Time allocation to active daily domains, physical activity, and health indicators in older adults: Cross-sectional results from the OUTDOOR ACTIVE study.

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Abstract

Background

Physical activity (PA) is one of the key determinants of healthy ageing. Research showed that time allocation plays an important role in PA. Therefore, an understanding of the time use of older adults is crucial for developing PA programs. The aim of this study was to examine the associations of time allocation and objectively measured PA, and several health indicators in older adults.

Methods

In this cross-sectional study all 915 participants of the OUTDOOR ACTIVE study were included. The participants were 65 to 75 years old and resided in a subdistrict of Bremen, Germany (50.9% female). The active daily domains were derived from the SLOTH model (leisure activities, occupation, active transport, home-based activities). PA was objectively measured with accelerometers over seven consecutive days. Binary logistic regressions were used to test the associations of total PA and time spent in the domains with several health indicators (self-rated health, overweight, obesity, activities of daily living (ADL), handgrip strength).

Results

Participants over the age of 70 years were significantly less physically active than those under 70 years and women were significantly more physically active than men. Regardless of age and sex, most time was spent on home-based activities (women: 118.5 ± 87.8 min/day; men: 80.2 ± 69.4 min/day). Both PA and time spent on leisure activities were associated with a lower risk of bad self-rated health (0.36; 95%-CL: 0.20, 0.65 for PA; 0.93; 95%-CL: 0.87, 0.99 for leisure activities) and less limitations in ADL. PA and active transport seemed to lower the risk of overweight (0.39; 95%-CL: 0.25, 0.62 for PA; 0.80; 95%-CL: 0.69, 0.93 for active transport) and obesity (0.36; 95%-CL: 0.21, 0.60 for PA; 0.77; 95%-CL: 0.64, 0.92 for active transport). Having an occupation was associated with a lower risk of bad self-rated health (0.60; 95%-CL: 0.40, 0.92).

Conclusions

The results of this study provide insights in the time allocation to active daily domains and total PA of older adults, as well as the associations with health indicators. These findings have important implications for the development of PA programs. Future research should examine the associations further in longitudinal studies.

Background

One of the key determinants of healthy ageing is regular physical activity [1]. It is not only positively associated with increased quality of life and independent living, but also with decreased risks of numerous non-communicable diseases [2–4]. The World Health Organization recommends at least 150 minutes of moderate physical activity (PA) per week for adults, including leisure-time activities, active transportation, household chores, and occupational PA [2]. However, the prevalence of people meeting this recommendation declines with age [3]. In Germany, only 18.0% of the 60- to 69-year-olds and only 13.6% of the 70- to 79-year-olds are physically active for at least 150 minutes per week [5]. Previous research has identified daily time allocation as one of several determinants of PA [6] and time use studies have accumulated in public health research in recent years [7]. These studies have associated time spent on health-related behaviours with various health indicators [7]. Research, for instance, suggest that time spent on leisure, home-based, occupational, and transport-related PA are associated with self-rated health and body mass index (BMI) [8]. However, only few time use studies investigating associations with health indicators have focused on older adults [6, 9, 10] and have rarely examined age differences within the group of older adults.

After retirement, the time that was previously spent at work needs to be newly allocated. Research showed that, compared to working adults, older retired people dedicate more of their time to household chores, passive as well as active leisure activities, and sleep. However, PA through leisure activities remains the domain the least time is spent on each day, pre- and post-retirement [11, 12].

One study by Espinel et al. [13] distinguished time allocated to self-reported sedentary, light, and moderate to vigorous PA (MVPA) in non-working adults over 65 years. The reported activities were categorised into the different PA-levels using METs. Most of time spent in MVPA was caused by household chores, with women devoting more time to them than men. Men spent more time doing leisure activities. Only 25.0% of participants met sufficient MVPA-levels through leisure activities. The study did not find any associations with age or the socioeconomic status [13].

Eibich [14], contrastingly, found that time spent on leisure activities, active and inactive, increases by one hour per day after retirement. He also found that time spent on repairs and gardening, as well as household chores increases and concludes that most retirees invest their new found time in an active lifestyle [14].

