%	61.8%	57.8%	62.2%
95% CI	59.3–71.5%	55.2–68.0%	48.7–66.4%	57.8–66.4%
$n_{unweighted}$	247	231	110	588
High	12.3%	8.7%	5.3%	9.1%
95% CI	8.8–17.1%	6.4–11.8%	2.9–9.6%	7.2–11.6%
$n_{unweighted}$	61	54	17	132
Men				
Overall	36.2%	43.3%	20.5%	46.1%
95% CI	32.6–40.0%	39.4–47.3%	17.4–23.9%	43.6–48.5%
$n_{unweighted}$	370	383	171	924
Social status[a]				
Low	20.6%	22.2%	23.8%	21.9%
95% CI	15.0–27.7%	15.9–30.0%	15.6–34.5%	18.1–26.4%
$n_{unweighted}$	57	60	31	148
Middle	53.3%	58.5%	61.9%	57.3%
95% CI	45.5–60.9%	51.3–65.3%	51.6–71.2%	52.8–61.6%
$n_{unweighted}$	198	219	102	519
High	26.1%	19.3%	14.3%	20.8%
95% CI	20.2–33.1%	15.4–24.0%	9.2–21.6%	17.5–24.5%
$n_{unweighted}$	110	94	33	237

[a]Social status available for 1,825 people only.

health status and a prognostic factor for future health limitations such as disability, muscular weakness, the loss of independence of living, and increased mortality [2, 8, 38, 39]. The relationship is linear. The results have to be adjusted for sex, height, and weight or body mass index [8]. In addition, there is a consensus that hand grip strength lower than 20 kg for women and 30 kg for men are indicators for the presence of sarcopenia [40].

Digit Symbol Substitution Test

Cognitive capability is of central importance to daily competence, autonomy, social participation and quality of life in old age. Limitations in cognitive capability are associated with disability in daily living, risk of falling and increased mortality [28, 29, 41, 42].

The Digit Symbol Substitution Test (DSST) from the Wechsler Adult Intelligence Scale (WAIS) [27] was used in DEGS1 to assess cognitive performance. The DSST is a screening test for the non-specific assessment of cognitive performance that is widely used in epidemiological and clinical studies. The test requires the integration of complex neuropsychological processes and measures a number of areas of cognitive function, in particular cognitive and psychomotor speed, attention, visual scanning and executive functions.[2]

The DSST is a speed-dependent substitution test in which participants copy simple graphic symbols that are paired to

the digits 1–9. On the test sheet a key is printed, showing the graphic symbols assigned to the digits. Underneath, in seven rows of 20 fields, the digits 1–9 are printed in a random sequence. Participants draw the appropriate symbol beneath each digit. As part of the test instructions, the first seven fields are completed as a rehearsal. The test score is the number of correctly and consecutively entered symbols within 120 s. The maximum attainable score is 133.

Exclusion criteria for the DSST are severe visual impairment, impaired writing ability or hand motor function (for example through paresis, severe joint disease, recent operation, fracture or other localised disease).

The interpretation of individual test results is based on the published age-specific norms from the German-speaking norm sample of WAIS [27].

Socioeconomic status

Socioeconomic status (SES) was determined using an index, which was based on information on school education and vocational training, professional status and net household income (weighted by household needs) and which enables a classification into low, middle and high status groups [43].

Statistical analysis

The results of the individual performance tests were calculated with 95% confidence intervals (95% CI) according to sex and age group. People for whom no data was available were excluded from the analyses. Differences between groups were analysed in linear regression analyses.

The cross-sectional analyses were conducted using a weighting factor, which corrects deviations in the sample from the population structure (as of 31 Dec 2010) with respect to age, sex, region and nationality as well as type of municipality and education [14]. A separate weighting factor was prepared for the examination part. Calculation of the weighting factor also considered probability of repeated participation of GNHIES98 participants, based on a logistic regression model. A non-response analysis and a comparison of selected indicators with data from cen-

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2 Cognitive processes required for the planning and control of actions and for self-regulation.

