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Research Article

The Role of Health Locus of Control in Walking Time, Hand Grip Strength and Alternate Stepping in a 60-93 Year-Old General Population

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Abstract

Individuals with an internal locus of control have been shown to be more self-confident and to perform better in several areas, compared to those with an external locus of control. Few studies have investigated the relationship between Health Locus of Control (HLoC) and physical tests. The aim of this study was to investigate whether and to what extent internal, chance and external HLoC is associated with the outcome of walking speed, hand grip strength and alternate stepping physical tests.

In this cross-sectional study, a total of 3,819 individuals, aged 60-93 years, constituted the study population. Associations between internal, chance and external HLoC and the results from the physical tests were examined in linear regression models, adjusted for sex, age, education, moving-related pain in upper extremities, back and lower extremities, heart disease, lung disease, depressive mood and cognition.

The regression models indicated that a higher result on the internal scale was associated with faster walking, a stronger hand grip and a greater number of steps, while a higher result on the external scale was associated with slower walking, lower hand grip strength and fewer steps.

The findings suggest that in a clinical setting, assessment of HLoC may contribute to the understanding of physical performance in terms of walking speed, grip strength and alternate stepping among adults 60-93 years old. Modification to ensure a stronger internal control has the potential to improve the performance of these physical tests, which could be worth considering in a medical or physiotherapeutic assessment.

Keywords: Health locus of control; Walking speed; Hand grip strength; Alternate stepping; Older adults

Abbreviations: LoC; HLoC; WS; HGS; AS; GÅS; SNAC; BMI; MADRS; COPD; MMSE; ICC

Introduction

The theory of a control focus (LoC), introduced by Rotter in 1966 within the framework of Social learning theory [1], describes how an individual's life situation can be partly explained on the basis of an internal or external control locus. That is, either taking responsibility for and acting on one’s own initiative in conjunction with different life events or believing that other people or external forces such as chance are in control or have the greatest influence [2].

Health Locus of Control (HLoC), a control locus set in a health perspective, was first described by Wallston in 1976 [3]. HLoC refers to the extent an individual believes her/his health to be mostly controlled by an internal, chance or external locus. Individuals with an internal HLoC consider that their own responsibility and actions form the basis for their health and well-being, while those with a chance or external locus believe that their health is largely a matter of luck or in the hands of other peo-

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ple such as doctors or healthcare professionals. This means that for those with a chance or external locus, health is something outside of themselves that they cannot influence or control [4].

Many studies have shown the importance of HLoC for general well-being and that health can be affected depending on whether an individual has an internal, chance or external health locus. Internal HLoC has been associated with higher quality of life [5], improved smoking habits [6], better self-rated health [7], maintaining physical function after hospitalization [8], less prone to depressive conditions [9], lower prevalence of cardiovascular diseases [10], greater tolerance of pain [11] and better adherence to anti-hypertensive treatment [12]. Furthermore, individuals with an internal HLoC are more likely to participate in health-promoting activities [13]. This differs from external HLoC, which has been shown to be associated with trust in health professionals [14] and often with a more passive attitude to health problems [15].

Walking Speed (WS), Hand Grip Strength (HGS) and Alternate Stepping (AS) have been used to provide an assessment of health status and functional ability in both healthy individuals and those with impaired health [16-20]. These tests examine several organ systems such as muscles, bones, heart-lung and the nervous system [21,22]. WS and HSG are also employed as criteria in estimating frailty [23].

To the authors' knowledge, no previous studies have examined the importance of HLoC in relation to WS and HGS among older adults. If HLoC can affect the ability to perform these tests, it would be an important factor to consider both for the physical performance itself and as an essential underlying personal factor in the assessment of physical health, functional ability or frailty. Thus, the aim of this study was to investigate whether and to what extent internal, chance and external HLoC are associated with the outcome of walking speed, hand grip strength and alternate stepping physical tests in a general population aged 60-93 years, adjusted for socio-demographics and health status.

Materials and Methods

Study Population

In this cross-sectional study participants were drawn from the longitudinal Good Aging in Skåne (GÅS) Project, which began in 2001 and is a part of the Swedish National Study on Aging and Care (SNAC). The design of the GÅS and SNAC study is described elsewhere [24,25].

