Objectively-measured outdoor time and physical and psychological function among older adults

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Abstract

Aims: Objective measurements of outdoor time are essential to establishing evidence about the health benefits of going outdoors among older adults. To better understanding the health benefits of going outdoors, clarification of potential mediators to connect going outdoors with health benefits is necessary. This study aimed to investigate associations of objectively-measured outdoor time with older adults' physical and psychological function, and examine the mediating role of physical activity on these associations.

Methods: Baseline data from a randomized control trial of physical activity among older adults with global cognitive impairment was used. Data from 192 participants were analyzed. Measures included steps-per-day, objectively-measured outdoor time per day using global positioning systems, physical function (cardiorespiratory fitness, lower-extremity strength), psychological function (depression, well-being), and basic factors.

Results: Path analysis revealed that outdoor time was significantly associated with steps-per-day (path coefficient = 0.23) and depression (path coefficient = -0.16). Outdoor time was not directly associated with cardiorespiratory fitness, lower-extremity strength, and well-being. However, steps-per-day was associated with cardiorespiratory fitness (path coefficient = 0.18), lower-extremity strength (path coefficient = -0.22), and well-being (path coefficient = 0.14).

Conclusions: We found that objectively-measured outdoor time was indirectly associated with physical function and both directly and indirectly with psychological function through physical activity among older adults. This finding indicates that going outdoors influences older adults' health outcomes and is mainly mediated by physical activity.

Key words: Aged; Geographic Information Systems; Homebound Persons; Mental Health; Motor Activity

Introduction

Going outdoors more frequently and preventing housebound status are effective ways to promote older adults' health. For instance, going outdoors reduces mortality risk,[1] while housebound status can increase risk.[2,3] Previous studies indicate that going outdoors and housebound status are associated with physical, psychological, and cognitive health outcomes.[4–10] Since going outdoors does not require any special knowledge, motivation, cost, or time, it would be easier for older adults to incorporate increased outdoor activity into their daily lives compared with other well-known health-related behaviors such as smoking cessation, exercise, and healthy eating.

To establish evidence about the health benefits of going outdoors, objective measurements of outdoor time are essential. However, most studies employ self-report measures of outdoor activities. As physical activity level measured objectively differ considerably from self report,[11] self-reported going outdoors would not necessarily correspond to objectively-measured going outdoors. The validity of self-reported going outdoors is not yet established and only a few studies have used objective assessment methods. The SenTra project employed the Global Positioning System (GPS) to measure outdoor time, and revealed that objectively-measured outdoor time is associated with well-being,[12] but not cognition level.[13] Using home infrared sensors, Petersen et al.[14] showed that longer objectively-measured outdoor time was associated with better cognitive function, physical ability, and well-being. Suzuki et al.[15] also found a relationship between cognitive decline and number days going outdoor days measured by home infrared sensors.

To better understand going outdoors-related health benefits, it is necessary to clarify potential mediators that connect the two. However, no previous studies have examined mediators in the relationship between objectively-measured outdoor time and health outcomes. Thus, clarification is an essential step in the development of more effective health promotion programs emphasizing going outdoors. According to the discussions by previous studies,[5,6] physical activity might mediate the effects of going outdoors on health outcomes. Specifically, they revealed associations between going outdoors and disability[5] and cognitive function,[6] and discussed the potential mediating effects of physical activity on these associations. Although Kerr et al.[16] examined the independent associations of outdoor and physical activity with health outcomes, they did not measure outdoor time (excluded time in vehicles) or investigate mediating effects. If the effects of going outdoors on health outcomes are mediated by physical activity, it suggests that going outdoors with physically active ways (e.g., walking or cycling) would be more effective at promoting health than going outdoors without physical activity (e.g., car or motor bike).

The purposes of the present study were to investigate the associations between objectively-measured outdoor time and physical and psychological function, and to examine the mediating role of physical activity among older adults.

Methods

Participants and Procedures

The present study secondary analyzed baseline data from a community-based randomized control trial of physical activity for older adults with global cognitive impairment. A protocol of this trial (ID: UMIN000013097) is available at the UMIN Clinical Trials Registry website <http://www.umin.ac.jp/ctr/index.htm>. This website is accepted by the International Committee of Medical Journal Editors.

Participants were recruited from a sub-cohort of the National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes (NCGG-SGS; Shimada et al.[17]). The NCGG-SGS was conducted in 2013 in the Midori-Ward of Nagoya city, Aichi prefecture, Japan. Nagoya city consists of 16 Wards and is the prefectural capital of Aichi, Japan. This sub-cohort targeted all older adults living in the Midori-Ward, aged ≥ 70 years, and who were not certified as requiring support or care through the Japanese long-term care insurance system. In total, 24,271 individuals were invited to participate in the physical and cognitive screening survey, and 5,257 participated.

