Relationships of walking at individual, interpersonal and environmental levels among seniors

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Tem sempre presente que a pele se enruga,
o cabelo embranquece,
e os dias convertem-se em anos...
Mas o mais importante não muda,
a tua força e as tuas convicções não têm idade.
O teu espirito é como um espanador de teias de aranha.

Depois de cada de chegada, há uma partida.
Depois de cada conquista, há um novo desafio.
Enquanto estiveres vivo, sente e sabe que estás vivo

Se sentes saudades do que fazias, torna a fazê-lo.
Não vivas de fotografias amarelas.
Continua, mesmo quando outros esperam que desistas.
Não deixes que se enferruje o ferro que há em ti.
Faz com que em vez de pena, as pessoas sintam respeito por ti.

Quando, devido à idade, não conseguires correr, marcha.
Quando não conseguires marchar, caminha.
Quando não conseguires caminhar, agarra uma bengala e continua o caminho.
Mas nunca te detenhas.

Autor desconhecido

Always keep in mind that your skin will wrinkle
that your hair will go white
and that your days will become years...
But the most important thing never changes,
your strength of will and your convictions don't have an age limit.
Your spirit is like a feather duster to wipe away the cobwebs.

After every arrival there is a leaving.
After every accomplishment there is another challenge.
While you are alive, feel and know that you are alive.

When you are feeling sorry for yourself
about what you used to be able to do, do something new.
Don't live surrounded by the yellowed photos of yesterday.
Continue forward, even though you feel abandoned by others.
Don't let rust take away the steel that is in you.
Behave in a way that others respect you, not pity you.

When, due to your years, you cannot run, walk fast.
When you can no longer walk fast, walk.
When you can no longer walk, grab a cane and keep on going.
Never stop yourself.

Unknown author

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Abstract

The world population is ageing and older adults have becoming the least physically active age group. Regular physical activity has been advised in order to promote mobility and prevent chronic diseases, disable conditions and the consequent rise of heath care costs. In terms of public health, walking has been indicated as a relevant form of exercise to increase regular physical activity. However, there is limited knowledge about the social ecological characteristics capable to stimulate walking activity at recommend levels among older adults. Thus, the overall aim of this PhD thesis was to understand how individual, interpersonal and environmental factors interact with walking behavior, physical and mental health, among seniors. To achieve this aim a variety of methodologies were used: qualitative research, observational studies with questionnaires and objective measures and mediation analyses, involving older adults participants of the national walking and running program (n=150) and community-dwelling older adults (n=2859). The outcome measures included functional fitness, body mass index, vitality, psychological distress, physical activity assessed by accelerometry and questionnaire and perceptions of the neighborhood environment. At the individual level, our findings suggest that peak 30-minutes cadence of the walking training days were positively related to functional fitness in old women and that faster cadences should be promoted for significant effect of peak 30-minutes cadence on functional fitness parameters, in older men. At the interpersonal level, our findings indicated that social support is related to walking and older adults who walk and participate in group activities are more likely to have more vitality and less psychological distress. At the environmental level, perceptions of nearby parks were associated with walking at recommended intensity in seniors men and perceptions of traffic safety and pleasant environment with walking at recommended volume in seniors women. Our findings provide important insights for policy initiatives aiming to promote walking activity and physical and mental health among older adults.

Resumo

A população mundial está a envelhecer e os idosos representam o grupo etário mais inativo da população. A atividade física regular, tem sido aconselhada como um fator promotor de mobilidade nos idosos e de prevenção de doenças crónicas e de limitações funcionais que geralmente se traduzem no aumento dos gastos com a saúde. Em termos de saúde pública, a caminhada tem sido indicada como sendo o comportamento mais relevante para aumentar a atividade física regular. No entanto, o conhecimento sobre as características socio-ecológicas capazes de promover a caminhada dentro dos níveis recomendados, nos idosos, é ainda escasso. Assim, o objetivo geral desta tese de doutoramento foi contribuir para a compreensão da relação entre fatores individuais, interpessoais e ambientais e a caminhada, a saúde física e mental, nos idosos. Para alcançar este objetivo foram utilizadas várias metodologias: pesquisa qualitativa, estudos observacionais com questionários e medidas objetivas e análises de mediação, que incluiu idosos participantes no programa nacional de marcha de marcha e corrida (n=150) e idosos da comunidade (n=2859). As variáveis em análise incluíram: a aptidão funcional, o índice de massa corporal, a vitalidade, o stress psicológico, atividade física medida através de acelerómetros e questionários e as perceções do ambiente da área residencial. Ao nível individual, os nossos resultados sugerem que o pico de 30 minutos de cadência dos dias de treino de caminhada está positivamente relacionado com a aptidão funcional de mulheres idosas. A promoção de cadências mais rápidas é sugerida para um efeito significativo do pico de 30 minutos cadência nos parâmetros de aptidão funcional, em homens idosos. Ao nível interpessoal, os nossos resultados indicaram que o apoio social está relacionado com o tempo passado a caminhar. Adicionalmente, os nossos resultados sugerem que os idosos que caminham e participam em atividades de grupo são mais propensos a ter mais vitalidade e menos stress psicológico. A nível ambiental, a perceção de parques nas proximidades foi associada com a intensidade de caminhada dentro dos níveis recomendados, em homens idosos. Perceções de segurança no trânsito e de um ambiente agradável foram relacionadas com o alcance de níveis de volume de caminhada recomendados, em mulheres idosas. Os nossos resultados forneceram informações importantes para iniciativas políticas destinadas a promover a caminhada e a saúde física e mental dos idosos.

List of abbreviations

ALPHA - European Environmental Questionnaire

B-HIS - Belgium Health Survey

BMI - Body Mass Index

INE - Instituto Nacional de Estatística

GHQ - Global Health Questionnaire

IPAQ - International Physical Activity Questionnaire

SES - Socioeconomic Index

SFT - Senior Fitness Test

WHO - World Health Organization

General Introduction

1. The ageing and sedentary population

The world population has been experiencing a significant ageing, which leads to an increase of the proportion of older persons in the total population. The worldwide proportion of older adults increased from 9% in 1990 to 12% in 2013 and will continue to grow, reaching 21% by 2050 (UnitedNations, 2013). According to the Portuguese national statistical institute/instituto nacional de estatística (INE), Portugal is the 4th country in the European Union with the highest proportion of older adults (INE, 2015). In 2014, the resident population in Portugal comprised 14.4% of young people, 65.3% of working-age people and 20.3% of older adults (INE, 2015). Nowadays, the Portuguese population ageing has been taking place in the entire territory, being no longer a phenomenon that only occurs in the countryside (INE, 2011).

Population ageing has major social and economic consequences, since the prevalence of non-communicable diseases and disability increase as populations age (UnitedNations, 2013). Aging is associated with obesity, cardiovascular disease, type 2 diabetes, other leading causes of morbidity and mortality and functional limitations (Chodzko-Zajko et al., 2009). In Portugal, the evaluation of the limitations on the performance of daily life activities reveal that about 50% of the Portuguese older adults had difficulty in performing at least one of the six basic daily activities (see, hear, walk, memorize, understand, bathing/dressing). The main limitations reported were walk (27%), see (19%) and memorize (15%). Difficulty in walking was the most reported limitation and affects 700,987 Portuguese older adults (INE, 2011).

Advancing age is also associated with declines in physical activity and older adults have becoming the least physically active of any age group (Chodzko-Zajko et al., 2009). In Portugal, only 28% of older women and 45% of older men met the recommendations for physical activity, in a nationwide study using objectively assessed physical activity measurements (Instituto de Desporto de Portugal, 2011).

Evidence suggests that age-related disability is result of inactivity and disuse rather than of aging itself (Vopat et al., 2014). With the rising of proportion of seniors in whole population, it is critical to promote healthy

lifestyles and independent living for as long as possible, being physical activity a key factor preserving mobility and functional independence, in older adults (Rikli & Jones, 2013).

2. The role of regular physical activity preventing chronic diseases and disabling conditions

Regular physical activity reduces the risk of developing a large number of chronic diseases and disabling conditions and should be considered to counteract morbidity and mortality of the older population (Chodzko-Zajko et al., 2009). Physical activity is defined as any body movement produced by contraction of skeletal muscles that results in energy expenditure (Caspersen et al., 1985). Regular physical activity has been reported to be essential for an healthy aging (Nelson et al., 2007). The World Health Organization (WHO, 2010) suggest that, when compared to less active individuals, active older adults have lower rates of chronic diseases (cardiovascular, cancer, etc.) and are more likely to present higher levels of cardio-respiratory and muscular fitness, healthier lipid profile and body composition. As reported by McDermott & Mernitz (2006), a combination of aerobic activity, strength training, and flexibility exercises and daily physical activity may reduce medication dependence and health care costs while maintaining functional independence and improving quality of life in older adults. Moreover, regular physical activity is associated with significant improvements in overall psychological wellbeing (Chodzko-Zajko et al., 2009).

To obtain these health benefits, older adults are recommended to accumulate 30 minutes of moderate intensity aerobic physical activity on at least five days/week or 25 minutes of vigorous-intensity physical activity on at least three days/week, in bouts of at least 10 minutes duration. For additional health benefits, seniors are advised to increase their moderate intensity aerobic physical activity up to 300 minutes per week, or engage in 150 minutes of vigorous intensity aerobic physical activity per week. In addition, the guidelines recommend to engage in muscle-strengthening and flexibility activities involving

major muscle groups, on 2 or more days/week. Balance exercises are also advised to frequent fallers and older adults with poor mobility, on 3 or more days per week. Importantly, the guidelines also state that if chronic conditions limit the physical activity at the recommended minimum amount, older adults should engage in as much physical activity as tolerated in order to avoid being completely sedentary (Chodzko-Zajko et al., 2009).

In terms of public health, walking has been indicated as the most relevant form of exercise to increase regular physical activity at a moderate intensity in adults (Lee & Buchner, 2008). Walking is an excellent form of physical activity for older adults because it is familiar, cheap, easy, accessible, has a lower injury risk and can be performed in social settings (i.e., group walks) (Rowe et al., 2011). Moreover, walking confers health benefits when recommended intensities, frequencies and durations are achieved (Lee & Buchner, 2008). To meet current guidelines, individuals are encouraged to walk a minimum of 3000 steps in 30 minutes on 5 days each week (Marshall et al., 2009). Accumulating 10,000 steps/day have been also recommended as the desirable volume of walking activity per day to gain health benefits in adults (Hatano, 1993). Tudor-Locke et al. (2011) suggests that accumulate 30 minutes of daily moderate-to-vigorous physical activity with habitual daily activities in healthy older adults is equivalent to taking approximately 7000-10000 steps/day.

Promoting higher levels of participation by older adults in regular moderate-intensity physical activity is a public health priority, being one of the most effective solutions to prevent the rise of health costs (Chodzko-Zajko et al., 2009). The importance of walking to public health is now widely recognized and research calls for effective promotion and measurement of this important behavior (Tudor-Locke & Rowe, 2012).

Socio-ecological frameworks have been used to better understand factors influencing physical activity among older adults (Satariano & McAuley, 2003). In order to understand the multiple and interacting determinants of walking in older adults, an overview of social ecological approach key definitions will be described in the following section.

3. Understanding older adults' walking activity: an overview of social ecological models

Identifying determining factors of walking among older adults is crucial to address potential barriers and create opportunities to engage in sustainable active lifestyles. The social ecological models provide frameworks for understand the inter-relations between individuals and their social and physical environments (see fig.1). The social ecological perspective, tends to refocus attention from strictly intra-individual factors to multilevel variables, such as environmental and policy variables, that are expected to influence a behavior (Sallis et al., 2006). Health behaviors, are expected to be promoted when environments and policies support healthy choices, when social norms and social support encourage healthful choices and when individuals are motivated and educated to make those choices (Bauman et al., 2012).

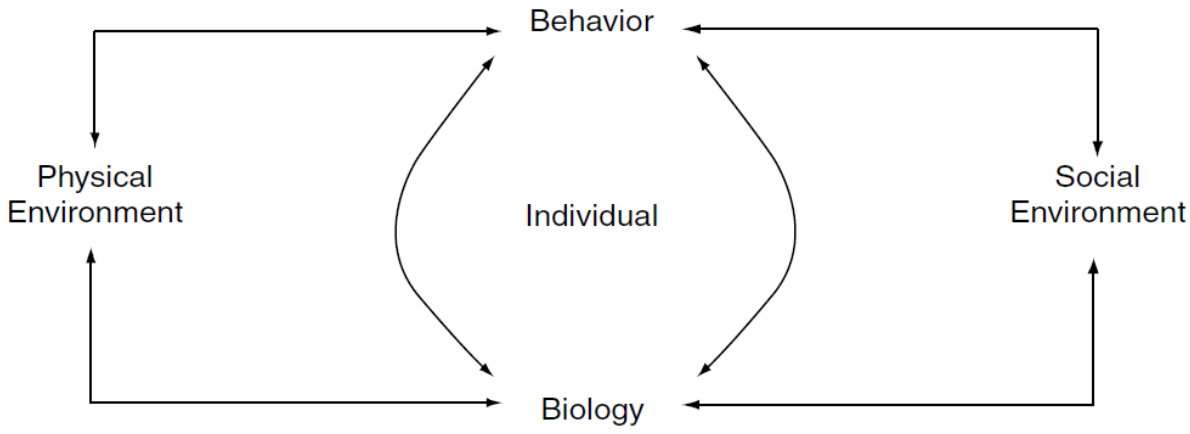

Figure 1 - Ecologic Model. Inter-relations between individuals and their social and physical environments from the US Department of Health and Human Services (2000).

The combination of environmental, policy, social, and individual factors link several different fields of research and showed to be effective in the reductions in tobacco use in the United States, and this experience has stimulated the application of multi-level models and interventions to many health problems (Sallis et al., 2008). Likewise, promotion and maintenance of physical activity at the individual level depends on critical community variables, such as environmental and policy factors (Satariano & McAuley, 2003).

Physical activity-related models often included individual (biological and psychological), interpersonal (social support and cultural norms), environmental (social, built and natural), and policy levels (national physical activity plans, urban planning and architecture, parks and recreation sector, etc.) (Bauman et al., 2012). A conceptual ecological model for physical activity showing different levels of influence and associated variables is illustrated in figure 2. The model proposes that changes at one level relies on characteristics of other levels.

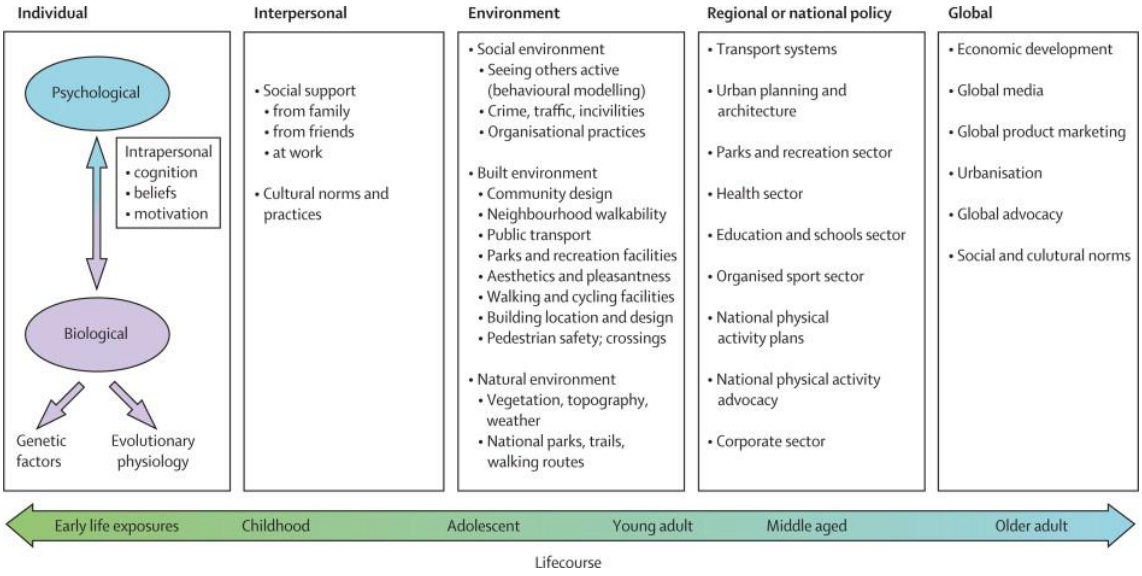

Figure 2 - Adapted ecological model of the determinants of physical activity from Bauman et al. (2012)

The individual level of influence consists of psychological and biological intrapersonal factors. Some of these factors can be changed, such as motivation and physiologic capacity, while others are invariable (genetics). Examples of demographic and biological determinants of physical activity among older adults are gender, age and general health status; senior men have been found to be more active than senior women and physical activity levels have been found to decrease with increasing age and deteriorating health (Koeneman et al., 2011). Self-efficacy is also one of the favorable psychological factors associated with higher levels of physical activity (Bauman et al., 2012).

The interpersonal level of influence includes social support from family, friends, peers and it also includes cultural and social norms (Bauman et al.,

2012). Supportive social and cultural environment were reported to be correlates of walking in older adults (Giles-Corti & Donovan, 2003).

At the environmental level of influence, there are three sub-levels of influence: social environment, built environment and natural environment. Different features of the neighborhood environment (walkability, access to services and shops, walking facilities safety and aesthetics) have been related with walking in older adults (Van Cauwenberg et al., 2011), however there is no consistent environmental correlates of physical activity among seniors (Bauman et al., 2012). Neighborhoods are particularly important to study the effect of the environment on physical activity, namely walking, in seniors. Given their reduced mobility and limited income, they spend more time in neighborhoods and characteristics of the neighborhood environment may actually determine an active or inactive aging (Yen et al., 2009).

The outer levels of the model represents the policy environment which can influence all other levels by means of laws, regulations, investments, incentives, etc. (Sallis et al., 2006) and global determinants that might be relevant at the population level (Bauman et al., 2012).

This version of the ecologic model contain 5 levels of influence (Bauman et al., 2012), however, for the current thesis, a condensed version of the ecologic model consisting of 3 levels of influence (individual, interpersonal, and environmental) was utilized.

