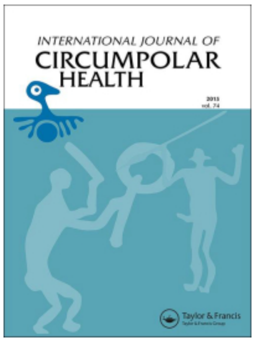

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Basic mobility, accidental falls, and lifetime physical activity among rural and urban community-dwelling older adults: a population-based study in Northern Iceland

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ABSTRACT
The objective of this research was to investigate late-life physical functioning and lifetime history of physical activity (PA) among older adults in rural and urban Arctic communities. Data was collected in a cross-sectional, population-based study among 65 to 92-year-old community-dwelling Icelanders (N = 175, 41% ≥75-year-old, 43% women, 40% rural). Late-life physical functioning was operationalised as: basic mobility (Timed Up and Go in seconds, TUG); fall risk (TUG≥12 sec); a fall (≥1 fall/year); and recurrent falls (≥2 falls/year). PA history was based on a self-assessment. Compared to urban participants, rural participants were more likely to have fallen recently, be at fall risk, and describe more PA history. Among urban participants, no fall in the past year was independently associated with more PA in middle adulthood; and worse basic mobility and late-life fall risk were independently associated with being in the ≥75-year-old group. Among rural participants, recurrent falls were independently associated with being a man; and better basic mobility was independently associated with more PA in late adulthood. To conclude, this evidence supports an important association between better late-life physical functioning and more mid- and late-life PA and encourages further research to understand high fall risk among older men in Arctic rural areas.

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Basic mobility; accidental falls; physical exertion; healthy ageing; rural health; residence characteristics

Introduction

Societies that invest in healthy ageing potentially enable their citizens to live both longer and healthier lives [1,2]. One of the key factors in healthy ageing is having the opportunity to engage in physical activity (PA), as PA is known to counteract age-related disability and to promote physical functioning [3,4]. Another key factor to address in healthy ageing is the older person's living environment, as restrictions in physical functioning (disability) represent a gap between a person's intrinsic capabilities and the demands of the environment (social and physical) [2,5]. Closing this gap should increase opportunities for optimal ageing in place [6].

Aspects of physical functioning that are particularly important to older adults, include good basic mobility and those with a recent fall history are more likely to have worse physical functioning than those who have not fallen [7]. Moreover, regular PA in midlife has been associated with better general physical functioning [8]; and more specifically midlife PA predicts better basic mobility, gait speed and lower extremity strength 25 years later [9]. Strong evidence supports that PA in the form of exercise programmes can lower both the risk of falls and the number of community-dwelling older people experiencing falls [10]. For years, this has been reflected in a detailed report from the World Health Organization [11], recommending regular, moderate PA to prevent falls and to reduce fall-related injuries. Questions remain of whether PA or physical exertion in other life-periods than midlife, may also contribute to late-life basic mobility and whether lack of PA in different life-periods may be associated with falls in old age.

Policy makers and professionals working in health promotion for individuals and communities must be aware of potential influences of the living environment on both PA behaviour and physical functioning in advanced age [12,13]. One of the more obvious environmental factors in older adults' lives is their place of residence, and evidence reflects for example that PA behaviour may differ markedly between older adults residing in rural versus urban areas

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[12,14]. Researchers should continue exploring potential urban-rural differences in important determinants of healthy ageing [2]. Learning how these determinants differ may expand our understanding of person-environment fit with respect to the heterogeneity of ageing in place in both urban [15] and rural communities [16]. For individuals who are ageing in Arctic communities the lack of daylight during winter seasons adds an extra challenge to their lives [17], and may require these individuals to function at an extra high physical level to accomplish their daily tasks and physical activities. The lack of outdoor lighting in rural areas potentially adds to this challenge among individuals who are ageing in communities which are both Arctic and rural.

The general aim of this study was to investigate aspects of late-life physical functioning and lifetime PA history among older community-dwelling adults living in rural and urban Arctic areas. More specific aims were: (1) to describe late-life physical functioning in the form of history of falls in the past year, basic mobility and late-life fall risk, (2) to describe lifetime PA history during adolescence (ages 12–19), young adulthood (ages 20–39), middle adulthood (ages 40–64), and late adulthood (age 65 and older), and (3) to explore the association between the late-life physical functioning variables and PA history during different life-periods. Additionally, all variables and associations were analysed based on participants' rural versus urban residency, gender, and age-group.

Materials and methods

Study design

This cross-sectional study was a part of a larger project on health and well-being of older community-dwelling adults in rural and urban areas in Northern Iceland. Data was collected from September 2017 to January 2018 and a detailed description of the methods and study area has been published elsewhere [18,19].

Research area

Three research areas were selected based on: their proximity to the main research centre, their closeness to the Arctic Circle [17], a definition of rural and urban communities [20], and an understudied older population in the rural areas. The urban area lies between the two rural areas and is separated geographically from them by a fjord and a mountain range [19]. The urban area is the largest town in Iceland outside of the greater Capital Area. The town's population was approximately 19,000 and 14.6% had reached 65 years of age. Despite the smallness of the town, it has a comprehensive urban infrastructure including a university, secondary national hospital, and various services for the Northeast of Iceland. The combined population of the two rural areas was approximately 4,000 and 19% had reached 65 years of age. Each of rural area had one town, which was not included in the study, with a primary health care centre and a small basic hospital. The participants from the rural areas lived on farms, in other isolated houses or in small fishing or agricultural villages with less than 200 inhabitants. In the urban area, people travelled less than 5 km to access health care, they had access to variety of recreational options and public transportation was good. In the rural areas, however, the average travel distance for health care was over 20 km and local recreational options were limited. In rural areas, the main roads were paved and kept open during the winter months. The smaller rural roads however were often not paved and heavy with snow or ice during the winter months. In rural Iceland, public transportation is uncommon.

