Journal of Physical Education and Sport ® (JPES), Vol.19 (issue 2), Art 158, pp. 1092 – 1098, 2019
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Sedentary behaviour patterns and spring-autumn seasonality in older Central European adults

JANA PECHOVÁ[1], JANA PELCLOVÁ[2], JAN DYGRÝN[3], IZABELA ZAJĄC-GAWLAK[4], LENKA TLUČÁKOVÁ[5]
[1,2,3] Institute of Active Lifestyle, Faculty of Physical Culture, Palacký University, CZECH REPUBLIC
[4] Department of Physical Education, The Jerzy Kukuczka Academy of Physical Education, POLAND
[5] Department of Sport Educology and Humanistic, Faculty of Sports, University of Prešov, SLOVAKIA

Published online: June 30, 2019
(Accepted for publication: June 06, 2019)
DOI:10.7752/jpes.2019.02158

Abstract:
Background: Older adults are considered the most sedentary and the most fragile group in our society. Understanding how seasonal and meteorological factors impact the sedentary behaviour (SB) is important for developing of strategies to improve their health. Therefore, the purposes of the present study were to examine: (1) potential spring-autumn variation in SB patterns among older adults from Central Europe, and (2) possible interactions between weather conditions and SB patterns. ***Methods***: 83 participants aged 55+ were repeatedly measured by accelerometers during one year – in spring and autumn months. Data about SB, physical activity (PA) and meteorological factors (daylight length, average precipitation and temperature) have been collected during both seasons. SB intervals (bouts) with a duration of 1–4, 5–9, 10–19, 20–29, 30–39, 40–59, and 60+ minutes were extracted to observe the spring-autumn differences. ***Results***: In older adults, total sedentary time was 412min and 435min in spring and autumn, respectively ($p<0.001$). In both seasons, approximately 85% of daily bout frequency comprised bouts ≤10 minutes long. Regarding to sedentary bout duration, about 45% of the daily sedentary time was accumulated in bouts ≤10 minutes long. No significant differences between spring and autumn with regard to the duration of sedentary bouts ($p>0.05$) and frequency of sedentary bouts lasting ≥20 minutes were found. Looking at weather conditions, SB was significantly lower when the temperature was above 10°C in the autumn ($p<0.01$). Daylight length and average precipitation were significantly associated with total sedentary time; however, the associations differed in seasons. ***Conclusions***: Although total sedentary time was slightly higher in autumn compared to spring, SB patterns did not differ significantly between spring and autumn. Overall, weather conditions appear to be important factors related to SB in elderly. Both, total sedentary time and SB patterns in relation to weather conditions should be considered when targeting older adults' SB and PA interventions in different seasons.
Key Words: *accelerometer, elderly, season, sitting time, weather*

Introduction

Demographic changes in Central Europe have a significant impact on the process of the ageing of the population, since over 20% of the population is older than 55 years. This proportion should increase to 25% in the coming decade (Economic and Financial Affairs, 2018). Regular physical activity (PA) is considered a basic element of healthy and independent ageing (Rocha et al., 2018). Conversely, sedentary behaviour (SB), which is recognized as any waking behaviour in a sitting/lying posture with very low energy expenditure (Tremblay et al., 2017), has been found to be associated with adverse health outcomes (Copeland et al., 2017) and increased risk of mortality (Ekelund et al., 2016).

Using an accelerometry assessment, it has been established that older adults spend a vast proportion of their day in sitting activities and they are the least active group in our society (Harvey, Chastin, & Skelton, 2015). To reduce SB in older adults, understanding the broad range of determinants that could impact on sitting is crucial. Several different determinants, including environmental ones, have been identified as relating to SB in older adults (Chastin et al., 2015). Nevertheless, while the seasonal variation of PA has been widely studied (Tucker & Gilliland, 2007; Witham et al., 2014), the influence of seasonality on SB in the elderly is less understood. Moreover, the majority of these studies are somehow limited; either the activity level has been assessed by questionnaires (King et al., 2000; Kornides et al., 2017) or, when using accelerometry, only a single measurement of each participant across the season has been performed (Klenk et al., 2012; Sartini et al., 2017; Schepps, Shiroma, Kamada, Harris, & Lee, 2018; Sumukadas, Witham, Struthers, & McMurdo, 2009; Wu, Luben, Wareham, Griffin, & Jones, 2016). Self-reported PA and SB from the elderly might be inaccurate (Van Cauwenberg, Van Holle, De Bourdeaudhuij, Owen, & Deforche, 2014) and a single measurement of activity