3.1 Relationships between walking and individual factors

Walking is a universal form of physical activity and could be promoted regardless of sex, age, education, ethnic group or income. Walking does not require expensive equipment, special skill, or special facilities and is particularly important due its potential to reduce disparities in physical activity behavior (Lee & Buchner, 2008).

In a literature review, Kerr et al. (2012) highlight that longitudinal, cross-sectional and intervention studies have demonstrated the benefits of walking in older adults, evidencing short-term cardiovascular-related health improvements. Evidence from epidemiological studies suggest that even small improvements in

the amount of daily walking is better than no walking, and greater increases confer larger health benefits (Murtagh et al., 2010).

Prior research also suggests that walking is associated with the improve of strength, endurance, agility and lower limb flexibility (Parkatti et al., 2012) and cardio-respiratory fitness, in older adults (Belman & Gaesser, 1991). Several large prospective cohort studies also link higher levels of physical activity, particularly walking, with 30%-50% reduction in the risk of osteoporotic fractures (Gillespie et al., 2003). There is also emerging evidence for psychological benefits accruing from walking in older adults, namely the reduction of depressive symptoms (Julien et al., 2013). Walking activity was also associated with a reduction in the risk to develop cognitive impairment, in older women (Yaffe et al., 2001).

Considering, regular walking at moderate-to-vigorous-intensity has a set of benefits at individual level, being associated with the prevention, maintenance and promotion of physical and mental health. However, in spite of the recognized benefits of introducing walking in older adults daily life, it is pertinent to analyze the proper volume, frequency and intensity required to produce benefits.

3.2 Relationships between walking and interpersonal factors

There is empirical evidence that social support is related with physical activity and exercise. Social support interventions, walking groups, partners for physical activity were found to be related with time spent in physical activity and frequency of exercise (Kahn et al., 2002). Studies have also shown that having a spouse and/or supportive family and friends are positively associated with increased physical activity (Sallis et al., 1992).

Social models and support from family and friends are important in stimulating older adults to adopt an active lifestyle, while support from people who are associated with being active (i.e., sports instructors, group members) are important for maintaining the adopted activity in older adults (van Stralen et al., 2009). Although the positive effects of the social support on older adults' physical activity (Booth et al., 2000) and health behaviors (Stahl et al., 2001),

few studies have explored the associations between interpersonal factors and walking behavior in older adults.

In a sample of Flemish older adults, Van Cauwenberg et al. (2014) found positive relationships between general forms of social support (frequency of contacts with neighbors, neighbors' social support, neighborhood involvement, participation and volunteering) and walking for transportation in older adults. Social cohesion (i.e. willingness of members of a society to cooperate with each other and agreement on norms and values) was found to be positively related to total walking (Mendes de Leon et al., 2009), however in the study of Fisher et al. (2004) this relationship was not significant. Moreover, Kamphuis et al. (2009) found that recreational walking was positively associated to social network size.

Concluding, research is only just beginning to unravel the relationship of interpersonal factors with older adults' walking behaviors (Van Cauwenberg et al., 2014). Given the recognized positive effects of the social support on health behaviors, this relationship should be further explored to promote walking among older adults.

3.3 Relationships between walking and environmental factors

Studies investigating relationships between physical environment and walking in older adults have been increasing in the last decade, however relationships are less frequently studied in older adults than in younger age groups (Rhodes & Nasuti, 2011). An overview of the literature findings on the relationship of different features of the neighborhood environment (walkability, access to services and shops, walking facilities safety and aesthetics) with walking in older adults will be presented in the next paragraphs.

Walkability of the neighborhood was positively associated with older adults' walking for transportation (Carlson et al., 2012; Frank et al., 2010; King et al., 2011), walking for leisure (Carlson et al., 2012), walking for exercise (Berke et al., 2007) and with the number of blocks walked per week (Michael et al., 2011). Two studies also found that walkability was not related to recreational walking (King et al., 2011; Nagel et al., 2008).

Objectively measured access to services and shops was positively related to total walking (Nagel et al., 2008). Greater land use mix access and diversity was related to more reported walking for transportation (Shigematsu et al., 2009). Michael et al. (2006) found a positive relationship for both objectively measured and perceived presence of a mall with recreational walking. The presence of recreational facilities near home was positively associated with walking for transportation (Shigematsu et al., 2009) however, no relationship was found of objectively measured access to services and recreation facilities with recreational walking (Nagel et al., 2008).

Concerning the walking facilities, the perceived presence of walking facilities was also positively related to transportation walking in American seniors (Shigematsu et al., 2009) and the presence of parks was positively related with recreational and total walking (Michael et al., 2006; Nagel et al., 2008). Hall & McAuley (2010) also found that older adults who did not attain 10.000 steps per day reported fewer walking paths than those who achieved 10.000 steps per day.

Safety and aesthetics have been found to be consistently important to older adults' walking activity (Cunningham & Michael, 2004). Shigematsu et al. (2009) found that perceived traffic-related safety and crime-related safety was not related to recreational walking. Hall & McAuley (2010) reported that participants who did not attain 10 000 steps per day perceived significantly less safety from traffic than those who achieved 10 000 steps per day. Michael et al. (2006) found a negative relationship of objectively measured presence of graffiti and vandalism with recreational walking. Sugiyama et al. (2009) found that the quality of paths to open spaces was correlated with walking behavior

Evidence suggest the need for additional research on this topic, because fewer such studies exist among older adults (Rhodes & Nasuti, 2011), some inconsistent results were verified on the literature, and to our knowledge only three studies included objective measures of PA assessed by pedometers or accelerometers (Hall & McAuley, 2010; King et al., 2011; Van Holle et al., 2014). Moreover, there is a need for a deeper understanding of older adults' perceptions of the neighborhood environment because older adults often

perceive barriers to walk differently than the general population (Haselwandter et al., 2015). As reported by Van Dyck et al. (2009), the study of the perceptions of the neighborhood environment could be an important contributor to the understanding of factors influencing the older adults' decision to get out and about in their own neighborhoods. Thus, exploring older adults' perceptions of the neighborhood environment would be important to design more effective community walking interventions.

4. Measuring walking

Different methods to assess walking activity have been developed. In general, self-reported and objective measurement devices have been used to measure walking in free-living conditions (Troiano et al., 2008). Walking is often assessed using self-report measures (Murphy, 2009), however, self-report of physical activity suffers from significant reporting bias (Sallis & Saelens, 2000) and in older adults in particular, self-report may also be influenced by fluctuations in health status, mood or cognitive ability (Rikli, 2000). Benefits of these methods include the ability to collect data from large samples and the possibility to assess frequency, duration and context of walking through a cost-effective measurement (Sallis & Saelens, 2000).

The International Physical Activity Questionnaire (IPAQ), is the most commonly used physical activity questionnaire (http://www.ipaq.ki.se). The IPAQ has been shown to be a valid and reliable instrument to measuring physical activity, sedentary behavior (Craig et al., 2003) and time spent in walking (van der Ploeg et al., 2010). The IPAQ short form assesses three specific types of physical activity, namely walking, moderate, and vigorous physical activity, during the last seven days. The IPAQ long form assesses different types of physical activity in different context, such as work (vigorous and moderate physical activity, walking), transport (bicycling, walking), house and garden (vigorous and moderate physical activity in the garden, moderate physical activity inside home), and leisure time (vigorous and moderate physical activity, walking). All questions in both versions assess the frequency (days)

and duration (time) of all the types of physical activities. Both versions can be interview-based or self-administered.

Objective physical activity measures have been increasingly used to overcome limitations of self-report measures (Murphy, 2009). Objective measurement devices such as pedometers, which measure steps, and accelerometers, which measure movement intensity, have become popular because they can provide information on the amount, frequency, and duration of physical activity, namely walking. These devices are small, mostly worn at hip bone level, can capture data for multiple days and are increasingly reliable and affordable (Troiano et al., 2008). Pedometers provide an inexpensive overall measure of walking activity (Corder et al., 2007). The main walking activity outcome using pedometers is step counts. They are easy to use and are able to provide feedback to individuals about their performance (Murphy, 2009). However, pedometers have some limitations for assessing ambulatory activity: (1) pedometer accuracy in slow speeds, especially below 3 km/h, is diminished (Melanson et al., 2004); (2) pedometer accuracy is also reduced for people who have variable gait patterns (Cyarto et al., 2004), and (3) some pedometers are not able to internally store data for more than 24 h.

Accelerometers are more sophisticated and effective than pedometers. They measure acceleration and have the capacity to assess volume and intensity of physical activity (Pruitt et al., 2008). In addition, accelerometers are able to measure step data (Tudor-Locke et al., 2011). Nevertheless, there are recognized limitations to the use of accelerometers to measure walking activity in older adults, including: (1) financial cost of monitors; (2) a lack of wear compliance could occur in older adults facing memory loss to wear the device or lack of visual and manual dexterity to properly attach the device in the recommended position, which significantly affects the quality of data (Murphy, 2009); (3) the nonlinearity of accelerometer output at higher intensities of activities (e.g. running), (Corder et al., 2007); (4) there are no widely accepted accelerometer cut-points to evaluate intensity levels in older adults (Pruitt et al., 2008) and (5) accelerometers are not able to register the type of activities,

being necessary to provide activity diaries to register the physical activities performed during the wear time.

Pedometers and accelerometers objectively measure total walking activity. The total number of steps per day have been used to measure the volume of walking activity, in a day. Using raw data we are also able to detect walking at the recommended intensities (Tudor-Locke et al., 2011). Moderate-intensity walking appears approximately equal to at least 100 steps/ minute. Peak 30-minute cadence (defined as the average steps/min recorded for the 30 highest intensity minutes in a day) have been used to evaluate the intensity of the ambulatory activity in older adults (Tudor-Locke et al., 2013). ActiGraph accelerometers reliability to assess cadence is high (>0.80), being in almost total agreement with directly observed cadence between 100 and 180 steps/minute (Rowlands et al., 2007).

The study of the relationships of peak 30-minutes cadence still rare, being one of the promising research directions to analyze intensities associated with walking benefits.

5. Promoting walking: the example of the Portuguese national walking and running program

Ecological models are being used to understand and explain physical activity. In addition, these models are also being used to design more effective interventions to promote physical activity in specific populations (Sallis et al., 2006). The social-ecological model uses a combination of individual, social, environmental and policy level strategies to achieve substantial changes in health behaviors, including physical activity (Sallis et al., 2008). In health research, interventions are often defined as specific strategies or programs developed to address a particular problem or issue, for example an inactive lifestyle. Physical activity-related social ecological interventions target multiple levels of influence of the physical activity behavior (Bauman et al., 2012).

The Portuguese national walking and running program is a country-wide intervention developed by the Portuguese Institute of Sport and Youth,

Portuguese Athletics Federation and the Faculty of Sports of the University of Porto which aims to mobilize the Portuguese population for the walking and running regular practice. The Portuguese national walking and running program intends to develop synergies with municipalities in order to offer regular and qualified walking and running training sessions monitored by certified sport technicians. This project is conducted on a weekly basis in municipal centers all over the country where trained instructors prescribe and supervise regular walking and running training sessions. In order to assure high-quality workout sessions, the Portuguese national walking and running program involves a technical training program for sport technicians, comprising different topics concerning training and health promotion. Moreover, an online platform supports the evaluation and monitoring of the participants' exercise. The program was created in 2009, and in June of 2014 was established in 25 municipal centers, reaching around 2000 registered participants, including around 500 seniors.

The Portuguese national walking and running program was based on ecological models, intervening at multiple levels of influence including the individual, interpersonal, and environmental levels. Strategies at the individual level include fitness monitoring and a website including educational materials about walking and running benefits, nutrition, tips for active lifestyles and the schedule of the programmed activities. At the interpersonal level, the municipal walking and running centers offer weekly group training sessions. Moreover, walking and running events are organized along the year. At the environmental level the main strategy applied is an advertising panel which is created to each of the municipal walking and running centers, containing a map with the trails around the walking and running municipal center, the distance and the level of difficulty of the routes, the contact of the sport technician and the schedule of the training sessions (see figure 3).

Figure 3 - Advertising panel of the walking and running municipal center of Guimarães.

The study of the older adults participants of the Portuguese national walking and running program seemed to be an opportunity for relevant research, since it is a country-wide intervention targeted at individuals of the Portuguese population. Understand how interpersonal and environmental factors interact with the individual ones of the older adults participants of the Portuguese national walking and running program was our main challenge. As a result, we expected to provide a more spread picture of the social and environmental factors capable to influence a range of individual benefits. Therefore, we can speculate that this thesis will allow the dissemination and implementation of a more effective political and social program reflected in opportunities for walking practice, among older adults.

6. Objectives of this thesis

Based on the literature synthesis described in the general introduction, it can be concluded that: (1) the study of the relationships of peak 30-minutes cadence still rare, being one of the promising research directions to analyze intensities associated with better walking benefits; (2) the relationship of interpersonal factors with older adults' walking behaviors should be further explored in order to promote walking among older adults; (3) few studies and inconsistent results were found in studies exploring the relationships between physical environment and walking activity among older adults; (4) almost of these studies included self-reported measures of physical activity, namely walking and (5) there is a need for a deeper understanding of older adults' perceptions of the neighborhood environment. Therefore, this thesis aims to address some of the above described shortcomings of the literature.

The overall aim of this PhD thesis was to understand how individual, interpersonal and environmental factors interact with walking behaviour, physical and mental health, among seniors. The general objective of this thesis supported the specific goals of the original articles presented in the experimental work of this thesis.

The paper I, aimed to analyze the experience of participating in a walking pilot program at individual, interpersonal and environmental levels in order to determine appropriate strategies to walking interventions, in older adults. This pilot study emerged, firstly, in order to explore qualitative information on social ecological factors relevant for walking behavior of the older adults participants in the Portuguese national walking and running program. The results of the first study helped us to define the following, second, third and fourth studies.

With the second paper we intended to explore the relationship of walking intensity with an individual factor (functional fitness). More specifically, the purpose of the second paper was to examine the relationship of peak-30 minutes cadence on a training day with agility, lower limb muscle strength, aerobic endurance and body mass index. We also aimed to detect if the peak 30-minutes cadence on a walking training day was higher than on a non-training day.

The third study of this thesis aimed to investigate relationships of walking with the second level of influence of the socio ecologic model (interpersonal) and the influence of walking and social support on older adults mental health (individual level). Particularly, the third study examined the direct effect of social support on walking, vitality and psychological distress and the mediating effect of walking on the relationship of social support with vitality and psychological distress. To address this aim, we used data from the Belgium Health Survey, an opportunity given by the Department of Movement and Sport Sciences of Ghent University, during my research stay there.

Finally, the fourth paper aimed to study the relationship of perceived neighborhood environment factors (third level of influence of the socio ecologic model) with objectively measured recommended volume and intensity of walking, in recreational senior walkers.

With these four papers we aimed to contribute to the understanding of the relationships of walking with individual, interpersonal and environmental factors, among seniors.

Experimental Work

This thesis was conducted in some municipal walking and running centers of the Portuguese national walking and running program (Lamego, Albergaria, Tondela, Lagos, Jamor e Porto). Moreover, one study included in this thesis was conducted using data from the Belgium Health Survey. The figure 4 illustrates the main methodological features of the experimental work, detailing for each paper, the sample size, participants' mean age, outcome variables, measurement techniques and the data analyses. The complete description for each section is presented in the corresponding paper at the methods section. All participants provided a voluntary written consent (see appendix) and the ethical approval was granted by the Ethics Committee of the Faculty of Sport from the University of Porto (CEFADE 27.2013).

The following papers were included in this thesis:

Paper I: The experience of older adults in a walking program at individual, interpersonal and environmental levels.

Paper II: Ambulatory activity of older adults participants in the Portuguese national walking and running program. An analysis of the peak 30-minutes cadence and its relation with functional fitness.

Paper III: Walking as a mediator of the relationship of social support with vitality and psychological distress in older adults.

Paper IV: Perceptions of the neighborhood environment associated with walking at recommend intensity and volume levels in recreational senior walkers.

Table 1 - Outline of this thesis

	Paper I	Paper II	Paper III	Paper IV
Final Sample	16 old women 3 old men	35 old women 26 old men	1802 old women 1057 old men	59 old women 26 old men
Mean age	67,42 years	68,56 years	79.85 years	68.48 years
Studied variables	Perceptions at individual, interpersonal and environmental levels Physical Activity Functional Fitness	Peak 30-minutes cadence BMI Functional Fitness Steps per Day	Psychological distress Vitality Walking activity per day Social Support	Perceptions of the neighborhood environment Peak 30-minutes cadence Steps per day
Measurement technique	Interviews IPAQ questionnaire ALPHA questionnaire Senior Fitness Test (Rikli & Jones, 1999)	Accelerometer Weight scale Stadiometer Senior Fitness Test (Rikli & Jones, 1999)	IPAQ questionnaire Vitality scale of SF-36 Global health questionnaire Social Support questionnaire	Accelerometer ALPHA questionnaire
Data analyses	Content Analysis Paired samples t tests	Single linear regression analysis Paired samples and independent samples t tests	Mediation Analysis	Binomial logistic regression analysis

Paper I: The experience of older adults in a walking program at individual, interpersonal and environmental levels.

Older adults experiences in a walking program at individual, interpersonal and environmental levels.

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Abstract

Walking programs are advocated to mobilize sedentary older adults. However, the study of age-specific walking programs are needed to develop interventions that offer best chance for success. The purpose of this study was to analyze the experience of participating in a walking pilot program at individual, interpersonal and environmental levels in order to determine appropriate strategies to walking interventions to older adults. A 10-months walking program was implemented, 3 times per week with nineteen older adults (mean age = 67,42±5,48). The participants were submitted to a pre and post evaluation of functional fitness, physical activity patterns and perceptions of the environment. After the program semi-structured interviews were conducted with twelve randomly selected participants. The results highlight the potential of this walking program enhancing physical and mental health, supportive social networks and walking routes in nature context which was crucial for the promotion of older adults active lifestyles and functional improvement.