Of the 5,257 individuals in this sub-cohort, 709 were selected as potential participants based on the following inclusion criteria: 1) had global cognitive impairment (scored 21–24 on the Mini-Mental State Examination),[18] 2) did not have gait dysfunction or other serious health problems, and 3) were not potential participants in other intervention studies. After recruitment documents were sent to the 709 individuals, 359 participated in the baseline assessment. However, 79 individuals were excluded because they withdraw (n = 24) or did not meet inclusion criteria (n = 55). Thus, the remaining 280 individuals participated and were allocated to either the intervention or control group.

Of these participants, 194 met the inclusion criteria of providing GPS data for outdoor time. However, 2 did not wear the accelerometer to measure physical activity for at least 8 days with ≥ 10 hours for each day. Thus, data from 192 participants were analyzed.

The NCGG-SGS and the trial were approval by the Ethics Committee of the National Center for Geriatrics and Gerontology. Written informed consent was obtained from all participants.

Measures

Physical activity

In the present study, steps-per-day was treated as the physical activity variable, and were measured using an accelerometer (GT40-020: ACOS Corporation, Limited: Nagano, Japan). Participants were asked to wear an accelerometer all day for 14 days. Since previous studies have used the a wearing time inclusion criteria of ≥10 hours per day for ≥ 4 of 7 days,[19] data were analyzed if participants wore the accelerometer at least 8 days for ≥ 10 hours each day. Each participant's average daily steps were calculated.

Outdoor time

Outdoor time was measured by GPS monitors (Globalsat DG-200 Data Logger: GlobalSat WorldCom Corporation: Taipei, Taiwan). This device's accuracy in a horizontal direction is 10 m for 2 distance root mean squared. Individuals were asked to wear the GPS at all times except when sleeping, and complete a daily log. The log had an entry column to determine whether the device was worn all day.

Considering home size and measurement errors, home area was defined as the 100 m radius from each home's representative point. Typically (when the connection is not poor), the GPS device can recode latitude and altitude every 30 seconds. Outdoor time per each day was calculated as the times when individual left and returned to the home area. Participants' data from each day was included if they: 1) wore the device at least 10 hours, 2) started and ended the day in the home area, 3) has no poor connection during times when left and returned to the home area, and 4) completed the log indicating the device was worn all day. Similar to physical activity, we analyzed data from each individual if they met these criteria for at least 8 days. Then, each participant's average daily outdoor time was calculated.

A geographic information system (ArcGIS for Desktop 10.3: Esri Japan Incorporation: Tokyo, Japan) was utilized for GPS data analysis.

Physical function

For physical function, cardiorespiratory fitness and lower-extremity strength were measured using the 6-minute walk test and 5-repetition chair stand test, respectively. The dose-response relationship between cardiorespiratory fitness and mortality is well-established.[20] The chair stand test is also a predictor of older adults' mortality.[21]

The 6-minute walk test measures how long individuals can walk in 6 minutes.

Longer distance indicates higher cardiorespiratory fitness. The 6 minute walk test has sufficient reliability and validity, and can be easily conducted in clinical settings.[22] Participants were asked to walk as fast as possible in 6 minutes along a straight 10 m course. The distance (in meters) walked in 6 minutes was recorded.

The 5-repetition chair test requires participants to stand up and sit down in a chair 5 times as fast as possible with their arms folded across their chest. The times (in seconds) they complete the task are measured. Lower times represent higher lower-extremity strength.

Psychological function

We investigated depression and psychological well-being as psychological function. The Geriatric Depression Scale (Japanese 15-item version)[23] was used to measure depression. Higher scores represent higher depressive symptoms. Psychological well-being was measured using a simplified Japanese version of the WHO-Five Well-Being Index.[24] This scale simplified the original Japanese version by changing it from a 6- to 4-point Likert scale. The range of this version is 0–15 and higher scores indicate higher psychological well-being.

Basic factors

This study assessed gender, age, and education years as basic factors.

Data Analysis

Gender (women = 0, men = 1) was treated as dummy variable. Pearson's correlation coefficients were calculated among each variable (outdoor time, steps-per-day, cardiorespiratory fitness, lower-extremity strength, depression, well-being, gender, age, and education).