Taking together the literature, the existing evidence suggests that most older adults invest more time into household chores as well as leisure activities and has indicated some gender differences. However, past studies on time use of older adults have often assessed PA with self-report measures. Moreover, apart from gender, little is known about how other demographic variables might affect time use. One important variable in this context might be occupational status past retirement age. Past research has shown that retirees may have more leisure time than those still working, and might invest that time in health promoting behaviours, such as physical activity [15]. In addition, there might be age differences within the group of older adults regarding time use, though this has been insufficiently studied.

The aim of this cross-sectional study is to examine the associations between time spent in active life domains, objectively measured PA, and health indicators in older adults in Germany. Specifically, we focus

on the differences between two age groups (under and over 70 years) and sex. We furthermore explore differences in time allocation between working and non-working older adults.

Knowledge about time allocation of older adults to active daily domains and their associations with health indicators provides important background information for the development of future PA programs.

Methods

Study design and population

The OUTDOOR ACTIVE study is part of the regional prevention network AEQUIPA (Physical activity and health equity: primary prevention for healthy ageing) [16]. Research goals of OUTDOOR ACTIVE are to assess prevalence of PA in older adults, explore barriers and drivers for being physically active, and to develop and implement a community-based outdoor PA promotion program [17]. First baseline data were collected between October 2015 and August 2016 using 1) a self-administered paper-pencil questionnaire regarding intrapersonal, interpersonal, and environmental determinants of PA, 2) a short physical examination (anthropometry and blood pressure) followed by a fitness test (modified public domain Senior Fitness Test [18] and handgrip strength test), and 3) accelerometry to objectively measure PA over the course of seven consecutive days.

Eligibility criteria included being between 65 and 75 years old, being non-institutionalised, and living in the district Hemelingen in the city of Bremen, in the North-West of Germany. Address data were provided by the registry office in Bremen in August 2015. All eligible individuals initially received a letter and were later contacted by phone, in cases where the number could be obtained through one of the available registers. In total, 4304 individuals were registered in the study region. Of these, 615 people were excluded because of acute health problems (n = 242), language barriers (n = 22), moving out of the study region (n = 295), or death (n = 56). Out of the remaining eligible 3689 individuals, 720 were never reached, 2052 refused participation, and 915 individuals took part in the OUTDOOR ACTIVE study (response rate: 24.8%). All participants provided written informed consent and the study was approved by the ethics committee of the University of Bremen in September 2015.

In the present study, all 915 OUTDOOR ACTIVE participants were included. For analyses with accelerometer data, 570 participants, who wore the accelerometer for at least 20 hours a day, were included.

Measures

Accelerometer-assessed physical activity

To measure PA objectively, ActiGraph GT3x-BTw accelerometers were handed to the participants following the fitness test. They were asked to wear them on seven consecutive days, ideally for 24 hours straight, on their non-dominant wrist. The epoch length was set to 30 Hz. The participants were given short instructions on when to take them off (e.g. when using the sauna) and how to put them back on. Members of the project group collected the accelerometers after one week at the participants' homes, cleaned them, and

downloaded the data with ActiLife (Version 6.13.3 ActiGraph LLC, Pensacola, FL, USA). After preparing the data in ActiLife for statistical analyses, it was then transferred to the SPSS database. Average daily counts (vector magnitudes) were included in the analyses. Non-wear time was defined as 90 consecutive minutes with zero counts [19].

Assessment of the SLOTH model dimensions

We used the time budget SLOTH model (Sleep, Leisure, Occupation, Transport, Home-based activities) [20] to explore how the participants allocate their time during the day. Sleep was not included in the analyses since we only considered active domains (active leisure, occupation, active transport, home-based activities). Activities and time spent in these four domains were assessed by self-administered questionnaire.

For assessment of active leisure, we asked participants to report all organised (e.g. sports club, sports group, or a gym) as well as non-organised activities. The reported hours per week for the individual activities were added up, excluding riding a bike, since this activity could also be interpreted as a mode of transport. All paid and unpaid work including volunteer work was included in the occupation domain. Time spent on carrying out the occupation was not asked and could therefore not be included in the analyses. Time spent in active transport was assessed with a question based on the public domain Neighbourhood Environment and Walkability Scale (NEWS) [21] using twelve common destinations. The usual mode of transport as well as time spent on the trips were assessed. To calculate the average daily time spent in active transport, the frequency for each destination was estimated (see additional file 1). For the analyses only transport via bike and on foot were used. Home-based activities, which comprise housework and gardening, were assessed with the same question as leisure activities (i.e., hours per week engaging in the activities). To reduce the number of outliers, the maximum possible time for housework and gardening was set to 40 hours per week and for the rest of the active SLOTH dimensions to 20 hours per week.

