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Feasibility of population screening tests to establish a healthy ageing trajectory

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Abstract

Objectives: There are no agreed comprehensive tests for age-related changes to physical, emotional, mental and social functioning. Research into declining function focuses on those 75 years and older and little is known about age-related changes in younger people. The aims of this project were (1) to ascertain a comprehensive test battery that could underpin community-based health screening programmes for people aged 40–75 years and pilot both (2) community-based recruitment and (3) the utility, acceptability, response burden and logistics.

Methods: A total of 11 databases were searched using a broad range of relevant terms. An identified comprehensive, recent, high-quality systematic review of screening instruments for detection of early functional decline for community-dwelling older people identified many relevant tools; however, not all body systems were addressed. Therefore, lower hierarchy papers identified in the rapid review were included and expert panel consultation was conducted before the final test battery was agreed. Broad networks were developed in one Australian city to aid pilot recruitment of community-dwellers 40–75 years. Recruitment and testing processes were validated using feasibility testing with 12 volunteers.

Results: The test battery captured (1) online self-reports of demographics, health status, sleep quality, distress, diet, physical activity, oral health, frailty and continence; and (2) objective tests of anthropometry; mobility; lung function; dexterity; flexibility, strength and stability; hearing; balance; cognition and memory; foot sensation; and reaction time. Recruitment and testing processes were found to be feasible.

Conclusion: This screening approach may provide new knowledge on healthy ageing in younger people.

Keywords

Ageing, population screening, epidemiology/public health, functional decline, health promotion

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Background

Healthy ageing is promoted as the way of attenuating age-related decline in body system performance and maintaining people's community participation[1] by using active interventions to optimize well-being, and physical, mental, social and emotional capacities.[2] Theoretical trajectories of 'expected' and 'accelerated' age-related declining function were described by the World Health Organization (WHO),[3] as thresholds of disability which most people are expected to breach, at some stage in their lives. While age-related changes in body system functioning are widely acknowledged, the trajectory of healthy ageing is poorly understood.[4,5] Little is known about the processes of 'expected' healthy ageing in multiple body systems and there is little data on the trajectory of age-related changes occurring insidiously in independent, (presumed) generally healthy, community-dwelling people, or at what age, body performance changes could be first detected. Moreover, the critical points beyond which age-related decline becomes irreversible has not been identified.[4–6] Given the increasing number of people in developed countries living for longer, and the high costs of residential care for those who cannot live independently in the community, it is imperative that the normal processes of healthy ageing are better understood, so that preventive primary care interventions can be implemented in a timely manner to optimize health and independence.

Such is the importance of promoting and supporting healthy ageing that the recent 69th WHO Assembly adopted the Global strategy and action plan on ageing and health.[6] A decade of healthy ageing has been proposed (2020–2030) to highlight the global importance of healthy, independent older age.[6] The WHO has called on all partner organizations internationally to participate in research and clinical innovation that promotes and supports healthy ageing. This includes developing evidence-based tools to assess age-related changes, which can underpin clinical, community and population-based interventions to optimize functional ability.[6] Furthermore, agreed and quantifiable indicators, standards and metrics for healthy ageing are required to enable performance mapping. In Australia, to provide evidence-based healthy ageing assessments and interventions which will improve quality of life, increase capacity for participation, decrease hospital presentations and support personalized interventions, the Strategic Review of Health and Medical Research has made better health for older Australians a priority.[7] Laudable as these strategies are they cannot be actioned effectively at present because there is no standard, comprehensive, evidence-based screening tool battery, and no formal opportunity to systematically and repeatedly screening community-dwelling individuals as they age.

