2017, *Retos, 32,* 44-47
 ISSN: Edición impresa: 1579-1726. Edición Web: 1988-2041 (www.retos.org)

Accelerometers: Devices that contribute to healthy aging
Acelerómetros: Los dispositivos que contribuyen al envejecimiento saludable

*Raquel Leirós-Rodríguez, *Mª Elena Arce, *José L. García-Soidán, *Gael Naveira-Barbeito
*Universidad de Vigo (España), **Consellería de Saúde da Xunta de Galicia (España)

Abstract. In this paper accelerometers were used as a persuasive technology to monitor exercise training and to promote healthy habits in senior citizens. The sample was composed by 100 users of a nursing home. Subjects were randomly assigned to an experimental and a control group. The intervention program lasted four months. Both groups carried accelerometers on a daily bases during one month, with no prior indication about exercise practice. The procedure was repeated two months later, but the experimental group was encouraged to increase the amount of time devoted to physical activity. Results showed a statistically significant increase in the amount and intensity of physical activity, regardless of whether subjects received the incentive to do it. These findings support the efficiency of using accelerometers as persuasive technology, as well as for generating new opportunities for active and healthy aging.
Keywords: Accelerometry; Ageing; Public Health; Kinetics; Physical development & measurement.

Resumen. En este trabajo se utilizó un acelerómetro como una tecnología persuasiva para supervisar la práctica de ejercicio y promover hábitos saludables en las personas de edad avanzada. La muestra fue compuesta por 100 usuarios de un hogar de ancianos. Los sujetos fueron asignados aleatoriamente a un grupo experimental y un grupo control. El programa de intervención duró cuatro meses. Ambos grupos llevaron el acelerómetro durante un mes diariamente, sin ninguna indicación previa sobre la práctica de ejercicio. Dos meses después, se repitió el procedimiento, pero el grupo experimental fue alentado a incrementar la cantidad de tiempo dedicada a la actividad física. Los resultados mostraron un aumento estadísticamente significativo en la cantidad e intensidad de la actividad física, independientemente de si los sujetos recibieron el incentivo para hacerlo. Estos hallazgos apoyan la eficacia de la utilización de acelerómetros como la tecnología persuasiva, que la generación de nuevas oportunidades para el envejecimiento activo y saludable.
Palabras clave: Accelerómetro; Envejecimiento; Salud Pública; Cinemática; Desarrollo físico y su evaluación.

Introduction

It is a documented fact that a settled lifestyle is mostly linked to an increased risk of morbidity and mortality in developed populations. The lack of physical activity (PA) has been identified as the fourth risk factor for deaths globally (Brown & Flood, 2013; Sardinha et al., 2012). However, despite evidence of the protective factor of PA (Baptista et al., 2012; Colley et al., 2011; Paterson & Warburton, 2010), it has been shown that PA levels are particularly low in the age group of 60 years and older (Bobillier Chaumon, Michel, Tarpin Bernard, & Croisile, 2014; Lisowska, 2011).

The use of Information and Communication Technologies (ICT) increases the sedentary way of life. Nowadays, most daily tasks can be done without even leaving home (Lisowska, 2011). While ICTs have a negative impact on people's lifestyle, they also can be used as a tool for the promotion of healthy lifestyle habits that facilitate the longevity through an active ageing (Bobillier Chaumon et al., 2014). Technological gadgets for measuring activity and the applications for mobile phones are the technological products most commonly used fot this purpose. These devices are known as 'persuasive technology' or «technology for motivation». These technologies are defined as devices for data processors, or applications designed with the aim of revamping the attitudes and behavior of people in order to improve their quality of life. Within this group of instruments, it stands out the accelerometers.

