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Slowness as a predictor of functional decline in older adults: Comparison of Moberg picking-up test and walking speed

Nazanin Abolhassani PhD[1, 2], Sarah Fustinoni BSc[1], Yves Henchoz PhD[1]

[1] Department of Epidemiology and Health Systems, Center for Primary Care and Public Health (Unisanté), University of Lausanne, Switzerland

[2] Institute of Primary Health Care (BIHAM), University of Bern, Bern, Switzerland

Corresponding author:

Nazanin Abolhassani
Department of Epidemiology and Health Systems, Center for Primary Care and Public Health (Unisanté), University of Lausanne, Switzerland
Addressee: Route de la Corniche 10, 1010 Lausanne, Switzerland.
Email: nazanin.abolhassani@unisante.ch

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Brief summary: This article compares the capacity of slowness measurements (Moberg picking up test (MPUT) and walking speed) in older adults to predict non-fatal adverse consequences of frailty. MPUT may be an alternative measurement of slowness.

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ABSTRACT

Objectives: Slowness, generally assessed by walking speed (WS), is an estimator of frailty and its outcomes. Because of potential difficulties in assessing WS, the Moberg picking-up test (MPUT) might be an alternative. This study investigated the capacity of slowness measurements (WS and MPUT) to predict non-fatal adverse consequences of frailty, primarily: decline in basic activities of daily living (BADLs); and secondarily: decline in instrumental activities of daily living (IADLs), fall, hospitalization and incident disease.

Design: Observational (prospective longitudinal study)

Setting and participants: This study used data from the population-based Lausanne cohort 65+. At baseline, 1887 individuals (aged 72-77 years) completed both WS (time to walk 20-meters at usual pace) and MPUT (time to pick up 12 objects) assessments.

Methods: All outcomes, assessed at 1-year and 4-year follow-ups, were entered in separate logistic regression models with adjustment for age, sex and respective values at baseline. The prediction of all outcomes by either WS or MPUT was assessed using area under the ROC curve (AUC) and compared by chi-squared tests.

Results: There were positive associations between slowness either assessed by WS (RR=2.48; P-value<0.001) or MPUT (RR=1.91; P-value<0.001) and decline in BADLs at 1-yeat follow-up. These associations remained significant at 4-year follow-up for both WS (RR=2.28; P-value<0.001) and MPUT (RR=1.95; P-value<0.001). There was no significant difference between predictive values of slow WS and MPUT for decline in BADLs at 1-year (P-value: 0.328) and 4-year follow-ups (P-value: 0.413). The prediction was not significantly different for secondary outcomes, except for decline in IADLs for which the prediction was slightly better for WS.

Conclusions and Implications: MPUT may be an alternative measurement of slowness with predictive value of functional decline. No significant difference in predictive capabilities of MPUT and WS for specific adverse consequences of frailty is promising in favor of using MPUT for measuring slowness.

KEYWORDS: Walking speed; Moberg picking-up test; slowness; frailty.

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INTRODUCTION

With the increase in life expectancy, older adults make up a large population portion. Population aging is accelerating rapidly worldwide, from 461 million people older than 65 years in 2004 to an estimated 2 billion people by 2050 [1]. In 2015, 17.4 percent of Europeans were aged 65 or older. Europe is further along in the demographic transition and will remain the oldest region in the world through 2050; and this trend is expected to accelerate between 2030 and 2050 [2, 3]. The rapid expansion of the aging population has brought a concomitant rise in the number of older adults with frailty and related risk of adverse outcomes such as disability, fall, hospitalisation and premature death [4-7]. While frailty is widely used, research is still ongoing on the definition and assessment of this concept [8]. Although there is no consensus on a frailty definition, Fried's phenotype model with five dimensions (shrinking, weakness, exhaustion, slowness, and low physical activity) is one of the most evaluated and commonly used [8-10].

Among the five criteria of the frailty phenotype, slowness is considered as the main warning sign of functional decline in older adults [11]. Generally assessed by walking speed (WS) [9], slowness is in itself a widely used criterion in geriatric assessment, and has become a good single estimator of frailty and its outcomes [12, 13]. As a reliable and sensitive measure of functional ability closely associated with frailty and survival in older adult populations, WS has been referred to as the "6th vital sign" [14-17]. However, there are potential difficulties in assessing WS in terms of the space needed and its feasibility for people with certain conditions such as mobility problem. While most studies about reliability of WS as the predictor of adverse health outcomes among community-dwelling adults were based on measurements in clinical settings, there is evidence that WS assessed in laboratory setting may not fully reflect the WS of individuals in their everyday life context [18-20]. Therefore, due to difficulties and limitations of assessing WS, whether in ecological or clinical settings, alternative measurement methods may be useful.

The Moberg picking-up test (MPUT) is a timed test first developed in neurorehabilitation to evaluate hand motor activity. It consists in picking up several small objects to put them in a box, as fast as possible [21]. As the time to complete the task is measured, MPUT might be an option for measuring slowness in older populations; in addition, it is simple, quick to administer, easy to replicate, and inexpensive to acquire [22]; furthermore MPUT can improve the issue of biased estimates due to non-random exclusion of individuals unable to complete WS [23]. A previous study on slowness measurement in old age showed a positive association between WS and MPUT [24]. Also, another study comparing WS and MPUT in predicting mortality as an adverse outcome of age-related frailty showed an association between poor performance in MPUT and increased mortality at short and long term, thereby indicating that MPUT can be an alternative to WS in the slowness assessment with similar predictive capability for mortality [23].

To our knowledge there is no study comparing the capability of WS and MPUT in predicting non-fatal adverse outcomes. Thus, this study aimed to investigate the capacity of slowness measurements (WS and MPUT) to predict non-fatal adverse consequences of frailty, primarily: decline in basic activities of daily living (BADLs); and secondarily: decline in instrumental activities of daily living (IADLs), fall, hospitalization, and incident disease.