Population screening over the past 50 years has been successful for early detection of diseases such as bowel and breast cancer.[8] Comprehensive screening of key physical, mental, emotional and social attributes of ageing could provide currently unavailable, but essential information on the 'expected' trajectory of healthy ageing in body systems.[3,4,6] Australia has Medicare-funded primary healthcare initiatives in general practitioner (GP) clinics to screen for chronic disease (45+ GP assessment) and incipient frailty (75+ GP assessment), where some elements of disability and age-related functional decline are assessed.[9] However, these initiatives have not been well subscribed by GPs or patients, they do not comprehensively assess body system performance, and the findings are not collated in such a way as to provide population data on healthy ageing.[10,11] Whom to screen in the population, the core screening elements for healthy ageing, and how often to screen, is also not clear. Given the quickly approaching decade of Healthy Ageing (2020–2030), it is important to commence early comprehensive population screening for people aged 40 years and over to better understand the ageing trajectory and to introduce cost-effective feasible interventions to reverse primary age-related changes not detected in routine medical examinations.[12] Screening people for age-related changes from 40 years would also capture accelerated ageing changes reported in Aboriginal and Torres Strait Islander, refugee and homeless populations.[13,14]

This article describes establishment and feasibility testing of a comprehensive test battery to underpin community-based screening programmes for people aged 40–75 years and has three aims: (1) to establish a comprehensive evidence-based test battery of validated screening tools for physical, mental, emotional and social aspects of ageing; (2) to test a recruitment strategy for community-dwelling adults aged 40–75 years; and (3) to pilot the test battery for utility, acceptability, response and organizational logistics.

Methods

Ethical approval

Ethical approval was obtained in 2017 from the Southern Adelaide Local Health Network (South Australia; 391.16 and 407.16).

Aim 1: establishing a comprehensive evidence-based test battery of validated screening tools

The authors used the following iterative approach to collate the test battery.

Evidence base. The authors completed a rapid literature review to identify (1) a 'wish list' of attributes and/or predictors of declining function in body systems which may be age-related (see Table 1 and (2) relevant screening tools (see Tables 2 and 3). In line with rapid review protocols, this review sought the highest hierarchy, best quality, most recent literature relevant to the search question.[46] Databases searched comprised Medline, Embase, AMED, AgeLine, CINAHL, PsychInfo, Psychology and Behavioural Sciences

Table 1. 'Wish list' of measures describing attributes of healthy ageing.

Demographics	**Anthropometry**	**Derived measures**
Age	Height	Body mass index
Gender	Weight	Waist–hip ratio
Main language spoken at home (influence on social engagement)	Girth (waist, hip, arm)	Muscle mass
Nationality at birth	Skin fold	Fat mass
Locality	**Physiological measures**	**Physical functioning**
Living status	Blood pressure	Peripheral muscle strength
Marital status	Heart rate	Core muscle strength
Paid/unpaid work	Temperature	Endurance
Social activities	Blood glucose	Regular exercise history
Family engagement	Respiratory rate	Dexterity
Income	Lung function	Reflexes
Pets	Blood oxygenation	Flexibility
Transport	**Emotional health**	Grip strength
Education	Depression	Daily physical activities
Health	Anxiety	Physical exertion
General health	Sleep amount and quality	Walking speed
Existing health conditions	Self-assessed health status	**Psychological functioning**
Medications and supplements	Fear (of being alone, movement, future)	Interaction with family and community
Recent hospitalization	**Continence**	Cognition
Recent ED presentations	Bladder function	Hobbies
Smoking	Bowel function	Forgetfulness, confusion
Alcohol consumption	**Oral health**	**Sensation**
Regular pain	Dental information	Smell
Communication	Ease of eating	Taste
Speech	Nocturnal bruxism	Foot
Balance	**Nutrition**	Vision
Falls and near misses	Food intake (number of meals per day)	Hearing
Capacity and length of time maintaining balance with different visual clues	Fluid intake	Ear health

ED: emergency department.

Table 2. Risk assessments and normal values.

Assessments	Normal range/value
Blood pressure[15]	90–140 for systolic and 60–90 mmHg for diastolic
Heart rate[15]	60–100 beats/min
Respiratory rate[15]	12–20 breaths/min
Core temperature[15]	35.5°C–37.5°C
Blood oxygenation[15]	>96%
Blood glucose[15]	3.0–7.7 mmol/L

Collection, Cochrane Library, Wiley Online Library, PubMed and Sociological abstracts, using broad terms of age*; health*; screen*, chang*; with truncations and synonyms. All databases were searched up to 31 August 2016.