Selection of participants

The study population consisted of community-dwelling individuals, aged 65 years and older, living in rural and urban areas of Northern Iceland. Potential participants had to meet the following inclusion criteria: (1) to be 65 years of age or older, (2) to live in the community (not institution), (3) to have enough cognitive function to communicate verbally by telephone and independently set up a meeting time for data collection. The Icelandic National Registry was used to draw a stratified random sample of 400 potential participants, by age, gender, and place of residence. Of these 400 individuals selected, five had passed away, 20 did not fulfill the inclusion criteria and 73 were unreachable. Therefore, 302 older individuals received an information letter, two weeks prior to a telephone call. If the individual was willing to participate, the telephone call included a basic screening for eligibility and a time was scheduled for the research interview and measurements. A total of 175 (58%) agreed to participate in the study. Those who declined to participate did not differ significantly from the study sample regarding age ($p = 0.77$) and residency ($p = 0.55$), however, women were more likely to decline participation than men ($p = 0.01$). The most common reasons given for not participating included a lack of time and recent participation in other studies.

Procedures and variables

Four research assistants were trained in standardised research procedures for face-to-face interviews and assessments in participants' homes. The data was collected during the part of the year when the days are short (September to January), due to the high latitude of the research area.

Physical functioning

Four variables reflecting physical functioning were created based on measurement of basic mobility with the Timed Up and Go (TUG) test [21] and a standardised question on fall history, namely "In the past 12 months, have you had any fall including a slip or trip in which you lost your balance and landed on the floor or ground or lower level?" [22]. Basic mobility was reflected in two variables: time to complete the TUG test in seconds (TUG time variable), and late-life fall risk variable based on completing TUG in ≥ 12 seconds (TUG ≥ 12 sec = 1; TUG <12 sec = 0;) [23,24]. Fall history in the past year provided two variables: fall(s) (≥ 1 fall/year = 1; no fall/year = 0) and recurrent falls (≥ 2 falls/year = 1; no or one fall/year = 0).

PA history

A single item question on PA was created, aiming for simplicity and to potentially reflect what has been described as health-enhancing PA: "In general, health-enhancing PA comprises activities that are classed as of at least moderate intensity. Moderate intensity PA raises the heartbeat and leaves the person feeling warm and slightly out of breath. It increases the body's metabolism to 3–6 times the resting level (3–6 metabolic equivalents – METs)" [25]. Participants were asked to respond to the following question: "During the following life-periods, how many days per week did you physically exert yourself (in sport, recreation or work) to the extent of triggering sweat and shortness of breath?". The response options were: never, 1–3 days/week, 4–7 days/week (most days of the week). These response options were selected for simplicity and to differentiate between participants who had memories of physical exertion as a large part of their daily life (most days of the week), those who were sedentary (never), and those who were active to some extents (1–3 days/week). The participants answered the same PA question for each of four life-periods: adolescence (ages 12–19), young adulthood (ages 20–39), middle adulthood (ages 40–64), and late adulthood (age 65 to present). Within each life-period, the responses to the question were assigned a value of zero (never), 1 (1–3 days/week) and 2 (most days/week). This question was motivated by a single-item self-report measure of PA with established criterion validity of a 7-day recall period compared with accelerometry measurements [26–28]. As our intention was to reflect PA lifetime history it was not realistic to include well known details of sustained 10 min PA bouts and a total of 30 min or more daily.

Background characteristics

The participants confirmed information from the Icelandic National Registry on their urban versus rural residence, age, and gender. Additionally, they answered questions on the following: educational level, diagnosed diseases, prescribed medications (supported by their medication list), whether they lived alone, walking aid use (indoor and outdoor), height and weight. An educational-level-variable was created with two categories, primary school education only (the compulsory education in Iceland, at any given time) and education beyond primary school. Body Mass Index was calculated based on a known formula (BMI in kg/m^2). A categorical age-group variable was created, a younger-old and an older-old group (65–74 years old and 75–92 years old, respectively). The age-bands are based on gerontological research where people aged 65 years and over has been widely defined as older adults (based on retirement) [29: 463–524] and a proposal suggesting 75 years and older should mark a future category of old age [30]. Therefore, in this study younger-old group were theorised to represent individuals with potential age-related changes in social roles (for example associated with official retirement age) and physical functioning, while the older-old group represents individuals who are expected to have experienced more substantial age-related changes in social roles and physical functioning.

Statistical analysis

Continuous variables were described with means (*M*), standard deviations (*SD*) and ranges, and categorical variables were described with frequencies and percentages. All variables were compared by residence (rural or urban), gender (man or woman), and age-group (younger-old or older-old); with an independent *t*-test for continuous data, a Mann-Whitney *U*-test for ordinal data and a Pearson's chi-square test for binary data.

Linear regression and binary logistic regression analysis were used to study the association between four dependent variables for late-life physical functioning (basic mobility, late-life fall risk, fall in the past year and recurrent falls in the past year), and seven independent variables reflecting PA history in four life-periods and participants' background (residence, gender, age-group). Prior to the linear regression analysis, the positively skewed TUG time variable was log-transformed (log base 10). A commonly used 10 cases per independent variable "rule of thumb" [31, p. 461] was used as a guiding-limit for selection of independent variables, as our aim was to run separate analyses based on residency and our rural participants were only 70.