METHODS

Study population and design

Participants were selected from the Lausanne cohort 65+ (Lc65+), an ongoing population-based longitudinal study investigating age-related frailty among persons aged 65 years and over living in Lausanne, Switzerland. Detailed description of the study design has been published previously [25, 26]. Briefly, participants were randomly selected from the official population register in three waves (2004, 2009 and 2014). In 2004, the first sample included 1564 persons (born 1934 – 1938); in 2009, the second sample included 1489 persons (born 1939 – 1943); and in 2014, the third sample included 1678 persons (born 1944 – 1948). Since then, participant follow-up assessments included annual postal

questionnaires as well as performance tests conducted every third year at the study evaluation site. The current prospective longitudinal analysis used data from the first and second samples at the age of 72-77 years in 2011 and 2016, respectively, as well as 1-year follow-up (2012 and 2017 for the first and second samples, respectively) and 4-year follow-up (2015 and 2020, respectively). Eligible participants were those who completed both the WS test and the MPUT in 2011 (first sample) or in 2016 (second sample); the two samples were combined **(supplementary figure 1).** The protocol was approved by the Ethics Committee.

Walking speed (WS) and MPUT assessments

WS was assessed by the time in seconds to walk a 20-meter distance at usual pace in a quiet, well-lit corridor. The MPUT was assessed by the time in seconds to pick up 12 small objects scattered on a table in front of seated participants with the dominant hand and to place them into a box as fast as possible [24]. WS and MPUT were dichotomized, according to the sex-specific 80th percentile (p80) distribution in the study samples, into normal/fast (≤p80) versus slow (>p80) [9].

Adverse frailty outcomes

Our primary outcome of the adverse frailty consequences was decline in BADLs and our secondary outcomes included decline in IADLs, fall, hospitalization, and incident disease.

For our primary outcome, we used the change in difficulties in BADLs between baseline and each follow up. Difficulties in BADLs were defined as current difficulties or help received in at least one of Katz' activities (feeding, bathing, dressing, using the toilet, and getting up from bed or lying on a bed) [27]. The change between baseline and each follow up was further categorized into two groups, i.e., 'no change or improved' and 'declined'.

Difficulties in IADLs were defined as current difficulties or help received in at least one of Lawton's activities (housework, shopping, preparing meals, using a phone, preparing drugs and managing

money) [28]. Similarly for IADLs, the change between baseline and each follow up was used and further categorized into two groups, i.e., 'no change or decreased' and 'increased'.

For fall, participants were asked each year if they experienced a fall during the last 12 months ('zero', 'one', 'two or more'). For 1-year follow up, the assessments of year 2012 and 2017 were considered for first and second samples, respectively. For 4-year follow up, all yearly assessments (2012, 2013, 2014 and 2015 for the first sample; 2017, 2018, 2019 and 2020 for the second sample) were taken into account. The 4-year cumulative fall was constructed with the following categories: 'zero' (if the answer to the question was 'zero' each year); 'one' (if the answer 'one' was given only once); and 'two or more' (if the answer 'one' was repeated at least twice or the answer 'two or more' was given at least once over the yearly assessments).

For hospitalisation, participants were yearly asked how many times they were hospitalized during the last 12 months. The number of hospitalisations was categorized into three groups ('zero', 'one', 'two or more'). The 1-year and 4-year follow-ups were computed using a procedure similar to the one described for fall.

For medical diagnoses, participants were asked whether they suffered from or received treatment for any of the 14 following selected health conditions or diseases, diagnosed by a physician, over the last 12 months: hypertension, myocardial ischemia, other heart disease, stroke, diabetes, chronic lung disease, asthma, osteoporosis, arthrosis or arthritis, malignant neoplasm, ulcer, Parkinson's, depression, and Alzheimer's. Using these data at baseline and short and long-term follow-ups, we defined incident disease as any new disease that was not mentioned at baseline but was reported at 1-year or 4-year follow-up, respectively. The total number of incident diseases was categorized into three groups ('zero', 'one', 'two or more').

Sociodemographic data

Socio-demographic data included sex; age at baseline, i.e. age of first and second samples in 2011 and 2016, respectively; educational level categorized, based on the International Standard Classification of Education (ISCED) [29], as low (obligatory school or ISCED 0-2), medium (apprenticeship or ISCED 3) or high (college, university degree or equivalent or ISCED 4-8).

Statistical analysis

Descriptive statistics were used to summarize the characteristics of included participants. Results were expressed as the number and percentage of participants.

For each adverse outcome, separately for 1-year and 4-year follow up, we used two models: model 1 included MPUT, sex and age at baseline; and model 2 included the same with WS as the predictor. Logistic regression (for decline in BADLs and IADLs) and multinomial (polytomous) logistic regression analyses (for fall, hospitalization and incident disease) were conducted, with adjustment for age, sex and respective values of each adverse outcome at baseline, and with separate models for 1-year and 4-year follow up. For those adverse outcomes defined relative to baseline assessments (i.e. decline in BADLs or IADLs and incident disease), those with maximum values at baseline were excluded. The results were presented per relative risk (RR) and relative risk ratio (RRR) after logistic and multinomial logistic regression, respectively. In order to visualize the difference between models 1 and 2 in predicting each adverse outcome, separately for 1-year and 4-year follow up, we computed the area under the ROC curve (AUC) of both models after logistic regression. They were then compared by chi-squared tests using a non-parametric approach taking into account the correlated nature of the data [30]. In the logistic regressions, we considered the three-level variables (fall, hospitalization and incident disease) as two sets of level variables (zero versus one and zero versus two or more). For secondary outcomes, we used Bonferroni correction to account for multiple comparisons, and a two-tailed P-value <0.0125 (=0.05/4) was considered statistically significant. A sensitivity analysis was conducted after excluding the MPUT and WS outliers, using an outlier detection approach for skewed data [31].

Statistical analyses were performed using Stata software version 16.0 (Stata Corp, College Station, TX, USA).

RESULTS:

The characteristics of included participants (who performed both MPUT and WS test, n=1887), values of both slowness assessments, and the prevalence of the adverse consequences of frailty at baseline are presented in **Table 1**. The majority of the participants were women (59.8%); the mean age was 74.9±1.4 years. For all studied adverse consequences of frailty, the majority of the participants had no problem at baseline, except for medical diagnoses for which 73% had at least one diagnosis. **Supplementary table 1** presents the characteristics of the subgroups of participants who were slow (>p80) in WS or in MPUT. The characteristics of 79 individuals without WS data – hence not included in following analyses – but with MPUT data are presented in **Supplementary table 2**. This subgroup was slower and had worst outcomes in terms of functional difficulties, falls, hospitalisations, and medical diagnoses (**Supplementary table 3**).