This search identified a comprehensive, recent, high-quality systematic review of screening instruments for detection of early functional decline for community-dwelling older people.[47] This included 107 screening tools which had been critically appraised using an established tool for psychometric properties and clinical utility.[48,49] Instruments identified in the review were classified into six categories: *Medical status* (27 tools for biological systems); *Performance capacity* (38 tools for physical and mental health, and cognition); *Participation* (20 tools for environment, function and motivation); *Demographics* (8 tools); *Anthropometry* (10 tools); and *Relationships with healthcare providers* (5 tools). As this review focused on early functional decline, most tools were immediately relevant to our proposed population; however, not all body systems were addressed. Lower hierarchy papers identified in the rapid review were included for other tools available to assess the body systems' issues not covered in the systematic review.

The authors considered the merits of each tool and prioritized according to established evidence of validity (see Table 3), free availability, not under copyright and if they provided thresholds/population norms relevant to community-dwelling people aged 40–75 years.

Evidence gaps. While the rapid review identified tools to assess each 'wish list' item, many of the assessments had not

Table 3. Attributes of ageing, assessment tools and population thresholds (if available).

Attribute	Recommended interpretation (italics indicates tools have been validated)	Identified population thresholds
Online surveys		
Psychological distress[16]	*Kessler Psychological Distress Scale (K10)*[16]	Yes[16]
Sleep quality[17,18]	*Pittsburgh Sleep Quality Index (PSQI)*[17]	Yes[17]
Oral health[19,20]	Oral Health Questionnaire[19]	No
Nutrition[21,22]	*Short Nutritional Assessment Questionnaire (SNAQ)*[21] and selected questions on food types and portions from Australian Dietary Guidelines	No
Speech and hearing[23]	*Speech, Spatial and Qualities of Hearing Questionnaire (SSQ5)*[23]	No
Continence[24]	*Pelvic Floor Bother Questionnaire (PFBQ)*[24]	No
Physical activity[25]	Active Australia Survey (AAS) (The Active Australia Survey, 2003)[25]	Yes[25]
Frailty[4]	*Clinical Frailty Scale (CFS)*[4]	No
Objective measurements		
Mobility[26,27]	Six Minute Walk Test (SMWT)[26,27]	Yes[27]
Perceived exertion[28]	Borg Exertion Scale[28]	Yes[28]
Dyspnoea[10]	Borg Dyspnoea Scale[10]	Yes[10]
Cognition[29]	General Practitioner Cognition Scale (GPCog)[29]	Yes[29]
Anthropometry[30]	BMI; waist circumference; waist–hip ratio; fat mass; muscle mass; triceps skin fold[30]	Yes[30]
Lung function[31]	FEV1, FVC, lung ratio[31]	Yes[31]
Grip strength[32–34]	Handheld dynamometer[32–34]	Yes[33,34]
Muscle function, functional strength, stability[35]	Functional Movement Screen (FMS)[35]	No
Flexibility[35]	Functional Movement Screen (FMS)[35]	No
Balance[36]	Balance Screening Tool(BST)[36]	No
Audiometry[37]	Functional Hearing Assessment[37]	Partial (minimum hearing norms (20–25 Db) are built into the tests)[37]
Vision assessment (if not tested in previous 12 months)[38]	Standard Vision Chart[38]	No
Dexterity[39–41]	The Purdue Dexterity Test[39]	Yes[39,40]
Reaction time[42,43]	Simple Response Time; Choice Response Time[43]	No
Foot sensation[44]	Monofilament testing[44]	No
Reflexes[45]	Biceps tendon (elbow); patella tendon (knee)[45]	No

BMI: body mass index; FEV1: forced expiratory volume in 1 s; FVC: forced vital capacity.

been validated for use in this population or did not provide expected population values (see Table 3). To ensure no assessment tools had been missed, relevant primary literature was identified from articles identified in the rapid review. Furthermore, additional searches were undertaken, using the same search strategy and conducted in the same manner as the rapid review, with each search focused and filtered by key words relevant to each gap.

Determining the test battery. An expert panel was convened, comprising the authors; partner and network representatives; and academics in disciplines relevant to healthy ageing (medicine, nursing (physical and mental), public health, allied health (physiotherapy, occupational therapy, psychology, nutrition, audiology, speech and language, social work), and dentistry). Researchers in the ‘gap’ areas were co-opted onto the expert panel by the research team, when that expertise was not already available on the panel. These included a respiratory scientist, sleep researcher, podiatrist and a specialist bowel and bladder physiotherapist.