Following univariate regression analyses, two multivariable regression models were created to further explore independent associations between the dependent variables and each of the independent variables. Model 1 had all four PA history variables (one for each life-period) and model 2 included all four PA history variables and was adjusted for gender and age-group. The multivariable regression analysis was completed for the total sample and stratified by rural and urban residence. Moreover, information from Q-Q graphs, variance inflation factor and tolerance were monitored to ensure that assumptions for linear regression were met. Only three (2.9%) of the urban participants experienced recurrent falls in the past year. As all three were men and belonged to the younger-old group, we were unable to run all planned binary logistic regression analyses in the urban group (due to zero cell count among women and the older-old). When running multivariable regression models by residence we explored the influence of including three covariates that were significantly associated with residence in univariate analyses (educational level, number of medical diagnoses, number of prescribed medication). None of these variables changed any of the models significantly (results not shown).

The level of significance was set at $p < 0.05$ and a 95% confidence interval was calculated, when appropriate. Statistical analysis was completed using SPSS, version 27 (SPSS Inc., Chicago, Illinois, USA).

Results

Participants' background characteristics, late-life physical functioning and PA history

The participants ($N = 175$) were 65 to 92 years old, 41% were 75 years or older, 43% were women and 40% lived in rural areas. Further information on the participants' characteristics, in total and by residence, gender and age-group are presented in Table 1. In brief, rural participants had lower educational level, fewer medical diagnoses and used fewer prescribed medications compared to urban participants. The participants in the older-old group used more prescribed medications and were more likely to use an outdoor walking aid compared to the younger-old group. Finally, men had higher educational level than women.

Table 2 describes falls in the past year, basic mobility, late-life fall risk and lifetime PA history; in total and by residence, gender, and age-group. Compared to urban participants, rural participants reported more falls in the past year, were more likely to be at risk for falls and scored higher on all PA history variables. Men were more likely than women to have experienced recurrent falls in the past year and scored higher than women on PA variables reflecting the life-periods of adolescence and young adulthood. Participants in the younger-old group (65–74 years old) scored higher on basic mobility and were less likely to be at risk for falls, than the older-old group (75–92 years old).

At least one fall in the past year (≥ 1 fall/year) and PA history

Table 3 presents both univariate and multivariable relationships between ≥ 1 fall/year and seven independent variables, in total and stratified by residence. The univariate analysis for the total sample, revealed increased odds of having had at least one fall in the past year among participants who; described more PA in adolescence or young adulthood, or lived in rural communities. The multivariable analysis stratified by residence, however, revealed that urban participants who described more PA in middle adulthood were less likely to have experienced a fall in the past year when accounting for PA in other life-periods, age-group, and gender (OR = 0.2; 95% CI = 0.05–0.9).

Recurrent falls in the past year (≥ 2 falls/year) and PA history

Table 4 presents both univariate and multivariable relationships between recurrent falls and seven independent variables, in total and stratified by residence. The univariate analysis for the total sample, revealed increased odds of having experienced recurrent falls in the past year among; men, participants who described more PA history during adulthood, (young, middle, and late) and rural participants. The multivariable analysis within the rural group, confirmed that compared to women, men were more likely to have experienced recurrent falls when accounting for PA in all life-periods and age-group (OR = 0.2; 95% CI 0.1–0.7).

Late-life basic mobility (TUG) and PA history

Table 5 presents both univariate and multivariable relationship between late-life basic mobility (TUG) and seven independent variables, in total and stratified by residence. The univariate analysis for the total sample,

Table 1. Participants' background characteristics in total and by residence, gender, and age-group.

		Residence			Gender			Age-group		
Variables	Total sample N = 175	Urban n = 105	Rural n = 70	*p*-value	Man n = 100	Woman n = 75	*p*-value	Younger-old n = 104	Older-old n = 71	*p*-value
Age, years, M (SD) [range]	74.2 (6.3) [65–92]	74.4 (6.4) [65–92]	73.9 (6.2) [65–89]	0.550	74.3 (6.2) [65–92]	74 (6.4)[65–92]	0.727	–	–	–
Gender, man, n (%)	100 (57)	63 (60)	37 (53)	0.350	–	–	–	55 (52.9)	45(63)	0.168
Residence, urban, n (%)	105 (60)	–	–	–	63 (63)	42 (56)	0.350	61 (59)	44 (62)	0.660
Educational level, primary school only, n (%)	78 (45.1)	40 (38.1)	38 (55.9)	0.022*	36 (36.0)	42 (57.5)	0.005	43 (42.2)	35 (49.3)	0.353
Medical diagnoses, M (SD) [range]	2.9 (1.7) [0–9]	3.2 (1.7) [0–8]	2.5 (1.8) [0–9]	0.009*	2.8 (1.7) [0–8]	2.9 (1.8) [0–9]	0.765	2.8 (1.6) [0–7]	3.0 (1.9) [0–9]	0.289
Medications, M (SD) [range]	3 (2.7) [0–10]	3.5 (2.8) [0–10]	2.3 (2.5) [0–10]	0.004*	3.2 (2.8) [0–10]	2.9 (2.7) [0–10]	0.451	2.5 (2.5) [0–10]	3.9 (2.8) [0–10]	<0.001*
Living alone, n (%)	40 (22.9)	29 (27.6)	11 (15.7)	0.066	19 (19)	21 (28)	0.161	19 (18.3)	21 (29.6)	0.080
Indoor walking aid, n (%)	4 (2.3)	2 (1.9)	2 (3)	0.654	2 (2)	2 (2.8)	0.746	4 (3.8)	0 (0)	0.104
Outdoor walking aid, n (%)	34 (19.4)	19 (18.1)	15 (21.4)	0.585	15 (15)	19 (25.3)	0.087	12 (11.5)	22 (31)	0.001*
BMI, kg/m^2, M (SD) [range]	28 (5) [19–56]	28 (5) [19–46]	28 (6) [20–56]	0.739	28 (5) [20–41]	28 (6) [19–56]	0.940	29 (6) [20–56]	27 (5) [19–41]	0.082

