In this study we showed that the relation between 'satisfaction' and 'loyalty' also depends on the age of the tenants. According to the expectation-disconfirmation-paradigm[6], the rate of satisfaction is the result of the gap between actual performance and expectations. A high satisfaction, however does not always lead to loyalty. Younger households move out in spite of a high satisfaction. Elderly households on the contrary, are loyal because of a lack of supply of other suitable dwellings1. If a housing association would offer a suitable alternative, for example sheltered or assisted housing, even satisfied elderly tenants have a tendency to move, without leaving their housing association.

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Clean indoor air increases physical independence. A pilot study

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M.C.L. Snijders, L.G.H. Koren, H.S.M. Kort, J.E.M.H. van Bronswijk, Clean air increases physical independence, a pilot study. Gerontechnology 1(2): 124 - 127. Clean indoor air enhances health. In a pilot study, we examined whether a good indoor air quality

increases the activity potential of older persons with chronic lung disease. Five older persons were studied while performing kitchen activities. Body movement and heart rate were monitored. Additionally, air parameters (indoor CO_2 and ultra fine dust particle ratio indoor versus outdoor) were logged. When performing tasks in clean air, the ratio of body movement versus actual energy expenditure is larger than in polluted air. We demonstrated a positive correlation between quality of indoor air and physical performance parameters, which may have implications for the individual's level of physical independence. Building technology and building services technology are in a position to guarantee clean air to the benefit of older persons.

Key words: indoor air, housing, lung diseases, independence

Physical independence tends to decrease with age. In case of older persons with Chronic Obstructive Pulmonary Disease (COPD), being 10% of the Netherlands population over 65 years[1], independence decrease is faster than in case of healthy contemporaries. Poor indoor air may induce health complaints, especially in persons with chronic lung disease[2]. In a pilot study, we examined whether clean indoor air increases physical performance of older persons with chronic lung disease.

MATERIALS AND METHODS

Five older persons (2 males and 3 females) with chronic lung disease were studied during a one-week period while performing kitchen activities in their own home environment. Their age varied from 53 to 73 years. Each person kept a diary in which the moments of kitchen activities were stated. By comparing activity patterns with the diary statements of each person, kitchen activity periods were selected.

Body movement in daily life (Tracmor-1, prototype developed at Eindhoven University of Technology, and University of Maastricht, the Netherlands) was monitored. Movements in three axial directions were counted by this monitor and logged each minute. To select kitchen activities with sufficient dynamic properties, periods were chosen that the individuals themselves logged as filled with kitchen activities and that was associated with body movements for three consecutive minutes[3].

Actual energy expenditure (AEE) and relative physical strain (expressed as the % of oxygen uptake during the kitchen activity divided by the oxygen uptake while sitting quietly[4]) were calculated from continuous pulse rate monitoring (Vantage NVTM, Polar Electro Oy, Finland) during kitchen activities and previously recorded standard values for physical performance. The latter were determined by a maximal cycle ergometer test and two sub-maximal exercise tests in a hospital (Elkerliek, Helmond, the Netherlands). An individual correction factor to account for changed metabolic rate of COPD individuals was established on a cycle ergometer as the ratio of resting metabolic rate between healthy subjects and subjects with COPD in a sitting position without cycling. The assumption that this factor accounts correctly for the metabolic difference needs further validation.

Indoor air quality was classified into two categories: clean air and polluted air. Two air parameters were logged (Almemo type 2290-8, Ahlborn, Holzkirchen, Germany) on a continuous base: CO_2 concentration in kitchen (Valtronics 2045, Envico, Zoeterwoude, NL), and dust particle ratio kitchen versus outdoor (particles > 0.3 μm; Met One R 4903, Oregon, USA). Assumed impact on health of air quality for individuals with chronic lung disease were taken from the literature; 680 ppm CO_2 and a dust ratio of 10 being the boundary between polluted and clean air conditions[4]. To eliminate acute, reversible health effects after a brief air-pol-

lution exposure, only periods of 15 minutes or more in the same air-quality category were included for comparison.
Statistical analysis at a confidence level of 0.05 was performed using Wilcoxon's signed-rank test (one-tailed), with the aid of SPSS Version 7.5[5].

RESULTS

Lowest pollution levels in clean air included 371 ppm for CO_2 and a 0.73 relative dust particle ratio (approximately 1.5 x 10^7 particles per m^3 indoor air), while highest pollution levels in dirty air showed 2485 ppm CO_2, and a dust ratio of 249 (2.6 x 10^9 / m^3 air), respectively.

Median and range of physical performance parameters were determined for each period of at least 5 minutes that a subject performed kitchen activities in either clean or polluted air. Comparison of activity parameters of all periods in clean air, and all periods in polluted air showed that all median values of the 4 parameters between the two groups were different (Wilcoxon, $p < 0.05$) (Table 1). Actual energy expenditure was lower in clean air than in polluted air, relative physical strain was lower in polluted air.

Larger relative differences were found in median body movement and the ratio of body movement versus actual energy expenditure (BM/AEE ratio). Both decreased 25 to 30% in polluted air as compared to clean air.

DISCUSSION

In a small number of older persons with chronic lung disease, we have demonstrated a relationship between the quality of inhaled air and physical performance parameters. When performing kitchen activities in clean air, the subject appears to perform 'healthier'. The amount of energy used for kitchen activities is higher in polluted air as compared to clean air, leaving less energy for other tasks or pleasures. This is best illustrated by the body motion/AEE ratio, which shows that at the same energy cost less work has been done. The increase in body movement and the decrease in actual energy expenditure are accommodations in physical performance that indicate positive effects of clean air exposure, leading to a higher level of physical independence.

The decrease in physical strain in polluted air seems to be in contradiction with common sense. There is some evidence that this is the result of a coping mechanism, resulting presumably from both a different content of the tasks performed (leaving most of it to the partner or other help), and a slower, performance of the tasks[4].
Both architectural design of a dwelling and the design of building services pertaining to

Table 1. Physical performance during kitchen activities (cooking and dish washing periods of at least 5 min) of elderly persons with chronic lung disease at two levels of indoor air quality. Median and range of four performance parameters; medians differ between clean and polluted air (Wilcoxon, $p < 0.05$). BM/AEE ratio: body movement versus actual energy expenditure ratio.

Physical performance parameters	Clean air		Polluted air	
	Median	Range	Median	Range
Number of days (individuals)	*17 (3)*		*31 (5)*	
Actual energy expenditure [J·kg-1·min-1]	163	75 – 247	168	82 – 272
Relative physical strain [%]	49	2 – 74	40	4 – 85
Body movement [counts·min-1]	14	2 – 40	10	5 – 26
BM/AEE ratio [counts·kg·J-1]	0.08	0.01 – 0.24	0.06	0.03 – 0.13

heating and ventilation are able to guarantee clean air under Dutch circumstances[6]. Given the continuing demographic increase of aged persons in most industrial countries, engineers should take these relationships into account. However, a study on a larger scale is needed to disclose the relation between indoor air quality and physical independence of elderly in more depth.

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