Tab. 2	Participation and reasons for non-participation according to specific performance tests in %								
	Timed Up and Go test	Chair rise test	Balance tests					Grip strength test	Digit Symbol Substitution Test
			Romberg Test	Semi-tandem Test	Tandem test	Single-leg stance right	Single-leg stance left		
Participation in test	97.2%	90.7%	96.0%	95.6%	89.4%	73.2%	73.1%	95.1%	96.7%
95% CI	95.3–98.4%	88.5–92.6%	94.1–97.3%	93.7–97.0%	86.9–91.5%	69.8–76.4%	69.6–76.2%	92.9–96.6%	94.7–98.0%
$n_{unweighted}$	1,795	1,675	1,774	1,769	1,667	1,410	1,406	1,774	1,802
Did not participate[a] for health reasons	1.1%	1.7%	2.3%	2.3%	4.3%	5.7%	5.4%	2.7%	1.4%
95% CI	0.7–1.8%	1.0–2.7%	1.6–3.3%	1.6–3.3%	3.1–5.8%	4.4–7.4%	4.2–7.0%	1.7–4.3%	0.9–2.4%
$n_{unweighted}$	22	33	43	46	77	99	97	40	21
Did not participate[b] for personal reasons	0.6%	1.4%	0.7%	0.8%	4.0%	6.3%	6.3%	0.6%	0.7%
95% CI	0.2–1.8%	0.8–2.5%	0.3–1.8%	0.3–1.8%	2.9–5.5%	4.9–8.1%	5.0–8.1%	0.2–1.8%	0.3–1.9%
$n_{unweighted}$	5	20	7	8	57	99	101	5	6
Did not participate[c] for technical/organisational reasons	0.8%	0.8%	0.7%	0.7%	0.8%	0.8%	0.8%	0.8%	0.6%
95% CI	0.2–3.2%	0.2–3.2%	0.2–3.2%	0.2–3.2%	0.2–3.1%	0.2–3.1%	0.2–3.1%	0.2–3.0%	0.1–3.5%
$n_{unweighted}$	24	24	22	22	23	23	23	23	17
Eligibility criteria not fulfilled[d]		4.4%		0.3%	1.2%	13.5%	13.5%		
95% CI		3.3–5.8%		0.0–1.8%	0.6–2.1%	11.2–16.3%	11.2–16.3%		
$n_{unweighted}$		84		1	21	213	213		
Not carried out for reasons not stated	0.3%	1.0%	0.3%	0.3%	0.4%	0.4%	0.8%	0.9%	0.6%
95% CI	0.1–0.8%	0.6–1.8%	0.1–0.8%	0.1–0.8%	0.2–0.9%	0.2–0.9%	0.4–1.9%	0.4–2.1%	0.2–1.5%
$n_{unweighted}$	7	17	7	7	8	9	13	11	7

[a]For example disease, pain, paresis
[b]For example refused, lack of confidence, no time
[c]For example space in study centre not suitable, lack of time at study centre
[d]Chair rise test: one stand not possible, balance tests: failed previous level.

sus statistics indicate a high level of representativeness of the net sample for the residential population aged 18–79 years of Germany [14]. To take into account the weighting as well as the correlation of participants within one community, the confidence intervals were determined using SPSS 20 procedures for complex samples. Differences are considered statistically significant if the respective 95% CI do not overlap or if a p value of less than 0.05 is yielded in regression analyses.

Results

The characteristics of the survey population 65–79 years of age eligible for the performance tests are shown in ◘ Tab. 1. Of the 1,853 participants, who visited the examination centre, 53.9% were women and 46.1% were men. Less than a quarter were in the age range 75–79 years. The majority of participants were classified into middle SES group (women 62.2%, men 57.3%), 28.1% of women and 21.9% of men into the low SES group and 9.1% of women and 20.8% of men into the high SES group. Women were significantly less likely to have high SES compared to men.

Participation rates in the different performance tests vary according to the different inclusion and exclusion criteria. The participation rates and an overview of the main reasons for non-participation are given in ◘ Tab. 2. The most frequent reasons for non-participation in all tests are health-related, mainly neurological or orthopaedic limitations or other health conditions precluding test completion. Since men and women show no significant difference with respect to participation behaviour for any of the performance tests, the results are not separately shown for men and women.

