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On the necessities to analyse the thermohygrometric perception in aged people. A review about indoor thermal comfort, health and energetic aspects and a perspective for future studies

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ABSTRACT

This study wants to examine the current bibliography concerning the thermohygrometric perception in aged people living in industrialized countries and its socio-economic consequences. Nowadays the number of European people between 70 and 90 years old is increasing, thus causing an aging of the average population. A proper and modern planning of indoor environments in residential buildings requires the presence of a good thermohygrometric comfort together with a low energy consumption level. The most common comfort indexes are the PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied) provided by Fanger's studies. Aged people present different demands with respect to the planning values suggested by Fanger. In particular, old people tend to live alone with a lower basal metabolic rate than active subjects and they are usually affected by pathologies provoked by the age. Medical studies revealed that pathologies might even be determined by indoor environmental conditions. Hence in order to have actual indoor comfort conditions able to satisfy aged people (especially during winter) different thermohygrometric values are required. This is why a higher energy demand is required and an optimization process should be performed to reduce the costs. Such condition will affect the future welfare of different countries.

1. About the importance of studies dealing with the thermal perception of aged people

The thermal comfort sensation is a psychological and physiological condition expressing the thermohygrometric perception of the human being about the environment (both indoor and outdoor) surrounding her/him (Del Ferraro, Iavicoli, Russo, & Molinaro, 2015; ISO, 2005; Parsons & Kenneth, 2018).

The thermal comfort is a consequence of the thermoregulation that the human body performs with respect to the conditions characterizing the environment surrounding the subject (ASHRAE, 2013a). Part of the energy that the human body produces (M) is consumed by the muscles (W); the rest of the energy (M–W) is dissipated towards the environment through the body skin (Q_{sk}) and the breathing apparatus (Q_{res}) or it can be stored (S), thus causing an increase in the body temperature.

$$M-W = Q_{sk} + Q_{res} + S = (C + R + E_{sk}) + (C_{res} + E_{res}) + S_{sk} + S_c \quad (1)$$

The heat the body dissipates towards the environment occurs through different ways of heat exchange: the sensible heat exchanged through the skin (C + R) due to conduction, convection and irradiation phenomena, the latent heat due to skin evaporation (E_{sk}), the sensible heat affected by the breathing (C_{res}), the latent heat due to evaporation phenomena during the breathing process (E_{res}). The rest of the heat is stored in the skin (S_{sk}) and the body (S_c) (Goromosov, 1968; Ormandy & Ezratty, 2012). This type of energy balance, even though it might seem simple, is actually complex depending on objective data (environmental conditions) and personal or subjective ones as the perception of a sensation (thermohygrometric comfort of a human being) (Golasi, Salata, de Lieto Vollaro, Coppi, & de Lieto Vollaro, 2016; Pisello, Castaldo, Piselli, Fabiani, & Cotana, 2016; Salata, Golasi, de Lieto Vollaro, & de Lieto Vollaro, 2016), not easy to quantify (Hensen,

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1991; Djongyang, Tchinda, & Njomo, 2010; Lin & Deng, 2008).

While focusing our attention on indoor conditions, it must be taken into consideration the fact that the world population, which has been developing since after the IIWW, tends to concentrate in those urban areas with a high density population (UN stated that 70% of the world population will live by 2050 in this type of environment) (POPULATION REFERENCE BUREAU, 2015). In highly anthropized cities, people tend to spend their time in indoor spaces while they perform their daily activities (it is estimated that people spend between 80% and 90% of their time in indoor spaces) (Pérez-Lombard, Ortiz, & Pout, 2008).

After the technological and financial development, the indoor conditions of houses are even more affected by thermoregulation systems functioning according to environmental parameters meant to provide thermal and, when it is financially possible, even hygrometric comfort (Pisello, Castaldo, Piselli, & Cotana, 2017). It seems clear that the comfort issues in indoor environments are highly affected by the functioning of energy-wasting systems which influence the general energy consumption (the civil and commercial sector are responsible for the 16% of the world energy consumption) (Hoyt, Lee, Zhang, Arens, & Webster, 2009; Rupp, Vásquez, & Lamberts, 2015).

The objective factors used to describe the quality of the environmental conditions, besides the air temperature, are the mean radiant temperature of the surrounding surfaces, the relative humidity and wind velocity. However, before stating that an environment has a good comfort level, the air exchange caused by the ventilation (natural or mechanical) must be also taken into consideration (Kingma, Schellen, Frijns, & van Marken Lichtenbelt, 2012).