Next, path analyses were conducted. To investigate the mediating role of steps-per-day on the association of outdoor time with physical and psychological function, an initial model (Model 1) was created by considering: 1) a path from outdoor time to steps-per-day, 2) all direct paths from outdoor time and steps-per-day to physical and psychological function, and 3) any paths from basic factors to outdoor time, steps-per-day, and physical and psychological functions with significant Pearson's correlation coefficients. Error covariance was considered between cardiorespiratory fitness and lower-extremity strength and depression and well-being, respectively. Subsequently, a final model (Model 2) was created by removing paths in order of p-value significance until all paths were significant.

Statistical causality was examined by changing the causal relationships of outdoor time and steps-per-day and physical and psychological function; specifically, physical and psychological function represented cause, and outdoor time and steps-per-day as effect. Next, Model 3 was created by considering: 1) a path from outdoor time to steps-per-day, 2) all direct paths from physical and psychological function to outdoor time and steps-per-day, and 3) and any paths from basic factors to outdoor time, steps-per-day, and physical and psychological functions with significant Pearson's correlation coefficients. Next, Model 4 was created by removing paths in order of p-value significance until all paths were significant.

Goodness of fit index (GFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA) were used as indices of model fit.

Statistical significance was set at $P < 0.05$. All statistical analyses were conducted using SPSS (version 21.0) and AMOS (version 21.0) software packages.

Results

Participant Characteristics

Table 1 represents participants' characteristics. The mean age was 76.2, 56.3% of respondents were male, average outdoor time was 3 hours 37 minutes, and average steps-per-day was 6654.6.

Associations of outdoor time and physical activity with physical and psychological function

Table 1 shows the Pearson's correlations among outdoor time, steps-per-day, physical and psychological function, and basic factors. Outdoor time was significantly correlated with steps-per-day, cardiorespiratory fitness, depression, and age. Steps-per-day was significantly correlated with cardiorespiratory fitness, lower-extremity strength, well-being, gender, and age.

The results of the initial path analysis model (Model 1) is shown in Figure 1. In this model, paths from gender to steps-per-day and cardiorespiratory fitness, from age to outdoor time, steps-per-day, cardiorespiratory fitness, lower-extremity strength, and depression, and from education to cardiorespiratory fitness had significant Pearson correlation coefficients. The indices of model fit were GFI = 0.98, CFI = 0.99, and RESEA = 0.028.

Paths were removed from Model 1 the in order of significant p-values for until all paths represented the significance levels, resulting in the final model (Model 2; Figure 2). Education was removed from Model 2 because it was not significantly associated with outdoor time, steps-per-day, and physical and psychological functions. Outdoor time was significantly associated with steps-per-day and depression, and steps-per-day were associated with cardiorespiratory fitness, lower-extremity strength, and well-being. The indices of model fitness were GFI = 0.98, CFI = 0.97, and RESEA = 0.044.

Additionally, the causality of outdoor time and steps-per-day with physical and psychological function was examined. Figures 3 and 4 represent the initial (Model 3) and final (Model 4) for causality changes. By changing causality, the associations between psychological functions (depression, well-being) and outdoor time and steps-per-day were non-significant. Cardiorespiratory fitness was significantly associated with outdoor time and steps-per-day in Model 4; however, the relationship between cardiorespiratory fitness and steps-per-day was non-significant in Model 3. Although Model 3 indicated a significant relationship between lower-extremity strength and steps-per-day, it was eliminated when paths were removed in order of p-value significance. Thus, when examining the statistical causality of outdoor time and steps-per-day and physical and psychological function, Models 1 and 2 (outdoor time and steps-per-day as cause, physical and psychological function as effect) better explained data than Models 3 and 4 (physical and psychological function as cause, outdoor time and steps per day as effect).

Discussions

To our knowledge, this is the first study to examine physical activity as a mediator of objectively-measured outdoor time and physical and psychological function among older adults. Although previous studies suggest have that promoting going outdoors and preventing homebound status is important for health maintenance, only a few have objectively measured outdoor time and examined the mechanisms influencing going outdoors and health outcomes. This study contributes to better understanding the beneficial effects of going outdoors on older adults' health.

