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Abstract

The purpose of this study was to examine relationships between participation in physical activities and long-term survival in older men and women. Cox proportional hazards regression models were used to investigate participation in different physical activities on 21-year all-cause mortality risk. The NLSAA survey was conducted in 1985 with 1,042 participants. As of 31st May 2006 (21 years from baseline), there were 919 recorded deaths (368 men and 551 women). Mortality analyses were from baseline interview to death or censorship (May 2006). Men and women were analysed separately in unadjusted models and adjusting for demographic and health-related variables. In separate unadjusted models, participation in outdoor activities, indoor productive activities, leisure activities, walking, undertaking activities requiring flexibility and physical effort each were associated with reduced long-term mortality among both men and women. In adjusted models, participation in physical activities had no significant association with mortality risk for men. Among women, participation in outdoor activities and leisure activities remained significantly associated with long-term survival in adjusted models. Among men, the benefits of physical activities for mortality risk were explained through demographic, health and psychosocial variables. However, participation in outdoor and leisure physical activities was beneficial for women and had a significant association with survival, even when controlling for demographic, health and psychosocial variables. Therefore, encouraging participation in specific physical activities, such as gardening, swimming and dancing among older women may improve long-term survival.

1.1 Introduction

Physical inactivity is the fourth leading global risk factor for mortality behind high blood pressure, tobacco use, and high blood glucose (WHO, 2010). Physical inactivity increases risk factors for high blood pressure, raised blood sugar levels, and obesity. Engaging in regular physical activity can help reduce the risk of developing specific diseases, and has the potential to reduce all-cause and disease-specific mortality. Furthermore, how well people age has been associated with how much regular physical activity they undertake (Warburton, Nicol, Bredin, 2006; Barengo, Antikainen, Borodulin, Harald, and Jousilahti, 2017). Physical activity in older age groups can lead to improved health outcomes, e.g., lower all-cause mortality, health service utilisation and use of prescribed medications (WHO, 2010). Physically-active older adults, in comparison with inactive adults, have been shown to

have lower rates of coronary heart disease, high blood pressure, stroke, type 2 diabetes, colon cancer, breast cancer, a higher level of fitness, a healthier body mass, and a biomarker profile which is more favourable in preventing cardiovascular disease (Physical Activity Guidelines Advisory Committee, 2008; Paterson, Jones & Rice, 2007). However, establishing a causal relationship between physical activity and health outcomes is not straightforward because, even if physical activity leads to health benefits, healthier older people are also more likely to participate in physical activities, so improved survival may be due to better health, higher levels of physical activity, or a combination of these and other factors. Therefore, developing an understanding of the different kinds of physical activities that could benefit older adults could provide an insight into the extent to which life expectancy is increased.

Previous research has found that a high level of recreational physical activity can reduce the likelihood of mortality over both 3 and 6 years for older adults, and that physical activity offers benefits to physically capable older adults, primarily in reducing the risk of functional decline and mortality (Simonsick, Lafferty, Phillips et al. 1993). Systematic reviews conducted by Olanrewaju et al (2016) and Halloway et al (2017) have found that promoting physical activity among older adults can also lead to positive effects related to cognition. Moreover, Sparling, Howard, Dunstan, and Owe (2015) in a study published in the British Medical Journal noted that even modest increases in physical activity for older adults would lead to health benefits.

Walking more than 4 hours a week is also associated significantly with a reduced risk of cardiovascular disease for older adults (LaCroix, Leveille, Hecht, Grothaus, & Wagner, 1996). More recent research has investigated the relationship between physical activity and mortality on various age groups ranging from those aged 16 to 84 (Wanner, Tarnutzer, Martin, et al. 2014; Lee, Sui ,& Ortega, et al. 2014; Yang, 2012). Although physical inactivity is already recognised as a risk for mortality, there is a lack of evidence-based research that focuses on older populations and specific types of physical activity (Hrobonova, Breeze, Fletcher, 2011; Brown, McLaughlin, Leung, et al, 2012). Research has also noted that leisure-based physical activity can reduce total and cardiovascular mortality and cardiovascular disease in older adults (Barengo, Antikainen, Borodulin, Harald, and Jousilahti, 2017).

The behavioural choice theory notes that people will weigh up all behavioural options available to them which include being sedentary and/or active (Epstein, 1998; Marcus and Forsyth, 2009). For instance, a person may have a number of options available to them which they can uptake such as watching the TV, talking with friends, or going for a walk. The options for activities available

to a person will compete with one another. The theory suggests that if being physically active is perceived as an attractive option (e.g., walking with a friend) the person may be more likely to uptake the activity.

The aim of this study was to investigate the relationship between different kinds of physical activity and long-term mortality in male and female adults aged 65 and over. Body movement that requires energy expenditure by skeletal muscles can be classed as a physical activity and, if undertaken regularly over a period of time, can benefit the individual by improving health, joint flexibility and muscle strength (Warburton, Nicol, Bredin, 2006). These activities could range from household work, jobs in and around the house, walking, and hobbies and sports including purposeful cycling and leisurely fishing.

2.1 Methods

2.2 The Nottingham Longitudinal Study of Activity and Ageing (NLSAA)

The overall aim of the NLSAA is to investigate the relationship between physical activity and health and well-being in adults aged 65 and over (Morgan, 1998). The original study included 1,042 community-dwelling adults aged 65 and over living in Nottingham, UK, to provide a sample which reflected the demographic composition of England and Wales (Morgan, 1998). Recruitment consisted of utilising electoral ward-level statistics from the 1981 census from three areas of greater Nottingham. Then via the consent and assistance of general practitioners the Nottinghamshire Family Practitioner Committee age-sex lists were used to identify patients which were 65 years or older whom resided in the survey area (Morgan, 1998). The initial baseline survey took place between May and September 1985 (Morgan, 1998).

2.3 Survey Design

The survey was conducted using a 318-item structured face-to-face survey that was designed to take between 45 to 90 minutes. Domains in the survey included physical and psychological health, cognitive impairment, social engagement and customary physical activity. Customary Physical Activity (CPA) was based on self-report and defined as those activities which had a minimum energy expenditure of 2 kilocalories per minute for a minimum of 3 minutes, performed weekly for at least the previous six weeks (Morgan, 1998). CPA included outdoor activities (e.g., light, moderate and heavy gardening work, working on the car, carpentry, repairs and DIY), indoor productive activities (e.g., light, moderate and heavy household work, decorating, home maintenance), leisure activities (e.g., cycling, swimming, keep fit, dancing, fishing), walking activity, and level of activity undertaken

requiring flexibility (e.g., reaching up high, bending down, using fingers) and strength (e.g., climbing stairs, pushing or carrying heavy loads). A comprehensive methodological overview of the NLSAA is reported elsewhere (Morgan, 1998). It is also important to note that the measurement units based on this study are derive from the original NLSAA study. Information on mortality within the sample was obtained from death certificates as they accrued. As of 31st May 2006 (21 years from baseline), there were 919 recorded deaths (368 men and 551 women). More information on the survey is presented within Appendix 1.

2.4 Cox proportional hazards regression models

Cox regression models were used to determine the participation in physical activities on 21-year all-cause mortality risk. The analysis on survival was from baseline interviews to death or censorship on 31st May 2006. Because of earlier reported gender-specific differences in the relationship between overall physical activity, health and mortality (Bath P.A & Morgan K, 1998; Bath P.A, 2003), separate analyses were conducted for men and women. In regards to the validity of the measurement instruments, the NLSAA dataset has been extensively researched and documented (Bath & Morgan,1998; Bath 2003). More specifically, for the reliability of results for this study, separate analyses were different models were created for analysis. More specifically, Models 1 were separate unadjusted models for participation in outdoor activities, indoor productive actives, leisure activities, the total flexibility score and the total effort score and the amount of time spent walking. Model 2 contained all the types of physical activities from Model 1 included within a single model. Model 3, the adjusted model, contained all of the activities from Model 2, with the addition of demographic, psychical health, psychological health and social activity variables. A forced entry method of variable selection was used in all models. Hazard ratios (HR) and 95% confidence intervals (CI) were estimated for all variables, and categories within variables.