The thermohygrometric comfort does not depend entirely on the environmental conditions present (which can be defined through objective factors that can be quantified in numbers), but rather it is affected even by subjective elements changing from one person to another which are really difficult to weigh. It is also affected by the type of activity performed, or the type of clothing the subject is wearing (Fanger, 1973; Xiong, Lian, Zhou, You, & Lin, 2016), the general health condition of the person, the adaptation capacity to the local climatic conditions, gender and age (Karjalainen, 2012). This makes more difficult the possibility to have a unique definition of the thermohygrometric comfort. Hensen defined it as “a condition where we are not moved to change the environmental conditions through our behaviour” (Hensen, 1991). The ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) defines it as “the mental condition where we express satisfaction for the thermal environment” (ASHRAE, 2013a). The personal opinion about the thermal comfort is deeply connected to subjective cognitive processes involving variables which are affected by physical, physiological and psychological factors. As a matter of fact and according to the World Health Organization (Ormandy & Ezratty, 2012), the comfort characterizing indoor environments where we live in which highly affects human health (especially some ranges of the population as children and old people) (Sunwoo, Chou, Takeshita, Murakami, & Tochihara, 2006).

1.1. Demographic aging

What is happening is an aging of the world population (Trezza et al., 2015). This phenomenon is due to a longer life expectancy (hence a lower death rate) of those generations living in developed countries going through a baby-boom which started in the past, with a simultaneous decrease in the fertility rate of the newly industrialized countries with a high population level (as China or Brazil) (POPULATION REFERENCE BUREAU, 2015).

The proportions of this phenomenon, especially in those firstly-industrialized countries, became so important that institutions must take care of their consequences. Surveys reported that in 2015 8,5% of the world population was formed by 65-years-old people, with a developing trend able to increase up until 167% by 2050 (He, Goodkind, & Kowal, 2016). In this scenario, Europe will be the continent characterized by the highest number of aged people, who will increase their number from 40 million to 219 million (five times more) (POPULATION REFERENCE BUREAU, 2015), whereas the States by 2030 will have 72 million of over-64-years-old people (20% of the entire population) (Shrestha & Heisler, 2011). Asia, though it is a young continent if compared to Europe or USA (except for Japan which is the “eldest” country in the world), will be considered as the continent with the highest aging rate for the next decades (POPULATION REFERENCE BUREAU, 2015). Table 1 reports briefly the current percentages of over-65-years-old people with respect to the entire population and demographic projections for the next ten years.

Table 1
Incidence of the percentage of the 65-yeras-old population in the world (Population Reference Bureau, 2015).

Region	Population [%]		
	2015	2030	2050
Africa	3,5	4,4	6,7
Asia	7,9	12,1	18,8
Europe	17,4	22,8	27,8
Latin America and Caribbean	7,8	11,8	186
North America	16,1	20,7	21,4
Oceania	12,5	16,2	19,5

In particular, in Italy the aging process is constantly increasing, even though over the past years it has been reported an increase in deaths due to old age and a slight decrease in life expectancy. 22% of the Italian population is formed by people who are older than 65-years-old while, if the attention is focused on over-75-years-old people (a part of the population presenting several issues in terms of health), the percentage is 112% (Demographic indicators, 2016).

This phenomenon will cause deep social changes, both financial and health related (Jay Olshansky et al., 2011; Miller, Vine, & Amin, 2017). It seems inevitable that an increase will occur in the number of subjects affected by chronic pathologies due to age and they will be institutionalized in health-care, structures, with a resulting increase in health expenses (Gerland et al., 2014). Hospitals and nursing homes will be structures destined to give service to bad cases only; hence guaranteeing comfort conditions to aged people in their own houses will be essential, since 65-years-old people tend to spend most of their time in closed environments or similar familiar spaces (Caley & Sidhu, 2011; Mendes et al., 2015). It seems evident that indoor thermohygrometric conditions of those areas will be adjusted according to their needs (Damiani et al., 2009), which are usually different if compared to younger subjects (Ahrentzen, Erickson, & Fonseca, 2016; Basu & Samet, 2002).

1.2. The thermohygrometric perception in aged people

The perception of the same environment variables (which affect the comfort or discomfort in the subjects) can determine different physiological and psychological responses in subjects with different habits, gender, age or geographic origin (Djongyang et al., 2010). The thermohygrometric comfort is deeply connected to a combination of so many factors that trying to find conditions common to every subject would inevitably lead to a high percentage of people experiencing a discomfort (Kuchen & Fisch, 2009). If the goal is to examine the needs of a part of the population, to determine the ideal environmental conditions, the analysis must be performed on subjects with common characteristics. Hence it is important to understand how the body of the aged subject, which statistically presents health issues due to old age, is different from the normotipo which represents (valid from a statistical point of view) transversally the entire population (Hwang & Chen, 2010).

Such normotipo in normal conditions (defined as “resting