Our major finding was that objectively-measured outdoor time was indirectly associated with physical function and both directly and indirectly associated with psychological function through physical activity. This finding indicates that the influence of going outdoors on health outcomes was primarily mediated by physical activity. Previous epidemiological studies report that self-reported going outdoors and homebound status are associated with various health outcomes.[1–10] Only a few studies (the SenTra project,[12,13] Petersen et al.,[14] and Suzuki et al.[15]) have examined objectively-measured outdoor time and health outcomes. However, they did not examine potential mechanisms underlying how going outdoors influences health outcomes. Based on objective outdoor time data, our study supports and reinforces existing evidence about the health benefits of going outdoors, and demonstrates the mediating role of physical activity on this relationship. Our results about the mediating role of physical activity and older adults are consistent with previous studies. For instance, previous studies[5,6] have discussed the mediating role of physical activity, and health benefits of physical activity on health outcomes are well-known.[25]

In our study, we observed a direct relationship between going outdoors and depression, although there were no relationships with cardiorespiratory fitness, lower-extremity function, and well-being. This implies that, instead of physical activity, other aspects of going outdoors (e.g., social interactions, better mood) are more important when understanding the relationship between going outdoors and depression among older adults. A systematic review concluded that physical activity in outdoor natural environments has greater benefits for psychological health than indoor physical activity.[26] Epidemiological studies report that social participations can reduce the depression risk.[27-28] A study also showed that lower going outdoors frequency was associated with decreased communication with neighbors and social participation.[4] Accordingly, we can assume that social factors mediate the relationship between going outdoors and depression. In our study, two psychological function variables (well-being, depression) were differentially associated with physical activity and going outdoors. While well-being represents a positive psychological states,[29] depression represents a negative state. There is a possibility that this difference in psychological status influences associations with physical activity and going outdoors. However, because of limited research, further studies should examine differences in associations between older adults' negative and positive psychological states with physical activity and going outdoors.

Our study found an average outdoor time per day of 3 hours 37 minutes. According to a Japan nationwide survey (National Time Use Survey 2010[30]) where respondents recorded behavior every 15 minutes for 2 days, it is estimated that men have an average outdoor time of 4 hours 53 minutes and women have an average 4 hours 11 minutes. The SenTra project in other countries reported average outdoor times as 4.0 hours per day using GPS data,[13] and 4.2 hours using in-home sensors.[14] Our recorded outdoor time is slightly lower, which could result from obtaining our data from older adults with cognitive impairments who may be less likely to leave home. Further examination of the determinants of outdoor time would help to understand lower levels in this population.

This study's strength is objective measurement of going outdoors and physical activity. However, the study has some limitations. First, although statistical causality was examined, the data were cross-sectional and causal associations cannot be demonstrated. Second, the sample size was small. Third, a convenience sample was used (baseline data from a randomized controlled trial) and the GPS device adherence was low. Thus, it is unclear if findings could be generalized to older adults with lower adherence or better cognitive health. Future larger longitudinal studies using a more representative sample are needed to more conclusively examine the health effects of going outdoors.

In conclusion, the major finding of this study indicates that going outdoors influences physical and psychological function among older adults and is mainly mediated by physical activity. Consequently, encouraging individuals to go outdoors, especially with physically active styles (e.g., walking, cycling) might effectively delay physical and psychological function decline. Further research on the causal role of going outdoors and health promotion is recommended.

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Disclosure statement

There are no potential conflicts of interest to disclose.

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Figure Legends

Figure 1. Initial model (Model 1) for associations of outdoor time and steps-per-day with physical and psychological function among older adults by path analysis. GFI = 0.98, CFI = 0.99, RESEA = 0.028. 6MWT, 6 minute walk test. 5CS, 5-repetition chair stand test. GDS15, Geriatric Depression Scale 15 item version. S-WHO-5-J, simplified Japanese version of WHO-Five Well-Being Index. $^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Figure 2. Final model (Model 2) for associations of outdoor time and steps-per-day with physical and psychological function among older adults by path analysis. GFI = 0.98, CFI = 0.97, RESEA = 0.044. 6MWT, 6-minute walk test. 5CS, 5-repetition chair stand test. GDS15, Geriatric Depression Scale 15 item version. S-WHO-5-J, simplified Japanese version of WHO-Five Well-Being Index. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