The results of the performance tests are summarised in ◘ Tab. 3.

Physical capability

Timed Up and Go test (TUG)
Of the people aged 65–79 years 97.2% participated in the TUG test. The main reasons for non-participation in the TUG test are health-related (1.1%) (◘ Tab. 2).

Participants needed an average of 10.7 s to complete the TUG test with a range from 4.6–46.3 s. The median is 10 s. The mean for women is 11.0 s and for men it is 10.4 s. These differences are statistically not significant (p=0.129) if age and SES group are taken into account. With increasing age all participants needed significantly more time to complete the TUG test.

Of all 1,853 people visiting the examination centre, 24 were unable to partic-

Tab. 3	Results from performance tests (means and 95% confidence intervals)			
Test	**Age group**			**Overall**
	65–69 years	**70–74 years**	**75–79 years**	
Time Up and Go test (TUG, time required in seconds) n=1,795				
Women	10.3	11.0	12.0	11.0
95% CI	9.9–10.7	10.5–11.4	11.3–12.7	10.7–11.3
Men	9.7	10.5	11.4	10.4
95% CI	9.4–10.1	9.9–11.0	10.7–12.1	10.0–10.7
Overall	10.0	10.7	11.8	10.7
95% CI	9.7–10.3	10.4–11.1	11.2–12.3	10.4–11.0
Chair rise test (time required in seconds) n=1,675				
Women	11.8	12.1	12.6	12.1
95% CI	11.0–12.7	11.6–12.7	12.0–13.2	11.7–12.6
Men	10.7	11.0	13.1	11.3
95% CI	10.2–11.2	10.6–11.4	11.9–14.4	10.9–11.7
Overall	11.3	11.6	12.8	11.8
95% CI	10.8–11.8	11.2–12.0	12.1–13.5	11.4–12.1
Balance test (score according to FICSIT4 protocol) n=1,774				
Women	4.1	3.9	3.2	3.8
95% CI	4.0–4.3	3.7–4.0	3.0–3.4	3.7–3.9
Men	4.3	4.0	3.6	4.0
95% CI	4.1–4.5	3.8–4.2	3.4–3.8	3.9–4.1
Overall	4.2	3.9	3.4	3.9
95% CI	4.1–4.3	3.8–4.0	3.2–3.5	3.8–4.0
Grip strength (mean value in kg) n=1,774				
Women	26.0	25.2	23.2	25.0
95% CI	25.3–26.7	24.6–25.7	22.5–24.0	24.6–25.4
Men	42.5	40.8	36.5	40.5
95% CI	41.7–43.4	39.6–42.0	35.4–37.6	39.8–41.3
Overall	34.1	32.5	29.0	32.3
95% CI	33.2–35.0	31.6–33.4	28.1–30.0	31.7–32.9
Digit Symbol Substitution Test (No. correct symbols) n=1,802				
Women	51.4	43.1	38.4	44.8
95% CI	48.6–54.2	41.3–44.9	36.6–40.3	43.4–46.3
Men	46.3	41.7	38.0	42.6
95% CI	44.4–48.2	39.9–43.3	35.0–40.9	41.3–43.9
Overall	48.9	42.4	38.2	43.8
95% CI	47.2–50.7	41.3–43.6	36.7–39.8	42.8–44.8

ipate in the TUG test for organisational reasons. Of the remaining 1,829 persons, for 2% the performance in the TUG indicated walking problems relevant to daily living, i.e. the time required to carry out the TUG test is 20 s or more. The majority of the 1.1% who were unable to participate for health reasons showed mobility limitations.

Chair rise test

Of the people aged 65–79 years 90.7% participated in the chair rise test; 4.4% were unable to perform the test, as they were unable to stand up once. Another 17% did not participate for health reasons, mostly due to health limitations (**Tab. 2**).