Introduction

Older adults' sedentary lifestyle and consequent low levels of fitness have been described as determinant risk factors for the development of several chronic conditions. Active lifestyles are, therefore, advocated in order to treat and prevent the age-related disability (American College of Sports et al., 2009). Despite of the strong evidence of the physical activity (PA) benefits on elder's health and functionality, a lack of implementation of simple, pleasant and feasible PA/exercise interventions for this growing population still exists.

In terms of public health, walking has been indicated as the most relevant form of exercise to increase regular PA at a moderate intensity (Owen, Humpel, Leslie, Bauman, & Sallis, 2004). Different intervention studies evidence health benefits of walking; showing short-term health-related improvements in previously sedentary adults (Murphy, Nevill, Murtagh, & Holder, 2007).

The ecological models can be used to develop more comprehensive interventions since they provide frameworks for understanding the multiple and interacting levels of influence of health behaviours (individual, interpersonal, environmental) (Sallis, Owen, & Fisher, 2008). These models seem to be crucial for the development of more efficient interventions that have the potential to change the behaviours of the older adults.

Considering, this study aimed to analyze the experience of participating in a walking pilot program at individual, interpersonal and environmental levels. Feedback on the program was also sought in order to determine appropriate strategies and preferences of the aged adults. A mixed methods design was used in order to integrate the information (qualitative and quantitative) in the interpretation of the overall results and provide a better understanding of a research problem.

Methods

Intervention and Participants

A sample of 19 older adults (mean age = 67,42±5,48 years) was recruited to participate in a 10-months walking program (from October 2012 to July 2013) specifically designed for older adults on the Walking and Running Municipal Center of Lamego (see table 1).This center is part of the Portuguese National Walking and Running Program, a project which aims to mobilize the Portuguese population for the walking and running regular practice with technical support. The eligible participants were restricted to older adults with the following characteristics: (1) retired; (2) being inactive in the previous 12 months, without usual exercise practice; (3) ability to independently exercise at moderate intensity and (4) medical authorization for the exercise.

Table 1. Intervention Ecological Strategies

Ecological level	Intervention strategies
Individual	· Individual report of the functional fitness monitoring.
	· Monthly mail with educational materials and schedule of the next month activities
Interpersonal	· Three walking/exercise sessions in group per week, including 10-minute warm-up, 20-30 minutes of walking at moderate intensity and 10 minutes cool-down.
	· Monthly activity "Walking Through the Villages". Participants walked along different villages of the district and convivial moments were provided to the participants.
Environmental	· Advertising panel with walking routes information.

Data collection

The 19 older adults were submitted to a pre and post evaluation of Functional Fitness (Senior Fitness Test - SFT), Physical Activity (International Physical Activity Questionnaire - IPAQ) and Perceptions of the Neighborhood Environment (European Environmental Questionnaire - ALPHA). Semi-structured interviews were conducted in the final of the program with 12 participants randomly selected from the entire group to access the perceptions of the participants on individual, interpersonal and environmental factors. Sample size was determined by data saturation (Sargeant, 2012) and gender distribution was consistent with the total sample. Ethics approval was granted by the Ethics Committee of the Faculty of Sport from the University of Porto (Process CEFADE 27.2013) and a written informed consent has been obtained from the participants.

Individual, Interpersonal and Environmental factors

Semi-structured interviews were conducted after 10 months of attendance to the walking pilot program (July 2013). The interview guide was based on ecologic models which aligns with the main aim of the study: "Analyze the older adults' experiences on a walking pilot program at individual, interpersonal and environmental levels". Participants were asked to reflect on their experiences in the walking program based on the 3 main questions related to individual, interpersonal and environmental factors: 1. How do you feel after

10 months of walking program attendance? 2. What do you think about being a group activity? 3. What do you think about the spaces used during the walking sessions?. Two pilot interviews were conducted with participants who are not part of the sample to refine the questions and define prompts. All interviews were conducted by an experienced interviewer and were digitally recorded with the informed consent of each participant. All interview recordings were transcribed and rendered anonymous with pseudonyms.

Functional Fitness

Senior Fitness Test battery (Rikli & Jones, 1999) was used to access the participants' functional fitness. This battery consists of 6 assessment items and was designed and validated ($0.77 \leq r \leq 0.83$) to assess the physiological measures related with functional mobility in older adults. The test items include the following assessments: lower body muscular endurance (thirty second chair stand), upper body muscular endurance (thirty second arm curl), aerobic endurance (six minute walk test), lower body flexibility (chair sit-and-reach), and dynamic balance and agility (the eight foot up-and-go to assess). All functional fitness tests were completed after a 10-minute warm-up. Before each test an explanation and demonstration was administered by the instructor and the opportunity to practice was given to the participant. Body weight, height and waist circumference were also objectively measured with an anthropometric assessment pack (Tanita BF-522) which includes a weight machine, a stadiometer and an inelastic tape, to measure each parameter respectively. BMI (kg/m2) was, therefore, calculated using the standard formula: mass (kg)/ height 2 (m).

Daily Physical Activity

PA was assessed by the International Physical Activity Questionnaire (IPAQ-SF). The IPAQ-SF questionnaire records the activity of four intensity levels: 1) vigorous, 2) moderate, 3) walking, and 4) sitting and has demonstrated validity and reliability in 12 countries, including Portugal (Craig et

al., 2003). As recommended by the authors, the last 7 day recall version was used to assess the PA levels of the participants.

Perceptions of the Neighborhood Environment

The perceived neighbourhood environment was assessed by the European Environmental Questionnaire ALPHA (Spittaels et al., 2009). This questionnaire consisted of nine themes of the neighbourhood: (1) types of residences; (2) distances to local facilities; (3) walking or cycle infrastructure; (4) maintenance of infrastructure; (5) neighbourhood safety; (6) pleasantness; (7) cycling and walking network; (8) home environment; (9) workplace or study environment. We used 7 of these 9 themes, excluding the 8th and 9th themes, because we were interested in detect the changes in the perceptions on the outdoor environments. The data was collected and was filled in by the researcher and according to the recommendations of the ALPHA Manual (Spittaels H, 2009). The reliability of the instrument has been shown by Spittaels et al. (2010) and it was translated from English to Portuguese by an experienced translator using validation / retroversion methodology.

Data Analysis

The data of the interviews were categorized in three main themes which were defined in advance: individual, interpersonal and environmental which represent the multiple levels of influence of an ecological model (Bauman et al., 2012). During the analysis process codes were grouped around similar ideas and concepts. Transcripts of interview were organized according to pseudonyms and the descriptive coding process was analyzed independently by two researchers. The results of this process were compared and discussed until an interpretive consensus was obtained. The patterns and relationships found in each theme were the basis of the interpretative process, where there was an attempt to provide explanations for the findings according to the theoretical framework and the data extracts. The Statistical Package for the Social Sciences (SPSS) Version 19.0 was used to analyze the quantitative data. With the purpose of analyzing pre and post differences within the group,

paired sample comparisons of continuous variables were performed using t tests, except for the few cases in which normality was not verified, and the Wilcoxon test was used as a nonparametric option.

Results

As reported in table 2, the participants were predominantly women (84,2%), and a higher percentage of our sample is married and live with the partner (68,4%). The majority of participants is lower educated and reported that worked mostly as housewife and farmer. All participants were all retired.

Table 2 - Demographic Characteristics of Participants (N=19)

Characteristic	Number (%)
Female	16 (84,2)
Male	3 (15,8)
Married	13 (68,4)
Widower	4 (21,1)
Single	1 (5,3)
Divorced	1 (5,3)
Primary Education	13 (68,4)
Secondary Education	5 (26,3)
Tertiary Education	1 (5,3)

The following sections present the perceived experience of the walking program at individual, interpersonal and environmental levels (qualitative data), combined with the calculation of pre and post significant differences of physical fitness, anthropometry, physical activity and perceptions of the neighborhood environment (quantitative data).

Individual factors

The qualitative results, which were illustrated by quotations from the interviews, revealed that the most of the interviewed participants reported improvements in the functional fitness parameters. Participants perceived

improvements on their body weight, agility, strength and flexibility, which was reflected in a greater facility in performing activities of daily living.

> "I was very still and I felt heavy. Not now! Now it seems that I can squat and move easily (happy). I used to have difficulties. It was hard to wear underpants but now I can tighten the laces of the tennis, I can squat, turn and walk." (I1)

The seniors also revealed improvements in aerobic endurance, translated into lower tiredness to walk and climb stairs. After the intervention participants perceived that they can walk more and easily in their daily lives. The participants expressed feelings of being more able to perform functional movements, such as walking, stair climbing and standing up suggesting a greater self-efficacy and self-confidence to walking.

> "I never thought to hiking with this age. But now I walk along different villages during some kilometers. I never thought that I could walk so much, but yes I can do it!" (I4)

The functional fitness quantitative findings reported in table 3 support almost all of these perceptions. The scores of the functional fitness tests were significantly better after 10 months of intervention on all tests except back stretch and seat and reach test where no significant differences were verified. Some participants also revealed that the walking program was an important contributor to greater joyful and openness and, in some cases, they also reported they got out from depressive mood states.

> "[How it feels to participate in the walking group?] Better, much better. [Why?] I don't need to think about my life, because I used to think a lot and I went down, got a depression and I had to take tranquilizers. Now I just take one to sleep. [It had to do with what?] I guess that it had to do with these activities, I'm more relaxed. I used to do not speak to anyone and I was very shy and I'm still being. But the other participants are pulling for me, and I laugh and occupy the time." (I5)

Interpersonal factors

In terms of interpersonal perceptions, "walking in group" as well as "family" and "friends" were reported as being important social supports for the

walking practice. All participants cited the walking program as the main reason to exercise more and to be more active. On the other hand, the participants revealed that when they walk outside of the walking sessions they call upon the support of friends and relatives.

> "[Do you restrict your physical activity to the walking sessions?] Yes, because I need to feel committed (...) I knew that there were people who were waiting for me, we have an appointment and the teacher was waiting for me also." (I4)

> "At night I use to go out for a walk with my wife and my daughter in the city center because there are a lot of people walking along." (I12)

The participants also reported that social criticism was raised from some people of the city to the walking group, namely to women, to whom they said: "Don't you have anything to do? You should be at home making the lunch!" (I12). Despite the criticism raised, most of the participants remained in the group. However, in order to avoid the embarrassment, the group decided to change the paths of walking from the city area to more natural surroundings, a decision which proved to be crucial for the group welfare and motivation.

Environmental factors

In relation to the physical environment the participants reported that developed a better physical and cultural knowledge of the Lamego district. The older adults revealed that the monthly activities "Walk Through the Villages" let them getting outside their living areas and enjoying vineyards, churches and streets where they had never been before. These activities were greatly appreciated by the participants and a special emphasis was given by the elderly who were interviewed to this activities.

> "[Did you visit these places before?] Some of them yes, others no. But now I know them in detail. We walked in places where cars do not cross and we have the opportunity to see beautiful places, landscapes and flowers." (I12)

The participants of the walking group also showed a preference for trails in the nature context. Most of the participants (75%) demonstrated that they appreciate the contact with nature, to breathe fresh air, to walk without traffic and to travel along different trails.

> "[Tell me about the journeys of the walking group?] We go to the forest of "Nossa Senhora dos Remédios", a traffic-free zone. (...) I think it is good; we breathe the air of nature and feel the aroma of trees." (I3)

The use of surroundings of their neighborhoods to the walk practice is new for some participants (50%). Almost of the respondents reported that they choose to walk in downtown area where it is usual to see other people walking at night:

> "At night I use to go out for a walk with my wife and my daughter in the city center because there are a lot of people walking along." (I12)

The perceived neighbourhood environment findings (see table 3) demonstrated better PA-related neighbourhood perceptions only in 2 themes (types of residences and safety related to traffic). No statistically significant differences were found in the other themes related with the neighbourhood environment. However, the results of the comparison of the PA measurements between the baseline and the post evaluation moments showed statistically significant improvements in the amount of moderate to vigorous physical activity (MVPA) and walking activity per week (see table 3). No statistically significant differences were found in the sedentary time per day between the baseline and post evaluation.

Discussion

The results of this study reflected the perceived experience of the participants of a walking program at individual, interpersonal and environmental levels. At the individual level, the participants emphasized improvements in the functional fitness parameters. This walking program which promoted walking at

moderate intensity and at the recommended durations and frequencies (American College of Sports et al., 2009) conferred perceived and objective functional benefits to the older adults participants. It is important to recall the exercise sessions characteristics that include warm-up, calisthenics exercises, walking at moderate intensity and stretching exercises. As the recent guidelines recommend this program involves endurance, strength and flexibility exercises (American College of Sports et al., 2009), showing a great impact in all functional tests with the exception to flexibility tests. Probably, stretching only in cool down was not enough to increase significantly the upper and lower flexibility. Other protocol design with stretching in warm-up, cool-down and in the middle of the walking training session showed positive effects in flexibility (Creswell & Plano Clark, 2011). Nevertheless, as stated by Sargeant (2012), there is insufficient evidence of the relationship between flexibility and the functional ability needed to perform everyday activities. Most importantly, the improvements on the other functional fitness parameters seems to lead to the maintenance of the mobility and functional decline prevention.

The participants also expressed positive self-perceptions of being more capable suggesting a greater self-efficacy and self-confidence to the exercise and PA, which is one of the favorable psychological factors associated with higher levels of PA (Bauman et al., 2012). Some participants also revealed that the walking program was an important contributor to develop a better mood and in some cases to get out from depressive states. This results were in concordance to a review investigating older adult's mental health (Guest, Namey, & Mitchell, 2013) which reported a significant decrease of depressive symptoms among older adults participating in walking and exercise programs.

In accordance with the authors Ogilvie et al. (2007) we also found indicators that older adults can benefit of social support from a walking group to increase their levels of exercise and physical activity (moderate-to-vogorous and walking), as well as from neighbors, family and friends who demonstrated to be crucial for the walking practice outside of the exercise sessions (Weiss, Maantay, & Fahs, 2010). On the other hand, some criticism was raised from some locals to the walking group, which embarrassed some of the participants.

This fact could be a barrier to the exercise and physical activity in view of the fact that people need to be supported and encouraged by their physical and social environments (Giles-Corti & Donovan, 2003). However, in order to avoid constrains, the group decided to change the paths of walking to more natural surroundings, a fact which proved to be essential for the contentment of all participants. As considered by the authors Rosenberg, Huang, Simonovich, & Belza (2013) and Santana, Santos, & Nogueira (2009), the participants of the walking group showed a preference for trails in the nature context, which was an important aspect to improve the motivation to participate in the walking program.

Other important strategy of this walking program was the monthly activity "Walk Through the Villages", which was very appreciated by the participants who reported that developed a better physical and cultural knowledge of the Lamego district. This strategy revealed to be in accordance with the authors Satariano & McAuley (2003) who emphasize the importance of developing ecological exercise and PA interventions in rural communities involving social, cultural and environmental factors. The results also demonstrated that the use of surroundings of their neighborhoods to the walk practice is new for some participants. The downtown, where the participants reported it was usual to see other people walking at night demonstrated to be an important context for walking practice outside the walking sessions. Observe and/or interact with other walkers gives seniors a social and environmental reinforcement to do the same (Nielsen & Hansen, 2007).

Concerning the results of the ALPHA questionnaire we found that the perception of the environment altered, in a favorable way, after the walking intervention only in the themes of “types of residences” and “neighborhood safety related to traffic”. As reported by Ries, Dunsiger, & Marcus (2009), increasing exposure to the neighborhood environment may result in changes in environmental perceptions related to physical activity. However, our program was developed outside of the residence areas, which may not be effective in changing perceptions of the neighborhood environment. Our results suggest to verify in future studies if the perception of the neighborhood environment seems

to be influenced by walking programs developed in the participants residential area. However the significant improvements on moderate-to-vigogous and walking activity per week reveal positive effects of the program on daily physical activity of the older adults. Furthermore, there are some limitations of the study: (i) the lack of a control group to compare the quantitative results of the intervention (change in the outcomes cannot be fully attributed to the walking intervention). Nevertheless, despite the importance of the suggested group, as the study intends to observe quantitative as well as qualitative data and considering that in this last methodology is not usually included a control group; (ii) self-reported physical activity is a subjective measure that may have been influenced by cognitive status; (iii) small sample size that may have been insufficient to achieve statistical power when analyzing quantitative data; (iv) generalization of the results is limited, because the study was just conducted in a small country town and results could differ for walking programs developed in other geographical areas of Portugal. In spite of these limitations, a key strength is that to our knowledge, this is the one of the few studies that simultaneously use of subjective and objective measures to better understand the older adults experience, improvements and preferences on a walking program. Moreover, the use of an ecological model also helped us to explore the multiple levels of influence of walking, which provided a more comprehensive analysis.

Conclusions

Considering, this study demonstrated the older adults experience in a walking pilot program at individual, interpersonal and environmental levels. This study suggests that this walking pilot program, promoting good health (physical and mental), supportive social networks and walking routes in nature context, was crucial for increasing levels of MVPA and walking of the older adults participants. Moreover, the aged adults emphasized the interpersonal strategies applied, showing the importance of the social level to create supportive interventions to promote walking in this specific population. The results of this pilot study are important to elucidate the technicians of the Portuguese National Walking and Running Program about the benefits of this walking pilot program

targeted for seniors, revealing the appropriate strategies and preferences to promote walking in later life. Walking promotion should centre around improving older adults confidence by the increasing of fitness levels and PA as well as promoting walks in group in nature context, which proved to be effective for the intervention success.