3.1 Results

3.2 Distribution of outdoor, indoor, leisure and walking activities

People with higher levels of outdoor activities had lower health index scores (i.e., fewer health problems) ($p<0.001$), lower depression (SAD) scores ($p<0.001$) and higher levels of social engagement ($p<0.001$). There were significant positive associations between the number of indoor productive activities undertaken and age group, gender and self-rated health. People with higher levels of indoor productive activities had lower health index scores (i.e., fewer health problems) ($p<0.001$), lower depression (SAD) scores ($p=0.052$) and higher levels of social engagement ($p<0.001$). There were significant positive associations between the number of leisure activities undertaken and age group, gender, employment status and self-rated health. People with higher levels of walking had lower

health index scores (i.e., fewer health problems) (p<0.001), lower depression (SAD) scores (p=0.006) and higher levels of social engagement (p<0.001). The total time spent walking varied from 0 minutes to 250 minutes (mean = 25.08; 95% confidence intervals (CI) = 32.78,39.52). Time spent walking was categorised to 0 minutes, 1-9 minutes and 10+ minutes. Walking time category was associated with age group (p<0.001), gender (p<0.001), employment status (p<0.001) and self-rated health (p=0.001). There were significant but weak correlations between the participation in different types of physical activities, and these are reported elsewhere (Morgan, 1998). Among men and women, it was found men have a stronger correlation (p=0.62) between the different types of physical activities as compared to women (p=0.59). Participation in physical activities was recorded in minutes. However, in order to aid the analysis for the purposes of this study the number of activities were given a numerical value i.e., whether participants reported in engaging in an activity, on a regular basis, at least 3 minutes per week over the previous six weeks.

3.3 Distribution of activities requiring flexibility and muscle strength

As shown in Table 1 below, the total scores for activities requiring flexibility varied from 0 to 19 (mean = 9.46; 95% CI = 9.22,9.68). Higher levels of activity involving flexibility were associated with age group (p<0.001), gender (p=0.011), socioeconomic class (p=0.001), employment status (p<0.001), self-rated health (p=0.001), physical health (p=0.001), depression (p=0.001) and social engagement (p=0.001). The total scores for activities requiring muscle strength varied from 0 to 19 (mean = 8.86; 95% CI = 8.61,9.10). Higher levels of activity requiring muscle strength were associated with age group (p<0.001), gender (p=0.01), socioeconomic class (p=0.001), employment status (p<0.001), self-rated health (p<0.001), physical health (p=0.001), depression (p=0.001) and social engagement (p=0.001). Tables 2 to 5 Appendix 3, tables 2 to 4 summarise the distribution of co-variables by group of CPA.

Table 1: Total scores of CPA participation for men and women

Physical Activity	Men (%)	Women (%)	Total (%)
Number of outdoor activities			
0	139 (34.2)	368 (59.5)	507(49.8)
1	45 (11.3)	120 (19.4)	165 (16.20)
2	94 (23.6)	99 (16)	193 (18.95)
3+	121 (30.3)	32 (5.2)	153 (15.02)
Total	399 (100.0)	619 (100.0)	1018 (100.0)
Number of indoor activities			
0	105 (26.4)	41 (6.6)	146(14.37)
1	86 (21.7)	61 (9.9)	147(14.46)
2	150 (37.8)	361 (58.3)	511(50.29)
3+	56 (14.1)	156 (25.2)	212(20.86)
Total	397 (100.0)	619 (100.0)	1016(100.0)
Number of leisure activities			
0	181 (45.5)	41 (59.3)	222(21.82)
1	140 (35.2)	19 (29.9)	159(15.63)
2	77 (19.3)	105 (10.8)	182(17.89)
Total	398(100.0)	619 (100.0)	1017(100.0)
Flexibility score			
Low	140 (35.4)	195(18.7)	335(33.07)
Medium	119 (30.1)	253(41.0)	372(36.72)
High	137 (34.6)	169 (27.4)	306(30.20)
Total	396 (100.0)	617 (59.2)	1013(100.0)
Strength score			
Low	148 (37.6)	234 (38.0)	382(37.82)
Medium	118(29.9)	222 (36.0)	340(33.66)
High	128(32.5)	160 (26.0)	288(28.51)
Total	394(100.0)	616 (100.0)	1010(100.0)
Walking (minutes)			
0	130(35.13)	270(48.47)	400(43.14)
<10	16(4.32)	21(3.77)	37(3.99)
≥ 10	224(60.54)	266(47.75)	490(52.85)
Total	370(100.0)	557(100.0)	927(100.0)

3.4 21-year mortality among men

Figure 1 contains the three Cox proportional hazard models separated according to gender. Among men, in the separate unadjusted models (Models 1), participation in outdoor activities ($p<0{\cdot}001$), indoor productive activities ($p=0{\cdot}041$), leisure activities ($p=0{\cdot}001$), walking ($p=0{\cdot}006$), the total flexibility score ($p<0{\cdot}001$), and the effort score ($p<0{\cdot}001$) were each significantly associated with long-term survival. Men who participated in three or more or two outdoor activities had a significantly

reduced mortality (Hazard Ratio (HR) = 0.47; HR = 0.55 respectively) when compared to men who participated in no outdoor activities. Men who participated in three or more indoor activities and one indoor activity had a reduced HR (HR= 0.65 and 0.70 respectively) when compared to men who participated in no indoor activities. Men who participated in two or more or one leisure activities had a reduced HR (HR= 0.65 and 0.70 respectively) when compared to men who participated in no leisure activity. Men who walked for 10 or more minutes had a reduced HR (HR = 0.70) when compared to men who reported undertaking no walking. Higher total flexibility and total effort scores were separately associated with reduced mortality (HR=0.91 and 0.91 respectively).

When all of these activities were included in a single model (Model 2), only the increased participation in activities requiring flexibility (HR = 0.95; p=0·012) was significantly associated with improved survival, although the total effort score (HR= 0.96; p= 0·068) approached statistical significance. However, when adjusting for demographic variables, physical health, psychological health and social activity (Model 3), none of the physical activity variables were significantly associated with long-term survival. In this final model, only age group (p<0·001) was significantly associated with long-term survival. Appendix 2, figures 2 to 9 provide a graphic display of time to death in the form of Kaplan Meier Survival Curves.

