INTRODUCTION

People in the Western world in general spend 80-90% of their time indoors (e.g. at home, at school, at the office etc.). Recent studies have indicated that indoor building conditions may be associated with mental health effects (Houtman et al., 2008), illnesses that take longer to manifest (e.g. cardiovascular disease and lung cancer (Lewtas, 2007; Babisch 2008)), a variety of asthma-related health outcomes (Fisk et al., 2007)) or obesity (Bonnefoy et al. 2004; WHO, 2011). A whole range of effects have been associated with indoor environmental stressors in office buildings such as Sick Building Syndrome (SBS), building related illnesses (e.g. humidifier fever and legionnaires disease) and productivity loss (Bluyssen, 2009). The increased asthma prevalence in most countries in the past decades, the first chronic disease in childhood (Eder et al. 2006), seems to be related to exposure in the indoor environment of schools and homes.

To be more successful in determining the health and comfort effects of certain indoor environmental aspects it seems essential to understand the mechanisms behind how and why people respond to external stressors (Bluyssen, 2014). An attempt is made to summarize the answer to the following question:

How and why do people respond to external stressors?

METHODOLOGY

To answer that question, an extensive literature study was performed to:
- Sketch the human systems available to make certain our body can maintain its balance and respond adequately to external and internal stressors and needs.
- Inventory important external stressors, stress mechanisms and identified relations between them as well as other factors that influence (modify and/or moderate) these relations.

Stress may be defined as “a physical, chemical or emotional factor that causes bodily or mental tension and may be a factor in disease causation” (Merriam-Webster Dictionary, 2011). A stressor or stress can trigger a mechanism or several mechanisms, and can cause an effect (or multiple effects) immediately (within seconds), medium term (within minutes to hours) or long term (days to years). When exposed to this stressor, stress or stress situation continuously (chronically) or repeatedly this may lead to an imbalance of the bodily systems,
characterised by changes in production of hormones and cytokines and other physiological processes to restore the balance.

RESULTS

A number of human systems are available to the human body to make certain our body can maintain its balance and respond adequately to external and internal stressors and needs. Those systems can be divided in systems that take care of the basic bodily processes and those that regulate or control the basic bodily and other processes required to keep healthy and comfortable. Three main control systems regulate the processes required to keep our body and mind healthy: the nervous system, the immune system and the endocrine system.

In the indoor environment physical and psychosocial factors can both lead to changes in production of hormones and cytokines causing changes in bodily and regulatory processes. Several stress response mechanisms have been brought forward that might explain why people can get sick or feel unwell in an indoor environment caused by indoor environmental stressors (physical, chemical and psycho-social) or why people feel and perform better in certain situations than other (Bluyssen, 2014):

1. Mechanisms starting with the endocrine system but also having an effect on the nervous system, the immune system and other bodily systems:
   - The HPA (Hypothalamus-pituitary-adrenal) axis: in response to various stresses, psychosocial and physical, an increase of secretion of anti-stress hormones can occur.
   - Disturbance of sleep-awake rhythm: Improper lighting, noise pollution during night, and even thermal discomfort during night, can lead to sleep disturbances.
   - Endocrine disruption: In the indoor environment, inhalation of air and ingestion of house dust have been considered important pathways for endocrine disrupting chemicals (EDCs).

2. Mechanisms mainly starting with the immune system but also having an effect on the endocrine system, the nervous system and other bodily systems:
   - Oxidative stress: can be caused by air pollution (lungs, eyes and brain, all organs), light (skin and eyes) and noise (ears) when there is an excess of free radicals (stolen electrons) over antioxidant defences.
   - Inflammation: the body’s response to the cause of the infection, an allergic reaction, can be directly caused by air pollution and indirectly by other mechanisms such as oxidative stress.
   - Cell death and cell changes: by physical, chemical or radioactive agents.

In addition, these stress responses may be altered by genetic factors, early developmental influences, or may be affected by lifestyle (Bluyssen, 2014):
   - Time and events: (un)conscious learning leading to behavioural conditioning and unexpected physiological effects.
   - Personal factors: from genetics to life style.

CONCLUSIONS

From the synthesis on the mechanisms of the human body, it was concluded that in order to answer the question ‘How and why do people respond to external stressors?’, all potential stressors and factors that can have an influence on the balance of the human systems could potentially be relevant to include. Interactions may occur between stressors in complex, real-life exposure as situations well as between various body responses to exposure(s). Our senses perceive individually, but interpretation occurs together. To truly evaluate the effect of an
indoor environmental situation, all routes of exposure (both physiological and psychological) and all interactions between and in the human systems can in principal be worth considering. It can also be seen that all human systems, the basic and the control systems, are involved. Major health effects presented seem to be associated with more than one stress response mechanism and with more than one stressor (see Figure 1). Time as in previous exposures, but also future anticipations, as well as in duration of exposures and as in combined exposures of stressors, need to be included!

<table>
<thead>
<tr>
<th>Stressors</th>
<th>Stress mechanisms</th>
<th>Diseases &amp; Disorders</th>
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<tbody>
<tr>
<td>Noise</td>
<td>Anti-stress</td>
<td>Depression</td>
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<tr>
<td>Indoor air quality</td>
<td>Circadian rhythm</td>
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<td>Lighting quality</td>
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<td></td>
<td>Cell changes/death</td>
<td>Cancers</td>
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Figure 1. Possible associations between stressors, mechanisms and diseases & disorders (Figure 1.3 in Bluyssen, 2014).

REFERENCES