The mean time required to perform five chair stands is 11.8 s, with a range from 4.0–41.2 s. The median is 11.0 s. After adjustment for age and SES group, women need significantly more time to perform the chair rise test (12.1 s) than men (11.3 s) (p=0.000). Furthermore, the influence of age is significant among men (p=0.001).

Balance tests

The results of the balance tests display the increasing degree of difficulty intrinsic in

this test. Participants performed the next, more difficult stage only if they completed the preceding stage. The proportion of people who were unable to perform the different stages rises from 3.3% for the Romberg stance to 25.5% for the single-leg stance (right leg) (**Tab. 2**). Health problems that led to non-participation in one or more of the balance tests were acute high blood pressure, limited walking ability, artificial joints and neurological or orthopaedic problems in the legs.

The highest possible score on the FICSIT4 balance scale is 5 points. DEGS1 participants scored an average of 3.9 points, and ranged from 0 to 5 points. The median is 4 points. There is no significant sex-difference in balance (p=0.08). The balance score adjusted for SES decreases significantly with age for both sexes. Among women it drops from 4.1 points for those aged 65–69 years to 3.2 points for those aged 75–79 years. Among men the balance score drops from 4.3 points for 65–69 year olds to 3.6 points for 75–79 year olds.

Grip strength test

Of the participants 95.1% performed the grip strength test. Most frequent reasons for non-participation were severe pain, injuries and operations of the hands, and acute inflammation and swellings.

The mean maximum grip strength for participants aged 65–79 years is 32.2 kg. The median is 31.0 kg. Grip strength is significantly different among men and women. For women the mean adjusted for SES, is 25.0 kg, for men 40.5 kg (p<0.001). Grip strength decreases significantly with age for both sexes.

The distribution of mean maximum grip strength according to height is shown in **Fig. 2**. It is evident that, with the exception of the eldest age group, grip strength increases with increasing height.

Severely reduced muscle strength (less than 20 kg for women, and 30 kg for men) is found in 9.5% of women and 5.1% of men and may be an indicator of sarcopenia.

Cognitive capability

The DSST was completed by 96.7% of the participants. Non-completion was due to
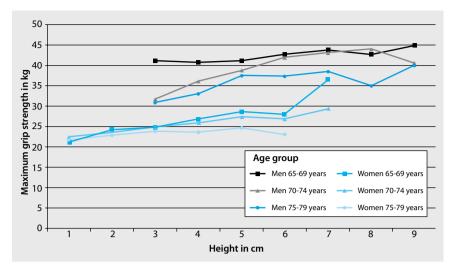
Fig. 2 ▲ Maximum grip strength according to height (arithmetic mean)

impaired hand function or severe visual impairments in all cases.

Overall the scores range from 0–96 points, with test scores following a normal distribution. The average score is 43.8 points (standard deviation 14.0). Women achieve higher scores overall (mean 44.8) than men (mean 42.6; p=0.02). The average score drops steadily with increasing age in both men and women. Women in the age group 65–69 years but not in the other age groups achieve higher average scores than men. Higher socioeconomic status is also associated with higher scores, even if the effect of age and sex is controlled for in the statistical analysis.

Discussion

The cross-sectional results of DEGS1 show the expected age-related decrease of functional capabilities. Although age is not the only determinant for declining capability, age-related physiological processes do play an important role. A variety of factors contribute to the decline in capability with increasing age. Besides genetic factors lifelong individual behavioural patterns (diet, exercise, and smoking) and environmental influences are highly relevant for age-related changes in cells, tissues and organs. This explains why age-related limitations in physical and cognitive function show great variability between individuals [44, 45, 46]. Consequently, prevention and health promotion are of outstanding importance in old age.

The results from DEGS1 are in line with results of various international publications (see below). However, when comparing results directly, differences in age groups, age range and health status (healthy, impaired) must be taken into account.

In a meta-analysis of TUG test results, Bohannon [47] reports a time of 9.4 s for 60–99 year olds and an increase in the required time with increasing age. However, the meta-analysis also shows a wide range of results. In a representative sample of people aged 69–104 years in Canada, Rockwood et al. [48] report a mean required time of 14.0 s (median). The mean required time in DEGS1 of 10.7 s (median 10 s) lies between those two figures and, in view of the age structure, is consistent with those results.

