THERMAL COMFORT FOR OLDER ADULTS. AN EXPERIMENTAL STUDY ON THE THERMAL REQUIREMENTS FOR OLDER ADULTS

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ABSTRACT

In this paper is presented an experimental study about thermal comfort requirements for older adults, trying to establish a specific range of parameters for optimal thermal conditions in residential indoor environments. One of the most important reasons for this study is the constant growth in the number of older people all the world, that wish to live in health and to continue their life style. Today, in most industrialized countries, people are living longer, thanks to technological and economic progress, with an average life expectancy of about 80 years, and it is estimated that in the future the population constituted by older adults, over 65 years, will continue to grow. In this context, is important to understand how older adults feel thermal comfort as the home environment plays an important role to provide healthy and comfortable life styles. To evaluate the thermal environmental conditions for human occupancy, in moderate indoor environments with mechanical heating or cooling systems, the PMV/PPD method is still used, also to evaluate thermal comfort of older adults. There is a wide literature and research activity about indoor thermal comfort, but most of the studies and references, like also the current standards, offer only general and overall approaches, with no differences with regard to age. In order to relate the conditions of thermal comfort to older people, more specific considerations and evaluations are necessary.

The purpose of this study is to define some specific thermal comfort requirements for older adults, with specific profiles and a range of related parameters, using software and virtual test rooms according to current evaluation methods. To perform this study, analyses and simulations are performed, using tools such as CBE Thermal Comfort Tools, Ashrae Thermal Comfort Tool and Perla Pmv. With these tools are simulated some situations in real conditions, such as rooms with different floor areas, different activities and clothings, and different internal gains. All the simulations and analyses are based on investigations on older adults behaviors. The results yeld specific values and indices, related to thermal comfort, able to represent the ranges of older adults thermal parameters and to define some daily profiles.

Keywords: thermal comfort, pmv/ppd method, older adults.

INTRODUCTION

Today in Europe, the average life expectancy is over 80 years, and it is estimated that in 2020, about 25% of the population will be over 65 years old [1]. This growing population of older people involves a great challenge about residential indoor environments with appropriate solutions and conditions. The home environment plays an important role to offer healthy and comfortable spaces. In 2025, there will be 360 million people aged over 60 years, in the industrialized countries of the world [2]. In Italy, in the last 50 years, aging of the population has been one of the fastest and it is estimated that in 2050 the people over 65 years will amount to 32% of the total population, with an average life expectancy of 83.6 years for men and 88.8 for women [3]. If the increase of longevity is certainly a great achievement, that evidences the growing improvement of living conditions and health progress, it will also be a major issue to be resolved in the future, in terms of the potentially growing number of sick people, an increases demand for assistance, reduction of well-being for older people and also the demographic transition towards the third age, with related modification of households, which involves large increases in energy demand.

Older adults are subjected to sensory changes, involving sight, hearing, feeling, smell and peripheral nervous system that result in different demand and requirements in terms of environmental comfort. In fact, these changes modify the physical and metabolic abilities and are caused by physiological deterioration of the human body but could also be caused by accidents or illness and can vary over time. In particular, the effects of aging on the perception of thermal comfort and on the body temperature control have recently been revaluated, according to Van Hoof *et al.* [4]. Until a few years ago, studies supported the hypothesis that the older adults do not perceive thermal comfort different from younger adults. Any differences about thermal requirements, related to sex or age, is evaluated and calculated as parameters by metabolic rate and by clothing insulation in PMV/PPD model. It has been shown that, the capability to regulate body temperature decreases with age, as basal metabolism decreases with age and leads to lower body temperatures. According to recent studies, older adults feel comfortable higher temperatures and perceive local thermal discomfort as very annoying. Lower metabolic rate and lower levels of physical activity, involve the demand of a warmer environment and higher temperatures. Also, the perspiration mechanisms, in people over 60 years, are less active than in younger people and the temperature threshold for the appearance of sweating increase progressively [5]. In older adults and in people with disabilities, there is a reduction in muscle strength, work capacity, and in the capability to transport heat from the internal organs to the skin surface, with decreased levels of hydration and vascular reactivity. All these phenomena, confirmed by many studies, represent a general framework of conditions for all older adults, although depending on sex, age and specific characteristics there may be sensitive differences.