Corresponding Author: JANA PECHOVÁ, E-mail: jana.pechova@upol.cz

level from a random week during the year can lead to random error in comparison between seasons. Finally, not just total sedentary time, but specific patterns of SB distribution in terms of the duration and number of sedentary bouts, should be considered (Diaz et al., 2016).

The total time spent on SB or SB patterns is associated with meteorological changes such as the daylight length and weather (Tucker & Gilliland, 2007). The ambient temperature seems to be the most relevant weather factor for older adults, since individuals avoid exposure to hot weather, as well as lower temperatures because of the risk of falls and injuries caused by slippery ice surfaces. Several studies have investigated only summer-winter differences, which represent extreme weather differences (Arnardottir et al., 2017; Clemes, Hamilton, & Griffiths, 2011; Hamilton, Clemes, & Griffiths, 2008; Jones, Brandon, & Gill, 2017). In order to recommend the best season to perform either cross-sectional or longitudinal monitoring of physical behaviour, neither summer nor winter is the best choice because of the significant influence of environmental factors (Kang, Bassett, Barreira, Tudor-Locke, & Ainsworth, 2012). In Central Europe, where there are four distinct seasons, the spring and autumn, with their rather mild weather conditions that are mostly without extremes, seem to be equivalent periods for SB assessments. However, the evidence for spring-autumn equivalence is missing. Therefore, the purposes of the present study were to examine: (1) potential spring-autumn variation in SB patterns among older adults from Central Europe, and (2) possible interactions between weather conditions and SB patterns.

Methods

Recruitment procedures

Community-dwelling older adults from the Universities of the Third Age in the Czech Republic, Slovakia, and Poland were recruited to participate voluntarily in the measurement of PA and relevant determinants (Pelclová, Gába, Tlučáková, & Pośpiech, 2012; Zając-Gawlak et al., 2016, 2017). In all cases, the participants were approached by researchers during selected lectures focusing on a healthy lifestyle. One hundred and four healthy retired older adults (≥55 years old) participated in repeated measurements during the spring and autumn months within a one-year period.

Only healthy older adults living independently were invited to participate in the study. Participants with physical conditions that might have interfered with the PA and SB measurements (e.g. major hip or knee surgery, paralysis, or a motor skills disorder) were excluded from the study.

Each participant gave their written consent. The project was approved by the institutional ethics committee (no. 80/2017) and conformed to the principles of the Helsinki Declaration.

Measures

All participants were asked to wear an ActiGraph GT1M accelerometer (Manufacturing Technology Inc., FL, USA) for eight continuous days during waking hours and remove the device during water-based activities. Using software supplied by the manufacturer, the sampling interval was set to a one-minute period. Non-wear time was defined by an interval of 60 consecutive minutes of zero counts per minute (cpm), allowing up to two non-zero interruptions. Activity levels were classified according to a widely-used cut-off points scale (Freedson, Melanson, & Sirard, 1998), so activities with an intensity of <100 cpm, 100–1951 cpm, and ≥1952 cpm were classified as SB, light-intensity PA (LIPA), and moderate-to-vigorous PA (MVPA), respectively. This threshold is also widely used in older adults (Gorman et al., 2014). The total time spent on SB was determined by summing all the minutes of that intensity in a day. Using the manufacturer's software, we defined SB intervals (bouts) with a duration of 1–4, 5–9, 10–19, 20–29, 30–39, 40–59, and 60+ minutes. Hence, a sedentary bout was defined as consecutive minutes in which the device registered <100 cpm. The frequency of sedentary bouts, which is equal to a break in SB (Healy et al., 2008), was defined as the number of bouts with a length of at least one minute in which the device registered >100 counts. The participants were instructed to attach the accelerometer to their right hip on their clothes or by using an elastic belt.

