International Journal of Family Medicine and Primary Care

Research Article
Published: 15 Apr, 2022

Therapeutic Implications of Genetic Risk Stratification for CAD Cognitive Performance of Healthy Older Adults is Resistance to Moist Heat Exposure: Results of a Controlled Trial

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Abstract

Ageing leads to changes in temperature control mechanisms that make elderly people more vulnerable to temperatures out of their comfort range. In addition to diminished thermoregulatory mechanisms, normal ageing is associated with cognitive decline. To compare the effects of moist heat and dry heat in controlled environment on the cognitive performance among community-dwelling older persons, we carried out a controlled trial. Fifty-one healthy older adults from outpatient geriatrics clinic participated in two sets of cognition tests in two environmental conditions, one with dry heat of 32.5°C and 30% Relative Humidity (RH), and one with a humid heat of 32.5°C and 70% RH. Five tests of the Automated Neuropsychological Test Battery of Cambridge (CANTAB) were applied in order to evaluate executive function, processing speed and attention. The mean age was 73.27 years, 72.55% were female, with a mean educational level of 11.58 years. No significant difference was found in the global cognitive score between dry heat and moist heat (100.47 ± 8.91, 99.52 ± 7.57, p=0.4). In our sample of healthy physically active older adults there were no changes in cognitive performance when exposed to moist heat stress compared to dry heat.

Keywords: Aging; Cognition; Neuropsychological tests; Moist heat exposure

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Received Date: *22 Mar 2022*
Accepted Date: *08 Apr 2022*
Published Date: *15 Apr 2022*

Citation:
Leopold Busse A, Rodrigues Guedes M, Maria Trezza B, Paulo Nascimento Saldiva H, Wilson Jacob-Filho W, Teixeira Gonçalves F. Therapeutic Implications of Genetic Risk Stratification for CAD Cognitive Performance of Healthy Older Adults is Resistance to Moist Heat Exposure: Results of a Controlled Trial. Int J Fam Med Prim Care. 2022; 3(2): 1060.

Introduction

Most studies investigating the effects of thermal stress on cognitive performance have recruited young adults to ascertain how heat stress may affect abilities that are crucial for military personnel and industry workers exposed to extreme environments [1-5]. However, few studies have directly investigated the effects of heat exposure on the cognitive functioning of older adults.

Trezza's study showed in a controlled study that a sample of healthy older adults managed to maintain cognitive performance when exposed to an environment with the air temperature set at 32°C. However, individuals exposed to higher relative humidity, have shown worse cognitive performance under heat [6].

We have hypothesized that some cognitive functions of older adults would be affected by high relative humidity in the hot temperatures that are routinely recorded in many cities of the world. We have carried out a controlled trial to compare the effects of moist heat and dry heat in controlled environment on the cognitive performance among community-dwelling older persons.

Materials and Methods

Subjects

A sample of healthy older adults, non-smokers nor alcoholics aged 60 years or older was selected by convenience, from the Geriatrics Service Ambulatory of the Hospital das Clínicas of the University of São Paulo Medical School. Written informed consent was obtained from all participants. The volunteers scored at least 24 on the Mini-Mental State Examination - MMSE four or less on the Geriatric Depression Scale (GDS-15) of 15 items and at least 10 on the Short Physical

Performance Battery - SPPB [7-9].

The laboratory's internal space was divided into the machine room, temperature and relative humidity control room, calibration room and test room, which had the purpose of simulating a living room so that the volunteers felt comfortable.

Sample calculation

The sample size was calculated assuming an alpha error of 10% for two-tailed tests and 80% power. Using the "t" test for a single sample subjected to two conditions, we calculated that a sample with 53 individuals would have 80% power to detect a difference with magnitude of effect of 0.34; which was previously [10].

General procedure

We have started after approval of the Research Ethics Committee, fully complying with the Declaration of Helsinki.

On the same day, two batteries of cognition tests per volunteer were performed in two environmental conditions, one with dry heat of 32.5°C and 30% Relative Humidity (RU), and the other with moist heat and thermal stress with 32.5°C and 70% UR.

Participants were randomized between the two environmental conditions to avoid biases such as learning that can be found in the repetition of the tests.

The two test sessions were separated by a rest interval of 30 min. At the end of the two sessions, the volunteers answered a questionnaire regarding the thermal discomfort promoted in the wet heat session.

Neuropsychological test battery - CANTAB

The cognitive battery consisted of five tests of the Cambridge Neuropsychological Test Automated Battery (CANTAB), Eclipse version 3.0, which was specifically developed for comparison of repeated cognitive evaluations performed on the computer [11].

We selected tests with representative of daily living activities: PAL - Paired Associates Learning, PRM - Pattern Recognition Memory, RTI - Reaction Time. These tests evaluate executive functions, visuospacial perception, and complex attention, working memory and processing speed. The program has randomized a sequence of five neuropsychological tests, as well as the sequence of each test, in order to minimize possible bias. These selected tests with a more detailed description can be found in a previous publication [6].

Statistical analysis

The analysis was done using the MEDCALC statistical software, version 17.6. Due to the fact that variables generally met reasonable assumptions for normality and no significant outliers were detected, paired t-tests were performed to compare interval data between the two sessions.

In order to develop composite scores for cognitive domains, Z-scores were obtained using the mean of the total sample as the reference and composite scores were calculated by arithmetic means. Composite scores were then scaled so that the average performance was assigned 100 and the standard deviation was established at 15. Tests in which lower scores indicate better performance had the signs reversed.