Accelerometers can be defined as electronic devices that measure the acceleration of a body when it moves. In other words, they are portable sensors for the study of kinematics of the human body. Despite the fact of being a wearable technology, some limitations could appear during the PA). It is an instrument of assessment which, in addition to provide a great sensitivity for measuring accelerometry, greatly facilitates a reliable study of the patient(García-Hermoso, Escalante, Domínguez, & Saavedra, 2013; Michaela, Š•astný, Jaroslav, & Miroslav, 2016). Furthermore, it brings us important information of his environment due, mainly, to its portability and low cost. As a result, a big quantity of applications for accelerometers has sprung as postural assessment and biomechanics for patients in trauma and Neurology, as well as the PA in sports and Geriatrics (Hartmann, Murer, de Bie, & de Bruin, 2009; Latt, Menz, Fung, & Lord, 2009; Mizuike, Ohgi, & Morita, 2009) monitoring and supervision. In addition, and previously noted, the accelerometers are useful for different areas of the socio-sanitary environment such as medicine, physiotherapy or sports, since they provide reliable and valid information obtained through the common behaviour of the subjects in their everyday environment. Unlike other cinematic devices, accelerometers are not exclusive to laboratory use. They are also valid for clinical and ambulatory use (Bischoff et al., 2003; Lohne-Seiler, Hansen, Kolle, & Anderssen, 2014; Moe-Nilssen & Helbostad, 2004).

According to this, it should be noted that accelerometry is a tool that shows itself adequate for monitoring human movements in an objective and reliable way, applicable in the daily life of subjects without implying large costs(Vespalec, Pavlík, Zvonaø, & Zeman, 2016). The accelerometers are being used in the supervision of different movements. You can get a wide range of measures such as: classification of movements, assessment of the level of PA, estimation of the metabolic energy expenditure, balance, pace of marching and control measure of getting up - sitting. These measures can be consulted by the health professional who keeps track of a patient, and also by an individual who wants to monitor his/her daily PA in order to establish healthy habits(Carrillo et al., 2017; Leirós-Rodríguez, Arce, & García-Soidán, 2015).

As a result of the efforts focused on this field, it has been concluded that it is essential for elderly people to maintain the highest possible level of functionality over the years, and therefore the most effective formula is the realization of PA. Through exercise, adults keep a good functionality and body composition (with appropriate percentages of lean, fat and visceral matter) (Dunsky & Netz, 2012; Fratiglioni, Paillard-Borg, & Winblad, 2004; Haight, Tager, Sternfeld, Satariano, & van der Laan, 2005). By this way, risk factors for the development of cardio-vascular and degenerative diseases are reduced, as it is already evident in many scientific studies (Dai, Wang, & Morrison, 2014; Lampinen, Heikkinen, Kauppinen, & Heikkinen, 2006; Malmberg, Miilunpalo, Pasanen, Vuori, & Oja, 2006). In addition, exercise also acts as a shield against the development of psychological and mental disorders. Older people with most accused functional decline are more likely to reduce their social activities and go out less from home, due to the real limitation imposed by physical deterioration, and the indirect limitation which

Fecha recepción: 26-07-16. Fecha de aceptación: 08-11-16
Raquel Leirós-Rodríguez
raleiros@alumnos.uvigo.es

makes that the elder confine in their activities for fear of not being able, falling or getting injured. With regard to introducing such devices in the daily lives of elderly people lease note that success depends to a large extent on the usability of technology (Selwyn, Gorard, Furlong, & Madden, 2003). These instruments can be applied with a double objective: to put in touch older adults with the use of technology and promote healthy lifestyles. In this line, the promotion of quality of life in elderly people need the understanding of their lifestyle and of their levels of PA (Peters et al., 2010). Since it is necessary to consider that assessing PA levels through interviews and surveys may be inaccurate for use in adults above 60 years old, since on many occasions the activity data reported by the individual is inaccurate or is limited due to the existence of cognitive or memory problems, or because of the social desirability of the participants. Plus, the instruments that are used are often self-administered, which can lead to a lack of reliability of the results due to the subjectivity of the answers. Linked to this fact, most of the instruments that measure PA, rarely measure the self efficacy and the state of change in behavior (Fauth, Schaefer, Zarit, Ernsth-Bravell, & Johansson, 2016), so if you want to know and promote changes in life habits is not enough to apply questionnaires and scales. The main advantage of the use of accelerometers, versus questionnaires or scales of assessment and promotion of PA, is that they allow to obtain an impartial assessment of most behaviors (Taraldsen, Chastin, Riphagen, Vereijken, & Helbostad, 2012).

All this makes the accelerometers to be positioned as one of the fundamental tools for Public Health. Therefore, elderly people with instruments of control of PA (i.e. accelerometers, pedometers, heart rate monitors, GPS) could spontaneously increase the amount of PA on a regular basis, as well as the intensity of it.