Meteorological factors

The data was intentionally collected during moderate seasons, representing spring (late March to the beginning of June) and autumn (October to the beginning of December). Records of the daylight length (minutes), daily average temperature (Celsius), and daily average precipitation (mm) were obtained from the closest weather station to the study area.

Statistical data analysis

One hundred and four community-dwelling older adults participated in repeated measurements during the spring and autumn. To be included in the analysis, accelerometer records for at least 10 hours for four days were required. Because of missing data (a lack of valid days) or damaged data records, seventeen participants were excluded from the data analysis. Four more were excluded because of their outlier data. The final sample comprises eighty-three participants (nine males), always with two time records.

Descriptive statistics including means and standard deviations were computed to describe older adults' basic anthropometric characteristics and total time spent on SB and SB patterns. The SB variables for both seasons were adjusted for identical wear time (795 min/day). The meteorological variables that were recorded included the daily average temperature, daylight length, and daily average precipitation. Data from each day of measurement was collected and then averaged for a specific week of measurement of each participant. An average value for each variable was assigned to each participant.

A paired t-test was performed to determine the difference in the time spent daily on SB between spring and autumn. Pearson correlation was used to evaluate the associations between the chosen weather conditions and total time spent on SB in the spring and autumn. Furthermore, the spring-autumn differences between proportions were calculated for the frequency and the duration of all sedentary bouts.

All the statistical analyses were performed using IBM SPSS Statistics v.21 (IBM Software Group, Chicago, IL). The significance level was set to 0.05.

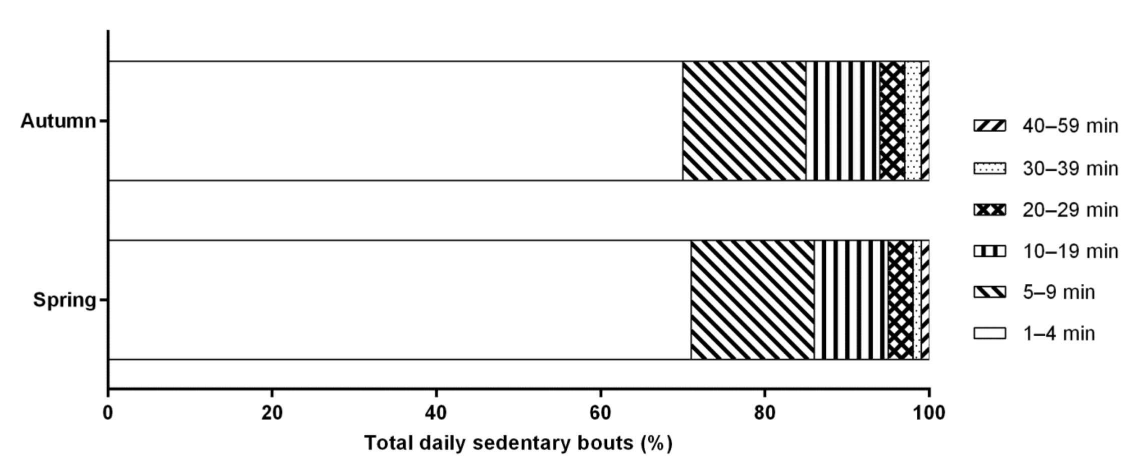
Results

Accelerometry data from repeated-measures was available for eighty-three older adults. One participant wore the device for five valid days; the rest of the group wore the accelerometer for at least six days. The average device wear time was 798±84 min during the spring monitoring and 792±86 min in the autumn. The average age of the participants at baseline was 65±6 years (50–81 years) and their body mass index, calculated by dividing the participants' weight by their height, was 28±5 kg/m^2. Table 1 provides the descriptive statistics of the SB patterns and mean values of weather conditions in both seasons. Concerning the amount of PA, the participants spent an average of 340±75 min and 320±64 min daily on LIPA during the spring and autumn, respectively. The daily averages for their participation in MVPA were 45±27 min and 39±22 min during the spring and autumn, respectively.