Table 3 - Pre and Post test Measures for Physical Fitness, Anthropometry, Physical Activity and Perceptions of the neighborhood environment (N=19)

	Pre Evaluation		Post Evaluation		*P*
	Mean	SD	Mean	SD	
Functional Fitness					
6 minutes	559,67	66,08	595,67	58,15	0,01*
Chair Stand	22,16	4,80	25,11	5,57	0,02*
Arm Curl	22,89	3,60	26,89	5,43	0,00*
Seat and Reach	5,37	8,60	6,42	8,23	0,37
Back Stretch	-12,56	14,20	-7,22	15,35	0,12
Up and go	4,54	0,70	4,02	0,64	0,00*
Anthropometry					
Weight (Kg)	67,88	11,98	66,73	11,81	0,00*
Waist Circumference	92,16	9,18	92,26	10,47	0,91
BMI	28,18	4,49	27,68	4,30	0,00*
Physical Activity					
MVPA (minutes per week)	39,64	63,53	152,14	85,23	0,00*
Walking (minutes per week)	140,77	95,76	245,00	154,37	0,04*
Sedentary time (minutes per day)	270,00	131,56	269,29	104,99	0,98
Perceptions of the neighborhood environment					
Types of residences	2,36	1,34	3,21	1,25	0,01*
Distances to local facilities	2,36	0,50	2,36	1,08	1,00
Walking infrastructure	3,64	0,84	3,29	1,14	0,16
Maintenance of walking infrastructure	3,64	1,15	3,57	1,28	1,00
Neighborhood safety (crime)	3,27	1,16	4,00	0,00	0,06
Neighborhood safety (traffic)	3,13	1,19	4,00	0,00	0,03*
How pleasant is your neighborhood	1,79	1,19	2,07	1,38	0,32
Cycling and walking network	2,43	1,22	2,43	1,02	1,00

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Paper II: Ambulatory activity of older adults participants in the Portuguese national walking and running program. An analysis of the peak 30-minutes cadence and its relation with functional fitness.

Ambulatory activity of older adults participating in the Portuguese National Walking and Running Program. An analysis of the peak 30-minutes cadence and its relation with functional fitness.

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Abstract

This study examined the relationship of peak-30 minute cadence with agility, lower limb muscle strength, aerobic endurance and body mass index (BMI) and compared peak 30-minute cadence between walking training and non-training days. Sixty one senior participants of the Portuguese National Walking and Running Program (men, n= 26; women, n=35) wore an accelerometer during 7 days to assess steps per day and peak 30-minute cadence on training and non-training days and completed the up and go, chair stand and 6 minutes tests, in the end of the training season . Body weight and height were also measured. Seniors reached higher walking intensity and volume on training days than on non-training days ($p<0,01$). The peak-30 minute cadence showed to be associated with functional fitness and BMI, in women. None of the relationships were significant, in men. Concluding, walking training sessions could have the potential to encourage higher peak 30-minute cadence and consequently functional fitness levels, in old women. In men, faster cadences may be needed to influence functional fitness parameters.

Introduction

Older adults have become the most inactive age group in Europe. According to the Euro-barometer on Sport and Physical Activity (2014), older adults are less likely to engage in moderate-to-vigorous physical activity (MVPA), which could lead to functional limitations and disabling diseases (Nelson et al., 2007). Since the functional limitations associated with an inactive lifestyle result in augmented disability and mortality, it is important to understand

how to counteract declines in older adults' MVPA in order to improve their functional fitness.

Functional fitness was defined by Rikli and Jones (1999) as the "physiologic capacity to perform normal everyday activities safely and independently without undue fatigue" and is related with the performance of functional movements, such as walking, stair climbing, carrying objects and standing up which are dependent on physical parameters such strength, endurance, body composition and balance (R. Rikli & Jones, 2001). Maintaining functional fitness preserves independence in later life (Sardinha, Santos, Marques, & Mota, 2015) and is associated with older adults' quality of life (Olivares, Gusi, Prieto, & Hernandez-Mocholi, 2011). Promoting higher levels of participation of older adults in regular MVPA seems to be a key factor in maintaining and increasing the functionality and the active life expectancy of the growing aging population (Chodzko-Zajko et al., 2009).

Walking is the most relevant form of exercise to increase regular physical activity (PA) at a moderate intensity and studies have shown the benefits of walking on self-reported health (Diehr & Hirsch, 2010), cardiovascular risk factors (Park et al., 2014), falls prevention (Okubo et al., 2015), functionality (Dondzila et al., 2015), vitality (Solberg, Hopkins, Ommundsen, & Halvari, 2012) and depressive symptoms (Perrino et al., 2011), among older adults. On the basis of such cited benefits, community programs, particularly walking programs, have been encouraged (De Smedt, De Cocker, Annemans, De Bourdeaudhuij, & Cardon, 2012). However, despite of the recognized benefits of walking and the potential of walking programs to mobilize inactive older adults through walking, few studies have evaluated the contribution that a community walking program makes specifically to the volume and intensity of daily PA, in older adults.

Intensity is a PA component referred to as the rate of work necessary to perform an activity (Tudor-Locke & Rowe, 2012) and can be measured in metabolic equivalents (METs), kilocalories, joules, milliliters of oxygen consumption and speed (Powell, Paluch, & Blair, 2011). Walking cadence (i.e., stepping rate) has also been associated with intensity, with 100 steps/min

corresponding to the cut-point of walking at moderate-intensity (Tudor-Locke, Camhi, et al., 2011). Peak 30-minutes cadence emerged as an indicator of the intensity of walking activity, representing the highest cadence (i.e., steps/min) accomplished during 30 minutes in one day (Tudor-Locke & Rowe, 2012) and have been used to evaluate the intensity of the ambulatory activity in older adults (Tudor-Locke, Barreira, Brouillette, Foil, & Keller, 2013).

Studies investigating relationships between daily ambulatory activity and functional fitness in older adults, have shown that peak 30-minute cadence is significantly correlated with body mass index (BMI), but only in older women (Schuna et al., 2013). Moreover, peak 30-min cadence was also independently related to functional walking capacity in older adults, although again the relationship is stronger in women compared to men (Gonzales, Shephard, & Dubey, 2014). According to our knowledge, these are the only two studies to date evaluating the relationship between peak 30-minutes cadence and functional fitness in older adults. In these studies, only the relationships between peak cadence, BMI and walking performance were studied, while the relationship between peak 30-minutes cadence and other parameters of functional fitness (e.g., agility, lower limb muscle strength, aerobic endurance) remain unexplored.

In the present study we aimed to characterize the ambulatory activity of the older adults participating in a walking and running program on both training and non-training days and to explore the relationship of peak-30 minutes cadence of a walking training day with agility, lower limb muscle strength, aerobic endurance and body mass index. We hypothesized that peak 30-minutes cadence on a walking training day would be higher than on a non-training day. Moreover, we hypothesized that peak 30-minutes cadence of a walking training session day is related with functional fitness and BMI, and that this relationship is stronger women than for men.

Materials and Methods

This cross-sectional study used data from a sample of 61 older adults (26 men and 35 women) which participated in the Portuguese National Walking and Running Program. This program aims to promote walking and running in the

Portuguese population by offering regular walking and running training sessions, monitored by certified sport technicians in municipal centers. This project is conducted on a weekly basis in municipal centers all over the country where trained instructors prescribe and supervise regular walking and running training sessions. An online platform supports the evaluation and monitoring of the participants' exercise. The program was created in 2009, and in June of 2014 was established in 25 municipal centers, reaching around 2000 registered participants.

The Portuguese National Walking and Running Program was based on ecological models, intervening at multiple levels of influence including the individual, interpersonal, and environmental levels. Strategies at the individual level include fitness monitoring and a website including educational materials about walking and running benefits, nutrition, tips for active lifestyles and the schedule of the programmed activities. At the interpersonal level, the municipal walking and running centers offer weekly supervised group training sessions (2 to 3 times per week). Moreover, walking and running events are organized along the year. At the environmental level the main strategy applied is an advertising panel which is created for each of the municipal walking and running centers, containing a map with the walking and running trails around the municipal center, the distance and the level of difficulty of the routes, the contact details for the sport technician and the schedule of the weekly training sessions

Procedure and participants

Invitations for participation in the study were sent electronically between March and May of 2014 via the sports technicians of 16 walking and running municipal centers who had older adults participants in the program. 4 walking and running municipal centers agreed to participate. A meeting with the older participants of each of these walking and running municipal centers was held to provide information on the study. Written informed consent was signed by the interested participants. After expressing interest in participating, the older adults wore an accelerometer during 7 days during waking hours, completed the Senior Fitness Test (SFT) (R. Rikli & C. Jones, 1999) and a socio-demographic

questionnaire, including questions about age, civil status and years of education. The evaluations were realized from June to July of 2014 (in the end of the training season).

Participation in this study was restricted to older adults with the following characteristics: (1) age ≥ 65 years old; (2) participants on the Portuguese national walking and running program for at least 6 months ; (3) ability to independently walk at moderate intensity (cadence ≥ 100 steps per minute) and (4) medical authorization for the walking and running program. One hundred and seven older adults were evaluated but 46 participants were excluded from the daily ambulatory testing because they did not provide at least 4 valid days of accelerometer data. Ethical approval was granted by the Ethics Committee of the Faculty of Sport from the University of Porto.

Measures

Functional Fitness

3 items of the SFT (Rikli & Jones, 1999) were used to assess the participants' lower extremity functional fitness. This six items battery was designed and validated to assess the physiological measures related with functional mobility in older adults. An overview of the test items, used in the present study, can be found in table 1. We only assessed the lower extremity-related functional tests because we wanted to relate it with walking intensity measures. Body weight and height were also objectively measured with an anthropometric assessment pack (Tanita BF-522) which includes a weight scale and a stadiometer to measure each parameter respectively. BMI was calculated using the standard formula (kg/m2). All tests were completed after a 10-minutes warm-up. Full detailed information on test administration and protocols can be found at the Senior Fitness Test manual (Rikli & Jones, 2013). Before each test protocol an explanation and demonstration was administered by the instructor and the opportunity to practice was given to the participant.

Table 1 - Description of the senior fitness test items from Rikli & Jones (2001) used in the present study.

Test	Purpose	Description
Chair Stand	To assess lower body strength, needed for numerous tasks such as climbing stairs, walking and getting out of a chair, tub or car.	Participants were asked to complete as many full stands as possible in 30 seconds with arms folded across the chest. The score corresponds to the total number of full stands executed within 30 seconds. Positively scored, higher of number of full stands = better lower body strength.
Up and Go	To assess agility/dynamic balance, which is important in tasks that require quick maneuvering, such as getting off a bus in time or getting up to attend to something in the kitchen, to go to the bathroom or to answer the phone.	The score was the number of seconds required to get up from a seated position, walk 8 feet (2,44 meters), turn, and return to seated position. Negatively scored, less seconds to complete the test = higher agility / dynamic balance.
6 Minutes	To assess aerobic endurance, which is important for walking distances, stair climbing, shopping, sightseeing while on vacation, etc.	Participants were asked to walk as fast as possible for 6 minutes around a 50 yards (45,7 meters) course. The score was the total distance walked in 6 minutes. Positively scored, higher distance walked in 6 minutes = better aerobic endurance.

Volume and Intensity of Ambulatory Activity

Actigraph accelerometers (model GT3X) were used to assess the volume and intensity of ambulatory activity. An actigraph accelerometer seems to be a reliable instrument for the cadence measurement since a high and significant reliability ($r = 0.99$, $P < 0.001$) have been demonstrated (Rowlands, Stone, & Eston, 2007). Participants were asked to wear the instrument over the right hip with an elastic belt for 7 consecutive days and were instructed to remove it during water-based activities (bathing and swimming) and sleeping. Accelerometers were initialized to collect activity and step data at 10 seconds intervals. Data were then integrated into 60 second epoch. Non-wear time was defined as 60 minutes of consecutive zero counts and 2 minutes of spike tolerance (Troiano et al., 2008). A valid day was defined as at least 10 hours of wear time per day. All non-wear time was excluded from further analysis. Actigraph data were downloaded using Actilife Lifestyle Monitoring System v. 6.11.3 software. This study used the raw data to define the volume (average of steps per day on valid days) and the intensity (peak 30-minutes cadence -

average of steps per min for the 30 highest intensity minutes, not necessarily consecutive, in a valid day) on training and on non-training days.

Statistical analyses

The data were analyzed using SPSS 22. Histograms graphs and skewness values were used to detect whether scores on all outcome variables were reasonably normally distributed. Outliers (n=3) were identified using a boxplot and were deleted to improve normality of the skewed dependent variables peak 30-minutes cadence and steps per minute on t-tests analysis. Independent sample t-tests were used to detect the differences between men and women on functional fitness parameters and ambulatory activity. Paired sample t-test was used to detect differences between training and non-training days in volume and intensity of ambulatory activity. Single linear regression models were used to determine the relationship between peak 30-minutes cadence of the days of training sessions with functional fitness parameters. All analyses were performed separately for each functional fitness test, considering age, BMI, education and steps per day as cofounders. Regression analyses to determine the relationship between peak 30-minutes cadence and BMI were adjusted to age, education and steps per day.

Results

Socio-demographic characteristics of the sample and descriptive statistics of the outcomes of the study are shown in table 2. The majority of participants were educated to below high school level and a higher percentage of men were married or living with a partner (96%), while 44% of women were single, widow or divorced. There were no sex-related significant differences in age, chair stand test and BMI. Only "up and go" and "6 minutes" walking tests differed significantly between men and women, with men showing higher performances on these tests ($p<0.05$).

Table 2 - Socio-demographic characteristics of participants and descriptive statistics of variables of study

Variable	Men (n=26)	Women (n=35)	p
Age (mean±SD)	67.92±3.82	69.03±4.73	0.332
Age range	65-80	65-80	
Civil Status (%)			
Married or legally cohabited	95.7	55.9	
Single, widow or divorced	4.3	44.1	
SES based on education (%)			
Low	78.3	79.4	
High	21.7	20.6	
Functional Fitness (mean±SD)			
Up and Go (seconds)	4.13±0.95	4.68±0.78	0.022*
Chair Stand (repetitions)	20.83±5.31	19.84±5.38	0.505
6 minutes walking (meters)	662.75±59.48	595.19±74.55	0.001**
BMI (kilograms/meters)^2	27.55±3.97	28.60±4.06	0.332
Accelerometer data collection			
Number of training days (mean±SD)	1,88±0,73	1,91±0,66	0,850
Number of non-training days (mean±SD)	4,28±1,17	4,43±1,35	0,660
Months of participation (mean±SD)	11,90±8,50	13,03±16,92	0,750

SD = Standard Deviation
* - p < 0,05
** - p < 0,01

Table 3 present the measures of the ambulatory activity (peak 30-minutes cadence and steps per day) of the participants on training and non-training days. No significant differences were observed in measures of ambulatory activity between men and women. Moreover, paired samples t-tests demonstrated significant differences on ambulatory activity measures between training and non-training days. Results showed that participants of both gender reached higher peak 30-minutes cadence and number of steps per day on training days than on non-training days (p<0,01).

Table 3 - Results for peak 30-minutes cadence and steps per day on training and non-training days

	Peak 30-min (non-training day)	Peak 30-min (training day)	p	Steps/day (non-training day)	Steps/day (training day)	p
Men	100.32±18.03	124.46±8.80	p<0.01	12852.62±4670.67	18405.82±6009.92	p<0.01
Women	99.58±18.40	124.68±12.09	p<0.01	12759.47±4973.05	18200.44±5410.01	p<0.01
p'	0.876	0.937		0.942	0.893	

p - paired samples t-test to detect differences between training and non-training days
p' - independent samples t-test to detect gender differences

The associations of peak 30-minutes cadence on training days with functional fitness can be observed in table 4. After adjusting for age, education

and BMI, peak 30-minutes cadence was negatively associated with the "up and go" test (95%CI= -0,106; -0,033) and BMI (95%CI=-0,410; -0,027) and was positively associated with "chair stand" (95%CI= 0,071; 0,654) and "6 minutes walking" tests (95%CI=1,554; 8,012), but only in women. After adjusting for age, education, BMI and steps per day, peak 30-minutes cadence was negatively associated with the "up and go" test (95%CI= -0,108; -0,013) and positively associated with "chair stand" (95%CI= 0,004; 0,768) and "6 minutes walking" tests (95%CI=1,967; 10,262), in women. These associations were present in women (p<0,05), but not in men. After adjusting for steps per day, peak 30-minutes cadence remained significantly associated with up and go, chair stand and 6 minutes walking, in women. However, controlling for steps per day attenuated the relationship between peak 30-minutes cadence and BMI to a non-significance, in women (p>0,05). None of the relationships were significant, in men.

Table 4 - Regression coefficients for the relationship between peak 30-minutes cadence and functional fitness on training days.

	Model 1	**Model 2**
	ß (95% CI)	ß (95% CI)
Men		
Up and Go	-0,006 (-0,059; 0,047)	0,045 (-0,012; 0,102)
Chair Stand	0,027 (-0,288; 0,342)	0,007 (-0,431; 0,446)
6 Minutes Walking	0,864 (-1,849; 3,577)	1,065 (-2,438; 4,569)
BMI	0,045 (-0,147; 0,236)	0,165 (-0,058; 0,387)
Women		
Up and Go	-0,070 (-0,106; -0,033)*	-0,060 (-0,108; -0,013)*
Chair Stand	0,363 (0,071; 0,654)*	0,386 (0,004; 0,768)*
6 Minutes Walking	4,783 (1,554; 8,012)*	6,114 (1,967; 10,262)*
BMI	-0,218 (-0,410;- 0,027)*	-0,082 (-0,339; 0,174)

Model 1: Adjustment for age, education and BMI.
Model 2: Adjustment for Model 1 + Steps per day.
* p<0,05

Discussion

Our study sought to compare the daily ambulatory activity of walking on training days with non-training days among participants in a national walking and running program and to examine the relationship of peak 30-minutes cadence of the walking training days with agility, lower limb muscle strength, aerobic endurance and body mass index.

In line with previous research, we found that there were no gender-related differences in peak 30-minutes cadence and steps per day. The results of the studies of Gonzales et al. (2014), Schuna et al. (2013) and Tudor-Locke et al. (2013) also found no differences between the genders for the average values of steps per day and peak 30-minutes cadence. Our findings also suggested that compared with non-training days, ambulatory activity on training days were higher in intensity (peak 30-minutes cadence) and volume (steps per day). This highlights the potential of walking training sessions to enhance the intensity and volume of daily PA of older adults, which is crucial for the reduction of mortality (Brown, Harhay, & Harhay, 2014) and improving health (Tudor-Locke, Craig, et al., 2011) of the community-dwelling older adults. As reported by Ogilvie et al. (2007) walking programs are a successful strategy to increase ambulatory activity.