The frequencies of primary (decline in BADLs) and secondary adverse outcomes (decline in IADLs, fall, hospitalization and incident disease) are summarized in **Table 2.** The prevalence of all the studied adverse outcomes increased over time; among them, the percentage of those experiencing at least one fall or hospitalization more than doubled.

Multivariable associations between both slowness assessments (WS and MPUT) and frailty adverse outcomes at 1-year and 4-year follow-up, adjusted for sex, age and respective values of frailty adverse outcomes at baseline, are presented in **Table 3.** Positive associations were observed at 1-year follow-up between slowness, either assessed by WS (RR=2.48; P-value <0.001) or by MPUT (RR=1.91; P-value <0.001), and decline in BADLs. These associations remained significant at 4-year follow-up for both WS (RR=2.28; P-value <0.001) and MPUT (RR=1.95; P-value <0.001). Overall, decline in BADLs was about twice as likely in slow individuals.

For decline in IADLs, the same pattern was observed, but its association with MPUT at 1-year follow-up did not reach significance after the Bonferroni correction (P-value <0.0125). Regarding other secondary outcomes, recurrent hospitalization was positively associated with slow WS or MPUT at short and long term follow ups. While WS was associated with multiple falls at 4-year follow-up (RRR=2.35; P-value <0.001), MPUT was associated with the incidence of one or more diseases at 1-year follow-up (RRR=1.52; P-value = 0.002) and with the incidence of two or more diseases at 4-year follow-up (RRR=1.74; P-value = 0.006).

Figures 1 and 2 present the comparison between predictive capabilities of slow WS and MPUT for each frailty adverse outcome, separately for 1-year and 4-year follow-up, illustrated by AUC values of the two logistic regression models. There was no significant difference between predictive values of slow WS and MPUT for decline in BADLs (our primary outcome), at 1-year and 4-year follow-up, nor for the secondary outcomes (fall, hospitalization and incident disease) after the Bonferroni correction (P-value <0.0125), except for predicting decline in IADLs at 1–year follow-up (P-value =0.001) (**Supplementary table 4**).

Sensitivity analyses (after excluding the outliers of WS and/or MPUT) showed comparable results of multivariable analyses and the AUC of models (using WS and MPUT) after logistic regression.

DISCUSSION

In this study, those participants having both WS and MPUT measurements were included to compare the association between each slowness measurements with non-fatal adverse consequences of frailty at short and long term. Furthermore, the capacity of both measurements in predicting the short and long term adverse frailty outcomes was compared.

The significant associations between MPUT and decline in BADLs and similar capability of MPUT compared to WS for predicting decline in BADLs support the MPUT as an alternative slowness measurement. It is worth mentioning that slowness, as a potential geriatric syndrome, is a complex construct acting on the continuum between normal aging and pathologic aging. The symptomatology

of slowing is diverse; for instance, in healthy community-dwelling individuals, increasing age is associated with slow walking, reductions in processing speed (slow thinking), and increased apathy (mood). This viewpoint suggests that the presence of slowing in one aspect could prompt to be aware of the presence of other slowing aspects [32, 33]. A study of slowing aspects in community-dwelling older people showed that slowing in walking is associated with slowing in thinking [34]. MPUT as a psychomotor speed test may be considered to assess slowness of one domain across multiple functional domains [35].

Several trials examined the associations between different physical frailty indicators including WS and ADL [13, 15, 36] or compared predictive validity of WS with other commonly used performance-based measures (such as Short Physical Performance Battery (SPPB), Timed Up and Go test (TUG), grip strength, and physical activity) for the onset of ADL difficulty in older adults [37, 38]. These studies indicated that older people with slower WS have a higher risk of developing ADL disability. Meanwhile, previous studies emphasized the possible influence of the follow-up duration when comparing the predictive capabilities of different measures regarding the development of ADL disability. For instance, while WS predicts the development of ADL disability after a follow-up of one year, physical activity predicts it better after a longer follow-up [38-40]. It may explain the different predictive capabilities of WS and MPUT for decline in IADLs, at 1-year follow-up in our study that was the only difference between predictive capabilities of WS and MPUT for all outcomes. This may also emphasize the importance of recurrent measurement of frailty [41]. Regarding MPUT, although manual dexterity has been considered crucial for ADL in some studies [42, 43], to our knowledge there is no study assessing the association between MPUT – as an indicator of slowness – and functional decline, and further comparing its predictive capability for functional decline with other measures.

Regarding fall, it should be noted that the relationship between WS and fall may be nonlinear, i.e. not only slower, but also faster individuals are at a higher risk of falling. This relationship was explained by the fact that the slower older people are less active, generally sicker and more likely to fall inside home,

while those who are fast are more likely to fall outside home because they are more exposed to environmental and behavioral risks [36, 44, 45]. It highlights the need to investigate the site of falls and the relationship between extremes (slowest and fastest) in MPUT and fall.

For recurrent hospitalization, our results suggest that MPUT may be an alternative slowness measurement. Meanwhile, previous studies showed heterogeneous results about WS as an independent marker of hospitalization [12, 46, 47]. It should be noted that hospitalization might occur for a variety of reasons, including elective admissions, the recurrent nature of some diseases [48] or hospital-acquired complications [49].

Regarding incident disease, a study among older patients undergoing cardiac surgery also concluded that slow WS could not be identified as independent predictor for major morbidity [50]. The majority of studies investigating the association between WS and incident disease focused on onset of specific diseases such as cardiovascular diseases (CVD), cancer, dementia or depression [51-53]. The results are also disease specific according to a meta-analysis, which reported a link between slow WS and the incidence of CVD in older adults, while no significant association was found between WS and the incidence of cancer [51].