Table 1. Descriptive characteristics for SB patterns in the spring and autumn seasons

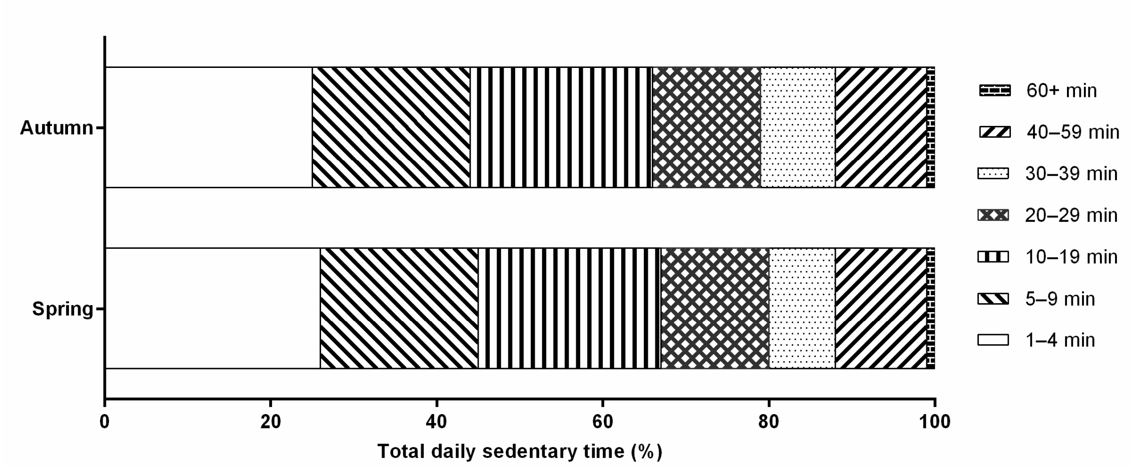
	Spring		**Autumn**	
	Mean	SD	Mean	SD
Sedentary behaviour patterns				
Total sedentary time (min/day)	411.8	76.2	434.6	67.9
Duration of bout 1–4min (min/day)	102.1	17.1	105.1	20.5
Duration of bout 5–9min (min/day)	77.3	16.8	81.0	17.7
Duration of bout 10–19min (min/day)	91.3	23.1	97.3	23.5
Duration of bout 20–29min (min/day)	55.4	23.7	58.7	22.7
Duration of bout 30–39min (min/day)	33.9	17.3	39.2	20.8
Duration of bout 40–59min (min/day)	46.8	29.9	47.9	31.3
Duration of bout ≥60min (min/day)	4.9	8.2	5.2	7.8
Total frequency of sedentary bouts (nr/day)	80.0	10.2	82.3	11.3
Frequency of bout 1–4min (min/day)	56.9	9.7	57.9	11.3
Frequency of bout 5–9min (min/day)	11.8	2.5	12.4	2.6
Frequency of bout 10–19min (min/day)	6.8	1.7	7.3	1.7
Frequency of bout 20–29min (min/day)	2.3	1.0	2.5	1.0
Frequency of bout 30–39min (min/day)	1.0	0.5	1.2	0.6
Frequency of bout 40–59min (min/day)	1.0	0.6	1.0	0.7
Frequency of bout ≥60min (min/day)	0.1	0.1	0.1	0.1
Weather conditions				
Avg. temperature (°C/day)	13	2	8	4
Avg. precipitation (mm/day)	2	2	2,5	2
Avg. daylight (min/day)	970	49	628	70

Figure 1. Average daily proportion (%) of sedentary bout frequency distribution



Note: Sedentary bouts with a length of 60+ min represent less than 1% of the daily distribution and they are not visible in this figure.

Figure 2. Average daily proportion (%) of sedentary bout duration distribution



The total time spent on SB differed between the two seasons (t=-4.305, p<0.001), it was shorter in the spring season. By looking at the percentage proportion of SB patterns and the duration and frequency of bouts, deeper information about SB can be gained. Figure 1 depicts the numbers of sedentary bouts in an average day. The proportion of bout frequency looked very similar in both seasons, but there were significant differences in 5–9-min bouts (p<0.05) and 10–19-min bouts (p<0.05).