Figure 1: Risk factors for all-cause mortality (men and women)*

Gender	1985 independent variable (possible range of values)	Category (n)	Model 1[1] HR (95% CI)	p	Model 2[2] HR (95% CI)	p	Model 3[3] HR (95% CI)	p
Men	Number of outdoor activities	0 (139)		<0·001		0·086		0·483
		1 (45)	0·75 (0·53,1·07)	0·111	1·04 (0·69,1·55)	0·863	1·19 (0·77,1·84)	0·431
		2 (94)	0·55 (0·42,0·73)	<0·001	0·79 (0·56,1·11)	0·174	1·02 (0·69,1·52)	0·901
		3+ (121)	0·47 (0·37,0·61)	<0·001	0·68 (0·49,0·95)	0·024	0·86 (0·58,1·28)	0·465
	Number of indoor activities	0 (105)		0·041		0·403		0·498
		1 (86)	0·70 (0·52,0·95)	0·020	0·78 (0·57,1·10)	0·168	0·82 (0·58,1·17)	0·285
		2 (150)	0·83 (0·64,1·07)	0·144	0·95 (0·72,1·26)	0·733	0·99 (0·73,1·37)	0·997
		3+ (56)	0·65 (0·46,0·92)	0·015	1·08 (0·73,1·60)	0·703	1·11 (0·73,1·69)	0·629
	Number of leisure activities	0 (181)		0·001		0·381		0·786
		1 (140)	0·70 (0·56,0·89)	0·003	0·83 (0·64,1·09)	0·182	0·91 (0·68,1·20)	0·489
		2+ (77)	0·65 (0·49,0·86)	0·003	0·86 (0·62,1·19)	0·372	0·96 (0·67,1·36)	0·804
	Minutes walking	0 (130)		0·006		0·367		0·433
		<10 (16)	1·05 (0·63,1·78)	0·841	1·07 (0·63,1·83)	0·194	1·41 (0·78,2·54)	0·257
		≥ 10 (224)	0·70 (0·56,0·88)	0·002	0·85 (0·68,1·09)	0·012	0·95 (0·72,1·25)	0·726
	Total flexibility score (0-20)	-	0·91 (0·88,0·93)	<0·001	0·95 (0·92,0·98)	0·012	0·98 (0·94,1·03)	0·501
	Total effort score (0-24)	-	0·91 (0·88,0·94)	<0·001	0·96 (0·92,1·00)	0·068	0·97 (0·93,1·02)	0·234
Women	Number of outdoor activities	0 (368)		<0·001		0·007		0·028
		1 (120)	0·61 (0·49,0·76)	<0·001	0·81 (0·63,1·03)	0·084	0·88 (0·68,1·13)	0·323
		2 (99)	0·51 (0·40,0·66)	<0·001	0·65 (0·49,0·85)	0·002	0·67 (0·50, 0·91)	0·010
		3+ (32)	0·42 (0·28,0·65)	<0·001	0·61 (0·38,0·99)	0·046	0·60 (0·36,0·98)	0·042
	Number of indoor activities	0 (41)		<0·001		0·104		0·131
		1 (61)	0·67 (0·44,1·01)	0·053	0·68 (0·45,1·06)	0·090	0·62 (0·38, 0·99)	0·045
		2 (361)	0·37 (0·27,0·53)	<0·001	0·62 (0·43,0·92)	0·016	0·63 (0·41,0·94)	0·027
		3+ (156)	0·34 (0·24,0·49)	<0·001	0·68 (0·44,1·05)	0·079	0·69 (0·44,1·09)	0·116
	Number of leisure activities	0 (367)		<0·001		0·015		0·011
		1 (185)	0·76 (0·63,0·92)	0·005	0·93 (0·75,1·14)	0·482	0·92 (0·74,1·15)	0·484
		2+ (67)	0·47 (0·35,0·64)	<0·001	0·60 (0·44,0·85)	0·004	0·59 (0·41, 0·83)	0·003
	Minutes walking	0 (270)		<0·001		0·096		0·418
		<10 (21)	0·75 (0·47,1·18)	0·211	0·83 (0·52,1·33)	0·443	0·82 (0·50,1·33)	0·423
		≥ 10 (266)	0·67 (0·55,0·80)	0·000	0·81 (0·67,0·98)	0·032	0·88 (0·72,1·08)	0·233
	Total flexibility score (0-20)	-	0·92 (0·89,0·94)	<0·001	0·99 (0·96,1·03)	0·594	1·00 (0·97,1·04)	0·863
	Total effort score (0-24)	-	0·91 (0·89,0·93)	<0·001	0·95 (0·93,0·98)	0·002	0·98 (0·94,1·01)	0·138

[1]Separate models for each activity variable; [2]Single model for all activity variables; [3]Adjusting for age group, socioeconomic class, physical health, self-rated health, employment status, depression, and social engagement. *model goodness of fit (-2 log likelihood ratio): Model 1 males: outdoor activity =3753.132, indoor activity=3771.224, leisure activity= 3770.978, walking =3447.872 flexibility = 3767.470, effort = 3743.549 Model 2 males =3401.280, model 3 males= 3019.895 Model 1 females: outdoor activity=6110.884 indoor activity=6119.992, leisure activity = 6133.277, walking = 5530.840, flexibility =6135.958, effort= 6123.109 , Model 2 females=5403.121, Model 3 females=3019.895

3.5 21-year mortality among women

Among the women, in the separate unadjusted models (Models 1), participation in higher levels of outdoor activities (p<0·001), indoor productive activities (p<0·001), leisure activities (p<0·001), walking (p<0·001), the total flexibility score (p<0·001), and the total effort score (p<0·001) were each significantly associated with long-term survival. Women who participated in three or more, two or even one outdoor activities had reduced mortality (HR = 0.42, 0.51, 0.61) when compared to women who participated in no outdoor activities. Women who participated in three or more or two indoor activities had reduced mortality (HR= 0.34 and 0.37) when compared to women who participated in no indoor activities. Women who participated in two or more or one leisure activities had a reduced HR (HR= 0.47 and 0.76 respectively) when compared to women who participated in no leisure activities. Women who walked for 10 or more minutes had a reduced HR (HR=0.67) when compared to women who reported not spending any time walking. Higher total flexibility and total effort scores for women were both associated with reduced mortality (HR = 0.92 and 0.91 respectively).

When all these activities were included in a single model (Model 2), participation in outdoor activities (p=0·007), leisure activities (p=0·015), and total effort score (p=0·001) remained significantly associated with long-term survival. Women who participated in three or more or two outdoor activities had reduced mortality (HR = 0.61 and 0.65) compared to women who participated in no outdoor activities. Women who participated in two or more leisure activities had reduced mortality (HR= 0.60) when compared to women who participated in no leisure activities. Women who walked for 10 or more minutes had a reduced HR (HR = 0.81) when compared to women who reported not spending any time walking. Higher total effort scores was associated with reduced mortality (HR=0.95). When adjusting for demographic, physical health, psychological health and social activity (Model 3), participation in outdoor activities (p=0·028), and leisure activities (p=0·011) both remained significantly associated with long-term survival. Older women who undertook three or more or two outdoor activities had improved survival compared with women who undertook no outdoor activities (HR = 0.60 and 0.67 respectively), independent of age, demographic, health-related, social activity and other physical activities. Women who undertook two or more leisure activities had improved survival compared with women who undertook no leisure activities (HR = 0.59). Women who participated in three or more outdoor activities had a reduced HR (HR = 0.88) when compared to women who participated in 1 outdoor activity (HR = 0.60). In addition, age group (p<0·001) and social engagement (p=0·006) were significantly associated with long-term survival.

4.1 Discussion

This study provides new knowledge about differences between men and women in the way specific types of physical activity can promote health and well-being in later life. Among older men, the finding that although each of the types of physical activity reduced long-term mortality, but that only activities requiring greater flexibility, e.g., reaching high, bending, crouching, remained significantly associated with improved survival when all activities were considered together, suggests that while men benefited from undertaking the other types of activity (e.g., indoor productive activity, outdoor activity, etc.), it was the activities requiring flexibility that had greatest impact and benefit.

However, the apparent benefits of undertaking regular physical activity were explained by age; younger older men undertake greater levels of physical activity, but their age provides the advantage for lowering all-cause mortality rather than participating in activities *per se*.

In contrast, the finding that older women's participation in multiple outdoor and leisure activities demonstrated significant benefits for long-term survival, even when accounting for age, socioeconomic class, health and social activities, accords with previous research that found the relationship between physical activity and mortality was stronger in women (Yang, 2012). This study adds to previous research by identifying the types of activity that have particular long-term benefits that reduce all-cause mortality in older people. Encouraging participation in specific physical activities, such as gardening, swimming and dancing among older women may improve long-term survival. Previous research suggested that a physically active lifestyle for older women such as taking up walking could lower all-cause mortality (Gregg, Cauley, Stone, et al, 2003). Previous research has also found that improved physically activity among older women will lead to an improved cognitive function (Weuve, Kang, Manson, Breteler, Ware, Grodstein, 2004; Yaffe, Barnes, Nevitt, Lui, Covinsky, 2001). More generally, previous research has found that physical activity is likely to lead to positive health outcomes in older adults (Sparling, Howard, Dunstan, and Owe, 2015; Gebel et al, 2015; Olanrewaju et al, 2016; Halloway et al, 2017). Furthermore, Hupin et al (2015) in a systematic and meta review noted that moderate to intense physical activity is likely to reduce all-cause mortality by 22% in adults who are aged 60 or older.