Comparisons by residence, gender, and older age-groups are based on independent *t*-test for continuous data and Pearson's chi-square test for binary data. Significant associations are marked with * ($p < 0.05$). M: mean. SD: standard deviation. Range: highest and lowest value. BMI: Body Mass Index. Younger-old: ages 65-74. Older old: ages 75-92. Percentages (%) are based on valid data for each variable. Missing data; education (n = 2), medical diagnoses (n = 2), indoor walking aid (n = 4).

Table 2. Falls in the past year, basic mobility, late-life fall risk and lifetime physical activity in total and by residence, gender, and age-group.

		Residence			Gender			Age-group		
Variables	Total sample N = 175	Urban n = 105	Rural n = 70	*p*-value	Man n = 100	Woman n = 75	*p*-value	Younger-old n = 104	Older-old n = 71	*p*-value
Physical functioning										
Fall, ≥ 1 fall/year, n (%)	46 (26.3)	13 (12.4)	33 (47)	<0.001*	29 (29)	17 (22.7)	0.346	32 (30.1)	14 (19.7)	0.103
Recurrent falls, ≥ 2 falls/year, n (%)	25 (14.4)	3 (2.9)	22 (31.4)	<0.001*	19 (19)	6 (8.1)	0.043*	18 (17.5)	7 (9.9)	0.159
Basic mobility, TUG, sec, M (SD) [range]	10.4 (2.7) [5–24]	10.1 (2.4) [6–18]	10.8 (3.1) [5–24]	0.111	10.2 (2.3) [6–17]	10.54 (3.2) [5–24]	0.438	9.8 (2.5)[5–23]	11.2 (2.9) [6–24]	<0.001*
Late-life fall risk, TUG ≥ 12 sec, n (%)	45 (26.8)	22 (21.2)	23 (35.9)	0.036*	26 (27.1)	19 (26.4)	0.920	19 (19)	26 (38.2)	0.006*
PA in adolescence				0.001*			<0.001*			0.562
Never, n (%)	16 (9.3)	13 (12.5)	3 (4.4)		5 (5.1)	11 (15.1)		8 (7.8)	8 (11.4)	
1–3 days/week, n (%)	47 (27.3)	35 (33.7)	12 (17.7)		21 (21.2)	26 (35.6)		32 (31.4)	15 (21.4)	
Most days of the week, n (%)	109 (63.4)	56 (53.8)	53 (77.9)		73 (73.7)	36 (49.3)		62 (60.8)	47 (67.2)	
PA in young adulthood				<0.001*			0.003*			0.391
Never, n (%)	24 (14)	21 (20.2)	3 (4.4)		7 (7.1)	17 (23.3)		13 (12.8)	11 (15.7)	
1–3 days/week, n (%)	56 (32.5)	46 (44.2)	10 (14.7)		31 (31.3)	25 (34.2)		39 (38.2)	17 (24.3)	
Most days of the week, n (%)	92 (53.5)	37 (35.6)	55 (80.9)		61 (61.6)	31 (42.5)		50 (49)	42 (60)	
PA in middle adulthood				<0.001*			0.069			0.812
Never, n (%)	29 (16.9)	25 (24)	4 (5.9)		13 (13.1)	16 (21.9)		12 (11.8)	17 (24.3)	
1–3 days/week, n (%)	60 (34.9)	43 (41.4)	17 (25)		33 (33.3)	27 (37)		45 (44.1)	15 (21.4)	
Most days of the week, n (%)	83 (48.2)	36 (34.6)	47 (69.1)		53 (53.6)	30 (41.1)		45 (44.1)	38 (54.3)	
PA in late adulthood				0.004*			0.620			0.290
Never, n (%)	37 (21.5)	32 (30.8)	5 (7.4)		18 (18.2)	19 (26)		17 (16.7)	20 (28.6)	
1–3 days/week, n (%)	80 (46.5)	43 (41.3)	37 (54.4)		50 (50.5)	30 (41.1)		52 (51)	28 (40)	
Most days of the week, n (%)	55 (32)	29 (27.9)	26 (38.2)		31 (31.3)	24 (32.9)		33 (32.3)	22 (31.4)	

Comparisons by residence, gender, and older age-groups are based on independent *t*-test for continuous data and Pearson's chi-square test for binary data. Significant associations are marked with * ($p < 0.05$). M: mean. SD: standard deviation. Range: highest and lowest value. TUG: Timed Up & Go test. PA: Physical activity. Adolescence: ages 12–19. Young adulthood: ages 20–39. Middle adulthood: ages 40–65. Late adulthood: age 65 to present. Younger-old: ages 65-74. Older old: ages 75-92. Percentages (%) are based on valid data for each variable. Missing data; falls (n = 1), TUG (n = 9), PA history (n = 3).

revealed a significant association only between worse late-life basic mobility and being in the older-old group. The multivariable analysis revealed varying results based on urban and rural residence. It was only in the urban group that worse late-life basic mobility was associated with being in the older-old group when accounting for PA in all life-periods and gender (β = 0.07; 95% CI = 0.037–0.11). In the rural group, however, better late-life basic mobility was associated with more PA in late adulthood when accounting for PA in all other life-periods, age-group, and gender (β = −0.07; 95% CI-0.01 to −0.14).