The present study showed that higher peak 30-minutes cadence was associated with better performance on the "up and go", "chair stand" and "6 minutes" tests and lower BMI , in women. These results are consistent with studies exploring the relationship of peak 30-minutes cadence with walking performance (Gonzales et al., 2014) and BMI (Schuna et al., 2013). Walking performed at higher intensities has been associated with muscle strength and with aerobic capacity in older adults (Nemoto, Gen-no, Masuki, Okazaki, & Nose, 2007). Furthermore, the study of Aoyagi, Park, Watanabe, Park, and Shephard (2009) also revealed that older adults who spend more than 15-20 min/day doing physical activity at moderate to vigorous intensity (>3 METs) are more likely to show a well maintained fitness.

There were however no associations between peak 30 minute cadence and any measure of functional fitness or BMI in men. A possible explanation for this finding could be the different cardio respiratory response to ambulatory activity by men and women, at a similar intensity, on the higher 30 minutes of cadence. For example, a study which aimed to explore the effects of the endurance training at high and low intensities on aerobic function in elderly subjects (Belman & Gaesser, 1991), reported that there was a tendency for greater improvement on cardio respiratory fitness after training, in women.

Cardio respiratory fitness is a physiologic parameter associated to functionality (Jackson, Sui, Hebert, Church, & Blair, 2009) and greater adaptations of women to similar walking intensity could mediate relationship of peak 30-minutes cadence with functional fitness. The peak 30-minutes cadence achieved by men may have provided an insufficient stimulus to enhance functional fitness in older men. This suggests that, for stronger associations of peak 30-minutes cadence with functional fitness parameters, older men should increase stepping cadence, in the walking training sessions. Future studies in a larger sample and testing higher cadences are needed to test this relationship in older men.

The results of the present study also showed that peak 30-minutes cadence (intensity) was no longer significantly associated with BMI after controlling for steps per day (volume), in women. However, the results of the other functional fitness parameters (up and go, chair stand and six minutes) remained statistically significant, when adjusted for steps per day. Steps per day appeared be correlated with BMI, in older women, which is in accordance with the studies of Schuna et al. (2013) and Strath, Swartz, and Cashin (2009). On the other hand, besides steps per day have also been associated with functional fitness in older adults (de Melo, Menec, & Ready, 2014), the results of the present study showed that the relationship of peak 30-minutes cadence with functional fitness parameters remained significant after controlling for steps per day. In accordance with Gonzales et al. (2014), these results strengthens the importance of walking intensity in order to enhance lower extremity functional performance in older women.

Strengths and limitations

The strengths of this study include the use of objective instruments to measure the ambulatory activity and the assessment of physiological parameters that support physical mobility through a widely used battery, senior fitness test (Rikli & Jones, 1999).

There are also some limitations of the current study. Firstly, the small sample limited the statistical power of the analysis and may have contributed to the lack of statistically significant associations of peak 30-minutes cadence and functional fitness parameters, in men. Second, the cross-sectional design does

not permit causality conclusions about the effect of peak 30-minutes cadence on improved functional fitness parameters. However, as stated by Gonzales et al. (2014), peak 30-minutes cadence is more likely to affect the functional fitness parameters because regular exercise promote the functional ability in older adults (Chodzko-Zajko et al., 2009). Finally, ambulatory activity was assessed using an accelerometer worn for only one week. The measures of ambulatory activity may be, therefore, affected by atypical conditions such as weather, specific events or disease. Future studies using randomized controlled experiments should investigate the effect of ambulatory activity on functional fitness.

Conclusions

Current results, though cross-sectional in nature, support the hypothesis that peak 30-minutes cadence of a walking training session day is higher than a non-training day suggesting that walk training may be required to encourage older adults to achieve the required MVPA to gain health benefit. Our results are also in accordance with the second hypothesis which suggests that peak 30-minutes cadence of a walking training session day is related with agility, lower limb muscle strength, aerobic endurance and BMI and this relationship is more significant for women than for men. When controlled for steps per day, this relationship remains significant with the exception of BMI. To that extent, facilitating walking training sessions for older adults could promote an appropriate volume and intensity of ambulatory activity, in older adults. Volume of physical activity seems to play an important role with regard to BMI, in older women. Faster cadences, a transition to jog or running, or to maintain the cadence while walking on an incline may be required for a significant effect of peak 30-minutes cadence on functional fitness parameters, in men. Current results, suggest that potential behavioral interventions for the functional fitness maintenance in older adults, might include the promotion of walking, considering intensity as an important factor to improve functional fitness in older adults.

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Paper III: Walking as a mediator of the relationship of social support with vitality and psychological distress in older adults.

Walking as a Mediator of the relationship of Social Support with Vitality and Psychological Distress in Older Adults

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Abstract

Background

Walking could be a behavior by which multiple dimensions of social support can influence mental health. A better understanding of these relationships may help to promote a better quality of life, in older adults.

Objectives

This study examined the association of social support with walking, vitality and psychological distress and the mediating role of walking on the relationship of social support with vitality and psychological distress.

Methods

This cross-sectional study used data from a sample of 2.859 older adults (1.057 men and 1.802 women, aged between 65 and 100 years old) which participated in the Belgian Health Survey of 2008. The older adults completed the SF-36 vitality scale, the Global Health Questionnaire, the International Physical Activity Questionnaire and a questionnaire on socio-demographic and social support attributes. Mediation analyses were conducted using the MacKinnon product-of-coefficients test.

Results

All social support variables were positively associated with vitality and negatively associated with psychological distress. Social support variables were also positively associated with walking, with the exception of practical help from neighbors. Walking mediated the associations of appreciation of social contacts (3%), frequency of social contacts (8%), participation in group activities (20%), closeness from family and friends (8%), concern and interest from people around (6%) with vitality. Walking also mediated 34% of the association between participation in group activities and psychological distress.

Conclusions

The findings of the current study suggest that mainly participation in group activities in later life is beneficial to improve vitality and reduce psychological distress of the older adults, with walking being a strong mediator of this relationship.

Keywords: aging, vitality, psychological distress, social support, walking.

Introduction

The increase in life expectancy and consequently growing number of older adults worldwide have gained attention in the last decades by the nations and international organizations due to its impact on health and economy (NIA & NIH, 2007). Consequently, public health organizations aspire to improve physical and mental health of the older adults in order to improve public health and prevent the rise of health costs (Atkins, Naismith, Luscombe, & Hickie, 2013). Mental health and psychological well-being are subjects of concern due to the high prevalence of depression (around 20%) verified in older adults in Western countries (Volkert, Schulz, Harter, Wlodarczyk, & Andreas, 2013).

Growing evidence suggests that social support plays an important role on the regulation of depressive symptoms (Julien, Gauvin, Richard, Kestens, & Payette, 2013) and stronger social support/social contacts with family and friends was associated with greater vitality in older adults (Garcia, Banegas, Perez-Regadera, Cabrera, & Rodriguez-Artalejo, 2005). Phongsavan et al. (2013), found a consistent relationship between increased frequency in phone contacts, social visits, and social group contacts and reduced risk of psychological distress. On the other hand, lack of social support was also associated with psychological distress in older adults (Boen, Dalgard, & Bjertness, 2012).

There is also some empirical evidence showing that social support is related with physical activity (PA) and exercise. Social support interventions, walking groups, partners for PA were previously found to be related with time spent in physical activity and frequency of exercise (Kahn et al., 2002). Moreover, more general forms of social support (support not specifically

directed toward encouraging PA) have also been associated to PA, namely walking, among older adults. In a sample of Flemish older adults, Van Cauwenberg et al. (2014) found positive relationships between general forms of social support (frequency of contacts with neighbors, neighbors' social support, neighborhood involvement, participation and volunteering) and walking for transportation in older adults. Moreover, Kamphuis et al. (2009) found that social network size was positively associated with recreational walking and Mendes de Leon et al. (2009) found that social cohesion was positively related with total walking, among older adults. Nevertheless, the evidence on relationship between social support and older adults' walking behaviors is still limited, and there is needed of more research exploring this relationship.

Despite the positive effects of social support on older adults' PA, vitality and psychological distress, less is known about the mechanisms explaining these relationships. PA could have an important mediating role in the relationship between social environment and mental health due its potential to buffer the adverse effects of stress (Diez Roux & Mair, 2010) and to increase vitality in older adults (Solberg, Hopkins, Ommundsen, & Halvari, 2012). Empirical evidence has reported that the greater sense of accomplishment and self-worth gained through PA protects older adults from psychological distress (Cairney, Faught, Hay, Wade, & Corna, 2005) and the social relations inherent to exercise participation are associated with subjective well being in older adults (McAuley et al., 2000).

In terms of public health, walking has been indicated as the most relevant form of exercise to increase regular PA (Sallis & Owen, 1999), and was also associated with an increase in vitality (Solberg et al., 2012) and a decrease of depressive symptoms in older adults (Perrino et al., 2011). To that extent and concerning the evidence of the relationships between social support, PA, and depressive symptoms, walking could be a behavior by which social support influences vitality and psychological distress. However, the mediation effect of walking on the relationship between social support and mental health has not yet been studied in older adults (+65).

To the best of our knowledge, only one study has tested a similar mediation model in a younger population. A cross-sectional study among Australian middle-aged and older adults (55-65 years old), investigated the mediating effect of PA on the relationship of the perceived social and physical environment with mental health-related quality of life (Van Dyck, Teychenne, McNaughton, De Bourdeaudhuij, & Salmon, 2015). Results showed that leisure-time moderate to vigorous PA and leisure-time walking were strong mediators (18% and 15% respectively) of the associations between social support for PA from family or friends and mental health-related quality of life.

To further investigate this model in older adults, the purpose of this study was to examine the mediating role of walking on the association of social support with vitality and psychological distress. The associations between social support, walking, vitality and psychological distress were also investigated in order to provide additional information on this relationship among older adults.

Materials and Methods

This cross-sectional study used a data set from the Belgian Health Interview Survey (B-HIS), of 2008. The main purpose of the B-HIS is to describe the health status of the Belgian population (Charafeddine et al., 2012). This cross-sectional household survey is organized every 4 to 5 years since 1997 and the target population comprises all Belgian residents, without restrictions of age or nationality. The study protocol description was published elsewhere (Van Oyen et al., 1997) and it was approved by the Ethical Committee of the Belgian Scientific Institute of Public Health. Trained interviewers performed data collection between May 2008 and June 2009, applying 3 types of questionnaire at respondents' home. The B-HIS 2008 included 1) a household form which collects socio-demographic characteristics; 2) a form based on topics such as chronic illnesses, long-term limitations, medication use, etc. applied by an interviewer of B-HIS team and 3) a self-administered form which collects information from all respondents aged 15 or older about health-related topics. All instruments were officially translated in all three official Belgian languages (Dutch, French and German) and were double-checked by the researchers of the B-HIS team.

Procedure and participants

Normally, the target sample size per B-HIS is 10000 participants divided across 3 Belgian regions. However, in order to obtain a wide perception of the older adults' health status, in 2008 an additional sample of 1250 older adults (≥ 75 years old) was added to the sample. Therefore, the total sample size for the 2008 survey was 11250 individuals. The participation rate was 55%. Additional details about the sample are available in the B-HIS report of 2008 (Charafeddine et al., 2012). The present study targeted older adults (≥ 65 years old), resulting in a final sample of 2859 older adults (1057 men and 1802 women). Table 1 presents the socio-demographic characteristics of the sample.

Table 1 - Socio-demographic characteristics of the sample

Variable	Sample Size (n=2859)
Age (Mean±Standard Deviation)	79.85±8.50
Gender (%)	
Men	37.0
Women	63.0
Civil status (%)	
Married or legally cohabited	40.8
Single	8.4
Widow	45.3
Divorced	5.5
Socioeconomic status based on education (%)	
Low	65.8
High	34.2
Residential zone (%)	
Urban	54.8
Suburban	17.7
Rural	27.5
Functional limitations (%)	
Limitations	62.4
No limitations	37.6
Daily smoking (%)	
Smoker	7.5
Non-smoker	92.5
Body mass index (Mean±Standard Deviation)	25.58 ± 4.34

Measures

Outcome measures

Vitality. Vitality was assessed by the SF-36 vitality scale (Ware & Sherbourne, 1992). This 4-item scale is part of the overall 36-items questionnaire SF-36 which has an extensive evidence of internal consistency, test–retest reliability, construct validity, concurrent validity, and responsiveness (Haywood, Garratt, & Fitzpatrick, 2005). The vitality scale gives an overall idea of self-perceived energy/fatigue and is associated with both physical and mental aspects. The score of this scale ranges from 0 to 100, with higher scores indicating greater vitality. Scores ≤45 represent clinically significant fatigue

(Donovan, Jacobsen, Small, Munster, & Andrykowski, 2008). The average score for vitality in our sample was 58.14 ± 22.65.

Psychological distress. The General Health Questionnaire (GHQ) is one of the most common instrument to assess psychological distress by screening problems such as depression, anxiety and somatic symptoms (Jackson, 2007). The GHQ is considered reliable, with reliability coefficients ranging from 0.78 to 0.95 in previous studies (Jackson, 2007). We used the GHQ-12, including sum scores ranging from 0 to 12, with higher scores indicating higher psychological distress. The mean score for psychological distress in our sample was 1.43 ± 2.58.

Predictors

Social support. The selected questions of the B-HIS to evaluate social support (see table 2) were mainly based on validated instruments following the World Health Organization (WHO) recommendations (WHO, 1996). The questionnaire was also pretested and several procedures have been made in order to improve the reliability and comparability of findings (Charafeddine et al., 2012).

Table 2 - Social Support variables, questions, response options and the frequencies of responses in the present sample.

Variable	Question	Response Option	%
Appreciation of social contacts	How would you judge your social contacts?	(1) Really satisfying (2) Rather satisfying (3) Rather unsatisfying (4) Really unsatisfying	42.7 48.4 6.4 2.5
Frequency of social contacts	In general. how many times do you have contact with relatives. children. friends. …?	(1) At least once a week (2) At least once a month (3) At least 3 or 4 times a year (4) At least once a year (5) Never	85.3 9.6 3.1 0.7 1.3
Participation in group activities	How often did you take part in meetings or activities sponsored by organizations or associations such as a youth movement. sports club. recreational group (to play cards … parents' association. self-help group.…) in the past 12 months?	(1) At least once a week (2) At least once a month (3) At least 3 or 4 times a year (4) At least once a year (5) Never	22.7 13.1 9.8 4.4 50.1
Closeness from family and friends	How many people are so close to you that you can count on them if you have serious personal problems?	(1) None (2) 1 or 2 (3) 3 - 5 (4) 6 or more	3.6 40.8 34.5 21.1
Concern and interest from people around	How much concern and interest do person show in what you are doing?	(1) A lot of concern and interest (2) Some concern and interest (3) Uncertain (4) Little concern and interest (5) No concern and interest	33.1 36.8 16.9 8.2 4.9
Practical help from neighbors	How easy is it to get practical help from neighbors if you should need it?	(1) Very easy (2) Easy (3) Possible (4) Difficult (5) Very difficult	28.5 28.5 28.0 8.3 6.6

Potential mediator

Walking. In the present study walking was measured by the International Physical Activity Questionnaire (IPAQ). This questionnaire was part of the self-administered form. The IPAQ-Short Form questionnaire records the days, hours and minutes of PA at four intensity levels: (1) vigorous, (2) moderate and (3) walking, and has demonstrated validity and reliability in 12 countries, including Belgium (Craig et al., 2003). Reliability and validity of the IPAQ Questionnaire for assessing walking was tested by van der Ploeg et al. (2010), demonstrating IPAQ-Short Form as a reliable and valid instrument to estimate time spent in walking. The total time of walking per day was reported on the following questions of IPAQ-short form: "During the last 7 days, on how many days did you walk for at least 10 minutes at a time?" and "How much time did you usually spend walking on one of those days. The minutes of walking per day were reported in minutes in the second answer. The mean walking activity per day in our sample was 28.75 ± 46.59 minutes

Covariates

Several individual variables were considered as potential covariates in the current study based on evidence from previous literature, showing a significant association between vitality, depression, anxiety and psychological distress with: age, gender, socioeconomic status (SES) (Byles, Gallienne, Blyth, & Banks, 2012), marital status (Garcia et al., 2005), level of urbanization (Li, Liu, Xu, & Zhang, 2015), functional limitations (Atkins et al., 2013), body mass index (BMI) (Wiltink et al., 2013) and daily smoking (Almeida & Pfaff, 2005). Civil status was coded into "married or legally cohabited", "single", "widowed" or "divorced". SES was calculated based on education level (low: <12 Years; high: ≥ 12 Years). The level of urbanization was based on the criteria used in “België, territoriale verscheidenheid’ (Mérenne, Van Der Haegen & Van Hecke, 1997) updated with information from the 2001 census. As suggested by Van Dyck et al. (2015), physical functioning should be taken into account when studying PA in older adults. As a result, the following questions were used to detect functional limitations: "Do you usually have difficulty doing any of these activities

by yourself? (1) Getting in and out of a bed; (2) Getting in and out of a chair; (3) Dressing and undressing; (4) Bathing or showering; (5) Washing your hands and face; (6) Feeding yourself; (7) Using toilets". A 4-item response scale (1."No difficulty", 2."Yes, some difficulty", 3."Yes, a lot of difficulty", 4."I cannot achieve it by myself") was provided to report the answer. A binary variable was computed based on these questions (1 = No limitations; 2, 3, 4 = Limitations). BMI was calculated based on self-reported weight and height by the standardized formula (weight (kg)/ height (m)2). Daily smoking status was also asked by the question "Are you a current smoker?" (answer yes=1; no= 2). As in the present sample vitality and psychological distress were correlated to age, gender, marital status, SES, level of urbanization and functional limitations, all analyses were adjusted for these variables.