The aim of this study was to analyze the aplicability of accelerometers as a technology that promotes the PA in a sample of 100 adults. The hypothesis of this study was that the use of accelerometers encourages the practice of physical activity.

Methods

Participants

The intervention program was carried out over a period of four months with adults from a center of elderly home of the city of Orense (Spain). 100 subjects, 52 women and 48 men (52% and 48%, respectively) completed the program (Figure 1). The control group (CG) was composed of 50 adults, 26 women and 24 men (52% and 48%). The experimental group (EG) consisted of 24 men and 26 women (52% and 48%). The ages of the participants in the EG, ranged from 56 to 76 years (M = 67.67; SD = 6.03) and in the CG, between 55 and 80 (M = 66, 56; SD = 5.65). The physical characteristics of both groups were homogeneous (Table 1). They had no past or present neurological disorder, no musculoskeletal disease that could interfere with daily activities, and no significant auditory impairments, and they were not taking drugs that could have influenced the results of this study. Ethical approval was obtained from the Judgement of Investigations of the Faculty of Education and Sport Sciences from University of Vigo (Spain). The Judement's reference is 3-0406-14. All subjects signed an informed consent form prior to their participation.

Table 1.
Descriptive statistics

	Weight (kg)		Height (m)		BMI (kg·m2)	
	M	SD	M	SD	M	SD
Experimental Group	68,94	5,68	1,61	0,06	24,79	2,17
Control Group	68,85	5,91	1,63	0,07	24,65	2,17

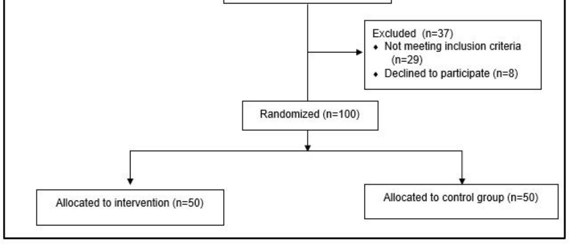

Figure 1. CONSORT Flow Diagram

Variables and Instruments

To do this, we analyzed the variable daily caloric expenditure, total steps, as well as the PA intensity low and medium intensity, measured both levels in METS (metabolic rate measurement unit). The employed accelerometer provides all these variables directly, without calculation by the user. The METS are used to reflect energy expenditure. Thus, 1 MET equals enough power to keep an individual at rest, being its value according to the consumption of oxygen (VO_2) of 3.5 ml/kg/min. I.e., an effort that equals 2 MET means that the individual consumes twice the metabolism at rest. It is considered that less than 3 MET efforts are mild, between 4 and 6 moderates MET, from 9 to 10 MET intense and more than 10 very intense MET.

Acceleration measurement was performed using a triaxial accelerometer ActiGraph GT3X+® (ActiGraph, Estados Unidos). This device allows you to store time series of acceleration data in a non-volatile flash memory. The autonomy of the accelerometer was forty days of continuous measurement, so it was not necessary to make any charge for as long as the participants wore the devices. The small dimensions of the modules (4.6x3. 3x1.5 cm), together with its low weight (19 g), make this device one of the best options to assess levels of PA.

Participants were instructed to place themselves the device with an adjustable belt at the low back (close to body's center of mass). For the purpose of enabling subjects to use accelerometers at all times, regardless of the activity they were doing, those were used combined with watertight covers. Thus, users of this technology could carry the devices in aquatic activities, wich are usual activity in senior centers. Another advantage of the small size of the accelerometer is that does not prevent to perform any activity, or forces to use a particular type of clothing.

Regarding to reports of PA that participants can generate by connecting the device via a data cable to the computer, we must note that the variables that participants consult through Actilife6® (Actigraph, Pensacola, FL) software are essentially two: Periods of sleep and daily PA levels (Table 4 and Figure 2, respectively). The Table 4 shows the variables about sleep scoring: sleep/wake hours and sleep statistics such as onset, sleep latency, amount of sleep, and sleep efficiency using validated scoring algorithms. The Figure 2 shows the sedentary and activity bouts: identify bouts of low and high activity and details about a subject sedentary behavior.

Although the possibilities offered in the software are much broader, ranging from the calculation of accelerations in each one of the axes until tilt angles of inclination of the subject, for this study analysis was limited to PA levels.

Table 4.
Data analysis of periods of sleep that the user can consult through Actilife 6® (software accelerometer).