Of the five frailty criteria, slowness is the one most strongly associated with poor quality of life [54]. It is an important measure in comprehensive geriatric assessment, with predictive value for adverse outcomes such as hospitalization, institutionalization, mortality and falls [55]. Slowness is considered as a red flag for functional decline in older adults, contributing to the development of the frailty phenotype [11]. Our study confirms previous associations reported between slow walking speed and the incidence of disability in community-dwelling older adults [56, 57], and extends these associations to an alternative measure of slowness. In research settings, MPUT may be useful if space or other environmental characteristics hamper the completion of WS in valid conditions. A systematic review reported large variations in methodologies and descriptions of walking tests in the literature [58]. In clinical settings, the measurement of WS in older people may be challenging. A study among

hospitalized older adults reported that a minority were able to complete WS, while 95% could successfully have a handgrip strength measurement [59]. Individuals unable to complete WS are usually imputed as meeting the slowness criterion, which results in an overestimation of frailty. Of the participant in the present study who were unable to complete WS but able to complete MPUT, less than half met the MPUT criterion for slowness.

The main strength of our study included a large sample of older community-dwelling adults who performed both MPUT and WS tests during the same assessment, and a short and long follow-up period that allowed us to compare predictive capabilities of both assessments for the non-fatal frailty adverse outcomes. This study also has several limitations. First, we used the sex-specific p80 distribution in the study samples for discrimination between slow vs. normal/fast for both WS and MPUT measurements. The optimality of the cut-off, especially because population-based normal values for MPUT are not available, needs to be further studied. Second, MPUT was initially developed to evaluate hand motor activity and sensory impairment; thus it uses small objects that may be difficult to grab. For increasing the specificity in slowness measurement, its modification with larger, easy-to-grab objects may be needed.

CONCLUSION AND IMPLICATIONS

MPUT may be an alternative measurement of slowness and can predict functional decline. No significant difference in predictive capabilities of MPUT and WS for specific non-fatal adverse consequences of frailty including fall, hospitalizations and incident disease are promising in favor of using MPUT as a measurement of slowness.

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Table 1: Characteristics of participants (N = 1887)

Gender, n (%)	
Men	759 (40.2)
Women	1128 (59.8)
Age, years, mean ± SD	74.9±1.4
Education, n (%)	
High	773 (41.1)
Middle	748 (39.7)
Low	361 (19.2)
Height (cm), mean ± SD	164.7±8.8
Weight (kg), mean ± SD	73.7±14.9
BMI, mean ± SD	27.1±4.8
MPUT, S, mean ± SD	13.1±2.8
Slowness (MPUT), n (%)	
Yes	376 (19.9)
No	1511 (80.1)
Walking speed, S, mean ± SD	16.9±3.9
Slowness (WS), n (%)	
Yes	376 (19.9)
No	1511 (80.1)
Difficulties in BADLs, n (%)	
Yes	267 (14.2)
No	1620 (85.8)
Difficulties in IADLs, n (%)	
Yes	801 (42.5)
No	1086 (57.5)
Fall, n (%)	
No	1485 (78.8)
One	317 (16.8)
Two or more	82 (4.4)
Hospitalisations, n (%)	
No	1583 (83.9)
One time	239 (12.7)
Two times or more	65 (3.4)
Medical Diagnoses, n (%)	
No	509 (27.0)
One	670 (35.5)
Two or more	708 (37.5)

Abbreviations: MPUT, Moberg picking-up test (time in seconds); WS, walking speed (time in seconds); BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living.

Table 2: Adverse consequences of frailty at 1-year and 4-year follow-up

	1-year follow-up	4-year follow-up
Primary outcome		
Decline in BADLs		
No change/improved	1663 (92.0)	1470 (86.1)
Declined	144 (8.0)	237 (13.9)
Secondary outcomes		
Decline in IADLs		
No change/improved	1384 (78.5)	1138 (67.5)
Declined	379 (21.5)	549 (32.5)
Fall		
No	1408 (78.0)	815 (48.1)
One	316 (17.5)	394 (23.3)
Two or more	82 (4.5)	484 (28.6)
Hospitalisations		
No	1397 (80.6)	747 (48.5)
One time	236 (13.6)	326 (21.2)
Two times or more	101 (5.8)	466 (30.3)
Incident diseases		
No	1305 (72.9)	1059 (63.4)
One	414 (23.1)	450 (27.0)
Two or more	72 (4.0)	160 (9.6)

Abbreviations: BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living.
Values are expressed as n (%).

Table 3: Multivariable association between slowness (assessed by either WS or MPUT) and frailty adverse outcomes at 1-year and 4-year follow-up

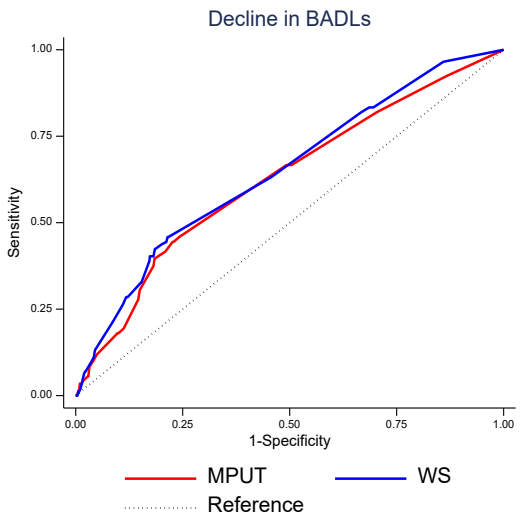
	Slowness based on WS				Slowness based on MPUT			
	1-year	**p-value**	**4-year**	**p-value**	**1-year**	**p-value**	**4-year**	**p-value**
Primary outcome								
Decline in BADLs[1]								
No change/improved	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
Declined	**2.48 (1.78 – 3.48)**	**<0.001**	**2.28 (1.77 – 2.94)**	**<0.001**	**1.91 (1.37 – 2.66)**	**<0.001**	**1.95 (1.66 – 3.08)**	**<0.001**
Secondary outcomes								
Decline in IADLs[1]								
No change/ improved	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
Declined	**1.92 (1.58 – 2.33)**	**<0.001**	**1.79 (1.55 – 2.06)**	**<0.001**	1.26 (1.02 - 1.55)	0.035	**1.35 (1.15 - 1.57)**	**<0.001**
Fall[3]								
No fall	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
One time	1.26 (0.92 - 1.71)	0.145	1.12 (0.79 - 1.58)	0.524	1.10 (0.81 - 1.50)	0.553	0.89 (0.64 - 1.23)	0.482
Two or more times	1.78 (1.05 - 3.01)	0.032	**2.35 (1.74 - 3.17)**	**<0.001**	1.32 (0.76 - 2.27)	0.323	1.36 (1.01 – 1.83)	0.043
Hospitalisations[2]								
No	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
One time	**1.83 (1.32 - 2.53)**	**<0.001**	1.14 (0.78 – 1.66)	0.502	1.32 (0.94 - 1.85)	0.108	0.90 (0.62 - 1.29)	0.559
Two times or more	**2.60 (1.66– 4.07)**	**<0.001**	**2.75 (2.04 - 3.71)**	**<0.001**	**1.88 (1.18 – 2.99)**	**0.007**	**1.51 (1.13 - 2.04)**	**0.006**
Incident diseases[2]								
No	1 (ref.)		1 (ref.)		1 (ref.)		1 (ref.)	
One more disease	1.33 (1.00 – 1.76)	0.048	0.89 (0.65 – 1.20)	0.441	**1.52 (1.16 – 2.00)**	**0.002**	1.27 (0.96 – 1.69)	0.099
Two or more diseases	1.37 (0.77 - 2.42)	0.283	1.43 (0.95 - 2.16)	0.088	1.12 (0.62 - 2.03)	0.712	**1.74 (1.17 - 2.59)**	**0.006**