Statistical analyses

The data were analyzed using SPSS 22. Histogram graphs and skewness values were used to detect whether scores on all outcome variables were reasonably normally distributed (skewness values range between -1 and 1). A logarithmically transformed variable [LG10 (variable + 0.01)] was computed to the positively skewed variables (walking and psychological distress) in order to improve normality. Before conducting the mediation analysis, the social support-related variables (appreciation of social contacts, frequency of social contacts, participation in group activities, concern and interest from people around and practical help from neighbors) were positively rescored.

The first step of the mediation analysis was to measure the association of appreciation social contacts, frequency social contacts, participation in group activities, closeness from family and friends, concern and interest from people around and practical help from neighbors with vitality and psychological distress, using a single linear regression analysis from each explanatory variable to each outcome. The un-standardized regression coefficients from this regression corresponds to path C (see Fig. 1 and Table 3). Second, in case of a significant association between one of the predictors and an outcome variable,

regressions were performed to predict the association between the explanatory variables (appreciation social contacts, frequency social contacts, participation in group activities, closeness from family and friends, concern and interest from people around and practical help from neighbors) and the mediator (walking). The results of these regressions provide the path A. Third, when path A was significant, regressions were performed to predict the outcome variables (vitality and psychological distress) from the mediator and explanatory variables, which respectively corresponds to the paths B and C.

After the estimation of coefficients of paths A, B, C and C', the mediating effect of the walking on the association between social support, vitality and psychological distress was tested using the product of the coefficients test (MacKinnon, Fairchild, & Fritz, 2007). The product of coefficients method, involves computing the product of AB, to calculate the mediated or indirect effect. This mediating effect (AB) was only reported if the A and B paths were significant. As reported by MacKinnon et al. (2007), if A and B paths are statistically significant, there is evidence of mediation.

The statistical significance of this effect was determined by dividing the product-of-coefficient by its standard error, which was calculated using the Sobel equation [SEab = √(a2 SEb2 + b2 SEa2)] (Sobel, 1986). This formula has been extensively used for the calculation of the standard error of mediated effect and is suitable to use in this study due to the large sample size (MacKinnon et al., 2007). Moreover, the proportion of mediation of walking on the association of social support attributes with vitality and psychological distress was estimated by the following equation: [ab/(ab+c)]. 95% confidence intervals (CI) were reported in all analyses.

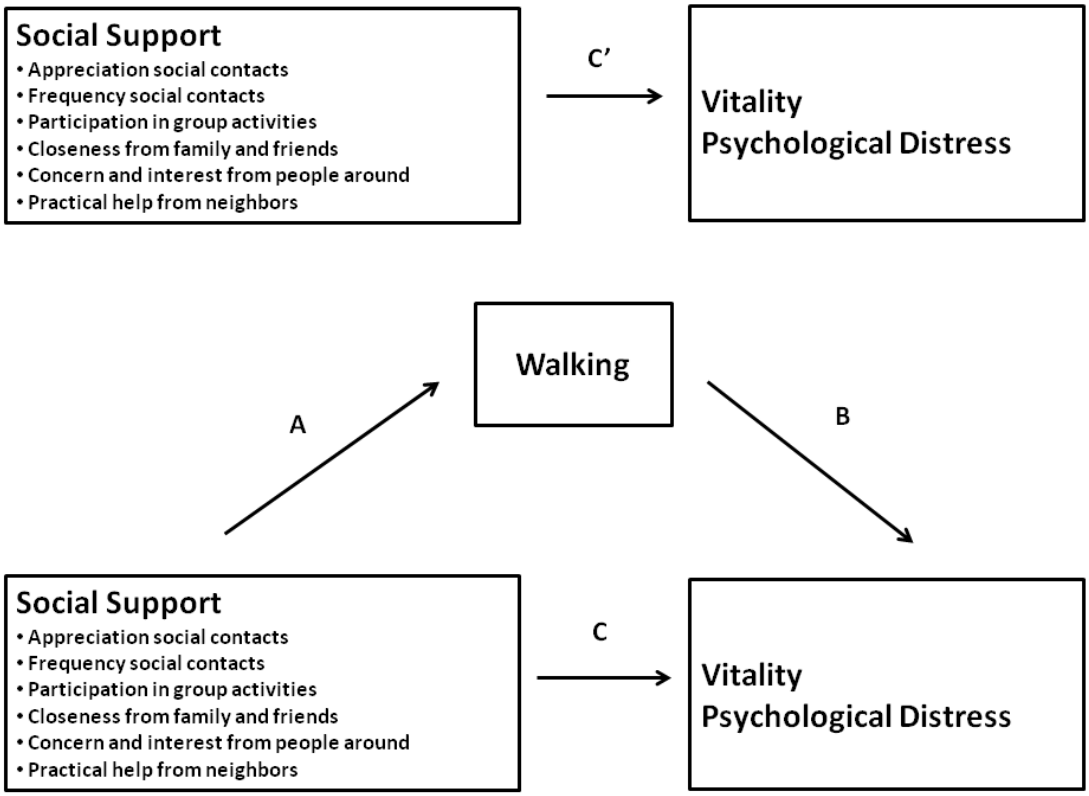

Figure 1 - Statistical mediation model.

Results

Effect of social support on vitality and psychological distress (path C')

The results of the single linear regression models revealed significant associations between all the explanatory variables and both outcomes (see table 3). Social support was positively associated with vitality and negatively associated with psychological distress. Greater scores of appreciation of social contacts (CI = 8.938; 11.702), frequency of social contacts (CI = 2.553; 5.630), participation in group activities (CI = 1.411; 2.601), closeness from family and friends (CI = 2.112; 4.515), concern and interest from people around (CI = 3.004; 4.783), practical help from neighbors (CI = 2.112; 3.854) were associated with better mental health-related vitality. On the other hand, greater appreciation of social contacts (CI = -0.504; -0.356), higher frequency of social contacts (CI = -0.281; -0.120), higher participation in group activities (CI = -0.068; -0.003), more closeness from family and friends (CI = -0.193; -0.065),

further concern and interest from people around (CI = -0.191; -0.097) and easiness on getting practical help from neighbors (CI = -0.183; -0.091) were associated with lower levels of psychological distress.

Table 3 - Associations of social support variables with vitality and psychological distress.

SF36 - Vitality Scale	**C' (SE)**	**95% CI**
Appreciation Social Contacts	10.320 (0.705)	8.938; 11.702
Frequency Social Contacts	4.092 (0.784)	2.553; 5.630
Participation in Group Activities	2.006 (0.303)	1.411; 2.601
Closeness from family and friends	3.314 (0.612)	2.112; 4.515
Concern and interest from people around	3.893 (0.454)	3.004; 4.783
Practical help from neighbors	2.983 (0.444)	2.112; 3.854
GHQ-12 - Psychological Distress	**C' (SE)**	**CI**
Appreciation Social Contacts	-0.430 (0.038)	-0.504; -0.356
Frequency Social Contacts	-0.200 (0.041)	-0.281; -0.120
Participation in Group Activities	-0.036 (0.016)	-0.068; -0.003
Closeness from family and friends	-0.129 (0.033)	-0.193; -0.065
Concern and interest from people around	-0.144 (0.024)	-0.191; -0.097
Practical help from neighbors	-0.137 (0.023)	-0.183; -0.091

SE = standard error; CI = confidence interval.
C' - coefficients were estimated by regressing the outcomes onto the social support variables.
The analysis was adjusted for age. gender. civil status. socioeconomic status. level of urbanization and functional limitations.
All outcomes were positively scored (higher score = higher vitality; higher psychological distress

Associations between social support and walking (path A)

The associations between social support variables and walking are presented in table 4. All explanatory variables except one (practical help from neighbors) were positively associated with the potential mediator (walking). Significant positive associations were found on the effect of appreciation social contacts (CI = 0.032; 0.256), frequency social contacts (CI = 0.015; 0.247), participation in group activities (CI = 0.097; 0.190), closeness from family and friends (CI =0.014; 0.202) and concern and interest from people around (CI = 0.018; 0.159) on walking. As a mediated model includes the hypothesis that the explanatory variable is associated with the mediator (Warner, 2012), we only considered the significant associations for the following path calculations.

Associations of walking with vitality and psychological distress, adjusted for social support variables (path B)

The results of the calculations for the path B, demonstrated a positive significant association of walking with vitality after controlling for appreciation of social contacts (CI= 1.780; 3.075), frequency of social contacts (CI= 1.905;

3.278), participation in group activities (CI= 1.752; 3.141), closeness from family and friends (CI =1.978; 3.349) and concern and interest from people around (CI = 1.869; 3.225). The results also demonstrated that greater walking activity per day is associated with less psychological distress when controlled for all social support variables eligible for this step of mediation analysis: appreciation of social contacts (CI= -0.075; -0.003), frequency of social contacts (CI= -0.085; -0.011), participation in group activities (CI= -0.087;- 0.012), closeness from family and friends (CI =-0.085; -0.011) and concern and interest from people around (CI = -0.085; -0.011).

Mediation effect of walking on the relationship of social support with vitality and psychological distress (path C)

Results of the mediator models are presented in table 4. Walking significantly mediated the relationship of appreciation of social contacts (3.3%, CI= 0.065; 0.634), frequency of social contacts (8.1%, CI= 0,029; 0.649), participation in group activities (19.9%, CI= 0.201; 0.504), closeness from family and friends (7,7%, CI= 0.028; 0.547) and concern and interest from people around (5,6%, CI= 0.039; 0.415) with vitality. Moreover, walking mediated 33,8% of the association between participation in group activities and psychological distress (CI= -0.012; -0.001), while the other models were not significant in this or previous steps of the mediation analysis.

Table 4 - Mediating effect of walking on the associations of social support with vitality and psychological distress.

Mediator	A (SE)	95% CI for A	B (SE)	95% CI for B	AB (SE)	95% CI for AB	Mediated %
			SF-36 - Vitality scale				
			Appreciation of social contacts				
	0.144 (0.057)	0.032; 0.256	2.428 (0.330)	1.780; 3.075	0.350 (0.145)	0.065; 0.634	3.3 %
			Frequency of social contacts				
	0.131 (0.059)	0.015; 0.247	2.592 (0.350)	1.905; 3.278	0.340 (0.158)	0.029; 0.649	8.1%
			Participation in group activities				
	0.144 (0.024)	0.097; 0.190	2.446 (0.354)	1.752; 3.141	0.352 (0.077)	0.201; 0.504	19.9%
			Closeness from family and friends				
	0.108 (0.048)	0.014; 0.202	2.663 (0.350)	1.978; 3.349	0.288 (0.132)	0.028; 0.547	7.7%
			Concern and interest from people around				
	0.089 (0.036)	0.018; 0.159	2.547 (0.346)	1.869; 3.225	0.227 (0.096)	0.039; 0.415	5.6%
			Practical help from neighbors				
Walking	-0.001 (0.035)	-0.070; 0.068					
			GHQ-12				
			Appreciation of social contacts				
	0.144 (0.057)	0.032; 0.256	-0.039 (0.018)	-0.075; -0.003	-0.006 (0.003)	-0.012; 0.001	
			Frequency of social contacts				
	0.131 (0.059)	0.015; 0.247	-0.048 (0.019)	-0.085; -0.011	-0.006 (0.004)	-0.013; 0.001	
			Participation in group activities				
	0.144 (0.024)	0.097; 0.190	-0.049 (0.019)	-0.087;- 0.012	-0.007 (0.003)	-0.012; -0.001	33.5%
			Closeness from family and friends				
	0.108 (0.048)	0.014; 0.202	-0.048 (0.019)	-0.085; -0.011	-0.005 (0.003)	-0.011; 0.001	
			Concern and interest from people around				
	0.089 (0.036)	0.018; 0.159	-0.048 (0.019)	-0.085; -0.011	-0.004 (0.002)	-0.008; 0.000	
			Practical help from neighbors				
	-0.001 (0.035)	-0.070; 0.068					

SE = standard error; CI = confidence interval.
A coefficients were estimated by regressing the potential mediator onto the social support variables.
B coefficients were estimated by regressing the outcomes onto the potential mediator.
AB coefficients represent the mediated effect.
The analysis was adjusted for age. gender. civil status. socioeconomic status. level of urbanization and functional limitations.

Discussion

The current study examined the associations between social support and walking, vitality and psychological distress and the mediating effects of walking on the association of social support with vitality and psychological distress. According to our knowledge, the present study was the first to explore this mediation model in older adults (+65 years old). In line with previous research, we found that older adults with more and better social support are likely to be more vital (CDC, 2005; Garcia et al., 2005; Newsom & Schulz, 1996). Similarly, the results of the present study documented that older adults with better scores on social support variables show lower levels of psychological distress. Social support has previously been associated with lower risk for severe depressive symptoms in older adults (Atkins et al., 2013; Perrino et al., 2011) and with less psychological distress in older adults (Phongsavan et al., 2013). These results

emphasize that social support attributes (appreciation social contacts, frequency social contacts, participation in group activities, closeness from family and friends, concern and interest from people around and practical help from neighbors) work as a buffer for stress and as a safeguard for vitality in older adults.

Moreover, all studied social support variables were positively associated with walking activity except one (practical help from neighbors). This is in line with previous research, indicating positive relationships of social support with walking for transportation (Van Cauwenberg et al., 2014), recreational walking (Kamphuis et al., 2009) and total walking (Mendes de Leon et al., 2009). Practical help from neighbors is related with instrumental support (e.g., receiving help with household tasks and shopping), which was previously associated with lack of opportunities for walking (Perrino et al., 2011), being a possible explanation for the non significant relationships between practical help from neighbors and walking activity per day.

Moreover, the present study showed that walking partly mediated the relationship of almost all of the studied attributes of social support with vitality. The strongest mediation effect was found for the relationship between participation in group activities and vitality (20%). These results suggest that older adults who participate in group activities are likely to walk more, which may result in better health-related vitality. A possible explanation for this finding is that participating in group activities and walking may share inextricable variance (Julien et al., 2013). In other words, all items included in the questionnaire for participation in group activities (sports club, recreational group, self-help group) involved some amount of walking, in some cases for transportation and in others for recreation. As reported by Garcia et al. (2005), social network is associated with vitality in older adults, and our results revealed that walking partly mediates this relationship.

The associations of appreciation of social contacts, frequency of social contacts, closeness from family and friends, concern and interest from people around with vitality were also mediated by walking, although these mediating effects were weaker (3%, 8%, 8% and 6%, respectively). A possible explanation

for these lower (yet significant) levels of mediation is that walking for recreation, which is probably more part of the item ‘participation in group activities’, is more strongly associated with less depressive symptoms than walking for transportation, which is probably more related to the items ‘social contacts, closeness from family and friends, concern and interest from people around’ (Julien et al., 2013). This could be explained by the intensity of walking. In fact, walking for recreation includes a wide variety of ambulatory intensity (eg, brisk walking, jogging, running, hiking, etc.), which could lead to greater intensities than walking for transportation (Spinney, Millward, & Scott, 2012). A previous longitudinal study reported that older adults who walked at lower intensities had a higher average number of depressive symptoms than the ones who walked at higher intensities (Lampinen, Heikkinen, & Ruoppila, 2000). Endurance training at moderate to vigorous intensity is also recommended for increasing vitality (Solberg et al., 2012).

The results of the mediation model with psychological distress as the outcome, demonstrated a significant mediation effect of walking only when participation in group activities was the explanatory variable. Walking mediated 34% of the relationship of the participation in group activities with psychological distress in older adults. Our current data are concordant with previous studies pointing out that older adults who do not walk have more depressive symptoms and that participating in group activities in the old age may be associated with less distress (Julien et al., 2013). Participation in social activities in later life has been associated with fewer depressive symptoms among older adults (Chiao, Weng, & Botticello, 2011) and our study showed that walking might enhance the positive association of the participation in group activities with psychological distress in older adults. There is also good evidence that aerobic PA enhances mood states (Fox, 1999), which could be related with the mediation effect of walking on this relationship.

The results from the other social support variables showed however that the mediation effect of walking on the associations of appreciation social contacts, frequency social contacts, closeness from family and friends and concern and interest from people around with psychological distress are weak

or do not exist. These associations should be explored through pathways other than walking in future studies. Links between PA and decreased distress should also be further explored, since they are affected by multidimensional factors that influence the significance of these pathways (Cairney et al., 2005).

Strengths and Limitations

There are some limitations of the current study. The cross-sectional design does not permit causality conclusions; secondly the use of self-report measures to assess walking is less accurate than measuring walking objectively. Future prospective studies, using objective instruments (such as accelerometers) to measure walking and making a distinction between recreational and transport-related walking are advised to improve clarity of the results. In spite of these limitations, a key strength is that to our knowledge this was the first study to explore the mediating effects of walking on the relationship of social support with vitality and psychological distress in older adults (+65). Strengths of this study also include the large sample size and the investigation of factors willing to change through interventions (social support, walking, vitality and psychological distress).

Conclusions

The main findings of the current study suggest that participation in group activities in later life is beneficial to improve vitality and reduce psychological distress of the older adults, with walking being a strong mediator of this relationship. To that extent, facilitating group activities and walking could be a promising direction for policies intended to promote mental health among older adults (a growing population with high prevalence of depressive symptoms). Older adults, caregivers, nursing homes managers, and society in general should be aware of the benefits of walking and participation in group activities on vitality and psychological distress and integrate them on older adults' daily life.

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Paper IV: Perceptions of the neighborhood environment associated with walking at recommend intensity and volume levels in recreational senior walkers.

Perceptions of the Neighborhood Environment Associated with Walking at Recommend Intensity and Volume Levels in Recreational Senior Walkers

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Abstract

Objectives: This study examined the relationship of perceived neighborhood environment factors with objectively measured recommended volume and intensity of walking in recreational senior walkers.

Methods: Data from a recreational seniors walkers-based sample from the Portuguese national walking and running program (n=85, age range between 65 and 80) were used. The older adults used an accelerometer during 7 days, completed the ALPHA questionnaire and filled a questionnaire on socio-demographic characteristics. Binomial logistic regressions were conducted to detect associations.

Results: Findings showed a positive relationship between perceptions about traffic safety (OR = 4.395; 95% CI = 1.024; 18.866) and pleasant environment (OR= 8.718; 95% CI = 1.803; 42.149) with the achievement of 10.000 steps per day, in seniors women. On the other hand, the positive perception of nearby parks was positively related with the compliance with peak 30-minutes cadence above 100, in seniors men (OR = 14.353; CI 95% = 1.321; 15.591). No more significant associations were found between perceptions of the neighborhood environment and walking at recommended intensity and volume levels.