In Bed	Out Bed	Latency (min)	Efficiency	Total Time in Bed (min)	Total Sleep Time (min)	Wake After Sleep Onset	Number of Awakenings	AVG Awakening (min)
17/02/16 20:23	18/02/16 08:50	3	95,72%	747	715	0	5	6,4
18/02/16 23:36	19/02/16 08:17	4	83,49%	521	435	0	10	8,6
19/02/16 15:06	20/02/16 20:31	3	69,85%	325	227	0	9	10,89
20/02/16 23:59	21/02/16 13:58	2	97,38%	839	817	0	2	11
21/02/16 22:59	22/02/16 11:43	4	93,32%	764	713	0	3	17

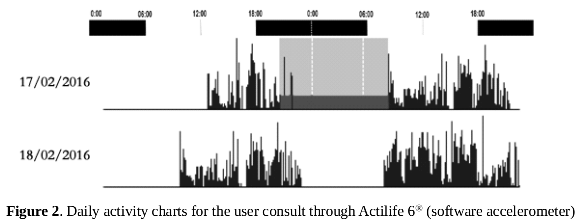

Figure 2. Daily activity charts for the user consult through Actilife 6® (software accelerometer)

The reason of giving access to small software modules is to make the environment friendlier for the users, especially taking into account the age range of the participants.

Procedure

The basic operation of ICT, such as the accelerometer and the necessary computer for daily activity monitoring, was secured when selecting participants. All of them were trained in this ability through workshops at the elderly Centre, which had a duration of one week (2 hours/day, Monday-Friday). These workshops were held the week prior to the initiation of the investigation.

The Intervention program lasted four months, between November of 2015 and February of 2016. In all cases, the guidelines given to the subjects who participated in the study were very similar. Both groups of senior adults were asked to measure the PA day performed, wearing an accelerometer during two periods of time. For the both groups, each of the periods lasted a month. The first period of 30 days, took place at November and the second period during the February.

During the first period, both groups carried the devices for a month without any other indication. That is, both were asked to follow their usual PA. The subjects belonging to experimental group (EC) were informed, at the begining of the second period, that they must increase their level of PA. The control group (CG) did not receive any other instruction at the beginning of the second period. It means that they were not recommended to increase their daily PA, or even walks or travels. They should only carry the accelerometer and monitor in their daily activity. In addition, this group was unaware of the existence of a EG.

All of them would use a computer to generate reports and take control of the daily sleep/rest hours.

Statistical Analysis

For the data processing the statistical package SPSS (version 22) was used. Data is presented as mean ± standard deviation. The variables showed a normal distribution according to the Kolgomorov-Smirnov test ($p > 0.05$) and existed homogeneity of variances, by applying the Levene test ($p = 0.12$). We used the 2 sample t-test, to make the comparison between the CG and the EG (test using d-Cohen, to measure the effect size) to compare the effect of factor use accelerometer (men vs. women) at the levels of PA. Furthermore, we used the paired t-test to make the comparisons pre and post internvention in both groups. The level of significance was $p < 0.05$.

Results

The results indicated that the CG, regardless that the researcher not provide instructions, had higher levels of PA than the EG (Table 2). The CG had higher values of daily caloric expenditure, total steps, steps during medium level of PA ($p < .01$) and during medium level of PA ($p < .001$).

Table 2.
Daily caloric expenditure and daily total steps at the beginning and end of program.

		DCE (kcal)		DTS		SLA		SMA	
	Period	M	SD	M	SD	M	SD	M	SD
Experimental Group	Nov.'15	2915.07	270.86	2846.89	507.07	1887.07	335.31	959.82	196.68
	Feb.'16	2915.45	270.47	2896.04	522.69	1887.23	336.42	959.05	197.17
Control Group	Nov.'15	2920.33	269.63	2852.80	513.84	1901.87	342.56	950.93	171.28
	Feb.'16	2974.19*	271.65	3408.55*	636.17	2092.12*	365.68	1024.43**	174.27

DCE: Daily Caloric Expenditure; DTS: Daily Total Steps; SLA: Steps during Low level of Physical Activity (<3 METS); SMA: Steps during Medium level of Physical Activity (3-6 METS). *p value < .01, p value < .001*

Table 3.
Comparison of the effects of use of accelerometer (pre-post test) on the levels of PA, daily caloric expenditure and total daily steps.