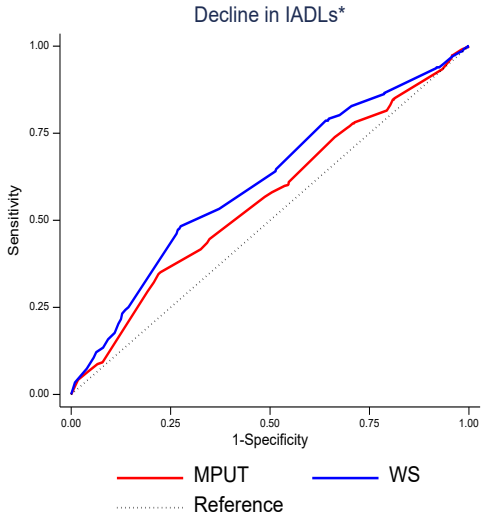
Abbreviations: BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living; WS, walking speed (time in seconds); MPUT, Moberg Picking-Up Test (time in seconds).

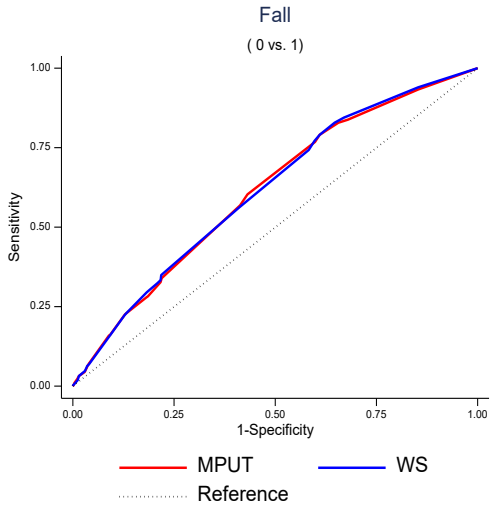
All analyses were adjusted for sex, age and respective values of frailty adverse outcomes at baseline (i.e. BADLs at baseline for decline in BADLs, IADLs at baseline for decline in IADLs and so on).

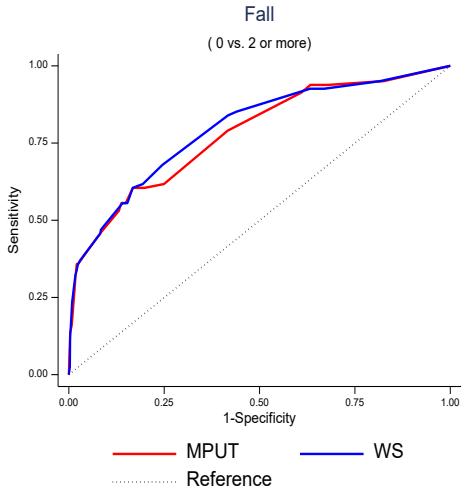
[1] Results are expressed as relative risk (RR) (95% confidence interval) using Logistic regression

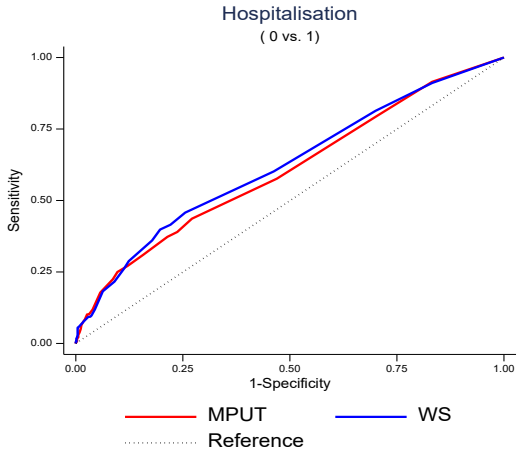
[2] Results are expressed as relative risk ratio (RRR) (95% confidence interval) using Multinomial (polytomous) logistic regression.