Assessment of health indicators

Self-rated health and activities of daily living (ADL) were assessed via questions from the public domain SF-36 v1.0 questionnaire [22, 23]. BMI was calculated using body weight (in kg) and height (in m), both measured during the short physical examination with a Kern MPC 250K 100M personal floor scale (Kern & Sohn GmbH, Ballingen, Germany) and a Seca 217 mobile Stadiometer (Seca GmbH & Co. KG, Hamburg, Germany), respectively. The classification by the WHO [24] was used for the distinction between normal weight, overweight, and obesity. Data on handgrip strength were collected during the fitness test using the Saehan DHD-3 Digital Hand Dynamometer SH1003 (Saehan Corporation, Changwon, South Korea) and the results were categorized using age and sex specific reference ranges [25].

Sociodemographic information

Participant’s age, sex, marital status, educational status, net household income, and occupational status were assessed by a self-administered questionnaire.

To assign each participant a socio-economic status (SES), an additive social class index was calculated using educational years (school years and training years combined), net household income (OECD), and the Standard International Occupational Prestige Scale based on Helmert et al [26]. Missing values were imputed using multiple imputation in SPSS 22 (IBM Corp. Armonk, NY) with five imputations, and the mean value as the final data. The SES was categorized into quintiles.

Statistical analyses

For the descriptive analyses absolute and relative frequencies were calculated for education level, marital status, socio-economic status, self-reported health, and occupational status. Means and standard deviations were calculated for age, total PA (Counts per minute, from here on CPM), and time spent in the active dimensions of the SLOTH model per day in minutes. The descriptive analyses were done separately for men and women, as well as for the two age groups (under and over 70 years). Each result is shown for the total study sample and separately for those participants, who actually perform these activities. Furthermore, the percentage of people engaging in these activities is shown.

To test for significant differences between groups, Mann-Whitney-U-tests were conducted since none of the variables were normally distributed.

Binary logistic regressions were used to test if total PA and the time spent in the active SLOTH model domains are significantly associated with several health outcomes (self-rated health, overweight, obesity, ADL, handgrip strength).

For analyses including objective PA data only participants, who wore the accelerometer for at least 20 hours on average per day, were taken into account.

All statistical analyses were conducted with SPSS 22.0 (IBM Corp. Armonk, NY).

Results

Table 1 shows descriptive characteristics of the study population. 50.9% of the participants were female and the mean age was 69.9 ± 3.1 years. 82.1% of the participants had lower secondary education, 59.8% belonged to middle class. 58.0% of the female and 82.2% of the male participants were married, and about half of them had a paid occupation or did volunteer work. The majority of participants (78.8%) rated their health as at least good with decreasing percentage in higher age groups.

The mean daily total PA shows a difference between men and women and a decline with higher age. Women over the age of 70 years were overall significantly less physically active than those younger than 70 years (1700.4 ± 432.4 CPM vs. 1840.0 ± 466.7 CPM, z=-2.6, p = < .01). The difference in men was also statistically significant, with older men being less physically active than their younger counterparts (1366.5 ± 316.2 CPM vs. 1475.1 ± 352.8 CPM, z=-2.9, p = < .01). Women were significantly more physically active than men (1770.4 ± 454.6 CPM vs. 1426.1 ± 340.5 CPM, z=-9.4, p = < .001).