The results of the chair rise test also differ due to different age groupings in the studies. Guralnik et al. [22] report a time of 14.5 s for persons over 70 years of age with no upper age limit, while Whitney et al. [49] report 13.4 s in a study of persons with a mean age of 73 years. A further meta-analysis by Bohannon [50] reports 11.4 s for 60–69 year olds and 12.6 s for 70–79 year olds. The mean time required in DEGS1 of 11.8 s is within this range. Age-stratified results are provided in the Health Survey for England [51]: the mean time required by women 60–69 years of age is 13 s as compared to 12 s

by men of the same age group. The average time required rises to 15 and 14 s respectively for 75–79 year olds. Corresponding age and sex differences are found in DEGS1.

The decline in balance with increasing age described in DEGS1 is consistent with the results of other studies [22, 36, 51]. Analyses of the known correlation between balance and falls [23] and mobility limitations [33] are planned for the future.

In Germany hand grip strength was first assessed in 2004 as part of the Survey of Health, Ageing and Retirement in Europe (SHARE) and in 2006 in the main survey of the Socio-economic Panel (SOEP). The results of these studies underline a strong positive correlation between hand grip strength and health [8]. The results of DEGS1 show a good level of consistency with the SOEP and SHARE data.

Longitudinal studies have shown that muscular weakness in middle age, assessed via isometric grip strength, is a good predictor of future disabilities, for instance in the activities of daily living (ADL) [52], or of mortality risk in old age [53].

The results from the grip strength and chair rise tests are indicator variables for decreasing muscular strength, one of the parameters defining sarcopenia. Thus, DEGS1 results allow estimating the number of persons affected by sarcopenia in the resident population 65–79 years in Germany in relation with their exercise and sports activities.

For the DSST, age-specific norms are available from a healthy German-speaking normative sample that included a total of 1,897 persons from Germany, Austria and the German-speaking region of Switzerland; among these, 421 persons were aged 65–79 years [27]. In this normative sample, the 95% CI for the mean test score were 48–53 for persons aged 65–69 years, 44–49 for those aged 70–74 years, and 39–44 for persons aged 75–79 years. As expected, age specific mean test scores in DEGS1 are very close to the lower CI limits for the respective age groups. This result is plausible, because the results presented here are based on the entire DEGS1 cross-sectional sample of 65–79 year olds, which does not represent a healthy refer-

ence population. In contrast to published norms, the present analysis also included test scores from people with impaired cognitive function due to pre-existing health conditions or diseases.

In addition to the effect of aging, the results presented show an association between the mean test scores and both, sex and socioeconomic status, as has been described in similar assignment tests such as the Letter Digit Substitution Test [54].

Conclusion and Outlook

The present analysis provides first empirical data on functional capabilities in the population 65–79 years of age. More in-depth analyses will first serve to analyse the distribution of functional test results according to anthropometric and socio-demographic factors. Further we will focus on generating population-based reference values. For example, age-, sex- and SES-specific reference values of hand grip strength also considering body height and weight are still lacking for the German population to date. Similarly, there is still lack of reference values for the DSST according to chronological age, sex and level of education in the German population 65–79 years of age.

Apart from test results regarding specific functional capabilities, composite physical functioning scores are frequently generated [35]. These are analysed in relation to mortality, falls, disability or hospitalisation. Based on the SPPB [22], we plan to develop an index using the DEGS1 results, which will provide a measure of overall capability based on several functional capability measures and which will facilitate correlation analyses. In particular, the association between functional limitations and diseases, fractures, hospitalisation, quality of life and disability in daily life will be analysed. The longitudinal components of DEGS also provide the opportunity to analyse individual changes in functional capabilities across the life course. These objectives are also highly relevant for the exchange of data in international comparisons [2, 3].

Regularly collected data on functional capability levels as part of the German health monitoring programme will facilitate monitoring of the burden of disease and associated care needs in an aging society [9, 10, 11].

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