	Variable	t (gl)
Experimental Group	DCE (kcal)	-34(51)
	DTS	.47(51)
	SLA	-.11(51)
	SMA	.822(51)
Control Group	DCE (kcal)	-19.51(47)*
	DTS	-13.818(47)*
	SLA	-17.66(47)*
	SMA	-34.75(47)**

DCE: Daily Caloric Expenditure; DTS: Daily Total Steps; SLA: Steps during Low level of Physical Activity (<3 METS); SMA: Steps during Medium level of Physical Activity (3-6 METS). **p < .01, **p < .001*

When you compare caloric expenditure, total steps and the PA level intensity under (3 METS) and medium (6 METS) pre and post-tests of the subjects who were instructed (EG) and those who not (CG), the result shows us differences only in the CG (Table 3).

Discussion

Principal findings

The aim of this study was to analyze the aplicability of accelerometers as a technology that facilitates the longevity and life quality in older adults. Having in consideration the results, we can see that the introduction of accelerometers in the daily life of the elderly people produces visible changes in their behavior. Such changes, at least in the short and medium term, are due to a change of attitude of the participants against the practice of PA. This change in attitude has been, for years, one of the challenges to achieve by managers and planners of PA programs for older adults (Beswick, Gooberman-Hill, Smith, Wylde, & Ebrahim, 2010; Lampinen et al., 2006; Sallis et al., 2006; Zaitune, Maria Paula do Amaral et al., 2010). It is important to point out that, it has been found that the fact of carrying an accelerometer longer, was more influential that the instruction to use it as a monitor of changes in levels of PA in two distinct periods. Therefore, the simple routine of using a wearable device such as accelerometers, contributes to increase PA levels in older people. In addition, devices employed by the subjects have not brought any kind of alteration in their daily routine tasks. The small dimensions of the accelerometers allow any kind of body movement and because of its great autonomy was not necessary to carry out any battery charge during the period in which the study was conducted.

Parallel to the increase in time spent on exercise, there was an increase in the intensity of it. This finding is very important regarding to the impact on life quality in older adults. The PA practiced by the elderly is from moderate to high intensity in order to reduce the appearance of functional limitations (direct effects on mobility and dexterity) and improve body composition (indirect effect on the percentages of fat and muscle mass) (Haight et al., 2005; Malmberg et al., 2006; Seidel, Brayne, & Jagger, 2011).

On the other hand, the feedback provided by the accelerometer could be linked to the increase of PA. Being able to carry out continuous monitoring of the activity reinforces the consolidation of patterns. Monitor everyday tasks and analyze performance helps that the subject will set new goals. In addition, unlike applications for smartphones, tablets and wearable technology, calculations provided by the accelerometer are real, since it takes into account factors such as the intensity of the exercise, the anthropometric characteristics of the subject and variables such as age and sex.

Envisaging the promotion of healthy lifestyle habits in the elderly from an ecological or overall appearance, all these improvements detected on parameters pertaining to the sphere must consider them not only as a part of the various factors that determine the quality of life of the people, but also as an indicator of how the PA works as a protective factor against cognitive impairment (Fratiglioni et al., 2004; Sallis et al., 2006). In addition, it has been shown how maintaining a good level of PA, inhibits the tendency to the home seclusion that often occurs in older people, leading them to a vicious circle of social isolation, physical inactivity, absence in activities in public environments, social invisibility (Lampinen et al., 2006).

The persuasive technologies, such as accelerometers, are increasingly integrated into the people daily life, contributing to highlight the gaps in levels of activity, which contributes to improve the way of life and to ensure a good quality of life in the adult stage. However, despite the increase in the availability of technological resources directed to the group of older adults, the use of them does not the usually focus on the promotion of the quality of life.

Limitations and future research

The main limitation of this study was the low level of knowledge in the use of ICT by the participants. This, most likely, indicates that Centers where subjects had a greater degree of ICT competence, program results could be better and also the availability to increase the PA level, controlled by accelerometers. The use of the accelerometer would have less effect in the levels of PA in a group with lower level of knowledge in the use of ICT. Another important limitation was the sample itself, that, although important, it is not representative of the entire total population of seniors in Ourense. Another limitation was not recording the PA chosen by the subjects. Above all in the CG that showed a significant increase of their PA levels, it would have been interesting to know what activities were those that represented this increase. For all of the above, the results of this study should be interpreted with caution; however, it can provide us information about the potential use of accelerometers to analyze and promote the healthy PA in older people.