Table 1
Characteristics of the study population

	Women			Men		
	Total (n = 465)	< 70 yrs (n = 210)	≥ 70 yrs (n = 255)	Total (n = 448)	< 70 yrs (n = 227)	≥ 70 yrs (n = 221)
	n (%)			n (%)		
Education						
Lower secondary education	374 (85.0)	162 (81.8)	210 (87.6)	332 (79.0)	151 (70.5)	181 (87.9)
Upper secondary education	56 (12.7)	31 (15.7)	25 (10.4)	77 (18.3)	56 (26.2)	21 (10.2)
No degree	10 (2.2)	5 (2.5)	5 (2.1)	11 (2.6)	7 (3.2)	4 (2.0)
Socioeconomic status						
Lower class	108 (24.6)	43 (21.9)	64 (26.6)	67 (15.9)	32 (15.0)	35 (16.9)
Middle class	264 (60.1)	112 (57.1)	151 (62.7)	250 (59.4)	122 (57.0)	128 (61.8)
Upper class	67 (15.3)	41 (20.9)	26 (10.8)	104 (24.7)	60 (28.0)	44 (21.3)
Marital status						
Married	251 (58.0)	118 (59.9)	133 (56.4)	347 (82.2)	179 (83.3)	168 (81.2)
Divorced	63 (14.5)	35 (17.8)	28 (11.9)	35 (8.3)	19 (8.8)	16 (7.7)
Widowed	99 (22.9)	33 (16.8)	66 (28.0)	20 (4.7)	4 (1.9)	16 (7.7)
Unwed/single	20 (4.6)	11 (5.6)	9 (3.8)	20 (4.7)	13 (6.0)	7 (3.4)
Occupational status						
Volunteer work only	162 (38.3)	76 (40.0)	86 (38.4)	114 (28.6)	58 (28.0)	56 (29.3)
Paid occupation only	37 (8.8)	26 (13.7)	11 (4.9)	67 (16.8)	42 (20.3)	25 (13.1)
Paid occupation + volunteer work	14 (3.3)	11 (5.8)	3 (1.3)	18 (4.5)	10 (4.8)	8 (4.2)
No occupation	201 (47.5)	77 (40.5)	124 (55.4)	199 (50.0)	97 (46.9)	102 (53.4)

	Women			Men		
Self-reported health status						
Less good or bad	103 (23.6)	39 (19.8)	64 (27.0)	78 (18.6)	37 (17.1)	41 (20.1)
Good	258 (59.2)	117 (59.4)	139 (58.6)	244 (58.1)	126 (58.3)	118 (57.8)
Very good or excellent	75 (17.2)	41 (20.9)	34 (14.4)	98 (23.4)	53 (24.6)	45 (22.0)
	Mean (SD)			Mean (SD)		
Age (years)	70.0 (3.1)	67.0 (1.4)	72.43 (1.7)	69.8 (3.1)	67.2 (1.5)	72.5 (1.9)
Total PA (CPM)	1770.4 (454.6)	1840.0 (466.7)	1700.4 (432.4)	1426.1 (340.5)	1475.1 (352.8)	1366.5 (316.2)
CPM: Counts per minute						

Table 2 reports the average time spent in the active domains of the SLOTH model stratified by age and sex in minutes per day. Disregarding the occupational domain where no time data is available, most time is spent on home-based activities (women: 118.5 ± 87.8 min/day; men: 80.2 ± 69.4 min/day), followed by active leisure time (women: 35.9 ± 34.0 min/day; men: 41.9 ± 36.8 min/day), and time in active transport (women: 14.4 ± 8.5 min/day; men: 12.5 ± 9.4 min/day). This pattern is consistent in all gender and age groups. The largest difference by age was found for home-based activities in women, where women ≥ 70 years spent roughly 20 minutes more time than younger women. There were sex differences in the amount of time spent in the investigated domains. Men spent statistically significantly more time on leisure activities than women (41.9 ± 36.8 vs. 35.9 ± 34.0 min/day, z=-2.3, p = .02). Women allocated statistically significantly more time to active transport (14.4 ± 8.5 vs. 12.5 ± 9.4 min/day, z=-3.8, p = < .01), home-based activities (118.5 ± 87.8 vs. 80.2 ± 69.4 min/day, z=-7.1, p = < .001), and housework (91.2 ± 69.5 vs. 44.1 ± 37.5 min/day, z=-11.4, p = < .001) per day.

Table 2
Time allocation to active SLOTH domains in minutes per day by age and sex