One of the most important aspects in the perception of quality and satisfaction of the indoor environment is the thermal comfort, which contributes to the well-being and overall health. The current method for the evaluation of thermal comfort is the PMV/PPD model (Predicted Percentage of Dissatisfied and Predicted Mean Vote) derived from the Fanger model, which is adopted in the International Standards ISO-7730 and ANSI/ASHRAE Standard-55 [6-7]. The indoor thermal comfort analysis is a field study, belonging to Building Science, with a very large literature and many research activities, but most of the studies, knowledge and predictive methods are developed for healthy occupants between 20 and 60 years old. In order to differentiate thermal comfort requirements for older adults, more specific considerations and evaluations are necessar. A better understanding of the optimal thermal comfort requirements for older adults can afford to design more appropriate equipments, insulations performances and technical solutions.

METHOD

In this paper, starting from a previous recent survey, which tried to define some typological daily profiles about life-style of older adults in Italy, an experimental study is proposed, simulating and evaluating thermal comfort requirements for older adults. This study, which uses some existing data about older adults life-styles, establishes some real common conditions about indoor residential environments and uses international calculation models for thermal comfort evaluation, integrates all these aspects and runs simulations with the purpose to meet more specific thermal comfort requirements and to recognize closer ranges of thermal parameters for older adults. A fundamental starting point was a previous survey, named PASS (Private Assisted House), developed in 2014 by University of Camerino, Regione Marche and

INRCA, that monitored fifty older adults, from 60 years old to 80 years old, recording information about their life-styles: daily times, activities, alimentation, types of clothing, sleep duration, etc. Based on all these data, were defined three main average profiles, able to represent, in general, the most probable behaviors of older adults. These three profiles are used to set personal factors of thermal comfort: metabolic rate coefficients and clothing insulation coefficients (Figures 1-2-3). The three profiles show three average daily trends about clothing index (clo) and metabolic index (met).

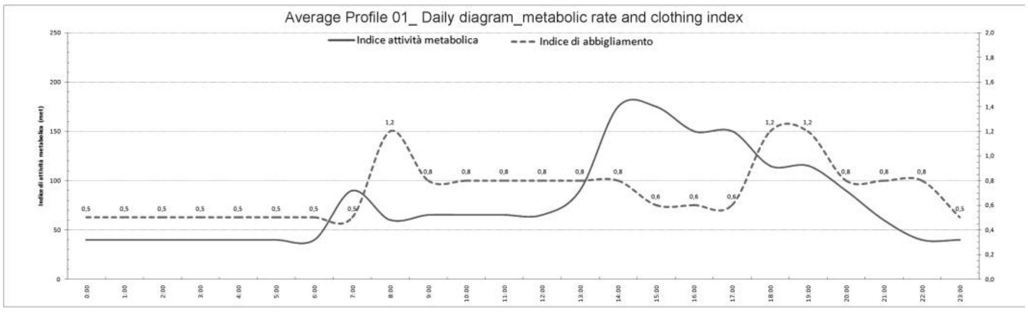

Figure 1: Average daily profile older adult 01. Diagram of profile of metabolic rates and clothing indices. The diagram shows trends, in Met and Clo, extracted from PASS survey, for a reference older adults (male, height 170cm, BSA 1,85 m^2, weight 70 kg, age 60 years old).