Late-life fall risk (TUG ≥ 12 sec) and PA history

Table 6 presents both univariate and multivariable relationship between late-life fall risk and seven independent variables, in total and stratified by residence. Based on the univariate analysis for the total sample, decreased late-life fall risk was associated with urban living (OR = 0.5; 95% CI = 0.24–0.96) but being in the older-old group increased the risk (OR = 2.6; 95% CI = 1.3–5.3). The multivariable analysis stratified by residence, however, revealed that increased late-life fall risk in the older-old group was only seen among urban participants (OR = 5.2; 95% CI = 1.8–15.2) when accounting for PA in all life-periods and adjusted for age-group.

Discussion

The results describe the history of falls in the past year, basic mobility, late-life fall risk, and lifetime PA history among older community-dwelling Icelanders; including interesting variations based on participants' rural-urban residence, gender, and older age-group. Compared to participants in urban areas, rural participants were more likely to have history of falls in the past year, higher prevalence of late-life fall risk, and they described more PA in all studied life-periods. Compared to women, men were more likely to have experienced recurrent falls in the past year, and they described more PA in adolescence and young adulthood. Compared to participants in the younger-old group, the older-old group had worse basic mobility and had higher prevalence of late-

Table 3. At least one fall in the past year and its association with seven independent variables, in total and stratified by residence.

	Univariate regression		Multivariable model 1		Multivariable model 2*	
Independent variables	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Total sample						
PA in adolescence	1.9 (1.04–3.5)	0.038*	1.5 (0.7–3.1)	0.274	1.5 (0.7–3.2)	0.282
PA in young adulthood	1.8 (1.1–3.2)	0.021*	2.0 (0.9–4.4)	0.083	2.1 (1.0–4.7)	0.065
PA in middle adulthood	1.2 (0.8–1.9)	0.411	0.6 (0.3–1.3)	0.163	0.6 (0.3–1.3)	0.165
PA in late adulthood	1.3 (0.8–2.0)	0.320	1.4 (0.7–2.7)	0.311	1.3 (0.7–2.6)	0.393
Residence	0.2 (0.09–0.3)	<0.001*				
Gender	0.7 (0.4–1.4)	0.347			0.9 (0.4–1.9)	0.742
Age-group	0.6 (0.3–1.1)	0.105			0.5 (0.2–1.0)	0.065
Urban						
PA in adolescence	1.7 (0.7–4.5)	0.275	2.5 (0.7–8.3)	0.143	2.5 (0.7–8.9)	0.145
PA in young adulthood	1.2 (0.5–2.7)	0.685	1.3 (0.4–3.9)	0.683	1.3 (0.4–4.2)	0.669
PA in middle adulthood	0.7 (0.3–1.5)	0.357	0.2 (0.05–0.9)	0.038*	0.2 (0.05–0.9)	0.032*
PA in late adulthood	1.1 (0.5–2.3)	0.885	2.9 (0.8–10.6)	0.103	2.7 (0.8–9.3)	0.121
Gender	0.6 (0.2–2.2)	0.471			0.7 (0.2–2.7)	0.598
Age-group	0.6 (0.2–2.0)	0.389			0.5 (0.1–1.9)	0.313
Rural						
PA in adolescence	1.2 (0.5–2.9)	0.738	1.3 (0.5–3.9)	0.593	1.2 (0.4–3.8)	0.707
PA in young adulthood	1.0 (0.4–2.4)	0.912	1.2 (0.3–4.9)	0.756	1.0 (0.2–4.3)	0.973
PA in middle adulthood	0.7 (0.3–1.7)	0.446	0.6 (0.2–2.1)	0.416	0.8 (0.2–2.8)	0.668
PA in late adulthood	0.8 (0.4–1.8)	0.631	0.9 (0.4–2.5)	0.908	0.6 (0.8–0.3)	0.609
Gender	0.6 (0.2–1.4)	0.222			0.4 (0.1–1.3)	0.134
Age-group	0.5 (0.2–1.4)	0.182			0.4 (0.1–1.1)	0.084

Statistics are based on binary logistic regression analysis. Significant associations are marked with * ($p < 0.05$). OR: odds ratio. CI: confidence interval. PA: Physical activity. Adolescence: ages 12–19. Young adulthood: ages 20–39. Middle adulthood: ages 40–65. Late adulthood: age 65 to present.
Rating scales for the independent variables: Physical Activity: never (0), 1–3 days/week (1), most days of the week (2). Residence: rural (1), urban (2). Gender: man (1), woman (2). Age-group: ages 65–74 (1), ages 75–92 (2).

Table 4. Recurrent falls in the past year and the association with seven independent variables, in total and stratified by residence.