	Women			**Men**		
	Total (n = 465)	< 70 yrs (n = 210)	≥ 70 yrs (n = 255)	Total (n = 448)	< 70 yrs (n = 227)	≥ 70 yrs (n = 221)
	Mean (SD)			Mean (SD)		
Leisure, only active						
Total	21.1 (31.4)	22.8 (29.4)	19.6 (33.0)	20.9 (33.4)	24.6 (36.8)	17.2 (29.2)
Participation rate %	58.7	62.9	55.3	50.0	55.9	43.9
Performers only	35.9 (34.0)	36.2 (29.8)	35.5 (37.5)	41.9 (36.8)	43.9 (39.6)	39.2 (32.9)
Occupation, including volunteer work						
Total	§			§		
Participation rate %	56.8	63.3	51.4	55.6	57.3	53.9
Performers only	§			§		
Transport, only active						
Total	11.9 (9.5)	11.3 (8.4)	12.4 (10.2)	10.5 (9.7)	10.6 (10.1)	10.4 (9.3)
Participation rate %	84.6	85.7	80.8	83.9	86.3	81.5
Performers only	14.4 (8.5)	13.2 (7.6)	15.4 (9.1)	12.5 (9.4)	12.2 (9.9)	12.7 (8.8)
Home-based activities						
Total	101.4 (91.3)	93.4 (79.8)	108.0 (99.4)	69.5 (70.2)	70.1 (70.5)	68.8 (70.0)
Participation rate %	85.6	86.7	84.7	86.6	88.1	85.1
Performers only	118.5 (87.8)	107.5 (76.1)	127.5 (95.8)	80.2 (69.4)	79.5 (69.9)	80.9 (69.1)
Housework						
Total	76.5 (72.0)	72.2 (63.7)	80.1 (78.1)	35.4 (37.9)	37.4 (37.8)	33.4 (38.0)
Participation rate %	83.9	85.7	82.4	80.4	82.8	77.8
Performers only	91.2 (69.5)	84.2 (60.9)	97.2 (75.7)	44.1 (37.5)	45.1 (37.1)	42.9 (38.1)

	Women			Men		
Gardening						
Total	24.9 (39.4)	21.1 (32.9)	28.0 (43.8)	34.0 (48.8)	32.7 (49.2)	35.4 (48.6)
Participation rate %	62.2	61.4	62.8	72.3	70.0	74.7
Performers only	40.0 (43.4)	34.4 (36.2)	44.6 (48.1)	47.1 (51.8)	46.7 (52.9)	47.4 (50.9)
§ Data not available						
SD: Standard deviation						

Table 3 shows the average time spent in the active SLOTH domains stratified by occupation status and sex. Regardless of the occupation status and gender, most time is spent on home-based activities (women with no occupation: 118.3 ± 89.3 min/day; with an occupation: 116.5 ± 86.1 min/day; men with no occupation: 83.2 ± 68.3 min/day; with an occupation: 67.7 ± 75.8 min/day). Participants with a paid occupation spent less time on each domain than those without an occupation. The only exception can be observed in women regarding housework, where employed women devoted more time to housework activities than unemployed women (101.5 ± 76.2 min/day vs. 90.0 ± 69.2 min/day). However, none of the differences by occupation status were statistically significant, regardless of sex.

Table 3
Time allocation to active SLOTH domains in minutes per day by occupation status and sex

	Women		**Men**	
	No occupation (n = 360)	Occupation§ (n = 52)	No occupation (n = 312)	Occupation§ (n = 85)
	Mean (SD)		Mean (SD)	
Leisure, only active				
Total	23.0 (33.2)	19.8 (27.3)	22.8 (35.7)	19.8 (27.9)
Participation rate %	61.4	67.3	52.6	56.5
Performers only	37.4 (35.4)	29.4 (28.8)	43.3 (39.2)	35.0 (29.0)
Transport, only active				
Total	13.1 (9.4)	10.2 (8.3)	11.7 (10.1)	9.3 (8.0)
Participation rate %	89.7	78.9	91.0	87.1
Performers only	14.6 (8.7)	12.9 (7.3)	12.9 (9.9)	10.7 (7.7)
Home-based activities				
Total	107.2 (91.8)	105.3 (88.8)	77.1 (69.2)	61.3 (74.8)
Participation rate %	90.6	90.4	92.6	90.6
Performers only	118.3 (89.3)	116.5 (86.1)	83.2 (68.3)	67.7 (75.8)
Housework				
Total	80.3 (71.1)	87.9 (78.9)	39.7 (38.8)	31.8 (37.1)
Participation rate %	89.2	86.5	86.9	81.2
Performers only	90.0 (69.2)	101.5 (76.2)	45.7 (38.1)	39.1 (37.5)
Gardening				
Total	26.9 (40.7)	17.5 (21.7)	37.4 (46.6)	29.6 (60.4)
Participation rate %	64.7	69.2	79.2	67.1
Performers only	41.5 (44.2)	25.2 (22.4)	47.2 (47.7)	44.1 (69.4)