Participants randomized from the national population register were invited to take part in the study by letter and written informed consent was obtained. A total of 6,991 eligible individuals were invited in two waves (Figure 1). From the first wave between 2001 and 2004, 2,931 (60.0%) out of 4,893 agreed to participate, while from the second wave between 2006 and 2012, 1,523 (72.6%) out of 2,098 agreed to participate. The first wave included participants in nine age-cohorts (60, 66, 72, 78, 81, 84, 87, 90 and 93 years) and the second wave participants in two age cohorts (60 and 81 years).

A total of 254 individuals from the first wave and 184 individuals from the second wave were excluded, as they did not complete any of the HLoC-scales. An additional 144 individuals from the first wave and 53 from the second wave were excluded, as they did not perform any of the physical tests (walking 15 m at normal speed, HGS or AS). The first and second waves were then merged, after which the study population consisted of 3,819 participants, 1,725 (45.2%) men and 2,094 (54.8%) women (Figure 1) (Table 1).

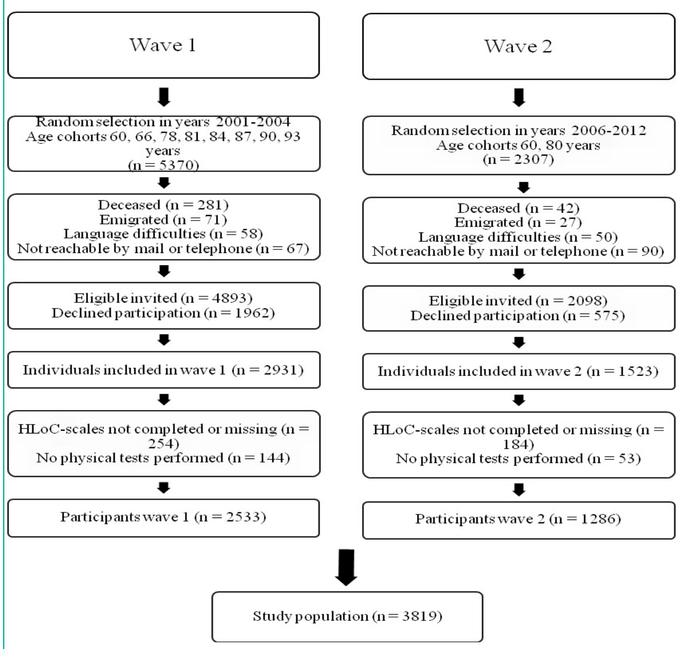

Figure 1: Flow sheet explaining the enrolment of participants in the first wave 2001-2004 and in the second wave 2006-2012.

Table 1: Description of study sample, N=3,819.

	Study sample n(%)	Internal Missing n(%)
Sex		-
Men	1,725(45.2)	
Women	2,094(54.8)	
Age, Mean (SD)	69.4(9.8)	-
Age decade		-
60	2,335(61.7)	
70	57(13.5)	
80	817(21.4)	
90	130(3.4)	
Education		11(0.3)
Primary school	1,787(46.8)	
Secondary school	1,110(29.1)	
University	911(23.9)	
BMI		82(2.1)
Underweight	139(3.6)	
Normal	1,302(34.1)	
Overweight	1,593(41.7)	
Obese	703(18.4)	
Moving-related pain Upper Extremities		2(0.1)
Yes	1,231(32.2)	
No	2,586(67.7)	
Moving-related pain Back/lower extremities		5(0.1)
Yes	1,891(49.5)	
No	1,926(50.4)	
Heart disease		5(0.1)
Yes	688(18.0)	
No	3,126(81.9)	
Lung disease		5(0.1)
Yes	476(12.5)	
No	3,382(87.4)	
Depressive mood		111(2.9)
Yes	533(14.0)	
No	3,175(83.1)	
MMSE		59(1.5)
≤24p	421(12.6)	
>24p	3,279(85.9)	

Socio-Demographics, Health Status, Lifestyle Habits and Health Locus of Control

Structured interviews including questions about health variables were carried out by trained medical staff in accordance with predefined research protocols. Self-reported questionnaires were used to obtain data on sociodemographics, lifestyle habits and HLoC. Assessments took place either at the research centre or, in cases of ill health, in participants' homes.