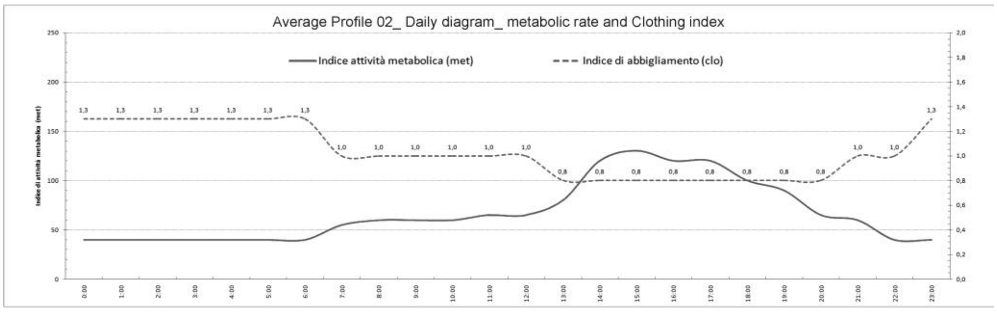

Figure 2: Average daily profile older adult 02. Diagram of profile of metabolic rates and clothing indices. The diagram shows trends, in Met and Clo, extracted from PASS survey, for a reference older adults (male, height 160cm, BSA 1,72 m^2, weight 70 kg, age 70 years old).

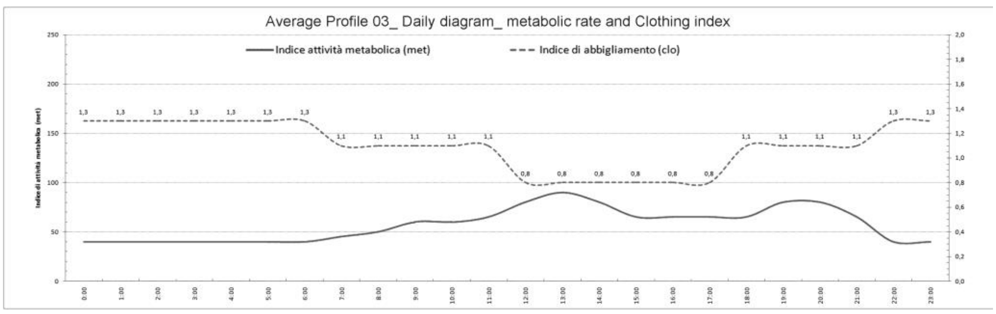

Figure 3: Average daily profile older adult 03. Diagram of profile of metabolic rates and clothing indices. The diagram shows trends, in Met and Clo, extracted from PASS survey, for a reference older adults (male, height 165cm, BSA 1,81 m^2, weight 75 kg, age 80 years old).

Before performing simulations and analyses, with the aim to represent conditions closer to the real current indoor residential environments, a building scenario is defined, like a virtual test room. The building scenario tries to represent a typical indoor environment, like a living-room, with which it is possible to detail some important features that mainly affect on mean radiant temperature of surfaces, like the existence of a window or the dimensions of envelope surfaces (Table 1).

Reference Test Room				
Architectural dimensions			Environmental features	
	Room	Window	Type of ventilation	natural
Width	4,00 m	1,50 m	R.H. control	no
Height	2,80 m	1,20 m	Cooling system	no
Depth	4,60 m		Heating system	radiators
Surface	18,4 m^2	1,80 m^2	R.H. range	40% - 60%
Volume	51,5 m^3		Air speed range	0,1 m/s – 0,3 m/s

Table 1: Default parameters of reference test room. The table shows geometric and other features of the virtual indoor environment, used to run pmv/ppd calculations.

With these conditions, the thermal comfort analysis process simulates and calculates the pmv and ppd index, for all the hours of the three average profiles with some default parameters, like clothing insulation indices, metabolic rates and indoor environment dimensions. In this process, only some parameters can be changed, like the air temperature, the mean radiant temperature and, within a restricted range, the air speed and the relative humidity. The adopted method is related to the target of the research, that does not want to recognize if and how the thermal comfort is felt, but on the contrary, as a function of an optimal comfort range, tries to know what levels of some manageable environmental factors should be necessary.