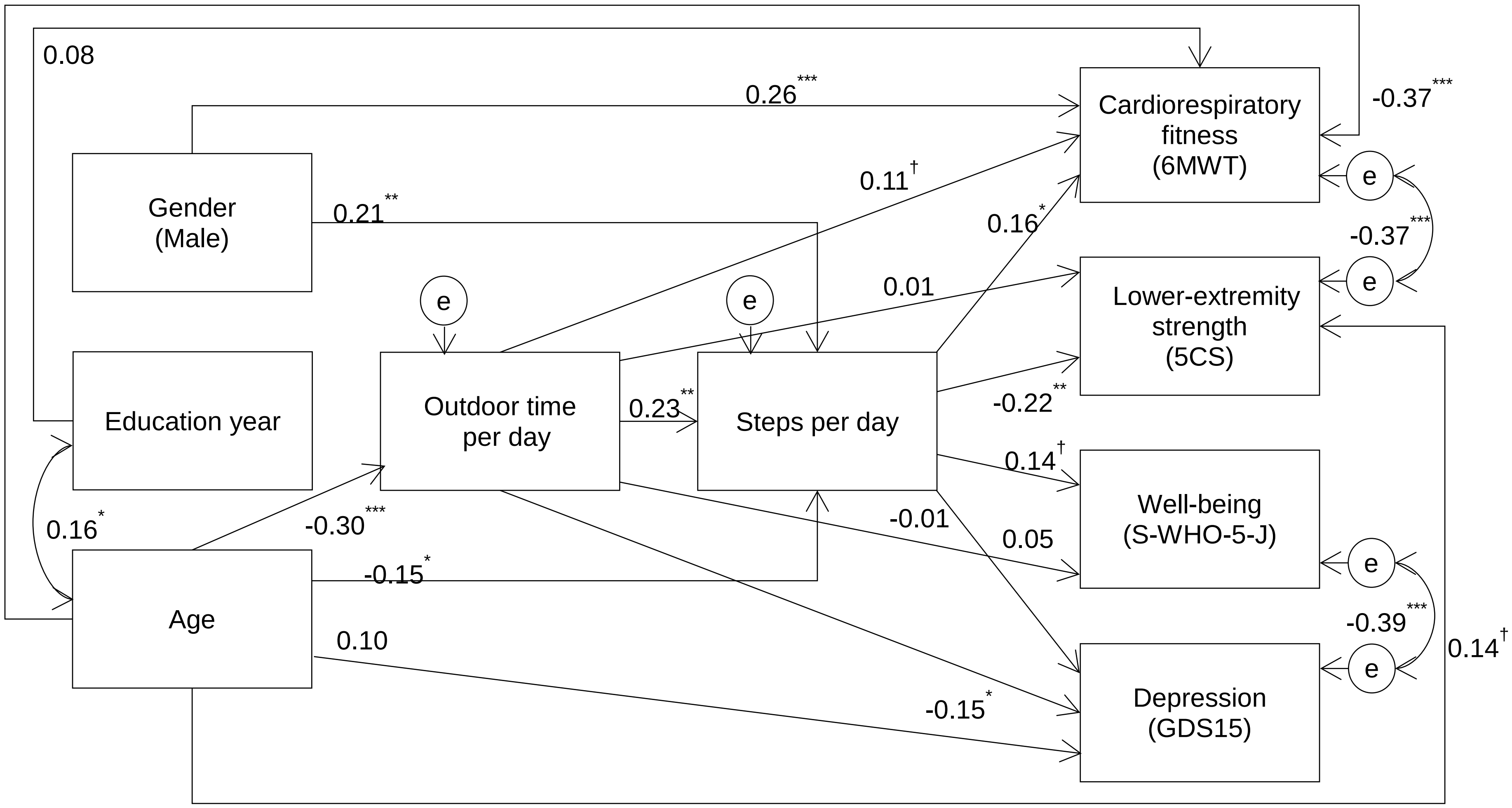
Figure 3. Initial model (Model 3) for changing causality of outdoor time and steps-per-day with physical and psychological function among older adults by path analysis. GFI = 0.98, CFI = 0.99, RESEA = 0.028. 6MWT, 6-minute walk test. 5CS, 5-repetition chair stand test. GDS15, Geriatric Depression Scale 15 item version. S-WHO-5-J, simplified Japanese version of WHO-Five Well-Being Index. $^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Figure 4. Final model (Model 4) for changing causality of outdoor time and steps-per-day with physical and psychological function among older adults by path analysis. GFI = 0.99, CFI = 0.98, RESEA = 0.051. 6MWT, 6-minute walk test. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Table 1. Descriptive statistics and Pearson's correlations among outdoor time, physical activity, physical and psychological function, and basic factors.