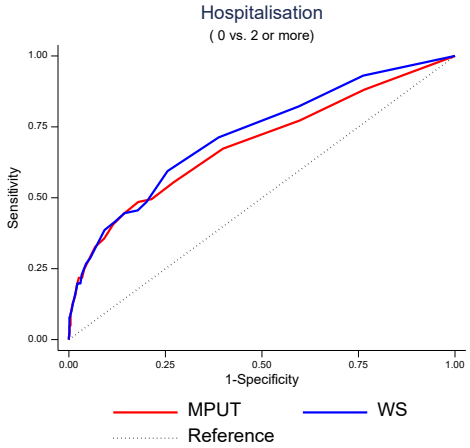

Decline in BADLs
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference

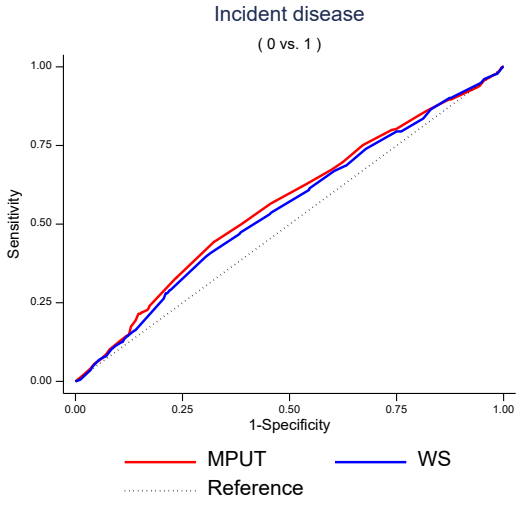

Decline in IADLs*
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference


Fall
(0 vs. 1)
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference


Fall
(0 vs. 2 or more)
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference


Hospitalisation
(0 vs. 1)
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference


Hospitalisation
(0 vs. 2 or more)
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference


Incident disease
(0 vs. 1)
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference

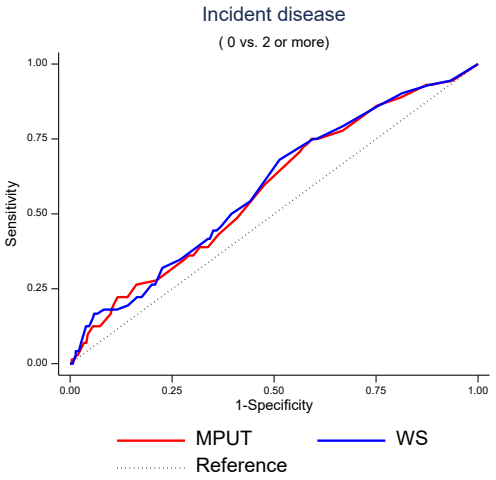
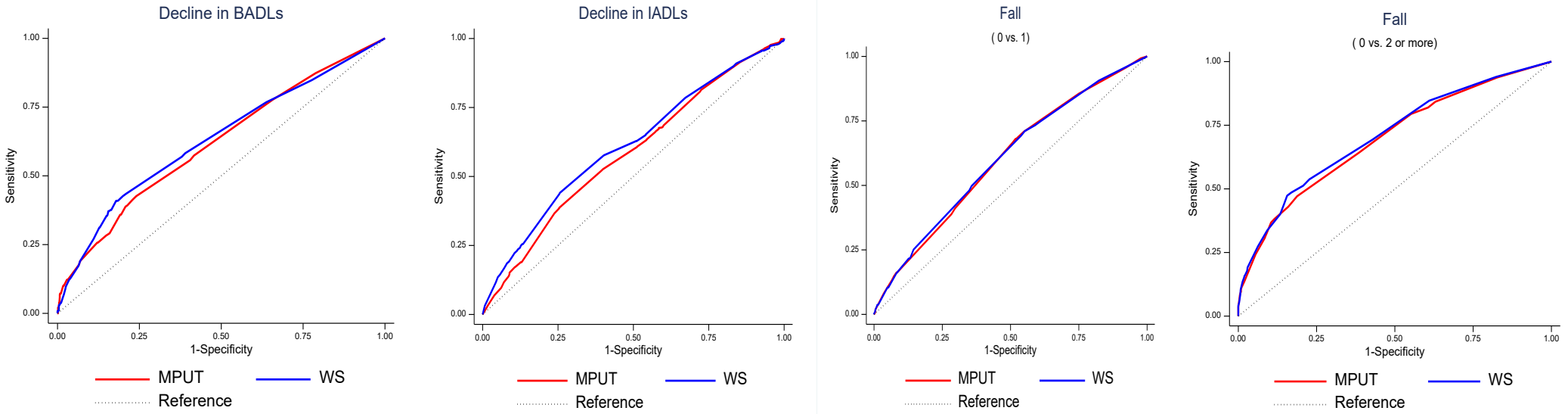

Incident disease
(0 vs. 2 or more)
Sensitivity
1-Specificity
0.00
0.25
0.50
0.75
1.00
MPUT
WS
Reference

Figure 1: ROC of model 1: Moberg Picking-Up test (MPUT) in red and model 2: Walking speed (WS) in blue in predicting frailty adverse outcomes at 1-year follow up
Abbreviations: BADLs, Basic activities of daily living; IADLs; Instrumental activities of daily living
*Significant difference for "Decline in IADLs"