Regular physical activity has shown to reduce the risk of developing breast cancer, colon cancer, coronary heart disease, stroke, hypertension, and depression (WHO, 2010). Regular physical activity will also lead to an increased energy expenditure which is essential to maintaining a healthy weight. Thus, there will be benefits to other aspects of health and well-being for men. It is noted that there is the potential for multi-collinearity among activity types. That is, if active people tend on average to be active across many activities, and the sedentary remain sedentary, the presence of collinearity will cause the variables to compete with each other for shared variance. This may explain for instance why some variables lose strength and/or significance from Model 1 to Model 2. For instance, this may explain why 2 or more leisure activities in men moves from 0.65 ($p = 0.003$) to 0.86 ($p = 0.37$ between Models 1 and 2. Future research will seek to perform a mediation analysis to measure the effect of physical activity with that of physical health.

Further research could investigate the factors that affect the levels of participation in physical activities. This study examined the types of physical activity on 21-year all-cause mortality of participation; further research could investigate all-cause mortality across various years, which could allow comparisons in findings to see if there are any changes in all-cause mortality. Further research could also examine possible benefits of promoting specific types of physical activity in older men and women. As age may be a strong predictor for mortality future research will seek to examine any changes in all-cause mortality with age as an adjusting variable. Moreover, the behaviour choice model would indicate that older adults might be more likely to engage in physical activity if it is perceived as an attractive option compared to competing interests. The small sample size in certain groups in the CPA may affect the accuracy of the estimates. Further research will seek to use differing lengths of follow up to look at how this may affect Hazard Ratios, and to examine whether CPA may change over time as this may indicate whether attenuation is likely to occur. Further research (alongside examining differing lengths of follow ups) will also examine the cause of mortality by key

types. The results of this study may be of interest to activity professionals whom could encourage various types of physical activity for older adults. More specifically, encouraging gardening, swimming and dancing among older women may improve long-term survival.

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Appendix 1: NLSAA protocol

5.1 Questionnaire Design

The survey was conducted using a 318 item structured survey which was expected to take between 45 to 90 minutes (Morgan, 1998). This research was conducted using items from Section 13 of the Nottingham Longitudinal Study of Activity and Ageing (NLSAA) which addresses Customary Physical Activity. Variables that were used in this study include outdoor activity, indoor productive activity, and leisure activity.

5.2 Customary Physical Activity

Customary Physical Activity (CPA) was modified for older subjects. 'customary' for older people in the NLSAA, are defined as "activities with a probable minimum energy cost of 2 kcal/min, performed continuously for a minimum of 3 minutes, at least weekly, for at least the previous six weeks" (Morgan, 1998).

Activities were grouped into 7 categories which could be classified as continuous and non-continuous (Morgan, 1998). Continuous activities such as participation in outdoor activities were judged based on the 'customary' criteria while non-continuous activities were judged based on amount of time put into it (Morgan, 1998).

5.3 Physical Capabilities

Strength (t-effort) and flexibility (t-bend) scores of participants were measured in view of "assessing actual functional capabilities of participants" (Morgan, 1998). The weight of participants was also measured (Morgan, 1998). A score of 0 meant the individual had a low strength and flexibility (reflecting weakness) and a score of 20 for t-bend and 24 for t-effort was a sign of high strength and flexibility. Physical capability scores (t-bend and t-effort) were also used as variables.

5.4 Cognitive Impairment

This involved the use of a "12-item Information/Orientation (I/O) scale from the Clifton Assessment Procedures for the Elderly (CAPE)" (Morgan, 1998). Questions were divided into two sections (Morgan, 1998). This procedure was used to measure the level of mental (memory) fitness of participants. Participants whose CAPE score fell below 8 were considered unfit (Morgan, 1998).

5.5 Psychological Wellbeing

Psychological Wellbeing was considered to "normal and pathological affective variations assessed as depression and morale" (Morgan, 1998). Symptoms of Anxiety and Depression (SAD) score was used as a covariate during this study. SAD score ranged from 0-42 (0 being absence of anxiety or depressive problems)

5.6 Social Engagement

Participation in social activities was looked at both as a factor for judging "wellbeing and also a control variable for many physical activities social component" (Morgan, 1998). This part of the survey involved the use of a 20-item scale which was predominantly based on a Yes/No response (Morgan, 1998). Items had been subjected to iterative tests to show reliability (Morgan, 1998). Items were removed based on certain criteria which involved looking at if "its removal improved the value of the reliability coefficient α" (Morgan, 1998b). This produced a "20-item (20 representing high

participation) scale with a 0.7 overall reliability α" (Morgan, 1998). Social Engagement score was included as a covariate.

5.7 Physical Health

This was assessed through the use of a "14-item health index (Morgan, 1998). A high score meant a person was less healthy and a low score indicated a more healthy state (Morgan, 1998b). Health index scores were complemented with other issues such as participant's history of smoking (Morgan, 1998). Participant's rating of their own present health status (using a five-point scale) was also considered as part of physical health rating (Morgan, 1998b). Physical Health Index was also used as a covariate.

5.8 Summary

A criteria for successful participations in the three (1985, 1989 and 1993) surveys carried out, was an I/O assessment score of not less than 8 (Morgan, 1998b). Though not all those who were eligible and did not participate had scores less than 8, some people did not participate due to other factors such as information withholding and this class were classified as missing data (Morgan, 1998).