	Descriptive statistics			Pearson's correlation coefficient							
	Mean or %	SD	Range	1	2	3	4	5	6	7	8
1. Gender	56.3%	—	—	—							
2. Age (year)	76.2	4.1	71–88	0.07	—						
3. Education	12.0	2.6	6–22	0.16*	-0.05	—					
4. Outdoor time (time)	3:37:10	2:07:32	0:31:24–11:27:52	0.12	-0.30***	-0.02	—				
5. Steps per day (steps)	6654.6	2958.8	1855.6–21424.9	0.22**	-0.20**	0.04	0.30***	—			
6. Cardiorespiratory fitness (m)	452.6	55.3	320–632	0.32**	-0.42***	0.16*	0.29***	0.33***	—		
7. Lower-extremity strength (sec)	7.7	2.2	3.5–18.2	-0.12	0.19**	-0.07	-0.10	-0.25***	-0.44***	—	
8. Depression (score)	2.6	2.2	0–10	-0.07	0.16*	-0.11	-0.18*	-0.07	-0.21**	0.05	—
9. Well-being (score)	10.4	3.1	0–15	0.10	-0.08	0.02	0.09	0.16*	0.22**	-0.03	-0.40***

SD, Standard Deviation; *p < 0.05, **p < 0.01, *** p < 0.001



0.08
0.26***
-0.37***
Cardiorespiratory fitness (6MWT)
Gender (Male)
0.21**
0.11†
0.16*
-0.37***
e
e
e
0.01
Lower-extremity strength (5CS)
Education year
Outdoor time per day
0.23**
Steps per day
-0.22**
0.14†
Well-being (S-WHO-5-J)
0.16*
-0.30***
-0.01
0.05
e
Age
-0.15*
-0.39***
0.14†
0.10
e
Depression (GDS15)
-0.15*

Figure 1.