Health Variables, Lifestyle Habits

Health variables covered heart disease, lung disease, Body Mass Index (BMI), depressive mood, cognition and experience of pain in the upper extremities or back/lower extremities when moving. Heart disease included myocardial infarction, angina pectoris or clinical heart failure. Lung disease comprised Chronic Obstructive Pulmonary Disease (COPD), asthma or tuberculosis. Moving-related pain from the upper extremities covered pain from the shoulders, elbows, wrists and hands. Pain from the lower extremities or back when moving involved pain from the back, hips, knees and feet.

To check the medical history after the medical examination, reported diseases were verified through the National Diagnosis Registry and medical records, for which the participants' permission had been obtained. Weight (kg) was measured using a balance scale with a precision of ±50g with participants in light clothing but with no shoes [26]. Height was measured without shoes to the nearest 0.1cm using a scale fixed to a wall with the participant standing erect with heels and shoulders against the wall and a straight fixed gaze [26]. Body Mass Index (BMI) was then calculated as weight (kg)/height (m^2) and cut off set to <18.5kg/m^2 underweight, 18.5-24.9kg/m^2 normal (healthy) weight, 25.0-29.9kg/m^2 overweight and ≥30kg/m^2 obese [27].

The Montgomery-Åsberg Depression Rating Scale (MADRS) was used as a test of depressive mood. The scale ranges from 0-60 points and a score ≥7 points was used as a cut off for depressive mood [28]. The MADRS has previously been validated for older adults [29]. The Mini Mental State Examination (MMSE) was used to assess global cognitive function [30]. The scale ranges from 0-30 points and 24 points was used as a cut off for cognitive impairment [31].

Physical Tests

The physical tests consisted of walking 15m at a normal (comfortable) and maximum speed, followed by the HGS test and the AS stair touching test. These physical tests were chosen in order to gain a broad impression of the participants' physical ability in terms of mobility, muscle strength, balance and coordination [32]. All tests were performed at the Department of Geriatrics, Malmö University Hospital. A trained registered research nurse instructed the participants about how the tests should be performed, monitored the performance but provided no encouragement during the assessment. The participants wore their normal clothes and shoes, and walking aids were allowed [32].

Walking 15 metres at normal and maximum speed: WS was used as a measure of functional mobility [33]. Following a dynamic start, the participants were asked to walk 15m at a normal (comfortable) and a maximum speed. The test took place in a hospital corridor and participants were allowed to accelerate and decelerate for several metres before and after the test. To ensure that the participants achieved their individual maximum speed, the nurse instructed them that the test was to be performed as quickly as possible without running. The time taken to walk was recorded using a digital stopwatch. Each test (normal and maximum WS) was performed once, and participants were allowed to rest for one minute between tests. High intraclass correlation (ICC >0.90) has been reported for walking 15m at both normal and maximum speed [34].

Hand grip strength: The Grippit®, a device that measures HGS, was used for this test [35]. Participants performed a standard testing procedure in accordance with the test leader's instructions. The hand grip device and a forearm support were mounted on a transportable base, ensuring correct arm and hand grip positions, and the participants started to squeeze the handle on command [34]. The test was carried out twice on each hand and the maximum force noted. The best result (maximum force) was used in the analysis. High intraclass correlation has been reported (ICC = 0.97) for both hands [36].

Alternate stepping: Participants stood with feet parallel at 5cm from the front of a 7.5cm high block stably positioned against a wall. They were asked to place one foot on the block and then return it to the floor as quickly as possible. A research nurse stood close by for safety but did not assist in the performance. The total number of steps completed in 15 seconds was recorded for both the right and the left lower extremity [37]. The best value from the tests (the dominant lower extremity) was used in the analysis. High intraclass correlation has been reported (ICC=0.78) [38].

Health Locus of Control

Internal and external HLoC were assessed by the Multidimensional Health Locus of Control (MHLC) questionnaire version B [39]. The questionnaire consists of three subscales for estimating internal, external and chance locus respectively. Each scale ranges from 0 – 39 points and contains 6 positively formulated statements based on a Likert scale with the following 5 response alternatives; agrees exactly = 1, agrees quite well = 2, neither agrees nor disagrees = 3, does not really agree = 4, does not agree at all = 5.