Appendix 2: Survival curves

Figure 2: Survival curve for total outdoor activity for Males

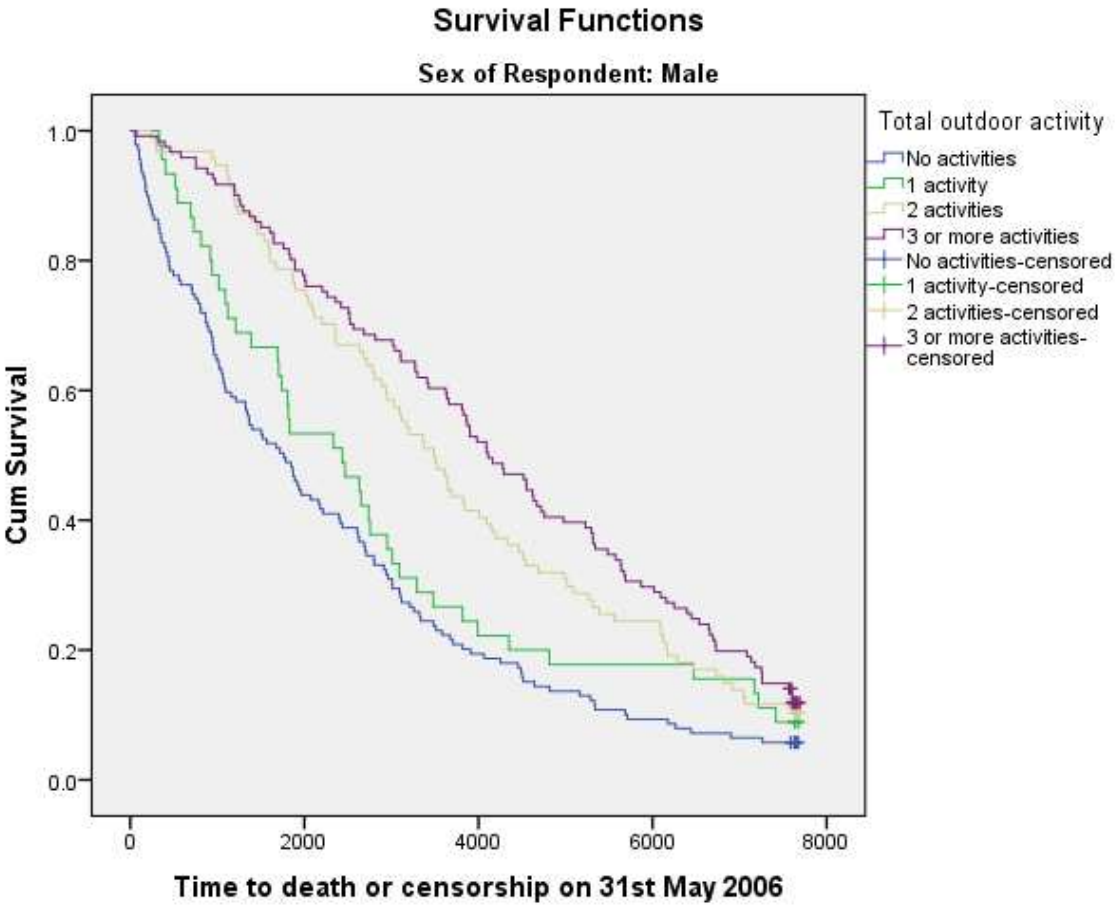


Figure 3: Survival curve for total outdoor activity for Females

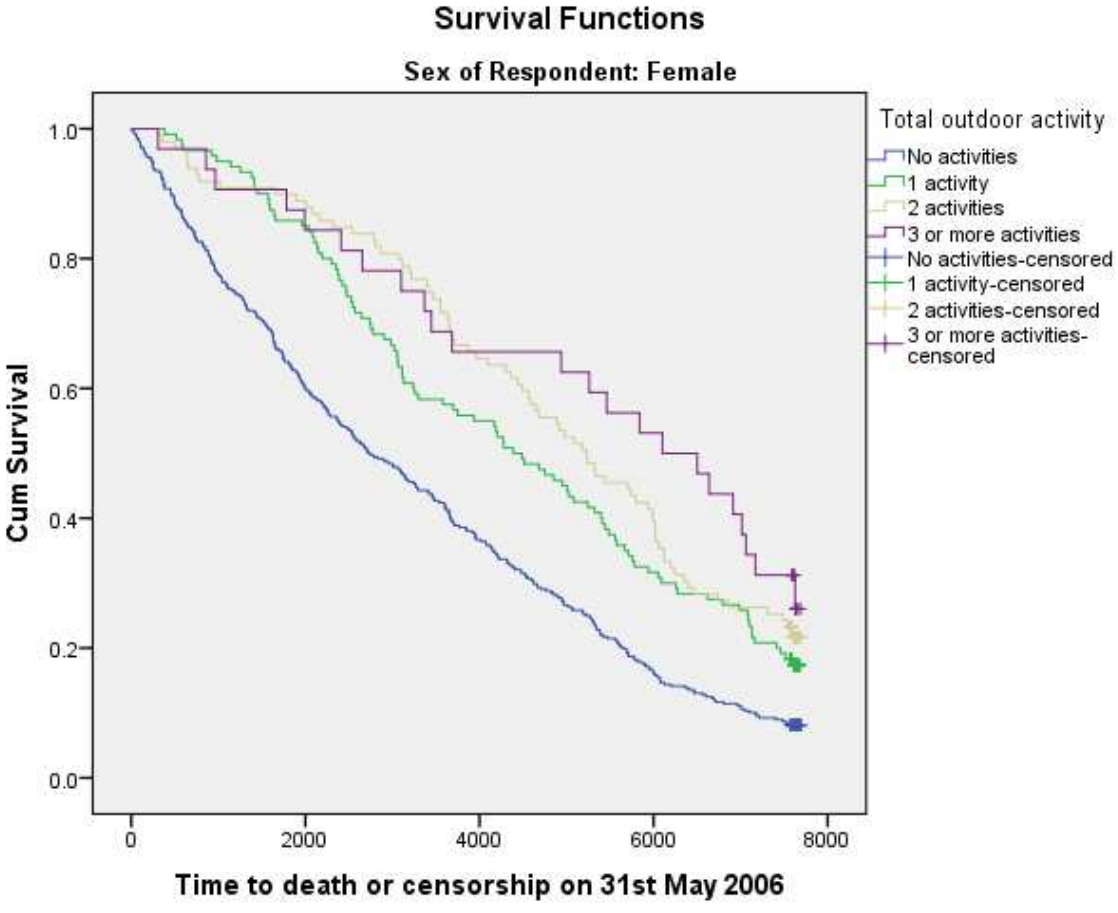


Figure 4: Survival curve for total indoor activity for males

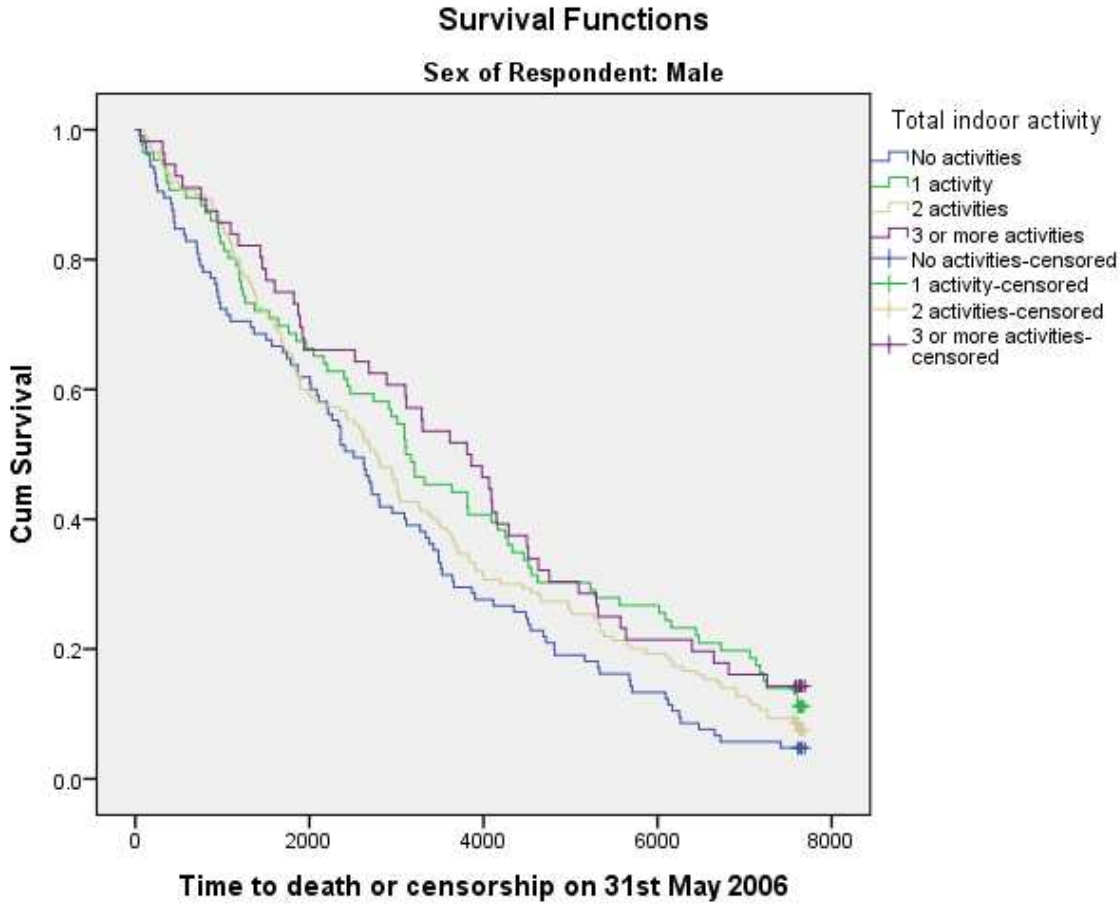