In addition to do new studies that overcome the limitations of the present paper, in the future, the study of ICT for promote the PA should be deepened in different populations. On the other hand, it must be checked whether the incentive effect of the accelerometers is prolonged in the long term.

Conclusions

The implementation of programs such as this one, which combines the use of ICT with tools that help to stimulate healthy lifestyle habits and to contribute to active ageing, could be included in the format of courses within the activities that offer elderly centers. At the same time, more studies are needed to assess the effectiveness of these technologies in the increasing rates of PA, obtaining data transferability to long term and the influence of sex and the socio-economic environment. At the same time, we must consider the influence of the participants in the degree of use of ICT.

In conclusion, we hope this work will encourage other scientists to investigate the promotion of healthy aging through persuasive technologies, in a way that contributes to the development of new focused tools to increase the rate of PA in older adults.

Author Contributions

All authors contributed to the scientific brainstorming, planning and writing process of the article.

Conflict of Interest

The authors declare no conflict of interest.

References

Baptista, F., et al. (2012). Prevalence of the portuguese population attaining sufficient physical activity. *Med Sci Sports Exerc, 44*(3), 466-473.

Beswick, A., Gooberman-Hill, R., Smith, A., Wylde, V., & Ebrahim, S. (2010). Maintaining independence in older people. *Reviews in Clinical Gerontology, 20*(02), 128-153.

Bischoff, H. A., et al. (2003). Identifying a cut-off point for normal mobility: A comparison of the timed 'up and go' test in community-dwelling and institutionalised elderly women. *Age and Ageing, 32*(3), 315-320.

Bobillier Chaumon, M., Michel, C., Tarpin Bernard, F., & Croisile, B. (2014). Can ICT improve the quality of life of elderly adults living in residential home care units? from actual impacts to hidden artefacts. *Behaviour & Information Technology, 33*(6), 574-590.

Brown, C. J., & Flood, K. L. (2013). Mobility limitation in the older patient: A clinical review. *Jama, 310*(11), 1168-1177.

Carrillo, V. J. B., Sierra, A. C., Loaisa, A. J., González-Cutre, D., Galindo, C. M., & Cervelló, E. (2017). Diferencias según sexo en el tiempo empleado por los adolescentes en actividad física y sedentaria en diferentes segmentos del día (gender differences in time spent by adolescents in physical and sedentary activity in different day segments). *Retos,* (31), 3-7.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of canadian adults: Accelerometer results from the 2007 to 2009 canadian health measures survey. *Health Reports, 22*(1), 7.

Dai, S., Wang, F., & Morrison, H. (2014). Predictors of decreased physical activity level over time among adults: A longitudinal study. *American Journal of Preventive Medicine, 47*(2), 123-130.

Dunsky, A., & Netz, Y. (2012). Physical activity and sport in advanced age: Is it risky?-a summary of data from articles published between 2000-2009. *Current Aging Science, 5*(1), 66-71.

Fauth, E. B., Schaefer, S. Y., Zarit, S. H., Ernsth-Bravell, M., & Johansson, B. (2016). Associations between fine motor performance in activities of daily living and cognitive ability in a nondemented sample of older adults: Implications for geriatric physical rehabilitation. *Journal of Aging and Health,* doi:0898264316654674 [pii]

Fratiglioni, L., Paillard-Borg, S., & Winblad, B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *The Lancet Neurology, 3*(6), 343-353.

García-Hermoso, A., Escalante, Y., Domínguez, A. M., & Saavedra, J. M. (2013). Efectos de un programa de ejercicio físico durante tres años en niños obesos: Un estudio de intervención (effects of an exercise program during three years in obese boys: An intervention study). *Retos,* (23), 10-13.

Haight, T., Tager, I., Sternfeld, B., Satariano, W., & van der Laan, M. (2005). Effects of body composition and leisure-time physical activity on transitions in physical functioning in the elderly. *American Journal of Epidemiology, 162*(7), 607-617. doi:kwi254 [pii]

Hartmann, A., Murer, K., de Bie, R. A., & de Bruin, E. D. (2009). Reproducibility of spatio-temporal gait parameters under different conditions in older adults using a trunk tri-axial accelerometer system. *Gait & Posture, 30*(3), 351-355.