Conclusions: These results indicate that community initiatives that encourage traffic safety and pleasant environment may help seniors women to walk at recommend volume levels. On the other hand, developing parks seems to be a promising direction to promote walking at recommended intensity, in seniors men.

Introduction

The world population is aging and the proportion of people over 65 is currently growing every year (United Nations, 2013). Along with this fact, older adults are the least physically active age group, which would lead to dependency, chronic illness and disease-related disability of a large age group (Nelson et al., 2007). To that extent, special attention should be given to the barriers and facilitators of physical activity (PA) and exercise, specifically in older adults (McDermott & Mernitz, 2006).

PA, especially walking, has a set of health benefits for the older adults (Kerr, Rosenberg, & Frank, 2012). Regular PA is important for maintaining long-term physical, cognitive, and emotional health and limiting the development and progression of chronic disease and disabling conditions (Chodzko-Zajko et al., 2009). Walking is an excellent form of physical activity for older adults because it is familiar, cheap, safe, easy, convenient and can be performed in social settings (i.e., group walks) (Rowe et al., 2011).

Prior research has shown that walking has cardio respiratory health benefits (Park et al., 2014), improve strength, endurance, agility and lower limb flexibility (Parkatti, Perttunen, & Wacker, 2012), prevent falls (Okubo et al., 2015) and there is also emerging evidence for psychological benefits accruing from walking by older adults (Julien, Gauvin, Richard, Kestens, & Payette, 2013). Considering, promoting higher levels of participation by older adults in regular walking at moderate-intensity could be a promising solution to the high priorities for this growing population: maintaining physical and mental health.

Current PA recommendations for older adults to promote and maintain health (Chodzko-Zajko et al., 2009), advice to achieve a minimum of 30 minutes of moderate-to-vigorous aerobic PA on most days of the week, emphasizing walking as the most common type of activity used for endurance exercise, in older adults. Moderate-intensity walking appears approximately equal to at least 100 steps/minute and to meet current guidelines, individuals are encouraged to walk a minimum of 3000 steps in 30 minutes on 5 days each week (Marshall et al., 2009). Peak 30-minutes cadence emerged as an indicator of the intensity of

walking activity, representing the average of the higher cadence accomplished during 30 minutes in a day (Tudor-Locke & Rowe, 2012). A peak 30-minutes cadence above 100 would suggest that an individual walked over a 30 minutes period, at moderate-to-vigorous intensity. 10.000 steps/day is the walking volume recommendation to consider an individual active (Tudor-Locke & Bassett, 2004). Both measures have being used to measure walking activity in older adults (Tudor-Locke, Barreira, Brouillette, Foil, & Keller, 2013; Tudor-Locke et al., 2011)

Ecological models have been adopted by researchers to explore PA behaviors with growing attention to physical environment (Sallis, Owen, & Fisher, 2008). These models seem to have the potential to change the behaviors of the older adults, since the promotion of PA at the individual level depends on interpersonal and environmental factors (Satariano & McAuley, 2003). Studies that apply a social-ecological framework could help to explain the independent associations between objective and perceived characteristics of the physical environment (i.e. neighborhood), including types of residences, safety, traffic, walking network, etc. and PA (Sallis et al., 2008). Neighborhoods are particularly important to study the effect of the environment on PA in seniors. Given their reduced mobility and limited income, they spend more time in neighborhoods and characteristics of the neighborhood environment may actually determine an active or inactive aging (Yen, Michael, & Perdue, 2009).

Studies investigating relationships between neighborhood environment and walking in seniors have been increasing in the last decade, however relationships are less frequently studied in older adults than in younger age groups (Rhodes & Nasuti, 2011). The research on neighborhood characteristics is particularly important in seniors (Cunningham & Michael, 2004) and has been revealing some relevant features of the environment associated with the walking behavior in this population.

Greater overall levels of walking were reported for older adults living in neighborhoods that were perceived or characterized as more walkable (Carlson et al., 2012; Frank, Kerr, Rosenberg, & King, 2010; King et al., 2011; Van Holle et al., 2014). However, two studies also found that walkability was not related to

recreational walking (King et al., 2011; Nagel, Carlson, Bosworth, & Michael, 2008). Walking have been also positively associated with objectively measured and perceived access to services and shops (Michael, Green, & Farquhar, 2006; Nagel, Carlson, Bosworth, & Michael, 2008; Shigematsu et al., 2009) and with presence of walking facilities (Hall & McAuley, 2010; Nagel et al., 2008; Shigematsu et al., 2009) and parks (Wen, Kandula, & Lauderdale, 2007). Safety and esthetics have been found to be consistently important to older adults' total walking activity (Cunningham & Michael, 2004). However, one study reported that perceived crime-related safety and neighborhood esthetics was not related to recreational walking (Shigematsu et al., 2009).

These results suggest the need for additional research on this topic, because fewer such studies exist among older adults (Rhodes & Nasuti, 2011), some inconsistent results were verified on the literature, and to our knowledge only three studies included objective measures of physical activity assessed by pedometers or accelerometers (Hall & McAuley, 2010; King et al., 2011; Van Holle et al., 2014). Within these studies, only one (Hall & McAuley, 2010) reported the relationship of environmental characteristics with objectively assessed recommended walking volume (10.000 steps), however no study was conducted to explore the relationships between the neighborhood environment and recommended walking intensity in older adults. Moreover, there is a need for a deeper understanding of older adults' perceptions of the neighborhood environment (Haselwandter et al., 2015).

Concerning, this paper aims to address some of the above described shortcomings of the literature. The purpose of the present study is to investigate the relationship between perceptions of the neighborhood environment with the objectively measured recommended volume and intensity of walking in recreational senior walkers.

Methods

Procedure and participants

Older adults participants in the Portuguese national walking and running program were recruited for this study. This program aims to mobilize the

Portuguese population for the walking and running regular practice and intends to develop synergies with municipalities in order to offer regular walking and running training sessions monitored by certified sport technicians in municipal centers. The invitations for participation in the study were sent electronically to the sports technicians of the walking & running municipal centers where older adults' participants exist. After expressing interest in participating, phone contacts were done between the sports technicians and research team to plan the evaluations in the walking & running municipal center. After that, a meeting with the elders' participants was realized and they received a complete explanation of the purpose, risks and procedures of the investigation, and a written informed consent was signed by the interested participants. After expressing interest in participating, older adults used an accelerometer during 7 days and completed the ALPHA questionnaire.

The eligible participants were restricted to older adults with the following characteristics: (1) age ≥ 65 years old; (2) participants on the national walking and running program; (3) ability to independently exercise at moderate intensity and (4) medical authorization for the exercise. Ninety-four older adults were evaluated from May to July of 2014 but 9 participants were excluded from the study because of the non compliance with at least 5 valid days. Ethics approval was granted by the Ethics Committee of the Faculty of Sport from the University of Porto (CEFADE 27.2013).

Measurements

Demographic variables

Demographic variables included age, gender and SES based on education. Educational level was assessed by asking participants to report their highest educational degree. Responses were categorized into "low SES" (from 0 to 4th grade), "medium SES" (from 5th grade to 12th) and " "high SES" (above 12 years of education). Because the walking behavior may be affected by the body mass index (BMI), we also adjusted all the analysis for BMI (weight[kg]/height [m2]). BMI was categorized as healthy weight (BMI=18.5–24.99), overweight (BMI=25–24.99), and obese (BMI≥30).

Walking

Walking was objectively assessed by the Actigraph GT3X (ActiGraphTM, LLC, Fort Walton Beach, FL, US) accelerometers, which is a valid and reliable instrument able to provide important measures about older adult physical activity patterns (Copeland & Esliger, 2009). Participants were asked to wear the instrument over the right hip with an elastic belt for 7 consecutive days and were instructed to remove it during water-based activities (bathing and swimming) and sleeping. Accelerometers were initialized to collect count activity and step data at 10 seconds epoch. Data were therefore integrated into 60 seconds epoch. Non-wear time was defined as 60 minutes of consecutive zero counts and 2 minutes of spike tolerance (Troiano et al., 2008). A valid day was defined as at least 10 hours of wear time per day. All non-wear time was excluded from further analysis. Actigraph data were downloaded using Actilife Monitoring System v. 6.11.3 software.

The final variables included in the analysis were the daily average of steps per day and the daily average of peak 30-minutes cadence. We used the raw data of steps per minute to determine the sum of the steps per day of each valid day. A mean of daily steps per day was obtained dividing the sum of the steps per day of each valid day by the number of valid days. The peak 30-minutes cadence was calculated with an average of the number of steps per minute of the highest 30 minutes in each day. The peak 30-minutes cadence was therefore averaged over all valid days. The daily average of steps per day was dichotomized into "achieve recommendation of 10.000 steps per day" and "did not achieve recommendation of 10.000 steps per day". The daily average of peak 30-minutes cadence was dichotomized into "peak 30-minutes cadence ≥ 100" and "peak 30-minutes cadence < 100".

Perceptions of the neighborhood environment

The perceived neighborhood environment was assessed by the short version of the European Environmental Questionnaire ALPHA (Spittaels et al., 2009). This questionnaire consisted of eight themes of the neighborhood environment: (1) types of residences; (2) distances to local facilities; (3) walking

or cycle infrastructure; (4) traffic safety; (5) neighborhood safety; (6) pleasantness; (7) home environment; (8) workplace or study environment. We used 6 of these 8 themes, excluding the 7th and 8th themes, as these are less relevant regarding the relationships with walking in retired older adults. The neighborhood was defined as "the area around your home that you could walk in 10-15 minutes, approximately 1,5 km". Participants were asked to answer each question with the option that best applies to their view of the neighborhood environment (yes or no). The data was collected and was filled in by a researcher and according to the recommendations of the ALPHA Manual (www.thealphaproject.net/). The reliability of the instrument has been shown (Spittaels et al., 2010) and it was translated from English to Portuguese by an experienced translator using validation / retroversion methodology.

Statistical Analysis

Data were analyzed using SPSS 22 (IBM Corp.). The binary logistic regression analyses were used to investigate the associations of perceptions of the neighborhood environment with walking at recommended intensity and volume. All logistic regression analyses were separated by gender and controlled for age, SES based on education and BMI. Multicollinearity among independent variables was tested by Spearman correlations. None of the variables was excluded as there were no correlations between independent variables with $r > 0.7$ (Yoo et al., 2014). Odds ratios (=OR) and 95 % confidence intervals (=95 % CI) were reported for all analysis.

Results

The characteristics of the participants and descriptive statistics from the variables of study are presented in table 1. A total of 85 participants, 59 women and 26 men, were included in the analysis. Mean age was 68 years, and participants were primarily lower to medium educated. Only 13% of women and 27% of men were highly educated. The prevalence of overweight and obesity was 52,5% and 28,8% in women, and 69,2% and 26,9% in men, respectively. No significant differences were observed in measures of walking activity between men and women. However, men showed a slightly higher peak 30-

minutes cadence (96,42±16,10 compared with 95,35±17,48, in women, p>0,05) and women presented a slightly higher mean for steps per day (13279,32±5782,58 compared with 11775,46±4958,54, in men, p>0,05). About 67,2% of women and 57,7% of men achieved the recommendation of 10.000 steps per day. While 42,9% of women and 50% of men showed to have a peak 30-minutes cadence above 100 (moderate intensity). No sex differences were observed on the scores of the perceptions of the neighborhood environment questionnaire.

Table 1 - Socio-demographic characteristics of participants and descriptive statistics of variables of study.

Variable	Men (n=26)	Women (n=59)	p
Age (mean±SD)	68, 62±5,04	68,42±4,83	0,868
SES based on education (%)			
Low	42,3	62,7	
Medium	30,8	23,7	
High	26,9	13,6	
Body Mass Index (%)			
Healthy weight	3,8	18,6	
Overweight	69,2	52,5	
Obese	26,9	28,8	
Ambulatory Activity (mean±SD)			
Peak 30-minutes cadence	96,42±16,10	95,35±17,48	0,792
Steps per day	11775,46±4958,54	13279,32±5782,58	0,254
10.000 steps (% of achievement)	57,7	67,2	
Peak 30-minutes cadence (%above 100)	50	42,9	
Perceptions of the neighborhood environment (mean±SD)[a]			
Types of residences	0.58±0.50	0.63±0.49	0.666
Nearby shops	0.62±0.50	0.53±0.50	0.448
Nearby public transportation	0.81±0.40	0.76±0.43	0.624
Nearby parks	0.42±0.50	0.37±0.49	0.688
Traffic security	0.85±0.37	0.71±0.46	0.190
Neighborhood security	0.92±0.27	0.90±0.30	0.722
Pleasant environment	0.42±0.50	0.47±0.50	0.665

SD = Standard Deviation
a - positively scored, ranging from 'no'= 0 to 'yes' = 1

The perceptions of the neighborhood environment identified as being most significantly associated with the compliance with 10.000 per day and peak 30-minutes cadence above 100 are shown in table 2. Seniors women who presented positive perceptions about traffic security (OR = 4.395; 95% CI = 1.024; 18.866) and pleasant environment (OR= 8.718; 95% CI = 1.803; 42.149) were more likely to achieve the 10.000 steps per day. No significant associations were found between perceptions of the neighborhood environment and the compliance with 10.000 steps recommendations, in men. The positive

perception of nearby parks appeared to be a statistically significant predictor of the compliance with peak 30-minutes cadence above 100, but only in men (OR = 14.353; CI 95% = 1.321; 15.591). No significant associations were found between perceptions of the neighborhood environment and the compliance with peak 30-minutes cadence above 100, in seniors women.

Table 2 - Associations between older adults' perceptions of the neighborhood environment and the compliance with 10.000 steps and peak 30-minutes cadence above 100.

	Men				Women			
	10.000 steps per day		Peak 30-m cadence above 100		10.000 steps per day		Peak 30-m cadence above 100	
Perceptions of the neighborhood environment	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Types of residences	4.039 (0.211; 77.443)	0.354	5.162 (0.594; 44.886)	0.137	0.643 (0.179; 2.308)	0.499	1.144 (0.358; 3.661)	0.820
Nearby shops	0.147 (0.006; 3.434)	0.233	0.426 (0.067; 2.695)	0.364	1.154 (0.346; 3.846)	0.815	1.303 (0.420; 4.045)	0.647
Nearby public transportation stops	8.959 (0.118; 682.43)	0.321	0.381 (0.021; 6.766)	0.511	0.280 (0.052; 1.150)	0.139	0.454 (0.122; 1.695)	0.240
Nearby parks	0.496 (0.037; 6.685)	0.597	14.353 (1.321; 15.591)	0.029*	2.392 (0.600; 9.537)	0.216	0.504 (0.146; 1.739)	0.278
Traffic safety	5.509 (0.251; 120.83)	0.279	0.391 (0.025; 6.220)	0.506	4.395 (1.024; 18.866)	0.046*	0.626 (0.181; 2.166)	0.460
Neighborhood safety	1.268 (0.034; 47.387)	0.898	0.690 (0.024; 19.787)	0.829	0.271 (0.025; 2.952)	0.284	0.392 (0.056; 2.754)	0.347
Pleasant environment	1.549 (0.113; 21.247)	0.743	3.103 (0.371; 25.948)	0.296	8.718 (1.803; 42.149)	0.007*	1.156 (0.376; 3.549)	0.800

OR - Odds Ratio
CI - confidence intervals
*p<0,05

Discussion

The current study employs a social ecological approach in order to understand the perceived neighborhood environment factors associated with objectively measured recommended volume and intensity of walking in recreational senior walkers. The study of this relationship may help to understand facilitators of engaging in walking at recommended intensity and volume. According to our knowledge, the present study is the first to use walking cadence to explore this relationship in older adults of both sex. Using a

recreational walkers-based sample from the Portuguese national walking and running program, we found the perceptions of the neighborhood environment associated with the achievement of 10.000 steps and peak 30-minutes cadence above 100.

The perceptions of the neighborhood environment identified as being most significantly associated with the compliance with 10.000 per day in older women were traffic safety and pleasant environment. Traffic safety has been previously associated with the achievement of 10.000 steps in older women (Hall & McAuley, 2010), however other studies reported that perceived traffic-related safety was not related with objectively measured total PA in US females (Morris, McAuley, & Motl, 2008) and with self-reported recreational walking in older adults (Shigematsu et al., 2009). Nevertheless, perceived traffic-related safety seems to be especially relevant for older adults' PA behavior (Van Cauwenberg et al., 2011) and our study showed that it is also prime mover for the achievement of 10.000 steps per day, in seniors women.

Prior research has shown that perceived pleasant scenery was positively associated with total PA in older adults (Chad et al., 2005; Sallis, King, Sirard, & Albright, 2007) and walking behavior (Stathi et al., 2012; Sugiyama, Thompson, & Alves, 2009) and absence of enjoyable scenery was associated with being sedentary in the rural old women (Wilcox, Bopp, Oberrecht, Kammermann, & McElmurray, 2003). In line with this evidence, our study found that perceived pleasantness (e.g. presence of trees and plants, etc.) was related with the compliance with 10.000 steps per day, in female older adults. Our findings suggest that, perceived pleasant environment facilitate women senior walkers's walking volume. Current findings support research reported elsewhere (Mendes de Leon et al., 2009), stating that promotion of walking behavior in seniors women may require the improvement of the safety and the pleasantness of the neighborhood environment.