The most frequent sedentary bout was 1–4 minutes in length. About 85% of the frequency of daily bouts comprised bouts ≤10 minutes long. At the same time, about 45% of the daily SB was accumulated in bouts ≤10 minutes long (Figure 2). The time spent on sedentary bouts ≥30 minutes long represents only a small amount of the total SB. No significant differences between spring and autumn with regard to the duration of sedentary bouts (p>0.05) were found.

Looking at weather conditions, the total time spent daily on SB was negatively correlated with the average temperature in the autumn (r=-0.338, p<0.01); it was significantly lower when the temperature was above 10° C in the autumn. A non-significant association was found in the spring (r=-0.018, p>0.05).

The mean precipitation was very similar in both seasons and it showed a positive correlation with the total time spent on SB in the spring (r=0.334, p<0.01) and a negative and non-significant correlation in the autumn (r=-0.156, p>0.05).

Daylight length was associated with the total time spent on SB in the spring, just as in the autumn (p<0.01). A positive correlation (r=0.333) was found in the spring, when the mean total time spent on SB was lower than in the autumn and longer daylight was actually associated with more time spent on SB. Nevertheless, the correlation in the autumn showed a negative association (r=-0.316), so on a day with longer daylight the participant might have accumulated less SB, as was the case in the spring months.

Discussion

In this study, we explored the role of the mild Central European seasons and weather conditions on SB patterns in older adults. We found a small but significant difference in the total time spent on SB between the spring and autumn and we observed associations of weather conditions with the SB patterns in older adults.

Our results confirmed that meteorological factors also influence SB patterns in a mild climate, while some other studies have suggested that it is mainly substantial weather changes that may influence PA and SB (Arnardottir et al., 2017; Cepeda et al., 2018; Wang et al., 2017). Since older adults are considered the least active group in society, we naturally expect them to be more sedentary with increasing age and decreasing fitness. A visual inspection of the daily proportion of sedentary bout patterns showed a similar distribution of bout duration and bout frequency in the spring and autumn. Apparently, it shows that different seasonal distributions can occur in terms of the number (frequency) of shorter sedentary bouts ≤20 min long. These differences are small and because we do not actually know the specific domains of SB in our group of participants, we can assume it might be caused by changes in their daily arrangements.

The most frequently studied weather variables are temperature, precipitation, wind speed, length of daylight, length of sunlight, and humidity. In our study, we observed three meteorological factors – daily average temperature, precipitation, and daylight length. Previous research has indicated that temperature is the strongest of these factors. We would intuitively expect time spent on SB to be higher at lower temperatures. Klenk et al. (2012) studied the effect of weather conditions on walking in their group of elderly German participants. A higher daily temperature was associated with more time spent walking. Furthermore, higher temperatures were associated with a higher probability of walking for at least 2.5 hours per week in elderly women, but not men (Dunn, Shaw, & Trousdale, 2012). The findings of Sartini et al. (2017) are in line with our findings that the amount of sedentary time in older adults is highest at the lowest temperatures. Sitting time was significantly lower when the temperature was above 10° C in the autumn.

The findings of our study suggest that the most important factor which is associated with seasonal changes in SB is the daylight length. During the autumn the daylight length was getting shorter and then the participants accumulated more sedentary bouts with more minutes in them compared to the spring. In autumn, the average daylight length was about 10.5 hours per day and a longer daylight length was associated with less SB. These findings are consistent with other studies which showed a significant association between the daylight length and SB (Arnardottir et al., 2017; Schepps et al., 2018; Wu et al., 2016).

Concurrently, other factors may interfere with these associations, i.e. the circadian rhythm (Valenti, Bonomi, & Westerterp, 2016). While the ambient temperature and precipitation can be "managed" by staying at home, exercising indoors, or wearing appropriate clothing, we need to think of the unalterable character of the daylight length. It changes continuously across the year and we are not able to affect it. That is why the daylight length seems to be one of the most important meteorological determinants influencing PA and SB. Even when it was raining, the time spent on SB was lower in the autumn week of measurement. This association also suggests that there are daily diurnal patterns of older adults which are similar regardless of the weather outside. The daylight length should be taken into consideration when designing the measurement in the studies or intervention programmes.