Higher scores on the internal subscale indicate that attitudes and behaviour in relation to health are more a matter of personal beliefs about what one can do oneself to promote better health. In contrast, higher scores on the external and chance scales indicate that health is more in the hands of other people, such as healthcare professionals, or that health cannot be influenced but is mostly a result of chance [39]. Cronbach's alpha for internal, chance and external HLoC was 0.74, 0.81 and 0.76, respectively.

Statistical Analysis

Descriptive statistics pertaining to the study population are presented in Table 1. Differences in proportions were tested with the chi-square (χ^2) test.

Results of the WS and HGS physical tests according to sex, age, education, co-habiting, BMI, moving-related pain in the upper extremities, moving-related pain in the back/lower extremities, heart disease, lung disease and depressive mood are presented as means and standard deviations. Significance tests for two groups were performed with Student's T-test and for three groups with ANOVA (Table 2). Correlation between physical tests and internal and external HLC was calculated using Pearson's correlation (r) (Table 2).

Table 2: Results of the physical tests, mean and SD, according to sex, age, education, smoking habits, BMI, moving-related pain in the upper extremities, moving-related pain in the back/lower extremities, heart disease, lung disease, depressive mood and correlations, Pearson's (r), between physical tests and internal, chance and external HLoC (N=3,819).

Physical tests Variables	Walking 15 metres normal speed		Walking 15 metres Maximum speed		Hand grip strength maximum force dominant hand		Alternate stepping number of steps	
	m/s(SD)	p-value	m/s(SD)	p-value	Kg(SD)	p-value	Number(SD)	p-value
Sex								
Men	1.39(0.26)	<0.001	1.80(0.39)	<0.001	38.1(10.33)	<0.001	18.0(5.08)	<0.001
Women	1.30(0.28)		1.58(0.36)		20.4(6.67)		15.9(4.89)	
Age(decade)								
60	1.46(0.22)	<0.001	1.85(0.32)	<0.001	31.6(12.54)	<0.001	18.7(4.51)	<0.001
70	1.25(0.24)		1.54(0.32)		26.1(10.11)		15.0(4.25)	
80	1.10(0.24)		1.34(0.32)		21.6(9.09)		13.0(4.23)	
90	0.95(0.23)		1.16(0.39)		18.6(8.30)		11.2(3.61)	
Education								
Primary school	1.27(0.27)	<0.001	1.57(0.37)	<0.001	26.2(11.89)	<0.001	15.2(4.76)	<0.001
Secondary school	1.36(0.27)		1.71(0.37)		29.2(12.68)		17.4(4.81)	
University	1.45(0.25)		1.88(0.36)		31.3(12.02)		19.4(4.79)	
BMI								
Underweight	1.32(0.31)	<0.001	1.63(0.39)	<0.001	22.8(9.71)	<0.001	15.7(5.23)	<0.001
Normal	1.38(0.28)		1.74(0.39)		27.4(11.82)		17.4(5.05)	
Overweight	1.35(0.28)		1.71(0.38)		30.1(12.66)		17.1(5.08)	
Obese	1.26(0.27)		1.56(0.38)		28.3(12.31)		15.6(4.81)	
Moving-related pain, upper extremities								
Yes	1.31(0.27)	<0.001	1.63(0.38)	<0.001	25.0(12.08)	<0.001	16.2(4.91)	<0.001
No	1.36(0.28)		1.71(0.39)		30.2(12.08)		17.2(5.13)	
Moving-related pain, back/lower extremities								
Yes	1.29(0.29)	<0.001	1.61(0.38)	<0.001	26.3(12.12)	<0.001	16.1(4.95)	<0.001
No	1.39(0.26)		1.76(0.39)		30.7(123.3)		17.6(5.08)	
Heart disease								
Yes	1.17(0.30)	<0.001	1.46(0.40)	<0.001	27.1(12.53)	0.002	14.4(4.97)	<0.001
No	1.38(0.26)		1.73(0.37)		28.8(12.24)		17.4(4.95)	
Lung disease								
Yes	1.35(0.28)	0.003	1.61(0.38)	<0.001	26.4(11.32)	<0.001	16.2(5.05)	0.004
No	1.29(0.28)		1.70(0.39)		28.8(12.42)		17.0(5.07)	
Depressive mood								
Yes	1.23(0.28)	<0.001	1.52(0.39)	<0.001	23.9(10.90)	<0.001	14.9(5.02)	<0.001
No	1.36(0.29)		1.72(0.38)		29.48(12.30)		17.3(4.94)	
MMSE								
≤24p	1.16(0.29)	<0.001	1.42(0.38)	<0.001	23.2(10.66)	<0.001	13.4(4.82)	<0.001
>24p	1.37(0.27)		1.72(0.38)		29.3(12.32)		17.4(4.91)	
Internal HLoC(Pearson's [r])	0.126	<0.001	0.123	<0.001	0.146	<0.001	0.099	<0.001
Chance HLoC(Pearson's [r])	-0.293	<0.001	-0.324	<0.001	-0.164	<0.001	-0.313	<0.001
External HLoC(Pearson's [r])	-0.296	<0.001	-0.333	<0.001	-0.165	<0.001	-0.316	<0.001