RESULTS

The study calculated PMV and PPD indices for 72 different configurations, 24 configurations, like 24 daily hours, for each of the 3 average profiles of older adults. In each single calculation are included personal factors, like not editable default parameters, and environmental factors, which are managed to reach near zero heat balance, enclosed in a optimal PMV range +0,5 and -0,5. Different tools are used to calculate pmv and ppd indices to confirm the accuracy of results. In particular, at first, calculations are made with the Ashrae Thermal Comfort Tool and the CBE Thermal Comfort Tool, then with the Perla pmv tool, an Italian software product which provides the ability to model a virtual room with specific dimensions and features, and at the end, indices given by different tools are compared to verify equality of results. The output of the analysis are three diagrams, one for each profile, where trends about pmv and ppd during the 24 hours are displayed (Figures 4-5-6).

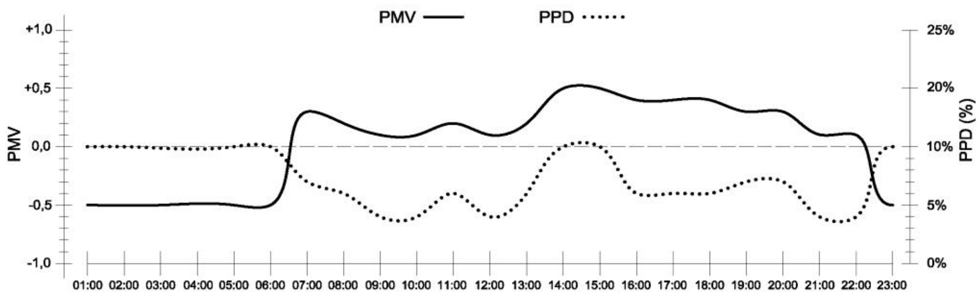

Figure 4: PMV/PPD diagram for average older adult profile 01. Diagram represents the trends of pmv/ppd indices, calculated as functions of personal and environmental factors, to achieve optimal thermal comfort levels.

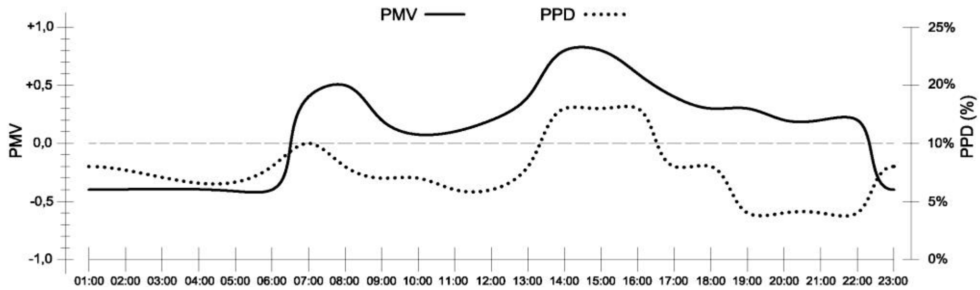

Figure 5: PMV/PPD diagram for average older adult profile 01. Diagram represents the trends of pmv/ppd indices, calculated as functions of personal and environmental factors, to achieve optimal thermal comfort levels.