One strength of our study is the repeated-measurement design employed in the same group of participants across two seasons (spring and autumn) and taking account of the different meteorological conditions. Another benefit of our study is the device-based measurement of SB; however, the qualitative studies collect more detailed information about SB accumulation and specific sedentary domains. For example, the studies by Chastin et al. (2014) and Dontje et al. (2017) inform us that older adults have referred to watching television or listening to the radio as their main reasons for sitting. A mixed approach using questionnaires and device-based methods may be an optimal way to identify the specific types of SB, so that we could gain a better understanding of when and how older adults are sedentary. The majority of our participants collected at least six days' worth of valid accelerometry data and so we were able to assess the whole week of SB patterns. On the other hand, measurement lasting only one week may be limited when estimating the seasonal volume and intensity of habitual physical behaviour of older adults. Finally, we were not able to differentiate indoor and outdoor activities on the basis of the methods that were used.

Conclusions

Overall, weather conditions and seasonality appear to be important factors related to active ageing. Older adults were less sedentary during the spring when the daylight is longer. However, SB patterns did not differ significantly between spring and autumn. Both, total sedentary time and SB patterns in relation to weather conditions should be considered when targeting older adults' SB and PA interventions in different seasons.

Acknowledgements

This work was supported by a research grant from the Czech Science Foundation No. 18-16423S and by the internal Olomouc University grant IGA_FTK_2018_003.

We would like to thank the women and men for participating in the study and Zuzana Svozilová and Dariusz Pośpiech for assisting with the collection of the PA and SB data.

Conflicts of interest
The authors declare that they have no competing interests.