Standard multivariate linear regression models were constructed to analyse the associations between the time taken to walk 15m, maximum HGS and number of AS as dependent variables and HLoC as an independent variable, adjusted for sex, age decade, education, BMI, moving-related pain in the upper extremities, moving-related pain in the back/lower extremities, heart disease, lung disease, depressive mood and outcome of the MMSE. The variables were simultaneously entered into the regression models and all variables with the sole exception of the HLoC scales were used as dummies (Table 3). For all regression models assumptions of normality, linearity and homoscedasticity were controlled for by examining the residual scatterplots, i.e., predicted values of dependent variables against residuals, and no deviations were observed [40]. Multicollinearity was tested for and none of the included variables had a variance inflation factor >2.0 [41]. For all models, the explained variance was assessed by the adjusted R-square and overall significance by the F-test. The level of significance was set to <0.05. An attrition analysis was carried out to compare Participants with non-participants (n=635, 14.2%) and differences in proportions regarding included variables were tested with the chi-square (χ^2) test (Table 4).

Data analysis was performed using SPSS for Windows, version 24.0 (IBM 211 Corporation, Armonk, NY, USA).

Ethical Considerations

The study was conducted in accordance with the Helsinki Declaration [42] and approved by the regional ethics committee at Lund University 2010-2012, registration no. LU 744-00. All participants provided their written consent and allowed retrieval of information from the National Patient Register medical records. Participants were informed that they could withdraw from the study at any time.

Table 3: Adjusted multiple linear regression models with walking speed(m/s), hand grip strength(kg) and alternate stepping(Nb) as dependent variables and HLoC scales as independent variables, adjusted for sex, age, education, BMI, moving-related pain in the upper extremities, moving-related pain in the back/lower extremities, heart disease, lung disease, depressive mood and cognition(MMSE).