Copies of the included screening tools were sent to the expert panel a week prior to a face-to-face meeting in August 2016. At the meeting, the expert panel discussed each screening tool for relevance, comprehensiveness, likely response and ease of administering in population screening. Where there were choices of screening tools for particular aspects of healthy ageing, the panel chose tools with the most convincing evidence of clinical utility and psychometric properties. Preference was given to tools with no cost or licencing requirements, and with population norms/benchmarks. The co-opted members tabled new screening tools in their speciality areas, and similar discussions occurred. A penultimate battery of screening tools was collated that would be delivered in two parts: as online self-reports and face-to-face objective data collection. Finally, an estimate of the amount of time required to complete the Inspiring Health Screening Tool Battery was made.

Avoiding adverse events. Sequences for testing, and stopping rules, were established for some objective tests, to avoid potential misadventures during testing (such as falls, undue fatigue or injury). For instance, the chosen balance test protocol would need to commence with a simple test that should be achieved by all participants (for instance standing on both legs, eyes open). If participants could not complete this, or subsequent tests after three attempts, they would not be allowed to proceed to more challenging balance tests.

Aims 2 and 3: recruitment and feasibility testing

Paid and unpaid workers (volunteers) in each partner organization were alerted to the feasibility study by posters and general email invitations. The primary role of participants in the feasibility study was to act as key informants, by providing insights into the likely perceptions of community-dwelling people about volunteering for screening with the test battery,[50] as well as establishing the capability of the target population, males or females aged between 40 and 75 years living independently in the community, to safely complete the assessments. A representative sample of this population rather than a specific number of participants based on the expected outcome of any assessment tool was recruited. Potential participants contacted the research team and were purposively recruited into age clusters (40–49; 50–59; 60–69; 70–75 years) with at least one man and one woman in each age cluster. We sought a sample of at least 12 participants on the assumption that the views of four participants in each age group should be sufficient to identify issues with test battery administration. Participants were asked to attend testing wearing close fitting exercise clothing that allowed ready participation in physical tests, and sports or walking shoes that could be removed easily.

Precedent. The feasibility study was conducted similarly to the biennial Tokyo Metropolitan Institute of Gerontology (TMIG) Healthy Aging Survey.[51] A resource manual of tests and instructions was prepared to standardize measurement procedures, outline the organization for data collection, and reduce interpretation error. Flinders University health discipline students and/or their academic supervisors (n = 12), whose participation was part of a university-wide interprofessional learning initiative, were used as assessors and were trained for accuracy, and efficiency, in the tests delivered at that station.

Proposed process of self-report. An online data collection form was designed to capture self-reported information. Participants were invited to complete this up to 1 week prior to undertaking objective testing. Consent was implicit in completion of the online survey, and advice was provided throughout the survey that participants could withdraw at any time. If participants did not have access to the Internet, they had the option of completing the survey in paper-form. If participants were under-confident in literacy, scribes were available to assist with paper-based survey completion on the day of objective measures testing.

Process of objective data collection. Objective measures were collected at a central venue (Flinders University Clinical Teaching and Education Centre). On arrival, participants provided signed informed consent before being screened for key physiological risks for ill-health which might make them ineligible to proceed to testing (see Table 2).[15] Participants were asked about medications, health conditions and health events which might put them at risk of falls or temporary cognitive deficits. These included recent hospitalizations or emergency department presentations, recent falls or ‘near misses’, recent vaccinations, or current and past pain concerns. If researchers believed that potential participants may not be safe to participate, they were excluded from the study at this point and counselled about seeking medical help.

Participants whose physiological measures were within normal limits and were not considered to be at risk of adverse events from testing proceeded to objective data testing. At each testing station, participants were re-consented verbally and reminded that if any test produced pain or physical difficulties, this should be reported; if necessary, the test would cease. Participants moved through each station until all were completed. The amount of time taken to complete each station was recorded.