	Univariate regression		Multivariable model 1		Multivariable model 2	
Independent variables	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Total sample						
PA in adolescence	1.8 (0.8–3.9)	0.143	0.2 (0.3–2.5)	0.868	0.8 (0.3–2.2)	0.630
PA in young adulthood	3.0 (1.3–7.0)	0.011*	2.3 (0.7–7.1)	0.149	2.4 (0.7–7.5)	0.149
PA in middle adulthood	2.6 (1.2–5.5)	0.012*	1.4 (0.5–4.0)	0.552	1.5 (0.5–4.5)	0.454
PA in late adulthood	2.0 (1.1–3.8)	0.031*	1.4 (0.6–3.1)	0.430	1.4 (0.6–3.1)	0.423
Residence	0.1 (0.02–0.2)	<0.001*				
Gender	0.4 (0.1–1.0)	0.049*			0.4 (0.1–1.2)	0.091
Age-group	0.5 (0.2–1.3)	0.164			0.4 (0.2–1.1)	0.083
Urban						
PA in adolescence	0.9 (0.2–4.2)	0.853	1.1 (0.2–8.2)	0.910		
PA in young adulthood	0.7 (0.2–3.5)	0.711	0.7 (0.1–6.4)	0.786		
PA in middle adulthood	0.8 (0.2–3.7)	0.806	0.7 (0.1–9.2)	0.788		
PA in late adulthood	1.1 (0.2–4.7)	0.947	1.5 (0.2–14.3)	0.740		
Gender	–	–				
Age-group	–	–				
Rural						
PA in adolescence	1.2 (0.5–3.3)	0.689	0.8 (0.2–2.7)	0.671	0.6 (0.1–2.3)	0.415
PA in young adulthood	1.9 (0.6–6.3)	0.289	1.4 (0.3–7.2)	0.654	0.9 (0.2–5.1)	0.919
PA in middle adulthood	2.0 (0.7–5.4)	0.186	1.4 (0.3–6.0)	0.623	2.0 (0.4–9.3)	0.376
PA in late adulthood	1.9 (0.8–4.5)	0.171	1.5 (0.5–4.4)	0.421	1.6 (0.5–5.4)	0.473
Gender	0.3 (0.1–0.9)	0.028*			0.2 (0.1–0.7)	0.013*
Age-group	0.7 (0.2–1.9)	0.433			0.5 (0.1–1.6)	0.227

Statistics are based on binary logistic regression analysis. We were unable to run all binary logistic regression analyses in the urban group, due to zero cell count among women and the older-old. Significant associations are marked with * ($p < 0.05$). OR: odds ratio. CI: confidence interval. PA: Physical activity. Adolescence: ages 12–19. Young adulthood: ages 20–39. Middle adulthood: ages 40–65. Late adulthood: age 65 to present.
Rating scales for the independent variables: Physical Activity: never (0), 1–3 days/week (1), most days of the week (2). Residence: rural (1), urban (2). Gender: man (1), woman (2). Age-group: ages 65–74 (1), ages 75–92 (2).

life fall risk. In the urban group, accounting for gender, age-group, and PA in other life-periods; no fall history in the past year was independently associated with more PA in middle adulthood; and both worse basic mobility and late-life fall risk were independently associated with being in the older-old age-group. In the rural group, accounting for age-group, and PA in all life-periods; having experienced recurrent falls was independently associated with being a man; and better late-life basic mobility was independently associated with more PA in late adulthood (age 65 to present).

Table 5. Late-life basic mobility (Timed Up & Go score in sec) and its association with seven independent variables, in total and stratified by residence.

	Univariate regression		Multivariable model 1		Multivariable model 2	
Independent variables	β (95% CI)	*p*-value	β (95% CI)	*p*-value	β (95% CI)	*p*-value
Total sample						
PA in adolescence	0.002 (−0.023–0.027)	0.880	−0.008 (−0.038–0.023)	0.624	−0.003 (−0.034–0.027)	0.829
PA in young adulthood	0.007 (−0.015–0.03)	0.516	0.006 (−0.027–0.040)	0.710	0.004 (−0.028–0.037)	0.796
PA in middle adulthood	0.006 (−0.016–0.028)	0.610	0.026 (−0.010–0.063)	0.152	0.026 (−0.009–0.061)	0.151
PA in late adulthood	−0.014 (−0.037–0.008)	0.214	−0.034 (−0.064- −0.003)	0.033*	−0.028 (−0.058–0.002)	0.070
Residence	−0.025 (−0.058–0.008)	0.133				
Gender	0.009 (−0.024–0.041)	0.598			0.019 (−0.014–0.053)	0.263
Age-group	0.058 (0.026–0.089)	<0.001*			0.056 (0.023–0.088)	<0.001*
Urban						
PA in adolescence	−0.008 (−0.036–0.020)	0.567	−0.015 (−0.050–0.021)	0.410	−0.011 (−0.045–0.023)	0.516
PA in young adulthood	<0.001 (−0.027–0.027)	0.982	0.012 (−0.026–0.049)	0.548	0.005 (−0.032–0.041)	0.801
PA in middle adulthood	−0.006 (−0.03–0.020)	0.661	0.001 (−0.041–0.044)	0.954	0.006 (−0.035–0.047)	0.766
PA in late adulthood	−0.009 (−0.035–0.016)	0.476	−0.013 (−0.050–0.025)	0.505	−0.012 (−0.048–0.023)	0.486
Gender	0.009 (−0.031–0.048)	0.654			0.006 (−0.035–0.048)	0.771
Age-group	0.070 (0.033–0.107)	<0.001*			0.069 (0.031–0.107)	<0.001*
Rural						
PA in adolescence	0.013 (−0.04–0.066)	0.618	0.027 (−0.034–0.088)	0.380	0.029 (−0.035–0.092)	0.370
PA in young adulthood	0.001 (−0.054–0.056)	0.969	−0.032 (−0.108–0.044)	0.403	−0.028 (−0.107–0.051)	0.477
PA in middle adulthood	0.016 (−0.035–0.066)	0.533	0.066 (−0.005–0.137)	0.069	0.061 (−0.014–0.135)	0.107
PA in late adulthood	−0.046 (−0.095–0.002)	0.060	−0.079 (−0.135- −0.022)	0.007*	−0.073 (−0.135- −0.012)	0.020*
Gender	0.004 (−0.053–0.062)	0.881			0.015 (−0.047–0.078)	0.627
Age-group	0.040 (−0.018–0.169)	0.169			0.018 (−0.046–0.082)	0.571