Figure 5: Survival curve for total indoor activity for females

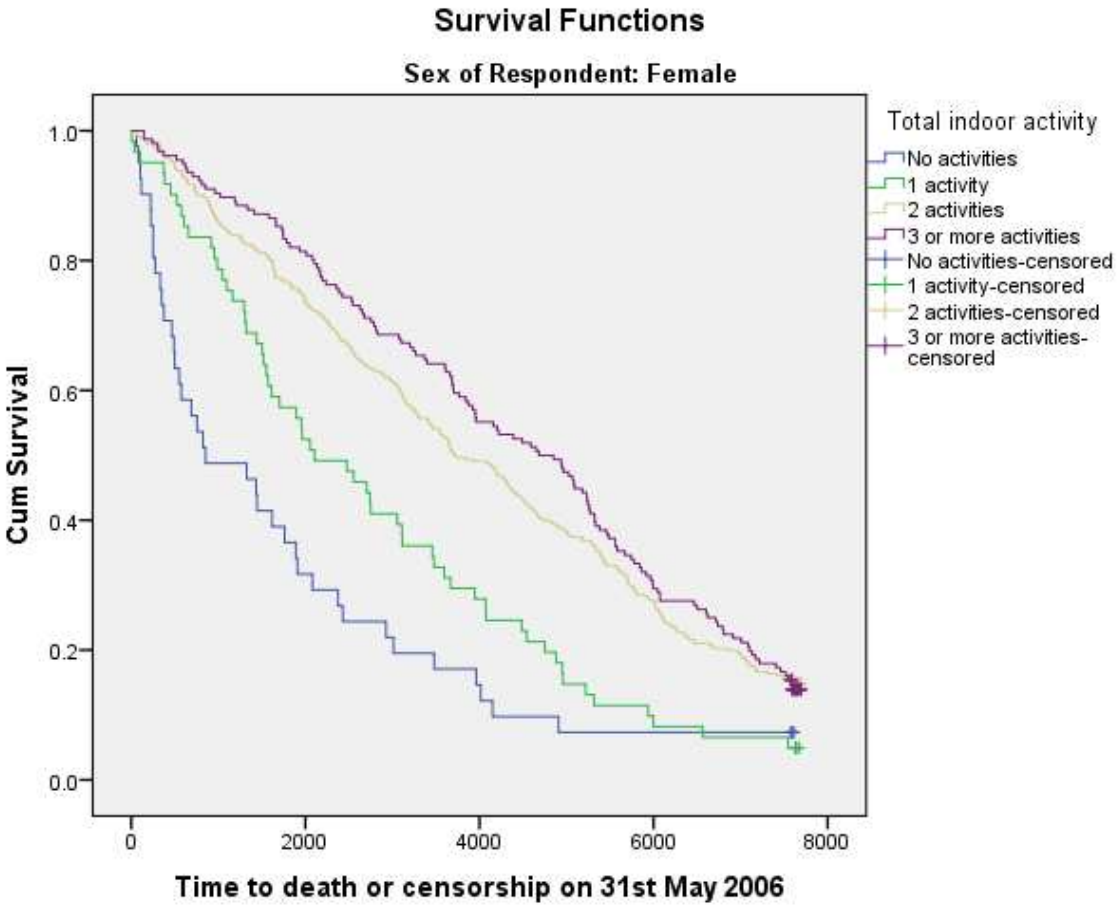


Figure 6: Survival curve for total leisure activity for males

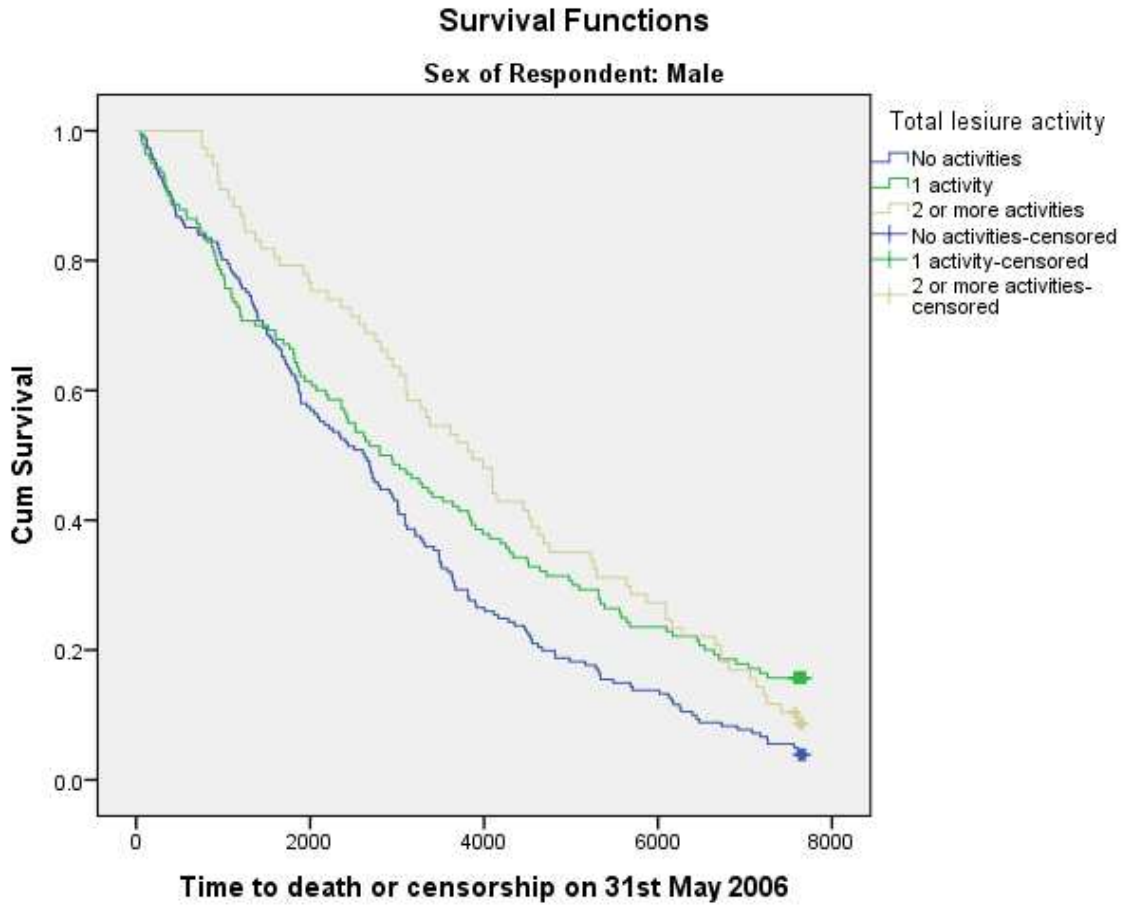


Figure 7: Survival curve for total leisure activity for females

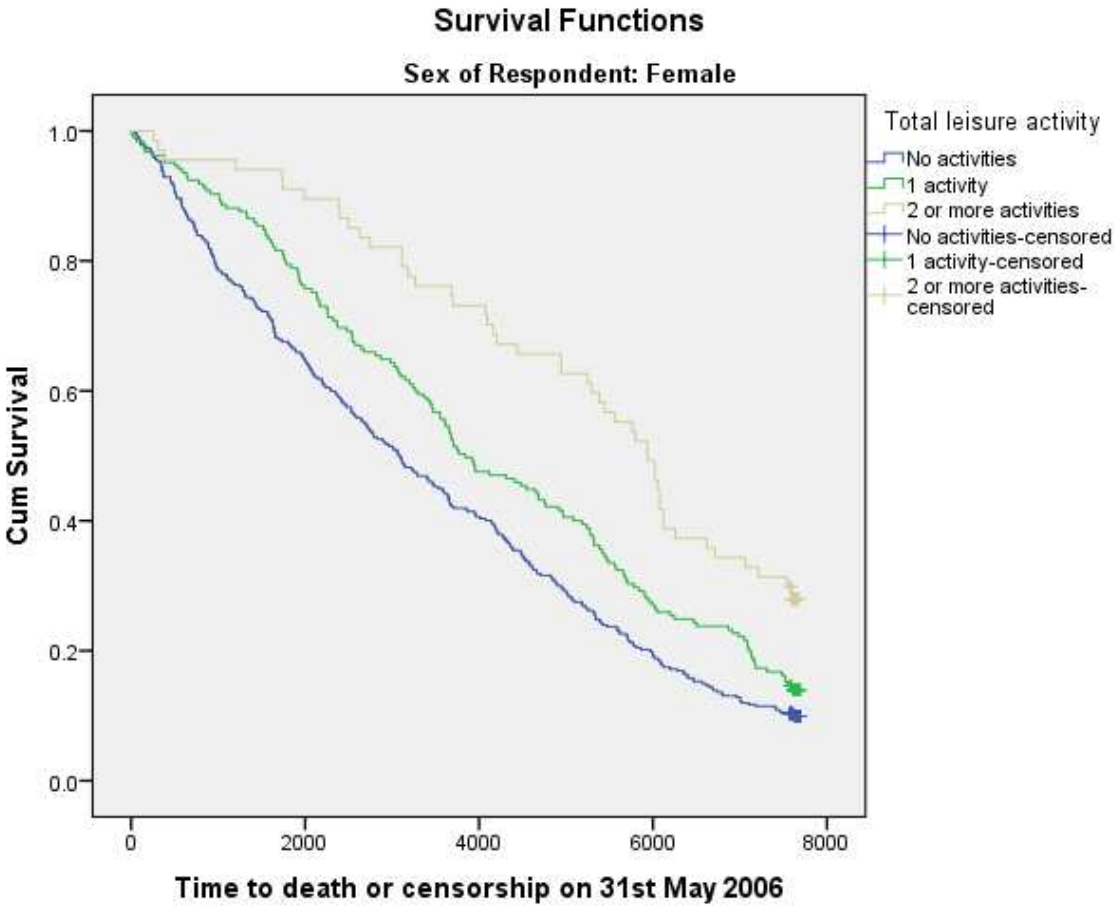