Women	Men
§ only paid occupation	
SD: Standard deviation	

Table 4 presents the results of the binary logistic regressions for the associations of health indicators with time allocation and total PA adjusted for age and sex. The results indicate that more time spent on leisure activities reduces the risk of bad self-rated health (OR: 0.93; 95%-CL: 0.87, 0.99) and limitations in activities of daily living, such as moderate activities (OR: 0.88; 95%-CL: 0.83, 0.94), bending, kneeling, and stooping (OR: 0.93; 95%-CL: 0.89, 0.97) as well as walking more than 1 km (OR: 0.90; 95%-CL: 0.84, 0.96). Participants without an occupation were more likely to rate their health as not good (OR: 0.60; 95%-CL: 0.40, 0.92) compared to those with a post-retirement occupation. More time spent in active transport seemed to lower the risk of having limitations when walking more than 1 km (OR: 0.79; 95%-CL: 0.65, 0.96), being overweight (OR: 0.80; 95%-CL: 0.69, 0.93), or obese (OR: 0.77; 95%-CL: 0.64, 0.92). The results indicated that higher total PA increases the likelihood for a better self-rated health (OR: 0.36; 95%-CL: 0.20, 0.65) and decreases the risk of having limitations regarding moderate activities (OR: 0.55; 95%-CL: 0.34, 0.89), as well as bending, kneeling, and stooping (OR: 0.38; 95%-CL: 0.24, 0.60). The risk of being overweight (OR: 0.39; 95%-CL: 0.25, 0.62) or obese (OR: 0.36; 95%-CL: 0.21, 0.60) also decreased with increased total PA. Time spent in home-based activities did not seem to be associated with any of the health outcomes and handgrip strength was not associated with any SLOTH domain or PA.

Table 4
Results of binary logistic regression on predicting health indicators, adjusted for age and sex

	Bad self-rated health	**Limitations when doing moderate activities (ADL)**	**Limitations when bending, kneeling, stooping (ADL)**	**Limitations when walking > 1 km (ADL)**	**Overweight**	**Obesity**	**Handgrip strength below normal range**
	OR (95%-CL)	OR (95%-CL)	OR (95%-CL)	OR (95%-CL)	OR (95%-CL)	OR (95%-CL)	OR (95%-CL)
Leisure, only active (hrs/week)	**0.93 (0.87, 0.99)**	**0.88 (0.83, 0.94)**	**0.93 (0.89, 0.97)**	**0.90 (0.84, 0.96)**	0.96 (0.92, 1.00)	0.96 (0.91, 1.01)	0.97 (0.89, 1.07)
Occupation (yes/no)	**0.60 (0.40, 0.92)**	0.90 (0.63, 1.30)	0.90 (.65, 1.25)	0.77 (0.52, 1.13)	0.76 (0.53, 1.08)	0.80 (0.54, 1.17)	0.85 (0.43, 1.66)
Transport, only active (hrs/week)	0.96 (0.79, 1.16)	1.07 (0.91, 1.25)	0.94 (0.81, 1.09)	**0.79 (0.65, 0.96)**	**0.80 (0.69, 0.93)**	**0.77 (0.64, 0.92)**	0.73 (0.53, 1.02)
Home-based activities (hrs/week)	0.99 (0.97, 1.01)	0.99 (.98, 1.01)	1.00 (0.99, 1.02)	0.99 (0.97, 1.01)	0.99 (0.97, 1.00)	0.98 (0.96, 1.00)	1.02 (0.99, 1.05)
Total PA[1] (CPM)	**0.36 (0.20, 0.65)**	**0.55 (0.34, 0.89)**	**0.38 (0.24, 0.60)**	0.61 (0.36, 1.02)	**0.39 (0.25, 0.62)**	**0.36 (0.21, 0.60)**	1.65 (0.75, 3.66)

[1] Only participants with at least 20 hrs/day of accelerometer data included (n = 570)

ADL: Activities of daily living

CL: Confidence limits

CPM: Counts per minute

OR: Odds ratio

Statistically significant results in bold

Discussion

This study investigated age and sex specific differences in time use in three active daily domains (leisure, transport, home-based) and examined associations between time allocation in these domains and objectively measured PA with different health outcomes (self-rated health, BMI, handgrip strength, ADL).