Lampinen, P., Heikkinen, R., Kauppinen, M., & Heikkinen, E. (2006). Activity as a predictor of mental well-being among older adults. *Aging and Mental Health, 10*(5), 454-466.

Latt, M. D., Menz, H. B., Fung, V. S., & Lord, S. R. (2009). Acceleration patterns of the head and pelvis during gait in older people with parkinson's disease: A comparison of fallers and nonfallers. *The Journals of Gerontology.Series A, Biological Sciences and Medical Sciences, 64*(6), 700-706.

Leirós-Rodríguez, R., Arce, M. E., & García-Soidán, J. L. (2015). Estudio piloto para la valoración del equilibrio en mujeres adultas con un elemento cinemático. *Retos: Nuevas Tendencias En Educación Física, Deporte Y Recreación,* (28), 90-93.

Lisowska, M. (2011). El uso de la tecnología persuasiva para promover una vida activa y saludable. *Universidad, Ciencia Y Desarrollo, ISSN 1909-0501, Fascículo 4(7),*

Lohne-Seiler, H., Hansen, B. H., Kolle, E., & Anderssen, S. A. (2014). Accelerometer-determined physical activity and self-reported health in a population of older adults (65–85 years): A cross-sectional study. *BMC Public Health, 14*(1), 1.

Malmberg, J. J., Miilunpalo, S. I., Pasanen, M. E., Vuori, I. M., & Oja, P. (2006). Associations of leisure-time physical activity with mobility difficulties among middle-aged and older adults. *Journal of Aging and Physical Activity, 14*(2), 133.

Michaela, B., Š•astný, J., Jaroslav, M., & Miroslav, J. (2016). Development of an analysis of swimming techniques using instrumentation and the development of a new measurement method at brno university of technology, centre of sports activities. *Journal of Human Sport and Exercise, 11*(1proc)

Mizuike, C., Ohgi, S., & Morita, S. (2009). Analysis of stroke patient walking dynamics using a tri-axial accelerometer. *Gait & Posture, 30*(1), 60-64.

Moe-Nilssen, R., & Helbostad, J. L. (2004). Estimation of gait cycle characteristics by trunk accelerometry. *Journal of Biomechanics, 37*(1), 121-126.

Paterson, D. H., & Warburton, D. E. (2010). Physical activity and functional limitations in older adults: A systematic review related to canada's physical activity guidelines. *International Journal of Behavioral Nutrition and Physical Activity, 7*(1), 1.

Peters, T. M., et al. (2010). Accelerometer-measured physical activity in chinese adults. *American Journal of Preventive Medicine, 38*(6), 583-591.

Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annu.Rev.Public Health, 27,* 297-322.

Sardinha, L. B., et al. (2012). Prevalence of overweight, obesity, and abdominal obesity in a representative sample of portuguese adults. *PLoS One, 7*(10), e47883.

Seidel, D., Brayne, C., & Jagger, C. (2011). Limitations in physical functioning among older people as a predictor of subsequent disability in instrumental activities of daily living. *Age and Ageing, 40*(4), 463-469. doi:10.1093/ageing/afr054 [doi]

Selwyn, N., Gorard, S., Furlong, J., & Madden, L. (2003). Older adults' use of information and communications technology in everyday life. *Ageing and Society, 23*(05), 561-582.

Taraldsen, K., Chastin, S. F., Riphagen, I. I., Vereijken, B., & Helbostad, J. L. (2012). Physical activity monitoring by use of accelerometer-based body-worn sensors in older adults: A systematic literature review of current knowledge and applications. *Maturitas, 71*(1), 13-19.

Vespalec, T., Pavlík, J., Zvonaø, M., & Zeman, T. (2016). Physical activity of czech schoolchildren in the autumn season. *Journal of Human Sport and Exercise, 11*(1proc)

Zaitune, Maria Paula do Amaral, Barros, Marilisa Berti de Azevedo, César, C. L. G., Carandina, L., Goldbaum, M., & Alves, Maria Cecilia Goi Porto. (2010). Factors associated with global and leisure-time physical activity in the elderly: A health survey in são paulo (ISA-SP), brazil. *Cadernos De Saúde Pública, 26*(8), 1606-1618.