The global composite score was obtained by the same methods, but in this case, we have used only one measure from each of the 5 tests, defined a priori as those which best represent the cognitive function evaluated: PAL total number of errors adjusted, PRM number of correct, RTI five-choice reaction time, RVP A' and SSP longest span length.

Results

Fifty-five subjects completed both trials. The mean age of the studied sample was 73.27 years (± 6.17). The average years of formal education was 11.58 (± 4.53), the mean MEEM score was 28.04 (± 1.9), the mean of GDS-15 was 1.39 (± 1.29) and the mean SPPB was 11.23 (± 0.9). Most of the subjects (74.51%) have had only one chronic disease or none. Moreover, 72.55% of participants had been practicing physical exercises regularly.

After computerized randomization, 22 (43.14%) volunteers performed the first session with dry heat and the remaining 29 (56.86%) with humid heat. No significant difference was observed between the groups in relation to: Age, schooling, comorbidities, and physical activity, SPPB, MMSE and GDS-15. In 74.5% of the participants, a higher degree of thermal discomfort was reported in the moist heat phase when compared with dry heat phase.

The comparisons of cognitive performance are shown in Table 1.

Discussion

The present study is the first to investigate the cognitive impact of isolated effects of relative humidity under heat exposure in older adults. After exposure to moist heat environment, consistent with regional climate change, healthy older adults have not shown any difference in cognitive performance compared to dry heat exposure phase. These results did not confirm our hypothesis and were different from the tendencies found in Trezza's study. In that study, there was no difference in cognitive performance between the comfort temperature of 23°C and hot passive exposure of 32°C, but worse performance was detected when there was a higher relative humidity, which had not been controlled [8].

We know that hot waves constantly cause increases in

Table 1: Comparisons between repeated measures under Dry Heat (DH) and Moist Heat (MH).

	DH	MH	*P* value*
Global Composite	**100.47 (8.91)**	**99.52 (9.43)**	**0.40**
PRM Composite Score	**100.82 (11.14)**	**99.17 (9.12)**	**0.32**
PRM Number of Correct	20.41 (2.76)	20.01 (2.53)	0.37
PRM Latency	2603.48 (1336.61)	2582.12 (986.58)	0.92
PAL Composite Score	**101.17 (15.83)**	**98.82 (12.67)**	**0.27**
PAL 1º Trial Memory Score	8.96 (4.39)	8.25 (3.21)	0.27
PAL Total Errors Adjusted	34.37 (25.01)	36.86 (23.67)	0.46
RTI Composite Score	**100.13 (12.32)**	**99.86 (12.20)**	**0.79**
5-choices Reaction Time	411.69 (100.82)	397.70 (54.42)	0.28
5-choices Movement Time	496.98 (228.52)	529.25 (226.28)	0.03
SSP Composite Score	**100.75 (11.47)**	**99.24 (10.20)**	**0.33**
SSP Span Length	4.68 (1.40)	4.70 (1.08)	0.93
SSP Time to Last Response	4327.92 (824.77)	4565 (968.01)	0.13
RVP Composite Score	**99.84 (11.88)**	**100.15 (11.70)**	**0.83**
RVP A	0.89 (0.08)	0.88 (0.09)	0.16
RVP Mean Latency	734.83 (498,47)	636.57 (185.17)	0.17

Results are presented in mean (standard deviation). *Paired *t* test

Abbreviations: PRM: Pattern Recognition Memory; PAL: Paired Associated Learning; RTI: Reaction Time; SSP: Spatial Span; RVP: Rapid Visual Processing

hospitalizations, especially in vulnerable elderly people [12].

The feeling of moist heat can be unpleasant and exhausting, especially with a longer exposure time. In a study of young men, prolonged exposure to a hot environment with progressive increase in relative humidity also demonstrated deterioration in physical performance [13].

Laboratory-based physiological studies have showed that the capacity to detect heat and to manifest appropriate physiological responses during exposure to heat can be compromised even in healthy elderly individuals [14]. However, a brief cognitive decline related to exposure to heat appears to be mediated mainly by a reduction in thermal comfort [15]. However, in our study, even with greater discomfort in the humid heat, there was no difference in cognitive performance.

The concept of cognitive reserve was originally proposed to explain discrepancies between the degree of brain pathology and cognitive outcomes [10]. Recently, this concept has been extrapolated to the context of transient insults [16]. Therefore, because the participants were active physically and highly functional, possibly influenced the maintenance of cognitive performance.

Several limitations need to be considered when interpreting the results of this study. First, the sample size was small and the calculated sample was not reached. Second, because of the study design, the time of exposure was quite brief; therefore, we do not know whether extensive exposure would affect cognitive performance. Last, the participants were very healthy, so we cannot extrapolate the results to vulnerable older adults. However, the thorough cognitive assessment as well as the rigorous temperature and humidity control of the chamber were the strengths of the present study. Thus, very appropriate conditions were created to detect differences in the two proposed conditions.

Conclusion

In our sample of healthy physically active older adults there were no changes in cognitive performance when exposed to moist heat compared to dry heat stress. Even that most of the elderly reported thermal discomfort. We recommend further research especially among vulnerable older adults.

Acknowledgement

The authors also confirm that all work was completed conforms to the provisions of the Declaration of Helsinki.

This work was supported by the [Fundação de Amparo à Pesquisa do Estado de São Paulo - FAPESP] under Grant [Number 2008-57717-6].

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