Figure 8: Survival curve for walking (2 categories)

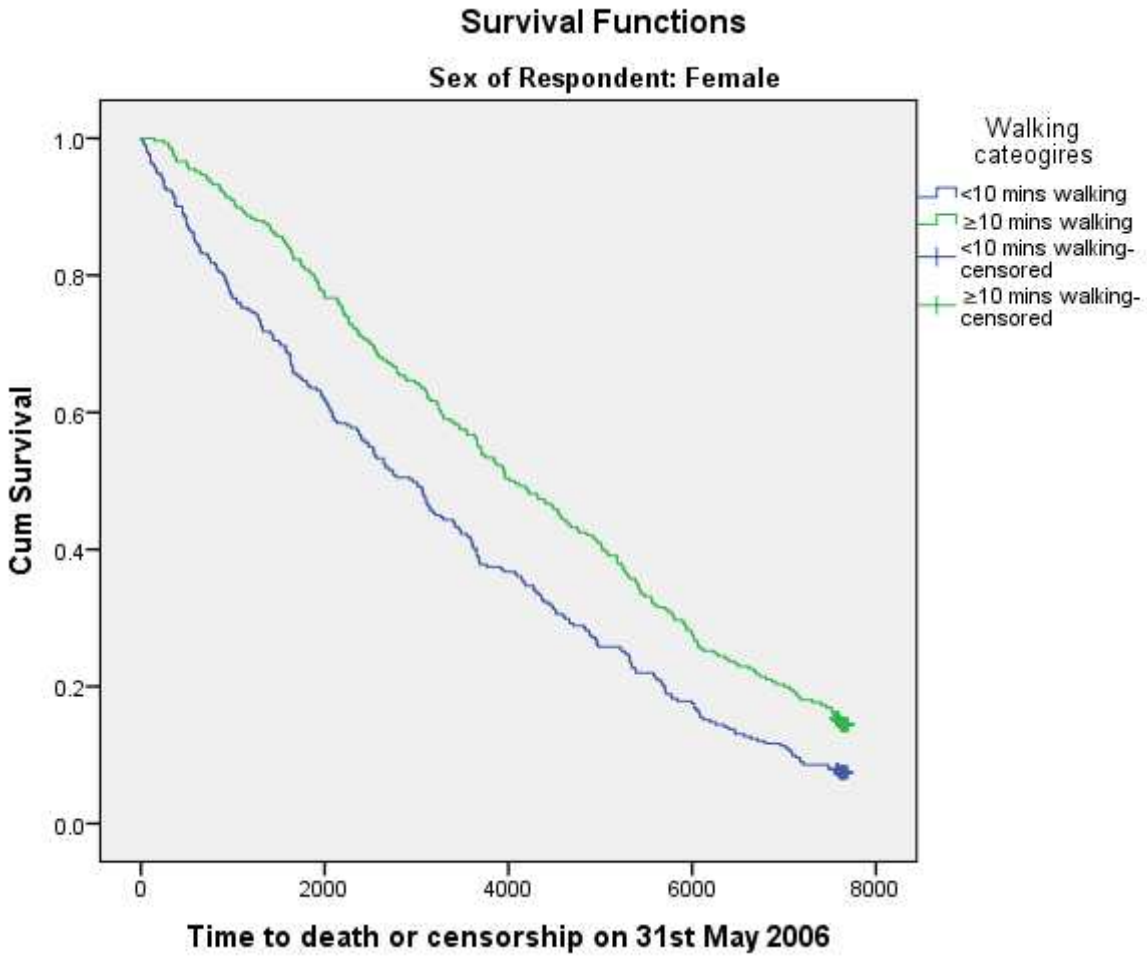
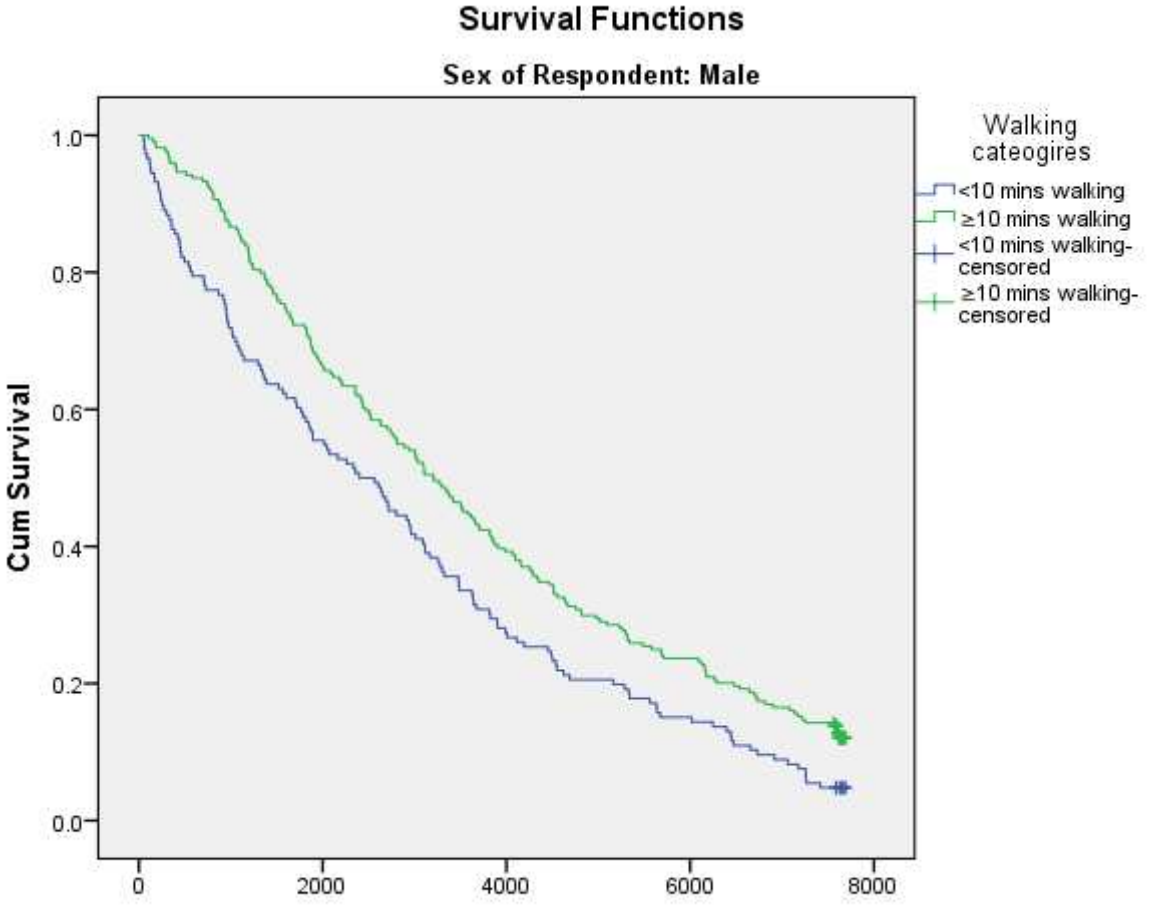


Figure 9: walking two categories (2 categories)



Appendix 3: Survival curves

Table 2: Distribution of participants according to number of outdoor activities in relation to demographic, health-related and social engagement variables.