Physical tests	Walking 15m at normal speed n =3,288			Walking 15m at maximum speed n =3,274			Maximum hand grip strength dominant hand n = 3,483			Alternate stepping, number of steps n = 3,444		
Variables	B[a]	95% CI	p-value	B[a]	95% CI	p-value	B[a]	95% CI	p-value	B[a]	95% CI	p-value
Sex women (ref. men)	-0.043	-0.058/ -0.028	<0.001	-0.165	-0.185/ -0.145	<0.001	-16.63	-17.14/ -16.12	<0.001	-1.34	-1.62/ -1.06	<0.001
Age (ref. decade 60)												
70	-0.158	-0.180/ -0.137	<0.001	-0.220	-0.249/ -0.192	<0.001	-4.27	-5.03/ -3.52	<0.001	-2.50	-2.91/ -2.08	<0.001
80	-0.293	-0.313/ -0.272	<0.001	-0.387	-0.414/ 0.360-	<0.001	-7.87	-8.59/ -7.16	<0.001	-4.18	-4.57/ -3.80	<0.001
90	-0.425	-0.469/ -0.381	<0.001	-0.551	-0.609/ -0.493	<0.001	-9.96	-11.50/ -8.52	<0.001	-5.91	-6.77/ -5.05	<0.001
Education (ref. primary school)												
Secondary school	0.022	0.005/ 0.039	0.011	0.030	0.008/ 0.053	0.008	-0.20	-0.79/ 0.39	0.506	0.90	0.58/ 1.22	<0.001
University	0.39	0.020/ 0.059	<0.001	0.091	0.065/ 0.116	<0.001	-0.42	-1.08/ 0.24	0.216	1.57	1.20/ 1.93	<0.001
BMI (ref. normal BMI)												
Underweight	-0.009	-0.049/ 0.030	0.614	-0.026	-0.079/ 0.027	0.332	-1.17	-2.53/ 0.18	0.089	-0.80	-1.52/ -0.08	0.029
Overweight	-0.024	-0.040/ -0.007	0.005	-0.036	-0.058/ -0.014	0.001	0.94	0.38/ 1.51	0.001	-0.39	-0.64/ -0.08	0.014
Obese	-0.101	-0.121/ -0.080	<0.001	-0.154	-0.182/ -0.127	<0.001	0.71	-0.01/ 1.42	0.052	-1.55	-1.94 / -1.16	<0.001
Moving-related pain												
Upper extremities(yes)	-0.032	-0.048/ -0.015	<0.001	-0.047	-0-069/ -0.025	<0.001	-2.68	-3.24/ -2.12	<0.001	-0.70	-1.00/ -0.39	<0.001
Back/lower extremities(yes)	-0.041	-0.056/ -0.026	<0.001	-0.061	-0.081/ -0.040	<0.001	-0.86	-1.39/ -0.34	0.001	-0.59	-0.88/ -0.31	<0.001
Heart disease(yes)	-0.058	-0.078/ -0.038	<0.001	-0.076	-0.102/ -0.049	<0.001	-0.20	-0.89/ 0.50	0.582	-0.68	-1.07/ -0.30	<0.001
Lung disease(yes)	-0.024	-0.046/ -0.002	0.029	-0.037	-0.065/- 0.008	0.012	-0.34	-1.09/ 0.41	0.372	-0.04	-0.44/ 0.37	0.853
Depressive mood(yes)	-0.056	-0.077/ -0.036	<0.001	-0.070	-0.097/ -0.043	<0.001	-1.29	-2.01/ -0.57	<0.001	-1.02	-1.41/ -0.63	<0.001
MMSE>24p(yes)	0.069	0.046/ 0.0092	<0.001	0.107	0.076/ 0.137	<0.001	2.41	1.62/ 3.20	<0.001	1.64	1.20/ 2.08	<0.001
Internal HLoC	0.006	0.004/ 0.008	<0.001	0.007	0.005/ 0.010	<0.001	0.08	0.01/ 0.15	0.019	0.08	0.05/ 1.20	<0.001
Chance HLoC	-0.004	-0.006/ -0.002	<0.001	-0.008	-0.010/ -0.005	<0.001	0.16	-0.04/ 0.07	0.562	-0.08	-0.11/ -0.05	<0.001
External HLoC	-0.003	-0.005/ -0.002	<0.001	-0.006	-0.008/ -0.004	<0.001	-0.26	-0.33/ -0.20	<0.001	-0.10	-0.13/ -0.06	<0.001
R^2		0.435			0.507			0.645			0.378	
Model fit	F(18, 3269) =141.7, p<0.001			F(18, 3255) =185.6, p<0.001			F(18, 3464) = 353.1, p<0.001			F(18, 3425) = 117.3 p<0.001		

Note: [a]Unstandardized regression coefficient

Results

The study population comprised 3,819 participants. Their mean age was 69.4 years (SD=9.8), and the proportion of women was 54.8%. Moving-related pain from the upper extremities was reported by 32.2% and moving-related pain from the back/lower extremities by 49.5%. Heart disease, including infarction, angina pectoris or heart failure, was reported by 18.0% and lung disease, including asthma, COPD or tuberculosis, by 12.5%. According to the MADRS, 14.0% were categorized as suffering from depressive mood and 12.6% scored ≤24 points on the MMSE scale (Table 1).

Lower mean values in the WS and HGS tests were found in participants with moving-related pain from the upper or back/lower extremities, heart disease, and lung disease as well as in those who were in a depressive state at the time of the study (Table 2).

