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Effect of cold indoor environment on physical performance of older women living in the community

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Abstract

Background: The effects of cold on older persons’ body and mind are not well documented, but with an increased number of older people with decreasing physical performance, these possible effects need to be understood.
**Objective:** to investigate the effect of cold indoor environment on physical performance of older women.

**Design:** cross-sectional experimental study with two test conditions.

**Setting:** movement laboratory in a climate chamber.

**Subjects:** eighty-eight community-dwelling, cognitively unimpaired older women (mean age 78 years).

**Methods:** participants were exposed to moderately cold (15°C) and warm/normal (25°C) temperature in a climate chamber in random order with an interval of 1 week. The assessment protocol included leg extensor power (Nottingham Power Rig), sit-to-stand performance velocity (linear encoder), gait speed, walk-ratio (i.e. step length/cadence on an instrumented walk way), maximal quadriceps and hand grip strength.

**Results:** physical performance was lower in 15°C room temperature compared with 25°C room temperature for leg extensor power \((P < 0.0001)\), sit-to-stand performance velocity \((P < 0.0001)\), gait speed \((P < 0.0001)\), walk-ratio \((P = 0.016)\) and maximal quadriceps strength \((P = 0.015)\), but not for hand grip strength.

**Conclusion:** in healthy older women a moderately cold indoor environment decreased important physical performance measures necessary for independent living.

**Keywords:** older women, cold indoor environment, physical performance, older people

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**Introduction**

There is evidence from British studies that poor older people threaten their health status by reducing expenditures on heating cost and electricity [1]. Most of this work has been performed in the UK with poor heating conditions in the 1980s. An increased morbidity among older people dwelling in colder homes has been shown [2] most likely associated with thermal indoor conditions.

Epidemiological studies have found excess mortality in older persons who have been exposed to heat waves and cold temperatures [3, 4]. Furthermore, there is some evidence of an association between low outdoor temperature and falls [5], but there are no results regarding indoor temperature.

Very few studies have examined the thermoregulation in older persons in response to exposure to cold temperatures. Failure to maintain core temperature during exposure to a cold environment [6] is explained by a higher level of skin thermal conduction [7] and by reduced reflex vasoconstriction [8].

The ability to quickly produce sufficient muscle force is of paramount importance for controlling body movements. In general, explosive muscle power decreases with age [9]. In older people decreased muscle power is associated with functional limitations [10, 11] and has been identified as an important determinant of mobility skills [12]. Oksa et al. [13] showed that a relatively low level of decrease in room temperature was sufficient to decrease muscle performance in young persons. Skelton et al. [14] found a 26% reduction in leg extension power of young subjects after cooling down the muscles by immersion into 15°C cold water. Indeed, poor explosive power performance may be more indicative of falls risk than traditional strength measurements in older people [15]. However, no studies have investigated muscle power and physical performance during exposure to cold indoor environment in older persons.

The aim of this study was to investigate the effect of cold indoor environment on physical performance of women 70 years or older. We hypothesised that there would be a deterioration in physical performance during exposure to an indoor cold environment.

**Methods**

**Subjects and design**

Eighty-eight community-dwelling women, 70 years or older, participated in this cross-sectional, experimental study with two test conditions (25°C versus 15°C room temperature). Exclusion criteria were (i) persons not able to follow instructions, (ii) the presence of uncontrolled cardiac illness, (iii) functional relevant disease, which significantly influences walking performance or leg extension and (iv) terminal illness. All the participants gave written informed consent. The study was approved by the ethical committee of the local university.

**Primary outcome**

Muscle power (force × velocity) of the lower limbs was assessed using the Nottingham power rig [16]. In a seated position, the participants were instructed to push with a single leg against a plate. After 1 sub-maximal trial of each leg, the maximum results of the left and right leg power of three trials each were summed.

**Secondary outcomes**

Sit-to-stand performance velocity was measured using a linear encoder (MuscleLab Power model MLPRO, Ergotest Technology, Langesund, Norway) fixed at the person’s hip.

Walking performance was assessed on an instrumented walkway (GAITRite® CIR Systems, Havertown, PA, USA) with normal, slow and fast speed in order to calculate step length and cadence adjusted to gait speed [17, 18]. The use of walking aids was allowed. Maximum gait speed (m/s) and
the walk-ratio (step length/cadence) [19] adjusted to 1 m/s gait speed [17, 18] were used for analysis.

Maximum quadriceps strength and hand grip strength were assessed with dynamometers (microFET2, Biometrics, Almere, The Netherlands and Jamar, MSD, Londerzeel, Belgium, respectively). Force momentum (Nm) was used as quadriceps strength outcome including force and the lever distance of the shank. For both strength measurements, the sum-value of the maxima of a single trial with both sides was used for analysis.

Skin temperature was measured (GTH 175/Pt, Greisinger, Regenstauf, Germany) proximal at the backside of the right calf.

Descriptive variables

The Short Physical Performance Battery (SPPB; habitual gait speed, standing up from a chair five-times, balance during closed stance, semi-tandem stance, tandem stance) [20], self-reported morbidity [21] and falls during the previous year, both recorded by interview, and cognition, screened by the Short Orientation Memory Concentration test (SOMC) [22] were used as descriptive variables. Furthermore, frailty was assessed including gait speed, grip strength, weight loss, exhaustion and physical activity [23].

Procedure

Participants were exposed to moderately cold (15°C) and normal/warm (25°C) temperature in a climate chamber 45 min before assessment and during all measurements. Both conditions were assessed in random order with an interval of 1 week. Clothing was standardised (thin pullover, thin long trousers). Before and between measurements, the participants were instructed to rest to avoid internal heat production by leg muscle activity.