Categorical Variable	Category	Number of Outdoor Activities, n (%)				
		0	1	2	3+	Total
Age	≤ 69yrs	80 (37.0)	33 (15.3)	49 (22.7)	54 (25.0)	216 (100.0)
	70 – 74yrs	103 (36.1)	49 (17.2)	77 (27.0)	56 (19.6)	285 (100.0)
	75 – 79yrs	144 (53.3)	46 (17.0)	49 (18.1)	31 (11.5)	270 (100.0)
	80 – 84yrs	122 (69.3)	30 (17.0)	13 (7.4)	11 (6.2)	176 (100.0)
	85 +	58 (81.7)	7 (9.9)	5 (7.0)	1 (1.4)	71 (100.0)
Gender	Male	139 (34.8)	45 (11.3)	94 (23.6)	121 (30.3)	399 (100.0)
	Female	368 (59.5)	120 (19.4)	99 (16)	32 (5.2)	619 (100.0)
Socioeconomic class	Class I & II	62 (41.1)	22 (14.6)	37 (24.5)	30 (19.9)	151 (100.0)
	Class IIIN & IIIM	290 (47.9)	102 (16.8)	114 (18.8)	100 (16.5)	606 (100.0)
	Class IV & V	150 (58.8)	41 (16.1)	41 (16.1)	23 (9.0)	255 (100.0)
Employment status	Not Employed	469 (52.1)	149 (16.5)	162 (18.0)	121 (13.4)	901(100.0)
	Employed (PT, FT)	38 (32.5)	16 (13.7)	31 (26.5)	32 (27.4)	117(100.0)
Self-rated health	Poor	54 (87.1)	6 (9.7)	1 (1.6)	1 (1.6)	62 (100.0)
	Fair	88 (59.1)	23 (15.4)	26 (17.4)	12 (8.1)	149 (100.0)
	Average	95 (56.9)	32 (19.2)	25 (15)	15 (9)	167 (100.0)
	Good	193 (41.7)	77 (16.6)	103 (22.2)	90 (19.4)	463 (100.0)
	Excellent	51 (34.2)	26 (17.4)	38 (25.5)	34 (22.8)	149 (100.0)
	Total	507	165	193	153	1018

Continuous variables	Number of Outdoor Activities, Mean rank (n)			
	0	1	2	3+
14 Item Health Index	583.43 (499)	515.35 (163)	419.74 (192)	338.58 (153)
SAD Score	543.23 (474)	496.33 (164)	435.94 (190)	384.05 (151)
Social Engagement Score	391.89 (474)	530.32 (164)	579.79 (189)	638.57 (151)

Table 3: Distribution of levels of indoor productive activities according to demographic, health-related and social engagement variables.

Categorical Variable	Category	Number of Indoor Activities, n (%)				
		0	1	2	3+	Total
Age	≤ 69yrs	25 (17.1)	33 (15.3)	104 (48.1)	54 (25.0)	216 (100.0)
	70 – 74yrs	38 (13.4)	33 (11.7)	139 (49.1)	73 (25.8)	283 (100.0)
	75 – 79yrs	39 (14.4)	35 (13.0)	136 (50.4)	60 (22.2)	270 (100.0)
	80 – 84yrs	26 (14.8)	27 (15.3)	103 (58.5)	20 (11.4)	176 (100.0)
	85 +	18 (25.4)	19 (26.8)	29 (40.8)	5 (7.0)	71 (100.0)
Gender	Male	105 (26.4)	86 (21.7)	150 (37.8)	56 (14.1)	397 (100.0)
	Female	41 (6.6)	61 (9.9)	361 (58.3)	156 (25.2)	619 (100.0)
Socioeconomic class	Class I & II	23 (15.2)	24 (15.9)	78 (51.7)	26 (17.2)	151 (100.0)
	Class IIIN & IIIM	80 (13.2)	87 (14.4)	302 (49.9)	136 (22.5)	605 (100.0)
	Class IV & V	42 (16.5)	36 (14.2)	126 (49.6)	50 (19.7)	254 (100.0)
Employment status	Not Employed	129 (14.3)	130 (14.4)	455 (50.6)	186 (20.7)	900(100.0)
	Employed (PT, FT)	17 (14.7)	17 (14.7)	56 (48.3)	26 (22.4)	116(100.0)
Self-rated health	Poor	24 (38.7)	16 (25.8)	19 (30.6)	3 (4.8)	62 (100.0)
	Fair	17 (11.5)	23 (15.5)	83 (56.1)	25 (16.9)	148 (100.0)
	Average	17 (10.2)	19 (11.4)	105 (62.9)	26 (15.6)	167 (100.0)
	Good	55 (11.9)	65 (14.0)	232 (50.1)	111 (24.0)	463 (100.0)
	Excellent	15 (10.1)	19 (12.8)	68 (45.9)	46 (31.1)	148 (100.0)
	Total	507	165	193	153	1018

Continuous variables	Number of Indoor Activities, Mean rank (n)			
	0	1	2	3+
14 Item Health Index	550.75 (139)	520.57 (146)	508.93 (509)	447.72 (212)
SAD Score	531.77 (124)	486.02 (141)	496.31 (504)	450.36 (209)
Social Engagement Score	416.37 (126)	485.65 (138)	477.87 (504)	561.84 (209)

Table 4: Distribution of levels of leisure activities according to demographic, health-related and social engagement variables.

Categorical Variable	Category	Number of Leisure Activities, n (%)			
		0	1	2	Total
Age	≤ 69yrs	95 (44.0)	80 (37.0)	41 (19.0)	216 (100.0)
	70 – 74yrs	147 (51.8)	87 (30.6)	50 (17.6)	284 (100.0)
	75 – 79yrs	150 (55.6)	92 (34.1)	28 (10.4)	270 (100.0)
	80 – 84yrs	106 (60.2)	50 (28.4)	20 (11.4)	176 (100.0)
	85 +	50 (70.4)	16 (22.5)	5 (7.0)	71 (100.0)
Gender	Male	181 (45.5)	140 (35.2)	77 (19.3)	398(100.0)
	Female	41 (59.3)	19 (29.9)	105 (10.8)	619 (100.0)
Socioeconomic class	Class I & II	79 (52.3)	44 (29.1)	28 (18.5)	151 (100.0)
	Class IIIN & IIIM	328 (54.1)	187 (30.9)	91 (15.0)	605 (100.0)
	Class IV & V	136 (53.5)	94 (37.0)	24 (9.4)	254 (100.0)
Employment status	Not Employed	501 (55.7)	281 (31.2)	118 (13.1)	900 (100.0)
	Employed (PT, FT)	17 (40.2)	17 (37.6)	56 (22.2)	117 (100.0)
Self-rated health	Poor	48 (77.4)	13 (21.0)	1 (1.6)	62 (100.0)
	Fair	94 (63.5)	42 (28.4)	12 (8.1)	148 (100.0)
	Average	99 (59.3)	54 (32.3)	14 (8.4)	167 (100.0)
	Good	229 (49.5)	152 (32.8)	82 (17.7)	463 (100.0)
	Excellent	55 (36.9)	59 (39.6)	35 (23.5)	148 (100.0)

	Number of Leisure Activities, Mean rank (n)		
Continuous variables	0	1	2 +
14 Item Health Index (1985)	555.95 (539)	461.84 (325)	404.02 (143)
SAD Score	531.41 (515)	463.99 (320)	399.69 (144)
Social Engagement Score	422.40 (516)	530.89 (319)	639.28 (143)

Contributions

WA, OF and PB all contributed to the design of this specific study, data analysis and the writing of the paper.

Declaration of interests

No conflicts of interest.