Statistics are based on linear regression analysis and the dependent variable is a log-transformed (log10) Timed Up & Go test score (TUG). Higher score on TUG reflects worse basic mobility. Significant associations are marked with * ($p < 0.05$). CI: confidence interval. PA: Physical activity. Adolescence: ages 12–19. Young adulthood: ages 20–39. Middle adulthood: ages 40–65. Late adulthood: age 65 to present.
Rating scales for the independent variables: Physical Activity: never (0), 1–3 days/week (1), most days of the week (2). Residence: rural (1), urban (2). Gender: man (1), woman (2). Age-group: ages 65–74 (1), ages 75–92 (2).

Table 6. Late-life fall risk and its association with seven independent variables, in total and stratified by residence.

	Univariate regression		Multivariable model 1		Multivariable model 2	
Independent variables	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Total sample						
PA in adolescence	1.1 (0.7–2.0)	0.618	1.0 (0.5–1.9)	0.940	1.0 (0.5–2.1)	0.928
PA in young adulthood	1.2 (0.8–2.0)	0.412	1.1 (0.5–2.2)	0.852	1.0 (0.5–2.1)	0.989
PA in middle adulthood	1.3 (0.8–2.0)	0.355	1.5 (0.7–3.3)	0.307	1.5 (0.7–3.4)	0.301
PA in late adulthood	1.0 (0.6–1.6)	0.882	0.7 (0.4–1.4)	0.319	0.8 (0.4–1.5)	0.455
Residence	0.5 (0.24–0.96)	0.037*			…	
Gender	1.0 (0.5–1.9)	0.920			1.2 (0.6–2.6)	0.630
Age-group	2.6 (1.3–5.3)	0.007*			2.6 (1.3–5.3)	0.009*
Urban						
PA in adolescence	1.0 (0.5–1.9)	0.890	0.9 (0.4–2.1)	0.819	1.0 (0.4–2.6)	0.949
PA in young adulthood	1.0 (0.5–2.0)	0.903	1.0 (0.4–2.5)	1.000	0.8 (0.3–2.3)	0.730
PA in middle adulthood	1.2 (0.6–2.2)	0.647	1.2 (0.4–3.2)	0.787	1.3 (0.4–4.3)	0.628
PA in late adulthood	1.2 (0.6–2.1)	0.653	1.1 (0.4–2.5)	0.910	1.0 (0.4–2.9)	0.959
Gender	1.3 (0.5–3.4)	0.586			1.4 (0.5–4.2)	0.547
Age-group	5.1 (1.8–14.6)	0.002*			5.2 (1.8–15.2)	0.002*
Rural						
PA in adolescence	1.1 (0.4–3.0)	0.785	1.6 (0.5–5.2)	0.425	1.5 (0.5–5.0)	0.506
PA in young adulthood	0.9 (0.3–2.3)	0.795	0.7 (0.2–3.2)	0.666	0.6 (0.1–3.0)	0.530
PA in middle adulthood	0.9 (0.36–2.1)	0.783	1.6 (0.4–6.4)	0.506	1.9 (0.4–8.1)	0.398
PA in late adulthood	0.4 (0.2–1.1)	0.084	0.3 (0.1–1.0)	0.051	0.3 (0.1–1.0)	0.057
Gender	0.6 (0.2–1.7)	0.354			0.6 (0.2–2.0)	0.412
Age-group	1.5 (0.5–4.2)	0.460			0.8 (0.2–2.8)	0.771

Statistics are based on binary logistic regression analysis. Significant associations are marked with * ($p < 0.05$). OR: odds ratio. CI: confidence interval. PA: Physical activity. Adolescence: ages 12–19. Young adulthood: ages 20–39. Middle adulthood: ages 40–65. Late adulthood: age 65 to present.
Rating scales for the independent variables: Physical Activity: never (0), 1–3 days/week (1), most days of the week (2). Residence: rural (1), urban (2). Gender: man (1), woman (2). Age-group: ages 65–74 (1), ages 75–92 (2).

The proportion of men was unusually high for a population-based study among older people. This does likely reflect the inclusion of people from rural areas where men are more likely to live than women [20] and that more women than men declined participation in the study. Participants' background characteristics revealed well-known gender and age-related differences, and emerging residence-related differences. In the literature, ageing in rural areas has been associated with many negative factors including poor health [32,33]. In contrast, our rural participants had fewer medical diagnoses and used fewer prescribed medications than the urban participants. This is a noteworthy change since 2004, when rural older adults in Northern Iceland reported more medical diagnoses than urban adults [34]. In 2004, however, the rural older Icelanders used less medication than the urban group which is in line with present findings.

Compared to both gender and age-group, participants' residence was more frequently associated with indicators of late-life physical functioning and lifetime PA history. While our findings of a higher frequency of falls among older people in rural areas supports other research results [35], this also contradicts findings in which residence was not associated with falls [36]. A better basic mobility in the younger-old group than the older-old group, is widely known and reflected in published reference values for TUG [37]. In contrast with earlier research [38,39], falls in the past year were not associated with older age-groups. Moreover, the findings revealed that gender was not associated with a fall in the past year, and recurrent falls were more common among men than women. This contradicts former research revealing older women being more likely than older men to have both a history of a fall [40,41] and to have experienced recurrent falls [42].