Statistics

The study sample size was designed to provide 80% power to detect a 10% difference between test conditions. The Kolmogorov–Smirnov test was used to ascertain normal distribution. Paired samples t-test was used to show differences between both test conditions (15 versus 25°C). The significance level of all statistical procedures was set to α = 5% (two-sided). All analyses were conducted using the SPSS version 16 software (SPSS, Inc., Chicago, IL, USA).

Results

No injuries or adverse events occurred during the tests due to exposure to the cold test condition. The descriptive parameters of the cohort are reported in Table 1. The maximum score of the SPPB was reached by 59% of the women; 39% had an optimum score in the SOMC test; co-morbidity was present in 92% of the women; 14% used a walking aid; 40% reported at least one fall in the previous 12 months. None of the women fulfilled three or more frailty criteria (two criteria 5%, one criterion 1.7%).

During exposure to the cold indoor environment mean skin temperature at the shank decreased from 31.9 °C (SD: 1.59°C) to 28.6°C (SD: 1.54°C). In general, physical performance was lower in cold compared with normal/warm room temperature (Table 2). The decrease of physical performance ranged from 2 to 10% with only hand grip strength being unaffected by the cold temperature.

Discussion

The results of this study confirm our hypothesis that physical performance in older women is reduced in a cold environment. Although skin temperature was lower in the cold test condition, some older people have little perception of differences between temperatures and are unlikely to perceive they are getting colder and put on more clothes [24]. So, although we did not offer them the ability to put on an extra layer of clothes to counteract the cold environment, they would not necessarily have done so.

The amount of decrease in performance was comparable with that reported in a study investigating drop jumps in young persons [13] but lower than reported in the studies using water immersion [14, 25]. We used a climate chamber because the ecological validity of this method appears to be higher than the application of ice or immersion into cold water.

Although the decrease of performance was relatively small, it appeared after only 45 min. Especially in frail persons, longer exposure may result in clinically relevant differences because reduced muscle power is related to mobility limitation and decreased functional performance [10, 26, 27], balance problems [28] and falls risk [15]. In addition, muscle power is more strongly related to functional performance than muscle strength [10, 26]. Furthermore, walk-ratio, which was also negatively affected by the cold environment, has also been shown to be associated with risk of falling [29]. Thus, a cold room temperature may increase the risk of falling in older women. Nevertheless, women with a wide range of performance levels were included in our study, as documented by an expected percentage of fallers and some users of walking aids.
Thermal conditions should be recorded and standardised. Falls risk may be increased in a cold indoor environment. A moderately cold indoor environment decreased physical performance in community-dwelling older women in only 45 min.

Falls risk may be increased in a cold indoor environment because of an altered walking pattern and a decrease in lower limb strength and power.

Thermal conditions should be recorded and standardised when performing observational and intervention studies with repeated measurements of motor function in older women.

but were not frail and in general healthy, which is obvious when comparing results of maximum gait speed [30] and SPPB scores [20] with reference populations. Hand grip strength was not affected by the cold environment. This could be explained by the fact that before and during assessments the use of hands/arms was not restricted, whereas the use of legs was restricted to avoid heat production by muscle activity.

The present study has several strengths and limitations that should be addressed. Strengths include the fairly large sample and the standardised measurement procedures. Limitations include the convenience sampling of non-frail women aged 70–95, which means that results cannot be generalised to men and to women younger than 70 years.

In conclusion, a moderately cold indoor environment decreased physical performance in community-dwelling older women. The results of the study indicate that observational and intervention studies with repeated measurements of motor function should record and standardise thermal conditions. To answer the question, “which is the best environment temperature for optimal physical performance in older people?”, future studies should include frail men and women with a wider range of cognition to be assessed under several thermal test conditions.

**Key points**

- A moderately cold indoor environment decreased physical performance in community-dwelling older women in only 45 min.
- Falls risk may be increased in a cold indoor environment because of an altered walking pattern and a decrease in lower limb strength and power.
- Thermal conditions should be recorded and standardised when performing observational and intervention studies with repeated measurements of motor function in older women.

**Conflicts of interest**

The sponsor did not have a role in the design, methods, subject recruitment, data collections, analysis and preparation of paper.

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**References**


**Table 2 Physical performance of all 88 women at 25 and 15°C room temperature**

<table>
<thead>
<tr>
<th></th>
<th>25°C room temperature mean (SD)</th>
<th>15°C room temperature mean (SD)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg power (W)</td>
<td>203.0 (74.97)</td>
<td>192.6 (66.06)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>STS velocity (m/s)</td>
<td>1.07 (0.22)</td>
<td>0.96 (0.18)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Max. gait speed (m/s)</td>
<td>1.73 (0.37)</td>
<td>1.67 (0.33)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Walk-ratio [m/(1/min)]</td>
<td>0.56 (0.08)</td>
<td>0.55 (0.08)</td>
<td>0.016</td>
</tr>
<tr>
<td>Quad. strength (Nm)</td>
<td>123.7 (34.5)</td>
<td>116.4 (35.5)</td>
<td>0.015</td>
</tr>
<tr>
<td>Hand grip (kg)</td>
<td>45.7 (9.18)</td>
<td>46.0 (8.75)</td>
<td>0.450</td>
</tr>
</tbody>
</table>

STS, sit-to-stand; Quad. strength = isometric quadriceps strength; note: sum-values of both legs/hands were calculated for leg power, quadriceps strength and hand grip.


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Functional decline of older patients 1 year after cardiothoracic surgery followed by intensive care admission: a prospective longitudinal cohort study

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Abstract

Background: there is a growing demand for cardiothoracic surgery in patients’ aged ≥65 years.

Objective: to explore which variables were independently associated with functional decline 12 months after cardiothoracic surgery followed by intensive care admission.