Feedback. After completion, participants provided verbal feedback in semi-structured interviews on the recruitment and consent process; the acceptability of screening tests; data collection processes; adequacy of online instructions, and the instructions provided at each measurement station; organization of measurement stations; engagement with measurers; and any other reflections. The data collectors at each measurement station also provided feedback on the objective data capture processes (e.g. adequacy of training, time allowed for data collection, and data entry). Feedback was collated and reviewed by the research team and modifications were made, as required, to testing processes to improve organization, information exchange and participant satisfaction, prior to future roll-out in a large-scale community screening study.

Data management and analysis. Data were recorded in a purpose-built Microsoft© Access© 2016 Database Management System, using a de-identified identifier (ID) unique to each participant. Responses to the online surveys and the data items recorded at the objective measurement stations were linked by this unique ID. The total amount of test time was calculated per participant and compared with the expert panel estimates.

Individual reporting. A draft personalized report was designed to summarize individual health status measures. This was offered to each participant, to share with their GP, if they wished. This report highlighted where individuals fell outside 'normal' population ranges, and it alerted participants (and their GPs) to health issues warranting more in-depth assessment and targeted intervention. Participants' feedback on the usefulness and comprehensiveness of these reports was captured.

Results

Aim 1: screening tests

Screening tools (individual, or groups of measures) were identified for all 'wish list' items in Table 1, with multiple 'wish list' items often incorporated into one tool. An evidence-based screening test battery of 45 individual items and tools was proposed to address all body systems.[4,15–45] Information on the test battery items is provided in Tables 2 and 3.

Self-reported information

The purpose-built online questionnaire collected information on birthdate, gender, culture and ethnicity, language spoken at home, marital status, living arrangements and housing status, education, employment and income, pet ownership, common forms of transport and community participation. Data were also recorded from eight validated instruments on psychological health, sleep quality, oral health, nutrition, speech and hearing, continence, physical activity and frailty (see Table 3). This table indicates where population norms were available for these measures. On average, participants took 40 min to complete the online questionnaire.

Objective data

Table 3 also outlines the objective tests collected at eight measurement stations, including which tests had population norms. It took participants approximately 2 h to circulate through the eight measurement stations.

Aim 2: sample

We recruited the first 12 volunteers who consented to the feasibility study, filling decade age clusters between 40 and 75 years (six women, six men, four from each decade). Participants reported being attracted to volunteering by the community outcomes that could occur from this type of population screening. Volunteers' main reasons for participating were wanting to be part of something positive in their community and to be involved in an activity that would provide them with comprehensive information on their personal health status, which they could not get anywhere else. They believed that the recruitment strategies were appropriate and were likely to attract others in their organization for future large-scale population data collection. They suggested that future testing could be promoted through the media, and in other community groups such as sporting clubs, churches and philanthropic organizations. All indicated they would assist in future recruitment strategies by describing their firsthand experiences.

Aim 3: utility, acceptability, response and organizational logistics

Data saturation occurred in the responses of the volunteer participants (n = 12) and the assessors (n = 12) with regard to the utility, acceptability, response and organizational logistics of the assessments.

Adverse events

There were no adverse events during testing, and participants and data collectors did not identify any opportunities for misadventure that had not already been identified by the expert committee. Participants and data collectors found that clothing instructions were appropriate and readily complied with and no one was excluded from objective testing because of their physiological measures.

Modifications to objective test

Testing for knee and ankle reflexes[15] was removed as other tests for balance and muscle performance could identify functional deficits related to reflex impairment.[26,27,35,36] Measurement of triceps skin fold was removed due to poor reliability between measurers, and sufficient other measures of anthropometry.[30] The Balance Screening Tool[36] provocation tests were reordered so that the safest balance tests were undertaken first (eyes open, standing on both and then each leg, for (up to) 5 s). People who could not complete these tests were not progressed to more difficult, potentially injurious tests, undertaken with eyes closed.

Modifications were made to the order and organization of testing of the functional muscle performance tests (FMS).[35] The original FMS target population (elite athletes) differed significantly from the study population, and given the feasibility study findings, it appeared unlikely that participants in any population-based screening study would be able to complete all tests safely. The FMS was thus administered by commencing with eight basic tests (deep squat; lunge on the floor (L, R legs), hurdle step on the floor (L, R legs), rotary stability (L leg, R arm; R leg, L arm); knee push up), with only those subjects who successfully completed these tests progressing to more advanced tests.