Furthermore, we explored differences in time allocation between working and non-working older adults. Results showed age and sex differences in total PA as well as in time use in the active daily domains. Participants with a paid occupation spent less time in almost every active daily domain than participants without an occupation. Furthermore, the results showed several associations between active daily domains and health indicators. Higher PA was associated with a lower risk of a bad self-rated health, less limitations when doing moderate activities or when bending, kneeling, and stooping, as well as a lower risk of being overweight, or obese. Time spent on leisure activities seemed to lower the risk of bad self-rated health and having limitations in ADL. Having an occupation was associated with better self-rated health. Time spent on active transport showed a lower risk for having limitations when walking more than one kilometer and being overweight, or obese. Home-based activities showed no significant associations with any health indicators.

This study showed that participants older than 70 years were significantly less physically active than those under 70 years. Yet, they spent more time in several SLOTH domains with increasing age. One reason could be the decreasing proportion of people having a paid occupation or doing volunteer work as they get older (women: 63.3% compared to 51.4%, men: 57.3% compared to 53.9%), which leads them to allocate their time differently. Another possibility why they spent more time in several SLOTH domains is that with increasing age, more time might be required to perform certain tasks, because of the ageing-related decline in health [27]. Both men and women in the older age group (age 70 + years) more often reported less good or bad health than the younger ones. Since our data only provides information about the time allocation to active domains and cannot provide information about the intensity, we can only speculate that although the time spent in the SLOTH domains increases with higher age, the intensity might decrease. Spinney et al. [28], for example, found decreasing rates of older Canadians meeting PA recommendations with increasing age, when looking at the active domains.

Furthermore, this study showed significant differences in objectively measured PA between men and women. These results are in contrast to several other studies objectively measuring PA in older adults. The systematic review by Sun et al. [3], for instance, found older men to be more physically active than older women. These differences could arise from differences in PA measurements. In this study the accelerometer was worn on the non-dominant wrist. However, most studies use PA monitors on the hip, which results in differences in the measured movements, especially regarding the upper body [3]. Since the women in our sample devote a lot of time to housework, which includes lots of upper body movements, it is possible that the higher amount of PA stems from this.

The sex differences in time allocation regarding home-based activities are in line with previous research by Adjei and Brand that was conducted in Germany [9], as well as Sprod et al. that was conducted in Australia [11, 29], who also found that women spend more time on housework but less on gardening than men. Gauthier and Smeeding [12] reported the same findings for overall home-based activities in nine different countries, but, contrasting our results, saw a decrease with age in women devoting time to housework and an age-related increase in men. In terms of the amount of time spent doing home-based activities, the same study found on average three hours per day being devoted to this domain in Germany [12]. Our results differ a lot with 80.2 ± 69.4 minutes per day in men and 118.5 ± 87.8 minutes per day in women. These

differences could be a result of measuring home-based activities, since our study used a questionnaire asking for weekly hours carrying out the activity, which can lead to recall bias and reporting errors. The review only included studies using time use diaries, that can deliver more accurate results [7]. Another reason could be different interpretations of housework.

Adjei and Brand [9] found positive associations between time spent doing household chores and self-reported health, in men and women. Our results, however, did not match these findings, which could also be a result of different operationalisations or assessment of time spent in housework.

In line with our results, a systematic review by Gauthier and Smeeding [12] reported average leisure time PA of 0.5 to 1 hour per day, with men devoting more time to it than women and Krantz-Kent and Stewart [30] found similar results in their American study.

While our findings suggest that active transport is the domain older adults devote the least amount of time on, several other studies reported leisure PA to be the domain the least time is spent on [11, 12, 29, 30]. Sprod and colleagues [11, 29] also made a distinction between active and inactive travel and reported almost three times more minutes per day being spent on it than our study. These differences could be a result of us only using everyday destinations, whereas Sprod et al. included every destination. Another explanation could be the difference in infrastructure between the study countries (Australia vs. Germany), that leads to the participants having to cover longer routes.

Our findings further indicated that the time spent in leisure activities is associated with better self-rated health, which is in line with the studies by Abu-Omar and Rotten [8], as well as Kaleta and colleagues [31]. Having an occupation seemed to increase the likelihood of a better self-rated health, which does not coincide with the existing literature, that found contrasting results [32]. The different results could stem from varying definitions of occupation and retirement, for example if having a part-time job whilst being retired counts as having an occupation.