All physical performances, walking 15m at normal speed, at maximum speed, HGS and AS, correlated positively with the results of the internal HLoC scale: walking 15m at normal speed r=0.12, n=3,423, p<0.001. The tested physical performances correlated negatively with the results of chance HLoC, walking 15m at normal speed r=-0.29, n=3,425, p<0.001, and external HLoC, walking 15m at normal speed r=-0.30, n=3,410, p<0.001 (Table 2).

Table 4: Attrition analysis comparing study sample to non-participants.

	Study sample, N=3819 n(%)	Non-participants, N=635 n(%)	p-value
Sex			
Men	1725(45.2)	243(38.3)	0.001
Women	2094(54.8)	392(61.7)	
Age, Mean(SD)	69.4(9.8)	77.6(12.1)	<0.001
Age decade			
60	2335(61.7)	224(35.3)	<0.001
70	57(13.5)	42(6.6)	
80	817(21.4)	218(34.3)	
90	130(3.4)	151(23.8)	
Education			
Primary school	1787(46.9)	235(64.0)	<0.001
Secondary school	1110(29.1)	86(23.4)	
University	911(23.9)	46(12.5)	
BMI			
Underweight	139(3.7)	32(8.2)	<0.001
Normal	1302(34.8)	146(37.3)	
Overweight	1593(42.6)	139(35.5)	
Obese	703(18.8)	74(18.9)	
Moving-related pain			
Upper Extremities			
Yes	1231(32.3)	129(27.8)	0.052
No	2586(67.7)	335(72.2)	
Moving-related pain			
Back/lower extremities			
Yes	1891(49.5)	240(51.7)	0.375
No	1926(50.5)	224(48.3)	
Hart disease			
Yes	688(18.0)	176(37.1)	<0.001
No	3126(82.0)	299(62.9)	
Lung disease			
Yes	476(12.5)	50(10.6)	0.233
No	3338(87.5)	423(89.4)	
Depressive mood			
Yes	533(14.4)	88(28.8)	<0.001
No	3175(85.6)	218(71.2)	
MMSE			
≤24p	481(12.8)	147(45.7)	<0.001
>24p	3279(87.2)	175(54.3)	

The adjusted multivariate linear regression showed that a higher result on the internal HLoC scale was significantly associated with walking 15m at a normal speed (B=0.006, p<0.001) as well as at a maximum speed (B=0.007, p<0.001), while a higher result on the chance and external HLC was significantly associated with a longer time to walk 15 metres at a normal speed (B=-0.004, p<0.001) and (B=-0.003, p<0.001) respectively, and walking 15m at a maximum speed (B=-0.008, p<0.001) and (B=-0.006, p<0.001). Furthermore, a higher result on the internal HLoC scale was significantly associated with a stronger hand grip (B=0.08, p=0.019), while a higher result on the external HLoC scale was significantly associated with a weaker hand grip (B=-0.26, p<0.001). In the alternating step test; a higher result on the internal HLoC scale was significantly associated with higher number of steps (B=0.08, p<0001), while a higher result on the chance and external HLC was significantly associated with a lower number of steps (B=-0.08, p<0.001) and (B=-0.10, p<0.001) respectively (Table 3).

Discussion

This study showed that internal, chance and external HLoC were significantly associated with normal and maximum WS and HSG, while internal and external HLoC were significantly associated with AS after adjustment for sex, age, education, BMI, heart and lung disease, depressive mood and cognitive impairment. High scores on the internal LoC scale were associated with better performance, while high scores on the chance and external LoC scale was associated with poorer performance. By considering HLoC as a personal factor [1], the results from this study complement previous reports on the importance of individual traits for physical performance. For example, studies using the big five personality traits have reported lower HGS to be associated with higher neuroticism and lower openness [43], while higher walking speed was associated with greater conscientiousness, extraversion, openness and lower neuroticism [44-46].