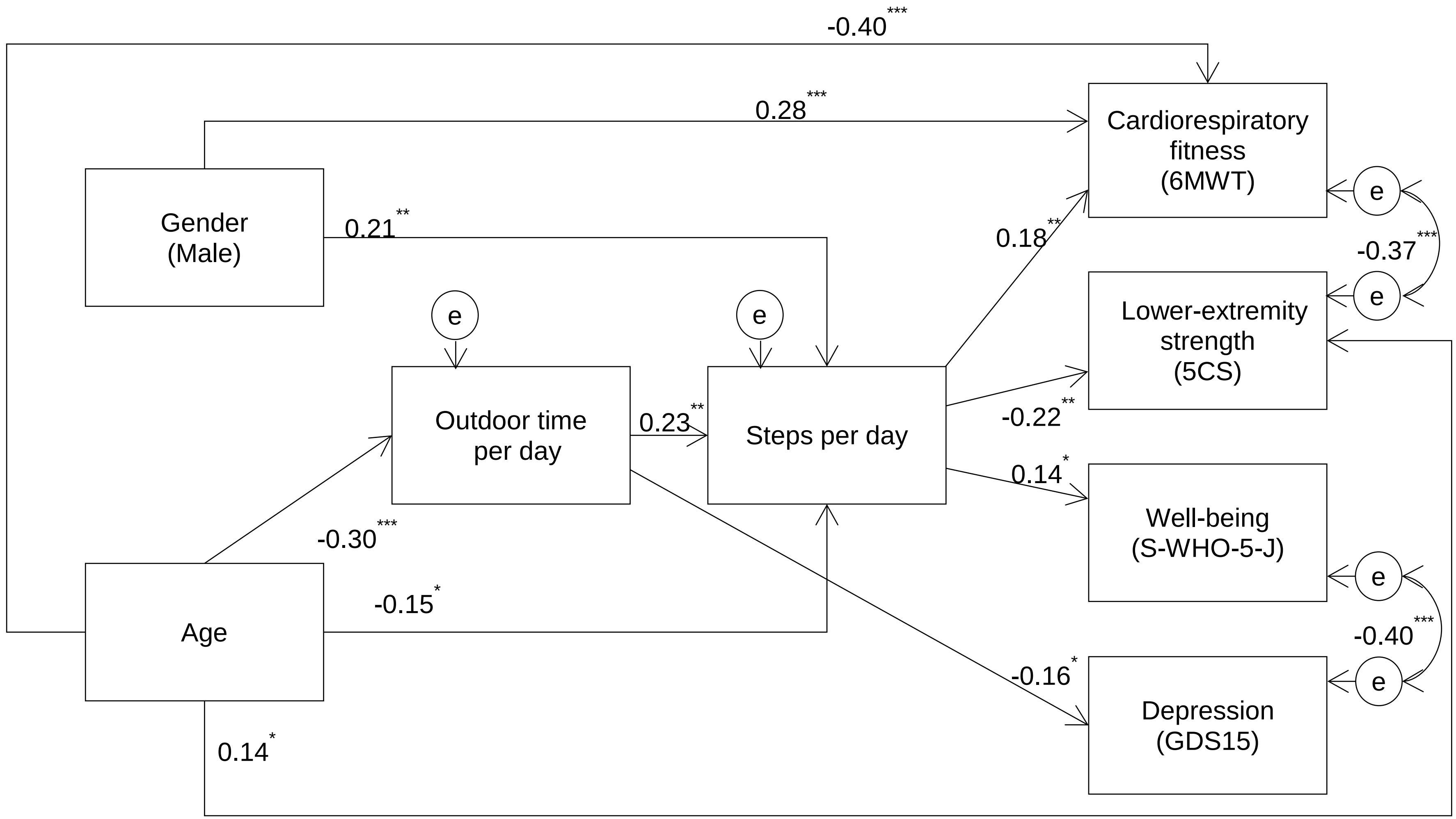

-0.40***
0.28***
Cardiorespiratory fitness (6MWT)
Gender (Male)
0.21**
0.18**
-0.37***
Lower-extremity strength (5CS)
e
Outdoor time per day
0.23**
Steps per day
-0.22**
0.14*
Well-being (S-WHO-5-J)
-0.30***
Age
-0.15*
-0.40***
-0.16*
Depression (GDS15)
0.14*

Figure 2.