Time spent in active transport was associated with a lower risk of overweight and obesity, and no limitations in walking more than 1 km. A comparison with existing research is difficult, since other time use studies often do not distinguish between active and inactive transport or define it as general PA [33] or commuting [8]. A study by Foley et al. [34] could, however, associate time in active transport with spending more time on healthy behaviours.

Our results showed that participants with higher total PA were more likely to rate their health as good, which is in accordance with prior research [35, 36]. In line with our results, a study by Riebe et al. [37] found an association between higher PA and a lower risk of obesity. Higher total PA was also associated with having no limitations doing moderate activities as well as bending, kneeling, and stooping. Yorston and colleagues [38], who focused on the associations of PA and physical function in older adults, found similar results. They reported people with higher levels of PA having a lower risk of functional limitations.

We found no associations of home-based activities and health outcomes. This is in contrast to the results from Adjei and Brand [9], that found older adults who spent more time doing home-based activities to have

higher odds of good self-reported health. Other studies, however, could not find any effects of household chores on either lower odds of being overweight [39] or on having a better health status [40].

Furthermore, our results showed no associations between time use and PA with handgrip strength. This is in contrast to a study by Spartano et al. [41], that found associations between PA and better handgrip strength in middle aged and older adults. They did not assess the time being physically active but time in MVPA and used handgrip strength in kilogram, whereas we used reference ranges. These differences in measurements could be a reason for the different results.

The study has a few limitations that need to be addressed. The questionnaire used in the OUTDOOR ACTIVE study was not initially designed for time use analyses, thus some domains of the SLOTH model were not fully assessed. Furthermore, the assessment of housework and gardening might be biased, since it was not clarified which tasks account to these domains. It is, for example, unknown whether the participants included cooking to housework or only referred to cleaning. Moreover, the activity “riding a bike” was excluded from the leisure domain, since it is possible that participants included time spent on riding a bike for transport in their answer. This could lead to underestimated time in this domain. Since the participants had to estimate their weekly time spent in leisure and household activities, recall bias and reporting errors could be an issue. The use of a proper time use diary could reduce these risks. Additionally, they would deliver data for full 24-hour days. However, the results of the present study are still a good indicator for the time allocation to active domains in older adults.

The assessment of transport only included everyday destinations, leaving out travelling to work, social events, or other obligations, which could lead to an underestimation of time allocation.

Another limitation of this study is the cross-sectional design. Therefore, no statements regarding causation can be made and associations because of possible reverse causation (e.g. between PA and self-rated health or between occupation and self-rated health) cannot be determined. Thus, future research should look at time allocation and PA, and its effect on health outcomes in a longitudinal study.

Despite the limitations, this study provided insights in time allocation of older adults to active daily domains and PA, which are important information for developing PA programs. Additionally, associations of time use and several health indicators were presented. One strength of this study is the representativeness of the sample for the population of Bremen-Hemelingen, when comparing social demographic factors. Furthermore, the PA data was assessed objectively using accelerometers, which is a reliable measurement for PA in older adults [42]. Furthermore, the SLOTH model is a well-known and fitting time budget model to analyse time allocation regarding PA [43].

Conclusions

The findings of this study have shown differences by age, sex, and occupational status in time allocation to active domains of daily living as well as in objectively measured PA in older adults. Furthermore, time use was associated with several health outcomes. Healthy ageing, and in this context also active ageing, is an important public health goal. This study provides information on how older adults structure their day, which

active domain they devote most time to, and which health indicators are associated with active domains, which has important implications for the development of PA programs. It shows that PA through active daily domains are beneficial for healthy ageing and should be integrated in PA promotion. For example, active transport could be used for obesity prevention or reduction, and the increase of leisure activities for reducing limitations in ADL. However, further research is needed to understand the specific links between time allocation to active domains and health indicators to increase active living as a part of healthy ageing.

Abbreviations

ADL Activities of Daily Living

BMI Body Mass Index

CPM Counts per minute

MVPA Moderate to vigorous physical activity

PA Physical activity

SES Socioeconomic status

SLOTH model Sleep, Leisure activities, Occupation, Transport, Home-based activities

Declarations

Ethics approval and consent to participate

The OUTDOOR ACTIVE study was approved by the ethics committee of the University of Bremen. All participants provided written informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

IS performed statistical analyses and drafted the manuscript. KB contributed to the conception and design of the study as well as statistical analyses. KB, BMA and FD critically revised and reviewed the manuscript. All authors read and approved the final manuscript.

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