References
Arnardottir, N. Y., Oskarsdottir, N. D., Brychta, R. J., Koster, A., Van Domelen, D. R., Caserotti, P., … Sveinsson, T. (2017). Comparison of summer and winter objectively measured physical activity and sedentary behavior in older adults: Age, gene/environment susceptibility Reykjavik study. *International Journal of Environmental Research and Public Health*, *14*(10). http://doi.org/10.3390/ijerph14101268
Cepeda, M., Koolhaas, C. M., van Rooij, F. J. A., Tiemeier, H., Guxens, M., Franco, O. H., & Schoufour, J. D. (2018). Seasonality of physical activity, sedentary behavior, and sleep in a middle-aged and elderly population: The Rotterdam study. *Maturitas*, *110*, 41–50. http://doi.org/10.1016/j.maturitas.2018.01.016
Chastin, S. F. M., Buck, C., Freiberger, E., Murphy, M., Brug, J., Cardon, G., … Oppert, J.-M. (2015). Systematic literature review of determinants of sedentary behaviour in older adults: A DEDIPAC study. *International Journal of Behavioral Nutrition and Physical Activity*, *12*(1), 127. http://doi.org/10.1186/s12966-015-0292-3
Chastin, S. F. M., Fitzpatrick, N., Andrews, M., & DiCroce, N. (2014). Determinants of sedentary behavior, motivation, barriers and strategies to reduce sitting time in older women: A qualitative investigation. *International Journal of Environmental Research and Public Health*, *11*, 773–791. http://doi.org/10.3390/ijerph110100773
Clemes, S. A., Hamilton, S. L., & Griffiths, P. L. (2011). Summer to winter variability in the step counts of normal weight and overweight adults living in the UK. *Journal of Physical Activity and Health*, *8*, 36–44. http://doi.org/10.1123/jpah.8.1.36
Copeland, J. L., Ashe, M. C., Biddle, S. J., Brown, W. J., Buman, M. P., Chastin, S., … Dogra, S. (2017). Sedentary time in older adults: A critical review of measurement, associations with health, and interventions. *British Journal of Sports Medicine*, *51*(21). http://doi.org/10.1136/bjsports-2016-097210
Diaz, K. M., Howard, V. J., Hutto, B., Colabianchi, N., Vena, J. E., Blair, S. N., & Hooker, S. P. (2016). Patterns of sedentary behavior in US middle-age and older adults: The REGARDS study. *Medicine & Science in Sports & Exercise*, *48*(3), 430–438. http://doi.org/10.1249/MSS.0000000000000792.Patterns
Dontje, M. L., Leask, C., Harvey, J., Skelton, D. A., & Chastin, S. F. M. (2017). Why older adults spend time sedentary and break their sedentary behaviour: A mixed methods approach using life-logging equipment. *Journal of Aging and Physical Activity*, *27*, 1–21. http://doi.org/10.1123/ijspp.2015-0012
Dunn, R. A., Shaw, W. D., & Trousdale, M. A. (2012). The effect of weather on walking behaviour in older adults. *Journal of Aging and Physical Activity*, *20*, 80–92.
Economic and Financial Affairs. (2018). *The 2018 Ageing Report: Economic and Budgetary Projections for the EU Member States (2016-2070)*. Brussels: Institutional Paper 079. http://doi.org/10.2765/615631
Ekelund, U., Steene-Johannessen, J., Brown, W. J., Fagerland, M. W., Owen, N., Powell, K. E., … Lee, I. M. (2016). Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *The Lancet*, *388*(10051), 1302–1310. http://doi.org/10.1016/S0140-6736(16)30370-1
Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the computer science and applications, inc. accelerometer. *Medicine & Science in Sports & Exercise*, *30*(5), 777–781.
Gorman, E., Hanson, H. M., Yang, P. H., Khan, K. M., Liu-Ambrose, T., & Ashe, M. C. (2014). Accelerometry analysis of physical activity and sedentary behavior in older adults: a systematic review and data analysis. *European Review of Aging and Physical Activity*, *11*(1), 35–49. http://doi.org/10.1007/s11556-013-0132-x
Hamilton, S. L., Clemes, S. A., & Griffiths, P. L. (2008). UK adults exhibit higher step counts in summer compared to winter months. *Annals of Human Biology*, *35*(2), 154–169. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=31730575&site=eds-live&authtype=ip,shib&custid=s7108593
Harvey, J. A., Chastin, S. F. M., & Skelton, D. A. (2015). How sedentary are older people? A systematic review of the amount of sedentary behavior. *Journal of Aging & Physical Activity*, *23*(3), 471–487. http://doi.org/10.1123/japa.2014-0164
Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2008). Breaks in sedentary time: Beneficial associations with metabolic risk. *Diabetes Care*, *31*(4), 661–666. http://doi.org/10.2337/dc07-2046
Jones, G. R., Brandon, C., & Gill, D. P. (2017). Physical activity levels of community-dwelling older adults are influenced by winter weather variables. *Archives of Gerontology and Geriatrics*, *71*, 28–33. http://doi.org/10.1016/j.archger.2017.02.012
Kang, M., Bassett, D. R., Barreira, T. V., Tudor-Locke, C., & Ainsworth, B. E. (2012). Measurement effects of

seasonal and monthly variability on pedometer-determined data. *Journal of Physical Activity and Health*, *9*(3), 336–343. http://doi.org/10.1123/jpah.9.3.336

King, A. C., Castro, C., Eyler, A. A., Brownson, R. C., Wilcox, S., & Sallis, J. F. (2000). Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. *Health Psychology*, *19*(4), 354–364. http://doi.org/10.1037/AB78

Klenk, J., Büchele, G., Rapp, K., Frankev, S., Peter, R., Nikolaus, T., … Rudolph, L. (2012). Walking on sunshine: Effect of weather conditions on physical activity in older people. *Journal of Epidemiology and Community Health*, *66*(5), 474–476. http://doi.org/10.1136/jech.2010.128090

Kornides, M. L., Rimm, E. B., Chavarro, J. E., Gillman, M. W., Rosner, B., & Field, A. E. (2017). Seasonal variations in meeting physical activity recommendations and development of overweight during adolescence. *Childhood Obesity*, *14*(1), 33–40. http://doi.org/10.1089/chi.2017.0118