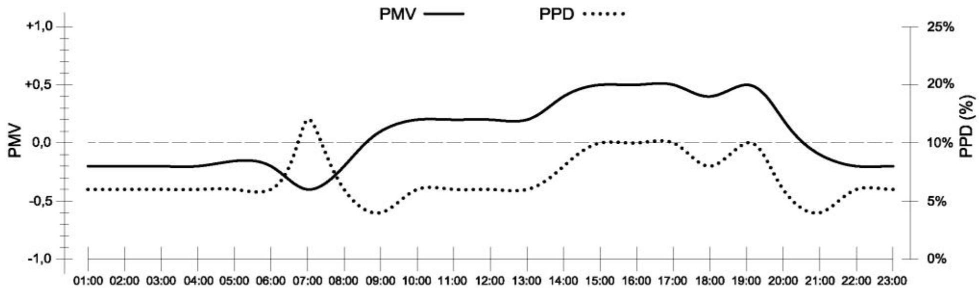

Figure 6: PMV/PPD diagram for average older adult profile 03. Diagram represents the trends of pmv/ppd indices, calculated as functions of personal and environmental factors, to achieve optimal thermal comfort levels.

The results are average daily pmv/ppd trends, obtained by using personal factors, that are predefined, and environmental factors that are managed, within restricted ranges, to achieve indices within an optimal thermal comfort range. To achieve these comfort levels, the necessary values of environmental factors are very reduced: air temperatures range from 20C° to 24C° and often over 22C°, radiant temperatures of surfaces need to be constant and homogeneous with air temperatures, relative humidity always within 40% and 60% and air speed steadily within a range from 0,1m/s to 0,3m/s (Figure 7). These values about environmental factors, could give back specific information about how energy performances are necessary to reach and maintain thermal comfort for different types of older adults. These values are theoretical and, in real conditions, are very difficult to obtain and to maintain without an integration of all building systems, with mechanical systems and equipments, controlled by a building automation system.

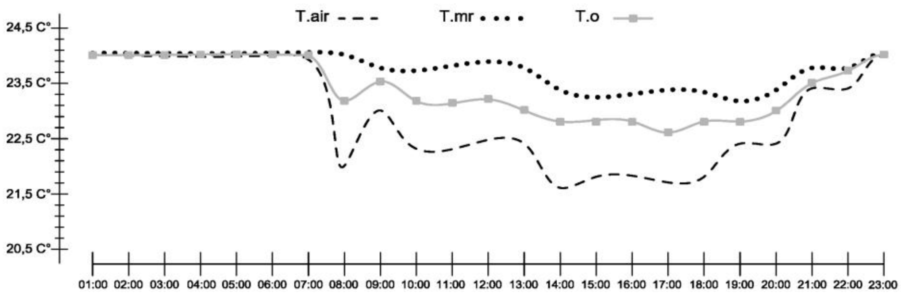

Figure 7: Indoor temperatures diagram for profile 01. Diagram represents the trends of air temperatures (T.air), mean radiant temperatures (T.mr) and operative temperatures (T.o) required to achieve and maintain pmv/ppd levels for average older adults profile 01, shown in figure 4.

DISCUSSION

This experimental study includes some restrictions and limitations, like: no differences between underheated and overheated periods, diseases or disabilities that affected thermoregulation in many older adults are not evaluated, starting data about survey on life-styles of older adults are not entirely useful and the ANSI/ASHRAE Standard-55 method, that is an overall evaluation system, could not give back a specific satisfaction assessment of older adults with the thermal environment. However, this experimental study, based on real behaviors of some older adults, examines the energy performances that residential indoor environments could have, highlighting some conditions as higher air temperatures are required, environmental factors need to be more stable, and also small variations can involve important reduction on thermal satisfaction of older adults.

CONCLUSION

Starting from the above discussion, is possible to accept that indoor residential environments, where older adults live, need a very high control of indoor climate conditions, so heating and cooling mechanical systems and other equipments, are required, involving important considerations about energy saving and energy building design solutions, because the achievement of thermal comfort for older adults need integrated and advanced strategies, like thermal mass, high insulation, no local discomfort phenomena and control systems for air speed, relative humidity and air quality. In this sense, building automation could be a very important support to obtain and maintain high indoor thermal performances. Further researches are planned, to continue the studies in this sector, targeting developments of building automation and integrated management of indoor thermal comfort for older adults. This study has been carried out, based on a previous work, named PASS, made with Regione Marche and INRCA.

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