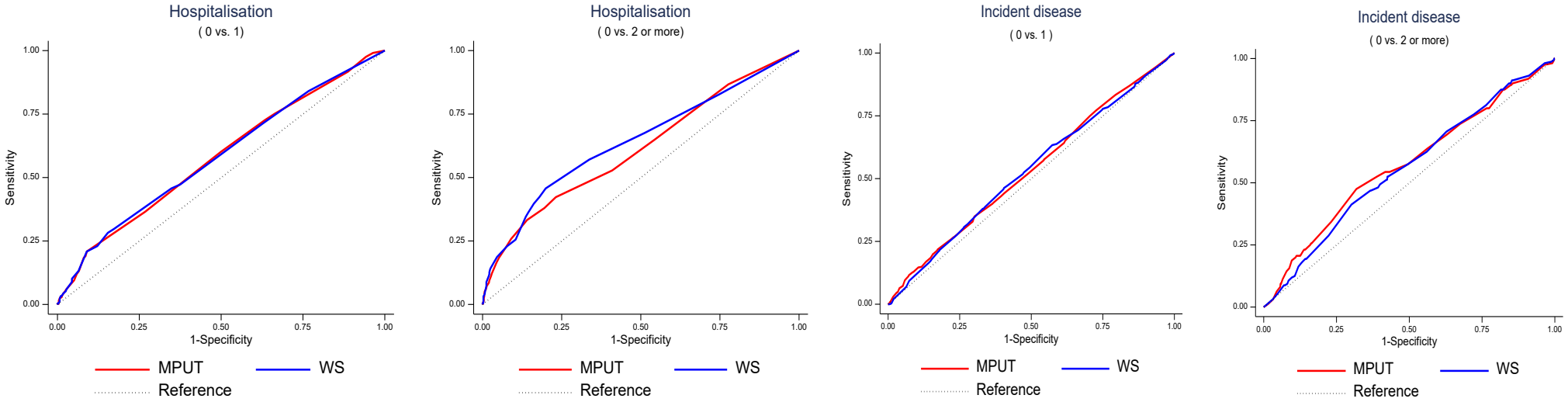
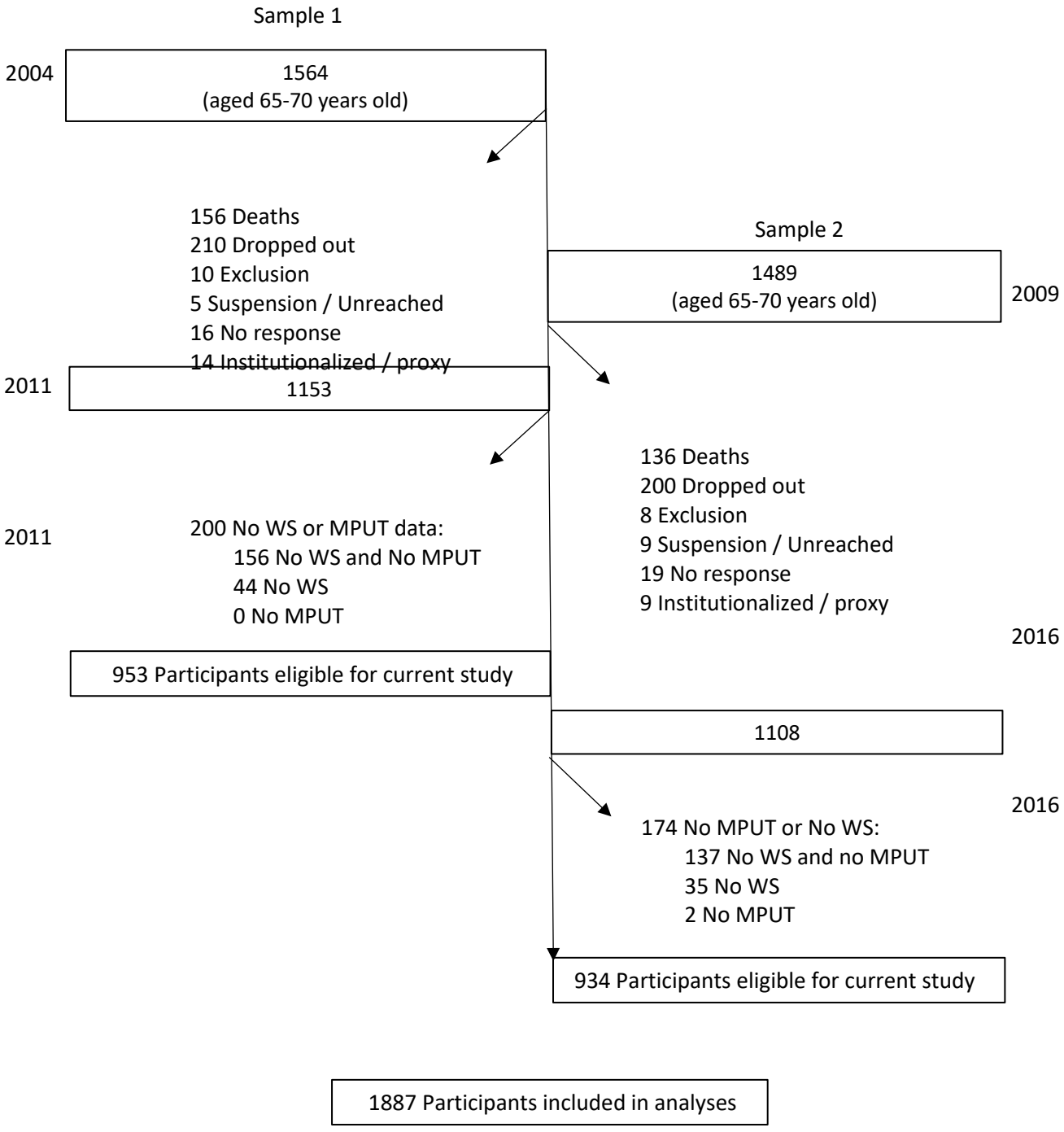


Figure 2: ROC of model 1: Moberg Picking-Up test (MPUT) in red and model 2: Walking speed (WS) in blue in predicting frailty adverse outcomes at 4-year follow up
Abbreviations: BADLs, Basic activities of daily living; IADLs; Instrumental activities of daily living

Supplementary figure 1: Procedure of participants' selection



Abbreviations: WS, walking speed (time in seconds); MPUT, Moberg Picking-Up Test (time in seconds).

Supplementary table 1: Characteristics of participants with slow WS or MPUT

	Slow in WS (N = 376)	Slow in MPUT (N = 376)
Gender, n (%)		
Men	151 (40.2)	151 (40.2)
Women	225 (59.8)	225 (59.8)
Age, years, mean ± SD	75.2±1.4	75.0±1.4
Education, n (%)		
High	119 (31.9)	140 (37.5)
Middle	150 (40.2)	148 (39.7)
Low	104 (27.9)	85 (22.8)
Height (cm), mean ± SD	162.5±9.4	163.5±9.6
Weight (kg), mean ± SD	77.8±17.3	75.9±16.5
BMI, mean ± SD	29.4±5.7	28.3±5.4
MPUT, S, mean ± SD	14.7±3.5	17.3±3.0
Slowness (MPUT), n (%)		
Yes	153 (40.7)	376 (100.0)
No	223 (59.3)	0 (0.0)
Walking speed, S, mean ± SD	22.4±5.4	19.2±5.9
Slowness (WS), n (%)		
Yes	376 (100.0)	153 (40.7)
No	0 (0.0)	223 (59.3)
Difficulties in BADLs, n (%)		
Yes	128 (34.0)	91 (24.2)
No	248 (66.0)	285 (75.8)
Difficulties in IADLs, n (%)		
Yes	265 (70.5)	218 (58.0)
No	111 (29.5)	158 (42.0)
Fall, n (%)		
No	266 (71.3)	276 (73.6)
One	73 (19.6)	66 (17.6)
Two or more	34 (9.1)	33 (8.8)
Hospitalisations, n (%)		
No	285 (75.8)	300 (79.8)
One time	67 (17.8)	59 (15.7)
Two times or more	24 (6.4)	17 (4.5)
Medical Diagnoses, n (%)		
No	55 (14.6)	73 (19.4)
One	110 (29.3)	119 (31.7)
Two or more	211 (56.1)	184 (48.9)

Abbreviations: MPUT, Moberg picking-up test (time in seconds); WS, walking speed (time in seconds); BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living.