Modifications to data collection organization

Minor changes were made to the allocation of screening tools to stations, to ensure more efficient data collection and participant flow. The stations for subsequent population testing comprised the following:

- *Station 1.* Assessment of cognition[29] and lung function;[31]
- *Station 2.* Audiometry;[37]
- *Station 3.* Muscle function, functional strength, stability and flexibility;[35]
- *Station 4.* Anthropometry,[30] grip strength,[32–34] dexterity,[39–41] reaction time;[42,43]
- *Station 5.* Mobility[26,27] and exertion;[28]
- *Station 6.* Balance,[36] foot sensation[44] and vision assessment.[38]

The purpose-built database performed well, providing standard data entry, easy data validation and opportunities to interrogate the data in a range of combinations.

Discussion

To the best of our knowledge, we have reported the first comprehensive, validated, English-language, freely available, evidence-based screening test battery for age-related body systems performance which could underpin population screening into healthy ageing in community settings. Compared with the Japanese-language test battery used by TMIG[51] to assess people aged 65 years and over in one Tokyo prefecture, our test battery is more extensive and captures body systems' performance in younger participants (aged 40–75 years). Of the 45 performance body systems' measures in our test battery, population norms were available for approximately half. This highlights the need for population-based research upon which to build a database of 'expected' performance in community-dwelling people aged from 40 years. For some measures (such as FMS[35] and balance[36]), the tests had been initially designed for population subsets (elite athletes, people with falls problems), and thus modifications were required for community-dwellers to ensure safety during testing.

We identified effective broad-based recruitment strategies for community-dwelling Australians aged 40–75 years. While some other countries have registers of birthdates of community-dwelling people which facilitates comprehensive recruitment and sampling for population-based studies,[1,51] there is no feasible or standard way of similar population-based recruitment in Australia.[7,10,11] Multipronged recruitment approaches (media, emails, public notices) disseminated through community-based partner organizations, the use of peer champions, the comprehensive capture of data on body systems performance, and the offer of individualized health reports appear likely to capture the interest of community-dwelling people. Our testing process did not impose significant individual strain on any participant, and there were positive comments about the scope and intent of the test battery. Participants particularly indicated that they appreciated knowing whether they were generally performing within population norms (or not) as well receiving individual health report to take to their GP (or other health professionals) for further discussion.

Repeated use of our test battery and population-recruitment processes could underpin successful future population-based screening of community-dwelling Australians aged from 40 to 75 years, which will produce new and much-needed information on healthy ageing.[7,9] This information will put more context around the WHO theoretical trajectory of disability and ageing[3] and will inform initiatives such as the WHO decade of Healthy Ageing.[6] Moreover, early signs of functional decline or frailty may be able to be identified efficiently in community-dwelling people from 40 years, rather than waiting until irreversible functional decline and frailty is established, and a health crisis has occurred.[4,5]

Limitations of this study include the small sample that tested feasibility, although it was representative of the age and gender groups for which the methodology was being developed. The authors acknowledge that generalizability to other demographic and cultural groups may be limited. The strengths include the multiple review methods and consultation to identify the 'best' assessment tools, and the establishment of safety in a representative population, albeit small, before roll out in a community setting.

Conclusion

In light of the current dearth of information on body systems' performance and health behaviours of seemingly healthy younger Australian community-dwellers, this study presented the first known, comprehensive, screening test battery based on evidence, which could be used to describe attributes and trajectories of healthy ageing in population testing. Further investigation on the application of the test battery, as a regular feature in community centres and in larger settings, is needed.

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Declaration of conflicting interests

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Ethical approval

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Informed consent

Written informed consent was obtained from all subjects before the objective assessment components of the study. And return of online surveys was considered implied consent.