Surprisingly, contrary to previous studies reporting positive associations of perceptions of the neighborhood environment with physical activity/walking behavior in senior men (Li, Fisher, & Brownson, 2005; Michael et al., 2006; Shigematsu et al., 2009; Sugiyama et al., 2009), no significant associations

were found between perceptions of residential density, land use mix-access, public transportation access, walking/cycling facilities, traffic-related and crime-related safety and pleasantness of the neighborhood environment and the compliance with 10.000 steps recommendations, in seniors men. An explanation for this finding is difficult to formulate, as no other studies have investigated relationships between perceptions of the neighborhood environment and the achievement of 10.000 steps per day in male older adults. Nevertheless, this could be explained by other social ecological factors other than physical environment, like individual, interpersonal and policy factors. For example, Van Holle et al. (2015) suggests that recreational walking might be enhanced by targeting not only neighborhood environmental factors but also self-efficacy, in older adults. Empirical evidence also shows that interpersonal factors (e.g. social support from family, neighbors and friends, walking groups, partners for physical activity, frequency of social contacts, neighborhood involvement, participation and volunteering, social network size, social cohesion, etc.) are related to walking (Kahn et al., 2002; Mendes de Leon et al., 2009; Van Cauwenberg et al., 2014). Moreover, policy can influence physical activity, namely walking, by means of laws, regulations, investments, incentives, etc. (Sallis et al., 2006).

Our findings also indicated the perceived existence of parks in the neighborhood are associated with the compliance with peak 30-minutes cadence above 100, in seniors men. As well, a number of studies have shown that the presence of a parks within walking distance was related to PA (Mowen, Orsega-Smith, Payne, Ainsworth, & Godbey, 2007), walking (Nagel et al., 2008; Shigematsu et al., 2009) and walking at recommended levels (Wen et al., 2007), in older adults. According to our knowledge, this is the first study to detect the relationship of perceived parks in the neighborhood with the achievement of peak 30-minutes cadence ≥ 100, as the outcome. This parameter indicates if individuals are walking a minimum of 30 minutes per day at a cadence ≥ 100 steps per minute (moderate intensity) (Marshall et al., 2009).Seniors men who perceived nearby parks were more likely to achieve this recommendation. As reported by Sellers et al. (2012), the park environment

facilitate intensity and the achievement of current physical activity guidelines, due to the lack of walking breaks verified in this context, which could be the reason for this relationship. Furthermore, parks may stimulate more walking among older adults who already walked (Van Cauwenberg et al., 2015).

Residential density, land use mix-access, public transportation access, traffic-related and crime-related safety and pleasantness of the neighborhood environment were unrelated to the compliance with peak 30-minutes cadence above 100, in men and women. Perceived nearby parks were also unrelated to the achievement of peak 30-minutes cadence above 100, in women. This does not necessarily imply that the physical environment is not related to the compliance with peak 30-minutes cadence ≥ 100, in seniors, but might rather reflect that some other social ecological factors are more relevant for the achievement of this recommendation. For example, walking at moderate-intensity in older adults has been associated with functional walking capacity (Gonzales, Shephard, & Dubey, 2015), having tools to measure intensity (e.g., heart-rate monitor, pedometer) (Bouchard et al., 2013) and with the participation in recreational walking groups, which includes a wide variety of ambulatory intensity (e.g., brisk walking, jogging, hiking, etc.) (Spinney, Millward, & Scott, 2012).

Strengths and Limitations

There are some limitations of the current study. The cross-sectional design does not permit causality conclusions; the small sample limited the statistical power of the analysis and may have contributed to some of the non statistically significant associations. Future studies should prospectively study, in larger samples, the association between perceptions/characteristics of the neighborhood environment and walking intensity in older adults. The use of objective measures, such as geographic information systems to objectively assess the physical environment, in combination with perceptions of the neighborhood environment could also provides more accurate findings of environmental influences on walking volume and intensity among seniors.

In spite of these limitations, a key strength is that to our knowledge this was the first study to explore the associations of the perceived neighborhood

environment with the compliance with 10.000 steps in old men and with the achievement of peak 30-minutes cadence ≥ 100, among older adults. Strengths of this study also include the use of objective instruments to measure walking activity and the investigation of environmental factors through a social ecological framework.

Conclusions

Walking is an important physical activity for older adults. Accordingly, planners should design or redesign communities to promote walking at recommend levels, in seniors. The results of the current study suggest that perceived traffic safety and pleasant environment are relevant for the achievement of 10.000 steps, in old women. These results indicate that community initiatives that encourage traffic safety and pleasant environment may help old women to walk at recommend volume levels. On the other hand, the findings of the present study also revealed that perceived nearby parks is significant for the compliance with peak 30-minutes cadence above 100, in old men. To that extent, parks should be developed in order to promote walking at recommend intensity, in older men. Hopefully, programs and policies promoting parks, traffic safety and pleasant environments may, in turn, help to maintain physical and mental health of this growing population.

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Discussion

The overall aim of this PhD thesis was to understand how individual, interpersonal and environmental factors interact with walking behavior, physical and mental health, among seniors. Research on this topic use mostly quantitative methods however, qualitative research can help to explain not only what, but also how and why environmental factors relate to physical activity, namely walking (Sallis et al., 2006). In the first study of this thesis, we decided to use qualitative research methods, namely interviews, in order to describe the experience of participating in a walking program at individual, interpersonal and environmental levels and to determine appropriate strategies to walking interventions, in older adults. From this study, emerged information on social ecological factors relevant for walking behavior of the older adults participants in the Portuguese national walking and running program. Health promotion (physical and mental), social support, social activities and walking routes in nature context were the main themes highlighted by the participants of the pilot study as important factors to influence their walking behavior.

The importance of walking programs promoting walking activity and physical activity in older adults has been documented. Snyder et al. (2011), for example, reported that a pedometer-based intervention increased the volume of ambulatory activity in older adults, with a secondary benefit in functional status measures. Park et al. (2014), reported that participants in a supervised walking group engaged in significantly more physical activity on the walking training days compared with on the walking non-training days. Jancey et al. (2008) also revealed that participants in a neighborhood-based walking program increased significantly the weekly walking time for recreation. Ogilvie et al. (2007), reviewing interventions to promote walking, showed that walking programs are a successful strategy to increase ambulatory activity. However, almost of the interventions focus on volume of walking rather on intensity. With the paper II, we complemented this literature showing that facilitating walking training sessions for older adults could be a promising direction to promote volume and intensity of daily ambulatory activity, in older adults.

The social ecological perspective, tends to refocus attention from strictly intra-individual factors to multilevel variables, such as environmental and

interpersonal, that are expected to influence a behavior (Sallis et al., 2006). In this thesis, our studies provide support for the important role of socio ecological models in increasing walking and subsequently physical and mental health among older adults. The study of the relationship of intra-individual factors with walking emerged in the second and third papers of this thesis. Our findings revealed positive associations of walking with physical and psychological parameters. At the physical level, our results demonstrated positive associations between higher intensity of walking and better functional fitness scores, in old women participating in the national walking and running program. Walking performed at higher intensities has been associated with fitness in adults and older adults (Aoyagi et al., 2009; Gonzales et al., 2014; Nemoto et al., 2007) and our findings are concordant with that evidence, in seniors women. However, the associations between walking intensity and functional fitness were not significant for men, suggesting that, for stronger associations of peak 30-minutes cadence with functional fitness parameters, older men may increase stepping cadence, in the walking training sessions. No significant associations have previously been identified between peak 30-minutes cadence and functional fitness parameters seniors men (Gonzales, Shephard, & Dubey, 2014), so these no significant results were somewhat expected.

At the psychological level, the social ecological perspective, helped us to study the influence of interpersonal factors on walking and combined influence of walking and social support on intra-individual psychological factors. Our findings showed that walking has a strong mediating effect on the associations of participation in group activities with vitality and psychological distress. Our results suggested that older adults who participate in group activities are likely to walk more, which may result in better vitality and lower psychological distress. Our results corroborates with previous research supporting physical activity as a mean to reduce stress and promote vitality, among older adults (Diez Roux & Mair, 2010; Solberg, Hopkins, Ommundsen, & Halvari, 2012). The importance of walking and participation in group activities, in this age group, has also been emphasized in a previous study (Julien et al., 2013), suggesting that older adults who are both walking and participating in group activities may

benefit from less depressive symptoms. Walking and participation in group activities are indeed of significant relevance not only for physical but also for mental health.

The social ecological models provide frameworks for understand the inter-relations between individuals and their social and physical environments. The relationships between social support (interpersonal factor) and walking activity per day were examined in the third paper. Besides the majority of studies relating walking with social support used physical activity-specific social support variables (i.e., exercise partners, exercise groups, support from family and friends to physical activity, etc.), there is an emerging evidence reporting positive associations between general forms of social support (i.e., social contacts, neighborhood involvement, participation and volunteering, social cohesion, social network) with walking (Kamphuis et al., 2009; Mendes de Leon et al., 2009; Van Cauwenberg et al., 2014). Our results are in concordance with the above cited studies, revealing that the following general forms of social support (appreciation of social contacts, frequency of social contacts, participation in group activities, closeness from family and friends, concern and interest from people around) were related with walking activity per day, in older adults.

On the other hand, our study demonstrated that practical help from neighbors was unrelated with walking. A possible explanation for this finding may be linked to the relationship of practical help from neighbors with instrumental support (i.e., receiving help with household tasks and shopping), which was associated in a previous study with lack of opportunities for walking (Perrino et al., 2011). Older adults who receive practical help from others are more likely to walk less because receiving help with daily tasks may reduce their need to walk. In summary, general forms of social support are advised to promote walking activity among older adults. However, we should be aware that too much practical help and instrumental support could inhibit walking activity, in seniors.

At the environmental level we pretended to explore the perceived neighborhood environmental factors related with recommended volume and

intensity of walking in recreational senior walkers. Studies with objectively measured walking are scare and most of the studies that relate features of the environment with walking generally were focused on volume and type of walking (transportation vs. recreation). In order to complement the literature, in the paper IV, we focused in walking intensity besides volume.

Our results revealed that perceptions of traffic safety and pleasant environment were positively related with the achievement of 10.000 steps per day, in seniors women and the perception of nearby parks was positively related with the compliance with peak 30-minutes cadence above 100, in seniors men. In fact, pleasant environment, safety and presence of parks are frequently associated to older adults walking behavior, in literature (Van Cauwenberg et al., 2011). These findings suggested that certain attributes of the neighborhood are important to recreational senior walkers achieve the current physical activity guidelines. However, it remains unknown why so many others perceptions of the neighborhood environment were unrelated to walking at recommended volume and intensity, in recreational senior walkers. We suspect that other social ecological factors (individual, interpersonal and policy factors) could have a stronger effect on these outcome variables. Intra-individual factors like self-efficacy (Van Holle et al., 2015), functional walking capacity (Gonzales et al., 2015) , interpersonal factors (e.g. social support from family, neighbors and friends, walking groups, etc.) (Kahn et al., 2002; Mendes de Leon et al., 2009; Van Cauwenberg et al., 2014) and policy (Sallis et al., 2006) can also influence walking behavior , among older adults. This can also be explained by the use of a recreational seniors walkers-based sample. The participation in recreational walking groups, which includes a wide variety of ambulatory activity (e.g., brisk walking, jogging, hiking, etc.) have been associated with the achievement of higher volume and intensities of walking, being one strong social ecological potential to influence walking at recommended intensity and volume (Spinney et al., 2012). Findings from our study need to be further explored in the general senior population.

Strengths and limitations

Strengths of this doctoral thesis include the focus on older adults. This strongly growing population is the least physically active of any age group. Insights into how to promote physical activity among seniors is required in order to promote older adults mobility and functional independence and to prevent the rise of health care costs. Second, as suggested by Sallis et al. (2006), a social ecological framework have been used to better understand the multiple and interacting factors influencing walking among older adults. Third, we studied the most relevant form of exercise to increase regular physical activity at a moderate intensity in adults - walking (Lee & Buchner, 2008). Fourth, this thesis includes studies using a variety of methodologies, i.e. qualitative and quantitative observational research, providing insights in relationships of walking at individual, interpersonal and environmental levels, among older adults. Fifth, we did not exclusively examine the main effects physical/social environment-walking relationships, but we also investigated the mediated effect of walking on the relationship of interpersonal with intra-individual factors. Sixth, the use of objectively assessed walking activity in the papers II and IV allows a more accurate form of measuring physical activity. Strengths of this study also include the investigation of factors willing to change through interventions (i.e., social support, walking, physical environment characteristics, etc.).

Next to these strengths, this doctoral thesis has some limitations that should be mentioned. First, the studies II, III and IV are cross-sectional and do not allow causality conclusions. Second, the use of self-report measures to assess walking in paper I and III, is less accurate than measuring walking objectively. Third, the small sample sizes of papers I, II and IV limited the statistical power of the analysis and may contributed to some of the non statistically significant associations.

Practical implications

The findings of this thesis highlight walking programs as potential behavioral interventions among older adults, being peak 30-minutes cadence an important factor for possibly improving functional fitness in older women. Relationships between peak 30-minutes cadence of walking training days were not significant in seniors men, which emphasis the need to promote faster cadences for functional fitness improvement, in old men.

We also showed that a supportive social environment may stimulate walking among older adults. More specifically, social contacts, participation in group activities, closeness from family and friends, concern and interest from people around were positively associated with walking. Actions that stimulate interpersonal relationships and participation in group activities should be therefore promoted in order to enhance walking activity in older adults. But one should take care when give practical help (i.e. help with household tasks and shopping) to older adults because receiving help with daily tasks has been associated with fewer opportunities to walk.

Our results also suggest that walking strongly mediates the relationship of participation in group activities with vitality and psychological distress. To that extent, facilitating group activities and walking could be a promising direction for policies intended to promote mental health among older adults.

The findings concerning environmental factors related with walking at recommended intensity and volume from the study IV can inform policies about which environmental factors to prioritize when planning environmental changes to promote walking. Our results may advise programs and policies to promote parks in order to promote walking at recommended intensity in seniors men and traffic safety and pleasant environments to promote walking at recommended volume in seniors women.

Directions for future research

There is a need to investigate the longitudinal effects of interpersonal and environmental factors on older adults' walking activity. Almost of the studies exploring these relationships used cross-sectional design which did not allow to infer causality. Moreover, walking is often assessed using self-report measures which may suffer from significant reporting bias (Sallis & Saelens, 2000). Future prospective studies, using objective instruments (such as accelerometers) to measure walking and making a distinction between recreational and transport-related walking are advised to improve clarity of the results. Longitudinal studies could also confirm the results of the mediation analyses on the relationships between social support - walking - mental health. Future research should also try to find out why certain environmental factors are/are not important for walking at recommended levels among older adults. Lastly, in order to further understand older adults' walking activity, studies based on social ecological framework should focus on detecting moderating and mediating mechanisms on the relationships between individual, interpersonal and environmental levels.

Conclusions

Using a social ecological framework, the current dissertation adds to a body of research focused on walking activity, in older adults. Considering the overall findings that emerged from the original studies we highlight the following conclusions:

- Peak 30-minutes cadence of the walking training days was positively related to functional fitness in seniors women;

- Older adults of both gender participating in the Portuguese national walking and running program achieved higher volume and intensity of walking on training days, when compared with non-training days;

- Walking activity per day has a strong mediating effect on the associations of participation in group activities with vitality and psychological distress;

- General forms of social support (i.e., social contacts, neighborhood involvement, participation and volunteering, social cohesion, social network) were positively associated with walking;

- Perceptions of nearby parks were associated with walking at recommended intensity in seniors men, participating in the Portuguese national walking and running program;

- Perceptions of traffic safety and pleasant environment were associated with walking at recommended volume in seniors women, participating in the Portuguese national walking and running program.

Our findings provide valuable information for policies involving interpersonal and environmental changes in order to promote walking activity among older adults. Future prospective studies using objective measures should be encouraged to confirm these findings.

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List of Publications

Peer-reviewed Scientific Journal Submitted Articles

The experience of older adults in a walking program at individual, interpersonal and environmental levels. Accepted in Journal of Activities Adaptation and Aging.

Ambulatory activity of older adults participants in the Portuguese national walking and running program. An analysis of the peak 30-minutes cadence and its relation with functional fitness. Submitted to Journal of Aging and Physical activity.

Walking as a mediator of the relationship of social support with vitality and psychological distress in older adults. Under review in European Journal of Ageing.

Perceptions of the neighborhood environment associated with walking at recommend intensity and volume levels in recreational senior walkers. Submitted to Journal of Aging and Physical Activity.

Peer-reviewed Scientific Journal Published Articles

Silva, J.; Padrão, P.; Gonçalves, C.; Esteves, R.; Carrapatoso, S.; Carvalho, J.; Severo, M.; Lopes, C.& Moreira, P. (2014). Association between sodium intake and hydration status amongst community-dwelling elderly people. Revista Española de Nutrición Comunitaria, 20 (S.1), pp. 63-67.

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Appendix

DECLARAÇÃO DE CONSENTIMENTO INFORMADO, LIVRE E ESCLARECIDO

O projeto de investigação intitulado “Impacto do Programa Nacional de Marcha e Corrida nas Perceções Ambientais e Fatores de Risco Cardiovasculares em Participantes Idosos” tem como objetivo verificar os efeitos do Programa Nacional de Marcha e Corrida nas perceções do ambiente, atividade física, funcionalidade e saúde dos participantes idosos.

A participação neste projeto que envolve os seguintes procedimentos: medição do peso, altura e tensão arterial; utilização de um aparelho na cintura durante sete dias (acelerómetro) para a avaliação da atividade física; preenchimento de 1 questionário e realização de 1 entrevista (perceções ambiente e atividade física) e realização de uma bateria de testes para avaliar a aptidão física.
Os dados são totalmente confidenciais e só serão usados para este estudo, sendo a equipa de investigação responsável pela sua conservação e pela sua destruição findo o estudo. Sendo do seu interesse, os participantes podem ter acesso exclusivo aos seus resultados.

Declaro que li e compreendi a explicação a respeito da participação no estudo acima citado, tendo-me sido dada a oportunidade de fazer as perguntas que julguei necessárias acerca dos procedimentos do estudo. Tomei também conhecimento que sou livre de desistir da minha participação no referido estudo a qualquer momento.

Tendo em conta o atrás exposto autorizo a minha participação no projeto de investigação acima referido, efetuando duas medições de todos os testes mencionados.

_____ _____

Data Assinatura do participante

_____ _____

Data Assinatura do investigador principal

Se aceita participar, por favor rubrique esta página e a seguinte e, de seguida, retire para si a primeira página (são ambas iguais e a primeira página é para si).