Rural participants reported more PA in all life-periods than urban participants, but former research findings on residence's association with PA in various life-periods are quite diverse and may reflect cohort and cultural differences in lifestyle. For example, in modern Iceland, adolescents seem to be less active if they live rurally compared to living in urban areas [43], which is contrary to research findings from Brazil revealing more PA among adolescents in rural areas [44]. This research from Brazil also showed that young people in rural areas were active through physical work rather than exercise. The same was evident in a study among 65–88–year-old Icelanders, where a large proportion of PA in Arctic rural areas involved physically demanding work [14]. This all relates to evidence supporting that if research focuses on PA in leisure time only, adults and older adults in rural areas are less active than urban people [14,32,45]. In our study, the PA question did not differentiate among the contexts in which participants physically exerted themselves. Therefore, a physically demanding work environment may be behind the uninterrupted lifetime history of PA among people ageing in rural communities.

The relationship between late-life physical functioning and PA history varied by rural and urban residence. Previous studies have shown that older people who have been physically active during their lifetime have better physical functioning than those who have a history of inactivity [8,9,46,47]. Our study reflects this differently in the urban and rural groups. In the urban group, increased PA in middle adulthood specifically was independently associated with lesser odds of having fallen at least once in the past year. This association is known [48,49] and provides the basis for the World Health Organization [11] recommending regular PA of at least moderate intensity to decrease fall risk and prevent fall-related injuries. However, in the rural group better late-life basic mobility was associated with more PA in late adulthood. Our results did not manage to support other research where more PA in earlier life-periods is associated with better basic mobility in late life [7,9,46]. In this context, it is important to note that our participants had to depend on a single item PA assessment, and their memory to report events in the past year and to compare former perceived physical exertion with the present.

Interestingly, men in rural areas were most likely of the participants to fall repeatedly, which may support research revealing that rural people commonly fall outdoors [35]. Falling outdoors has been associated with more physically intensive activities, while falling indoors is associated with poor health and frailty [50]. Younger age and being a man are also known risk factors for outdoor falls [51]. The recurrent falls among rural men can possibly be traced to the challenging Arctic outdoor environment and physically demanding tasks such as walking on uneven ground, lifting heavy objects, and taking care of domestic animals. According to Dynamic Systems Theory [52], experiencing a loss of balance or a fall not only depends on the capacity of the individual but also on the environment and the task at hand. Therefore, our results may differ from others because we included older people in Arctic rural areas where the daily physical environment may be quite challenging and therefore people may fall despite good physical functioning. Moreover, those who have been physically active throughout life might be taking even more risks and engaging in tasks that challenge their balance which may explain why our results from univariate analyses generally pointed in the direction of more PA history being associated with increased odds of reporting at least one fall or recurrent falls in the past year.

The results of this study should be interpreted with the following limitations and strengths in mind. The research area was restricted to Northern Iceland, yet the findings may be of value for other remote and Arctic regions. This was a cross-sectional study where participants had to depend on their memory to report on past events and PA history, and a single item self-assessment of PA can only capture a limited version of a PA history. Despite the face validity of the PA self-report measure, further psychometric properties have not been established. The sample was small which limited the statistical power and the number of variables in regression models. Therefore, regression analyses were restricted to main effects of independent variables. Moreover, it should be kept in mind that residency been described as a value-loaded variable [53] which may reflect multiple environmental components such as population density, physical geography, exposure to climate changes, access to health and recreational services, how well outdoor spaces are lit (artificial light), and social norms. These aspects of residency may potentially affect aspects of basic mobility, falls and physical activity, and should be researched further. The main strength of the study is that it is based on a stratified random sample from a National Registry. In addition, data was collected via face-to-face interviews and testing, which promoted the participation of people who had problems with reading, hearing, or writing. Finally, as our goal was to reflect the diversity of the community-dwelling population we decided not to exclude people with suspected minor cognitive impairments but included participants if they had enough cognitive functioning to communicate verbally by telephone and independently set up a meeting time.

Conclusions

The findings support a complex and an important association between the environmental context and older adults' characteristics, physical functioning, and history of physical activity. Older people in rural areas have a lifelong history of exerting themselves physically and the rural men seem to be particularly prone to recurrent falls. The causes and consequences of falls among rural older adults deserve more attention in research contexts, as do the potential influences of Arctic living environments on both lifetime PA and risk for falls. The findings on PA history may be helpful for educational and counselling purposes and to promote PA, especially among middle-aged and older adults. Yet, high quality longitudinal data collection is needed to further study the causal relationship between lifetime PA and late-life physical functioning. Big data that people collect on a variety of contemporary mobile devices may become a feasible option for answering future research questions on lifetime PA and its potential influences on late-life physical functioning.

Geolocation information

The research was carried out in Northern Iceland which is a relatively sparsely populated area which includes an urban town, smaller towns, fishing villages and rural agricultural area. This area of Iceland is located between 65° and 67° North.

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Disclosure statement

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Statement of ethical approval

The Icelandic National Bioethics Committee approved the study (no. VSN-16-100), and all participants gave written informed consent prior to data collection.

Declaration of contribution of authors

SAA developed the protocol, analyzed the data, interpreted the data, and wrote the manuscript. LE analyzed the data, interpreted the data and wrote the first draft of the manuscript. AKS was a grant holder, developed the protocol, and co-wrote sections of the manuscript. All authors read, edited, and approved the final manuscript.

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