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References

1. Ågren G and Berensson K. *Healthy ageing. A challenge for Europe*. Stockholm: The Swedish National Institute of Public Health, 2006.
2. Beard JR, Officer A, de Carvalho IA, et al. The world report on ageing and health: a policy framework for healthy ageing. *Lancet* 2016; 387(10033): 2145–2154.
3. WHO. *Health and ageing. A discussion paper*. Geneva: World Health Organization, 2001.
4. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. *Gerontologist* 2005; 45: 386.
5. Rockwood K and Mitnitski A. Limits to deficit accumulation in elderly people. *Mech Ageing Dev* 2006; 127(5): 494–496.
6. WHO. 69th World Health Organization (WHO) assembly, 2016, http://www.who.int/mediacentre/events/2016/wha69/en/
7. McKeon S, Alexander E, Brodaty H, et al. *Strategic review of health and medical research: better health through research*. Canberra, ACT, Australia: Australian Department of Health and Ageing, 2013.
8. Olver IN and Roder D. History, development and future of cancer screening in Australia. *Public Health Res Pract* 2017; 27: 2731725.
9. Medicare Australia, http://www.health.gov.au/internet/main/publishing.nsf/Content/mbsprimarycare_mbsitem_75andolder, http://www.health.gov.au/internet/main/publishing.nsf/Content/mbsprimarycare_mbsitem701_703_705_707 (2018, accessed 20 February 2018).
10. Hamirudin AH, Ghosh A, Charlton K, et al. Trends in uptake of the 75+health assessment in Australia: a decade of evaluation. *Aust J Prim Health* 2015; 21(4): 423–428.
11. Price K, Grimmer K and Foot J. Is the Australian 75+health assessment person-centred? A qualitative descriptive study of older people's perceptions. *Aust Health Rev* 2017; 41(6): 606–612.
12. Blake H and Lloyd S. Influencing organisational change in the NHS: lessons learned from workplace wellness initiatives in practice. *Qual Prim Care* 2008; 16(6): 449–455.
13. Means R. Safe as houses? Ageing in place and vulnerable older people in the UK. *Soc Policy Admin* 2007; 41: 65–85.
14. Smith K and Gilchrist L. Well-being of older Aboriginal Australians: the importance of 'keeping spirit strong'. *Australas J Ageing* 2017; 36(2): 112–113.
15. NHS. *What is physiological measurement? A guide to the tests and procedures conducted by physiological measurement diagnostic services*. Leeds: National Health Service, 2007.
16. Andrews G and Slade T. Interpreting scores on the Kessler Psychological Distress Scale (K10). *Aust N Z J Public Health* 2001; 25(6): 494–497.
17. Buysse DJ, Reynolds CF 3rd, Monk TH, et al. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989; 28(2): 193–213.
18. Buysse DJ, Hall ML, Strollo PJ, et al. The Pittsburgh Sleep Quality Index (PSQI). *J Clin Sleep Med* 2008; 4(6): 563–571.
19. Jones K, Brennan D, Parker E, et al. Are oral health-related self-efficacy, knowledge and fatalism indicators for non-toothbrush ownership in a homeless population? *Community Dent Health* 2016; 33(1): 48–53.
20. ARCPOH. Oral Health Questionnaire. Adelaide, SA, Australia: ARCPOH, 2016.
21. Wijnhoven HA, Schilp J, van Bokhorst-de van der Schueren MA, et al. Development and validation of criteria for determining undernutrition in community-dwelling older men and women: the Short Nutritional Assessment Questionnaire 65+. *Clin Nutr* 2012; 31(3): 351–358.
22. National Health and Medical Research Council (NHMRC). *Australian dietary guidelines summary*. Canberra, ACT, Australia: National Health and Medical Research Council, 2013.
23. Demeester K, Topsakal V, Hendrickx JJ, et al. Hearing disability measured by the speech, spatial, and qualities of hearing scale in clinically normal-hearing and hearing-impaired middle-aged persons, and disability screening by means of a reduced SSQ (the SSQ5). *Ear Hear* 2012; 33(5): 615–616.
24. Peterson TV, Karp DR, Aguilar VC, et al. Validation of a global pelvic floor symptom bother questionnaire. *Int Urogynecol J* 2010; 21(9): 1129–1135.
25. AIHW. The active Australia survey, 2018, https://www.aihw.gov.au/getmedia/ff25c134-5df2-45ba-b4e1-6c214ed157e6/aas.pdf.aspx?inline=true
26. Steffen TM, Hacker TA and Mollinger L. Six-minute walk test: a valuable test, when properly standardized – author response. *Phys Ther* 2002; 82: 827–828.
27. Chetta A, Zanini A, Pisi G, et al. Reference values for the 6-min walk test in healthy subjects 20–50 years old. *Respir Med* 2006; 100(9): 1573–1578.
28. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc* 1982; 14(5): 377–381.
29. Brodaty H, Pond D, Kemp NM, et al. The GPCOG: a new screening test for dementia designed for general practice. *J Am Geriatr Soc* 2002; 50(3): 530–534.
30. Norton K and Olds T. *Anthropometrica: a textbook of body measurement for sports and health courses*. Sydney, NSW, Australia: UNSW Press, 1996.
31. Miller MR, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J* 2005; 26(2): 319–338.