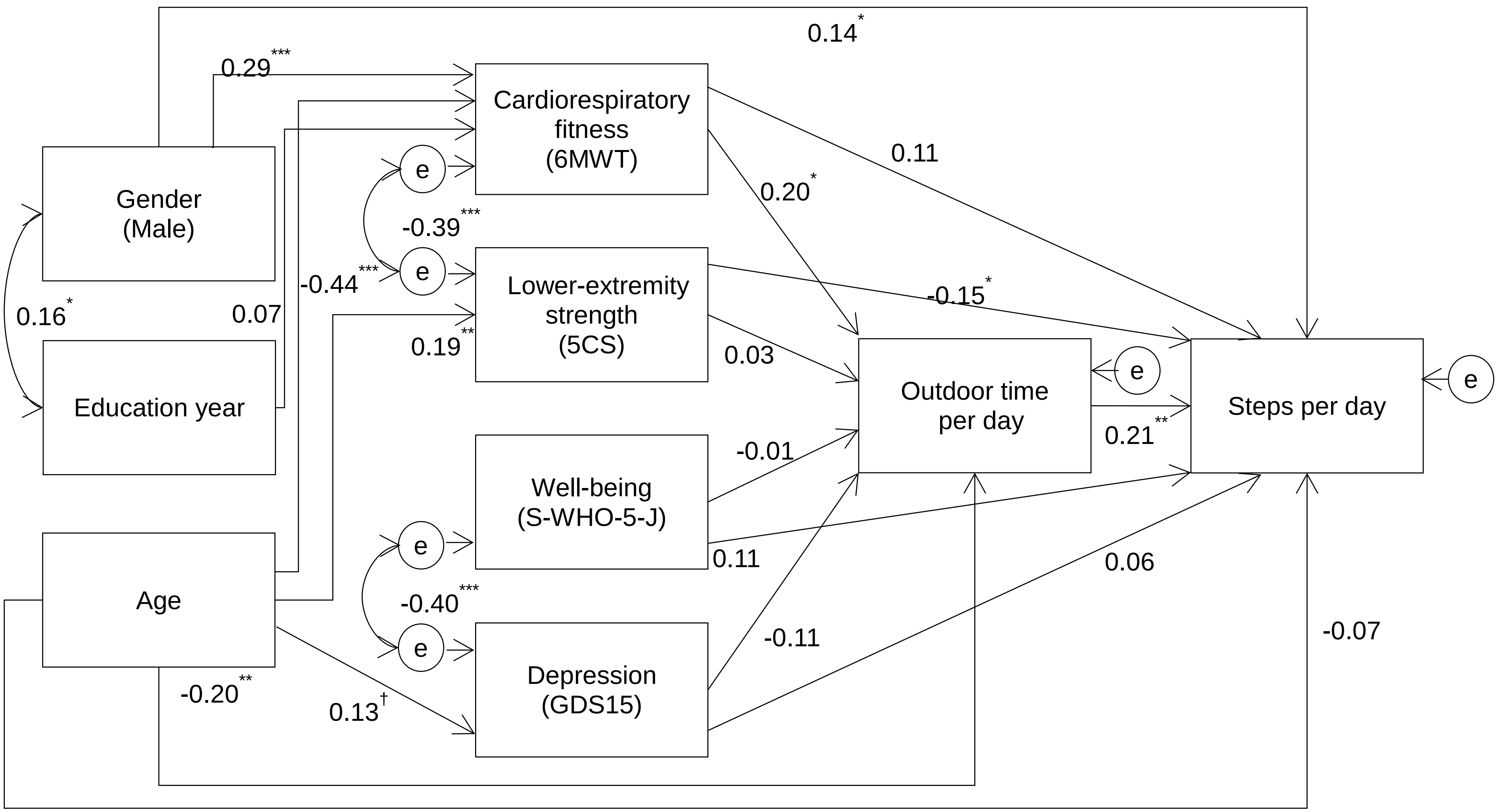

0.14*
0.29***
Cardiorespiratory fitness (6MWT)
Gender (Male)
e
0.11
0.20*
-0.39***
-0.44***
e
Lower-extremity strength (5CS)
-0.15*
0.16*
0.07
0.19**
0.03
Education year
Outdoor time per day
e
Steps per day
e
0.21**
-0.01
Well-being (S-WHO-5-J)
e
0.11
0.06
Age
-0.40***
-0.07
e
-0.11
Depression (GDS15)
-0.20**
0.13†

Figure 3.

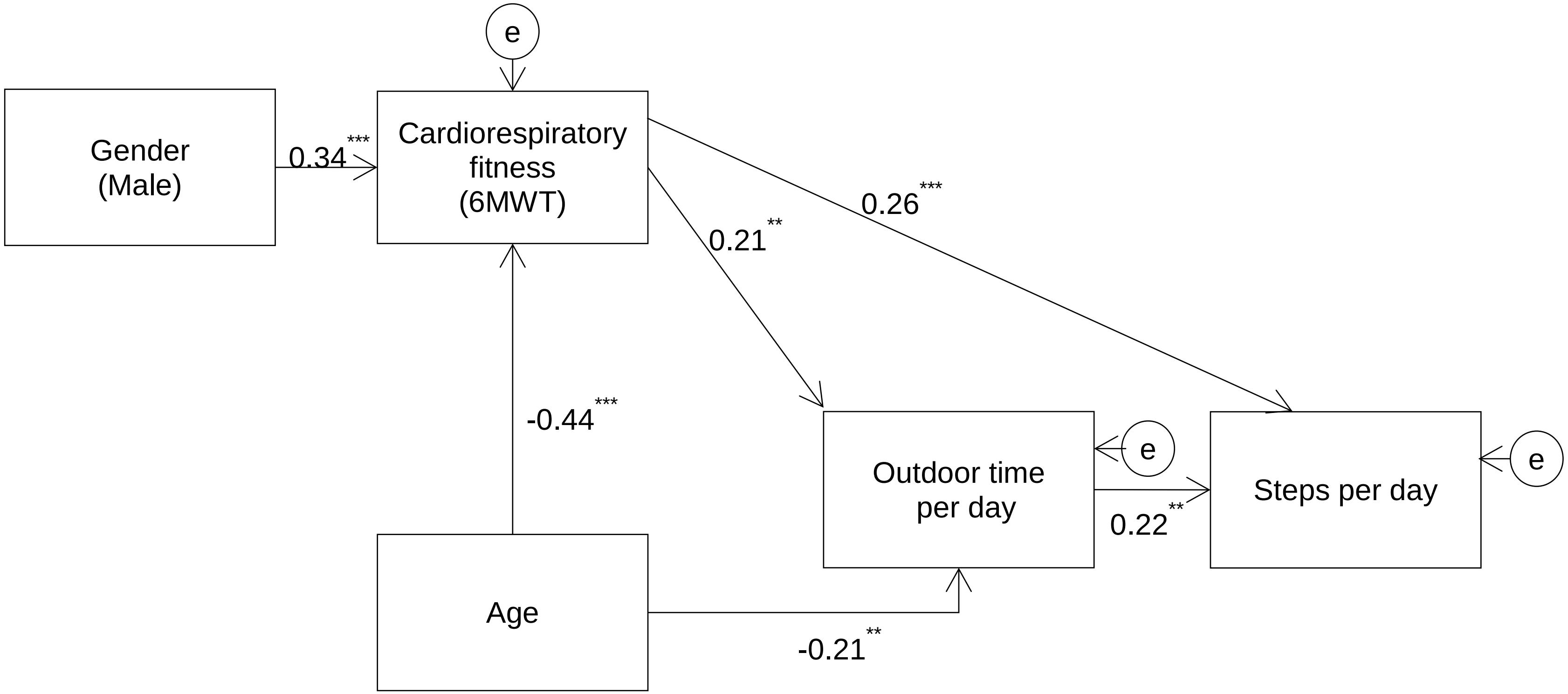

e
Gender
(Male)
0.34***
Cardiorespiratory
fitness
(6MWT)
0.26***
0.21**
-0.44***
Outdoor time
per day
e
Steps per day
e
0.22**
Age
-0.21**

Figure 4.