Supplementary table 2: Baseline characteristics of those participants having MPUT and not WS (N = 79)

Gender, n (%)	
Men	17 (21.5)
Women	62 (78.5)
Age, years, mean ± SD	75.3±1.5
Education, n (%)	
High	26 (33.3)
Middle	30 (38.5)
Low	22 (28.2)
Height (cm), mean ± SD	160.8±7.7
Weight (kg), mean ± SD	73.2±16.4
BMI, mean ± SD	28.5±5.4
MPUT, S, mean ± SD	15.4±4.8
Slowness (MPUT), n (%)	
Yes	36 (45.6)
No	43 (54.4)
Difficulties in BADLs, n (%)	
Yes	39 (49.4)
No	40 (50.6)
Difficulties in IADLs, n (%)	
Yes	70 (88.6)
No	9 (11.4)
Fall, n (%)	
No	51 (64.6)
One	16 (20.2)
Two or more	12 (15.2)
Hospitalisations, n (%)	
No	47 (59.5)
One time	18 (22.8)
Two times or more	14 (17.7)
Medical Diagnoses, n (%)	
No	5 (6.3)
One	10 (12.7)
Two or more	64 (81.0)

Abbreviations: MPUT, Moberg picking-up test (time in seconds); WS, walking speed (time in seconds); BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living.

Supplementary table 3: Adverse consequences of frailty at 1-year and 4-year follow-up (Those having MPUT and not WS, N = 79)

	1-year follow-up	4-year follow-up
Primary outcome		
Decline in BADLs		
No change/improved	52 (81.2)	30 (57.7)
Declined	12 (18.8)	22 (42.3)
Secondary outcomes		
Decline in IADLs		
No change/improved	46 (73.0)	29 (56.9)
Declined	17 (27.0)	22 (43.1)
Fall		
No	41 (64.1)	19 (33.9)
One	12 (18.7)	6 (10.7)
Two or more	11 (17.2)	31 (55.4)
Hospitalisations		
No	39 (65.0)	12 (24.5)
One time	16 (26.7)	5 (10.2)
Two times or more	5 (8.3)	32 (65.3)
Incident diseases		
No	38 (62.3)	30 (63.8)
One	17 (27.9)	10 (21.3)
Two or more	6 (9.8)	7 (14.9)

Abbreviations: BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living.
Values are expressed as n (%).

Supplementary table 4: Summary of the results for predicting frailty adverse outcomes

	1-year Follow-up				4-year Follow-up			
	AUC	**SE**	**95% CI**	**p-value**	**AUC**	**SE**	**95% CI**	**p-value**
Primary outcome								
Decline in BADLs*								
MPUT	0.63	0.025	0.58 – 0.67		0.62	0.020	0.58 – 0.66	
WS	0.65	0.024	0.60 – 0.69	0.328	0.63	0.021	0.59 – 0.67	0.413
Secondary outcomes								
Decline in IADLs*								
MPUT	0.56	0.017	0.53 – 0.59	**0.001**	0.58	0.015	0.55 – 0.61	0.037
WS	0.61	0.017	0.58 – 0.64		0.61	0.015	0.59 – 0.64	
Fall (0 vs 1)								
MPUT	0.61	0.017	0.58 – 0.65	0.842	0.60	0.017	0.57 – 0.63	0.633
WS	0.62	0.017	0.58 – 0.65		0.60	0.017	0.57 – 0.64	
Fall (0 vs ≥2)								
MPUT	0.78	0.029	0.72 – 0.84	0.041	0.69	0.015	0.66 – 0.72	0.141
WS	0.80	0.028	0.74 – 0.85		0.71	0.015	0.68 – 0.74	
Hospitalisation (0 vs 1)								
MPUT	0.60	0.021	0.56 – 0.64	0.274	0.58	0.019	0.54 – 0.62	0.876
WS	0.62	0.020	0.58 – 0.66		0.58	0.019	0.54 – 0.62	
Hospitalisation (0 vs ≥2)								
MPUT	0.69	0.031	0.63 – 0.75	0.099	0.61	0.017	0.58 – 0.64	0.052
WS	0.72	0.028	0.67 – 0.78		0.64	0.017	0.61 – 0.67	
Incident disease (0 vs 1)*								
MPUT	0.56	0.016	0.53 – 0.60	0.303	0.53	0.016	0.50 – 0.56	0.915
WS	0.55	0.016	0.52 – 0.58		0.53	0.016	0.50 – 0.56	
Incident disease (0 vs ≥2)*								
MPUT	0.58	0.034	0.51 – 0.65	0.613	0.57	0.025	0.52 – 0.62	0.518
WS	0.59	0.034	0.52 – 0.65		0.56	0.024	0.51 – 0.61	

Abbreviations: BADLs, Basic activities of daily living; IADLs, Instrumental activities of daily living; AUC, area under the ROC curve; SE, Standard error; CI, Confidence interval.
Model 1 included Moberg picking-up test (MPUT) (time in seconds), sex, age and respective values of frailty adverse outcomes at baseline (i.e. BADLs at baseline for decline in BADLs, IADLs at baseline for decline in IADLs and so on); and model 2 included walking speed (WS) (time in seconds), sex, age and respective values of frailty adverse outcomes at baseline. Models were compared by chi-squared tests.
*Those with maximum values of related frailty adverse outcomes at baseline were excluded from the analysis.