32. Roberts HC, Denison HJ, Martin HJ, et al. A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing* 2011; 40(4): 423–429.
33. Dodds RM, Syddall HE, Cooper R, et al. Grip strength across the life course: normative data from twelve British studies. *PLoS ONE* 2014; 9(12): e113637.
34. Steiber N. Strong or weak handgrip? Normative reference values for the German population across the life course stratified by sex, age, and body height. *PLoS ONE* 2016; 11: e0163917.
35. Cook G and Fields K. Functional training for the torso. *Strength Cond* 1997; 19: 14–19.
36. Mackintosh S, Datson N and Fryer C. A balance screening tool for older people: reliability and validity. *Int J Ther Rehabil* 2006; 13: 558–561.
37. ASHA. *Guidelines for audiologic screening*. Rockville, MD: American Speech-Language-Hearing Association, 1997.
38. Konan Medical. *Vision source: standard vision chart*. Irvine, CA: Konan Medical, 2016.
39. Tiffin J and Asher EJ. The Purdue pegboard; norms and studies of reliability and validity. *J Appl Psychol* 1948; 32(3): 234–247.
40. Desrosiers J, Hebert R, Bravo G, et al. The Purdue pegboard test – normative data for people aged 60 and over. *Disabil Rehabil* 1995; 17(5): 217–224.
41. Lindstrom-Hazel DK and VanderVlies Veenstra N. Examining the Purdue pegboard test for occupational therapy practice. *Open J Occup Ther* 2015; 3: 5.
42. Kosinski RJ. *A literature review on reaction time*. Clemson, SC: Clemson University, 2008.
43. Norton K, Norton L and Lewis N. Effects of short-term physical activity interventions on simple and choice response times. *Biomed Res Int* 2016; 2016: 5613767.
44. Boulton AJ, Armstrong DG, Albert SF, et al. Comprehensive foot examination and risk assessment. A report of the Task Force of the Foot Care Interest Group of the American Diabetes Association, with endorsement by the American Association of Clinical Endocrinologists. *Phys Ther* 2008; 88(11): 1436–1443.
45. New York University. *The precise neurological exam*. New York: School of Medicine, New York University, 2006.
46. Ganann R, Ciliska D and Thomas H. Expediting systematic reviews: methods and implications of rapid reviews. *Implement Sci* 2010; 5: 56.
47. Beaton K, McEvoy C and Grimmer K. Identifying indicators of early functional decline in community-dwelling older people: a review. *Geriatr Gerontol Int* 2015; 15(2): 133–140.
48. Grimmer-Somers K, Kumar S, Vipond N, et al. Best-practice in assessing patients with persistent pain: a systematic review of the pain assessment instrument literature. *J Pain Res* 2009; 2: 21–47.
49. http://www.unisa.edu.au/contentassets/c7325ae890dc45938c6b3cc115f56af3/icahe-compendium-of-early-fd-tools.pdf
50. McKenna SA, Iwasaki PG, Stewart T, et al. Key informants and community members in community-based participatory research: one is not like the other. *Prog Community Health Partnersh* 2011; 5: 387–397.
51. Muramatsu N and Akiyama H. Japan: super-aging society preparing for the future. *Gerontologist* 2011; 51(4): 425–432.