Pelclová, J., Gába, A., Tlučáková, L., & Pośpiech, D. (2012). Association between physical activity (PA) guidelines and body composition variables in middle-aged and older women. *Archives of Gerontology and Geriatrics*, *55*(2), e14–e20. http://doi.org/10.1016/j.archger.2012.06.014

Rocha, I. B., Melo, R. C., Marques, S. G. D. S., Macon, L. F., Francisco, M. D., Pontes, M. C. M., … Pontes Jr., F. L. (2018). Ballroom and circular dancing may improve the functional fitness of older senior women : a cross sectional study. *Journal of Physical Education and Sport*, *18*(3), 1544–1548. http://doi.org/10.7752/jpes.2018.03228

Sartini, C., Morris, R. W., Whincup, P. H., Wannamethee, S. G., Ash, S., Lennon, L., & Jefferis, B. J. (2017). Association of maximum temperature with sedentary time in older british men. *Journal of Physical Activity and Health*, *14*(4), 265–269. http://doi.org/10.1123/jpah.2016-0468

Schepps, M. A., Shiroma, E. J., Kamada, M., Harris, T. B., & Lee, I. M. (2018). Day length is associated with physical activity and sedentary behavior among older women. *Scientific Reports*, *8*, 1–8. http://doi.org/10.1038/s41598-018-25145-w

Sumukadas, D., Witham, M., Struthers, A., & McMurdo, M. (2009). Day length and weather conditions profoundly affect physical activity levels in older functionally impaired people. *Journal of Epidemiology and Community Health*, *63*(4), 305–309. http://doi.org/10.1136/jech.2008.080838

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., … Chinapaw, M. J. M. (2017). Sedentary Behavior Research Network (SBRN) – Terminology consensus project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 75. http://doi.org/10.1186/s12966-017-0525-8

Tucker, P., & Gilliland, J. (2007). The effect of season and weather on physical activity: A systematic review. *Public Health*, *121*(12), 909–922. http://doi.org/10.1016/j.puhe.2007.04.009

Valenti, G., Bonomi, A. G., & Westerterp, K. R. (2016). Diurnal patterns of physical activity in relation to activity induced energy expenditure in 52 to 83 years-old adults. *PLoS ONE*, *11*(12), 1–11. http://doi.org/10.1371/journal.pone.0167824

Van Cauwenberg, J., Van Holle, V., De Bourdeaudhuij, I., Owen, N., & Deforche, B. (2014). Older adults' reporting of specific sedentary behaviors: Validity and reliability. *BMC Public Health*, *14*(1), 1–10. http://doi.org/10.1186/1471-2458-14-734

Wang, G., Li, B., Zhang, X., Niu, C., Li, J., Li, L., & Speakman, J. R. (2017). No seasonal variation in physical activity of Han Chinese living in Beijing. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1–10. http://doi.org/10.1186/s12966-017-0503-1

Witham, M. D., Donnan, P. T., Vadiveloo, T., Sniehotta, F. F., Crombie, I. K., Feng, Z., & McMurdo, M. E. T. (2014). Association of day length and weather conditions with physical activity levels in older community dwelling people. *PLoS ONE*, *9*(1). http://doi.org/10.1371/journal.pone.0085331

Wu, Y.-T., Luben, R., Wareham, N., Griffin, S., & Jones, A. (2016). Weather, day length and physical activity in older adults: Results from the EPIC Norfolk cohort. *European Journal of Public Health*, *26*, 1–12. http://doi.org/10.1093/eurpub/ckw166.029

Zając-Gawlak, I., Kłapcińska, B., Kroemeke, A., Pośpiech, D., Pelclová, J., & Přidalová, M. (2017). Associations of visceral fat area and physical activity levels with the risk of metabolic syndrome in postmenopausal women. *Biogerontology*, *18*(3), 357–366. http://doi.org/10.1007/s10522-017-9693-9

Zając-Gawlak, I., Pośpiech, D., Kroemeke, A., Mossakowska, M., Gába, A., Pelclová, J., … Kłapcińska, B. (2016). Physical activity, body composition and general health status of physically active students of the University of the Third Age (U3A). *Archives of Gerontology and Geriatrics*, *64*, 66–74. http://doi.org/10.1016/j.archger.2016.01.008