Several temporary and more permanent physical, environmental and psychological causes in addition to HLoC can affect WS, HGS and AS. In particular, temporary causes can be a problem when the results of these tests, as well as other physical tests, are compared with standard values or, as indicated above, are included in the assessment of health status, frailty_or functional ability. Moreover, in terms of LoC, research has shown that older adults are more likely than younger individuals to acknowledge that external LoC is more important [47]. In view of the age and health status of the participants in the present study, we tried as far as possible to adjust for this fact. However, based on the aim of this study, a further hypothesis is that individuals with a predominantly internal HLoC have greater self-confidence and are more at ease in the sometimes unfamiliar clinical setting, thus performing WS, HGS and AS tests better than those with an external HLoC. Previous studies have shown that individuals whose actions in relation to health issues are characterized by an internal HLoC are more likely to exercise than those with an external HLoC, who do not take their own initiative for health promotion activities to the same extent. Thus, a likely explanation for the better results among those with an internal locus would instead be that they are fitter. However, more fit or not, it is difficult to completely disregard HLoC and whether internal or chance/external LoC is the indirect or direct explanation for physical performance.

In view of the above, one question is whether it would be worth while to try to influence individuals' HLoC as a means of making them more likely to exercise with possible long-term positive health effects and, if so, how best to do it – by improving the influence of the internal locus or reducing the influence of the external locus, or both? Overall, considering the results of the present study and earlier reported health effects associated with internal and external HLoC in older adults, an intervention aimed at improving the internal LoC would probably be best [48,49]. At the same time, HLoC does not solely predict specific health behaviours, as it also depends on how different individuals value their health and the effect of exercise [50].

Another question with reference to the present study is whether a change in internal or external HLoC would have any decisive significance for an improved result in WS, HGS or AS. Overall, even if an individual with e.g., low internal HLoC could be encouraged to rethink or change her/his attitude, thereby achieving a higher total score on the internal scale, the changes in the physical tests reported here would be small. Nevertheless, even small improvements in the physical tests can be of foremost importance. The difference in walking speed between 70-80- and 93-year-olds is approximately 0.15m/s. Individuals with the opportunity to change from a low to a high internal HLoC could improve their walking speed to a rate that corresponds to the difference between the oldest age decades. Thus, it is difficult to completely ignore the importance of HLoC and its impact on the physical tests reported in this study.

Limitations

There are limitations in this study. We included participants at two different time points, and although the risk is small, we cannot rule out that the result was altered by a cohort effect in some of the included variables. Another limitation could be a BMI misclassification. We used standing height when calculating the BMI, which can be questioned, as lower height in older adults is often due to physiological and pathological changes, which can lead to an overestimation of BMI [26].

The attrition analysis showed that the non-participants were older and that the proportion of women lower education, underweight, heart disease, depressed mood and scoring ≤24 points on the MMSE was greater compared to the participants. A selection bias cannot be ruled out and the generalizability of the results should be done with caution. However, since it looks like non-participants are a more fragile group, e.g., greater proportion with lowered mood and heart problems, it is not unlikely that in addition to performing worse in the physical tests, the proportion with internal HLoC would also be smaller [8,9]. Thus, this would rather emphasize the overall result of this study, that more of an internal HLoC is associated with better results on the physical tests.

Strengths

Strength of this study is the large sample and that participants were randomized from a general population in the southern part of Sweden, representing both rural and urban areas. To reduce selection bias, home visits were made, and help was offered to those who had problems reading due to impaired vision, cognitive impairment or other disabilities that could make it difficult to answer the questionnaires. All examinations and interviews were conducted by personnel who were specially trained for the study.

Conclusion

In a clinical setting, assessment of HLoC may contribute to the understanding of physical performance in terms of WS, HGS and AS among older adults aged 60-93 years. A sense of internal control over one's own health was associated with faster walking, a stronger hand grip and a higher number of alternate steps. The findings suggest that modification of control beliefs has the potential to improve the performance of these physical tests, which could be worth considering in a medical or physiotherapeutic assessment.

Author Statements

Data and Code Availability

Data analysis was performed using SPSS for Windows, version 24.0 (IBM 211 Corporation, Armonk, NY, USA). The authors do not have permission to share data.

Conflict of Interest Statement

The authors declare no competing interests.

Authors' Contributions

Data collection: HE and SE; Study design: HE, LSW and SE; Data analysis: HE, LSW and SE; Writing the manuscript: HE, LSW and SE

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