BrainProtect® - A cognitive training program with nutritional and physical counseling components: a retrospective analysis of its effects in healthy individuals

Julia Maria Falkenreck,[1] Mandy Roheger,[2] Hannah Weigert,[1] Andrea Friese,[3] Petra Jahr,[4] Ingrid Becker,[5] Gereon Nelles,[6] Elke Kalbe,[2] Maria Cristina Polidori[1,7]

[1]Ageing Clinical Research, Department II of Internal Medicine and Center for Molecular Medicine Cologne, Faculty of Medicine and University Hospital Cologne, Cologne; [2]Department of Medical Psychology I Neuropsychology and Gender Studies & Center for Neuropsychological Diagnostics and Intervention (CeNDI), University Hospital Cologne, Cologne; [3]AF Gehirntraining, Bedburg; [4]C Plus, Krefeld; [5]Institute of Medical Statistics and Computational Biology, University Hospital of Cologne, Cologne; [6]Neuromed-Campus Hohenlind, Cologne; [7]CECAD, University of cologne, Faculty of Medicine and University Hospital Cologne, Cologne, Germany

Abstract

Cognitive integrity has a multifactorial basis and is essential for quality of life and wellbeing. Several lifestyle programs including those using cognitive training have been developed in the past recent years to preserve cognitive health, but there is still debate about the most effective strategy to be used. We retrospectively analyzed data from 289 healthy participants of the BrainProtect® cognitive training program, developed by the German Association for Memory Training (Bundesverband Gedächtnistraining e.V.). Eight weekly 90-minute sessions of cognitive exercises were holistically structured to include physical exercises and nutrition counseling basing upon social interaction. The large majority (79.9%) of the participants showed improved cognitive scores after the intervention with respect to the baseline, with more than 10/69 points gained. Almost 60% felt their cognitive efficiency increased and an average increase in all cognitive domain explored could be observed.

This retrospective analysis of preliminary data suggests that BrainProtect® might improve mental fitness after 8 weeks of multidomain cognition-centered training. These encouraging results need to be confirmed in further randomized studies.

Introduction

Cognitive integrity is essential for quality of life and wellbeing. With a steadily increasing global life expectancy at birth currently averaging 73 years, the maintenance of adequate cognitive performance has become a public health priority, not only for the prevention of dementia disorders, but also as an essential part of active aging.[1] In fact, studies have shown that cognitive ability stands in context with important life outcomes, including not only academic success and job performance, but also health, morbidity and mortality.[2-5]

One reason for the urgent need of maintaining cognitive integrity is the demographic explosion with a rising number of old and very old persons being biologically younger and having a high potential of self-fulfillment and at the same time the possibility to further serving the society. The other critical implication of an adequate use of strategies for good cognitive performance as early as possible in life is the evidence of preclinical neurodegenerative processes many years prior to symptom onset of dementia, without effective intervention to prevent the illness. Cognitive impairment in general and dementia in particular have devastating effects on the ability to perform in daily life and therefore on the burden of disability worldwide.[6]

Although research shows that general cognitive ability is heritable[7,8] and stable at any age, a large body of recent evidence stands in contrast to this, indicating that intelligence can be heightened by cognitive training.[9-12] There are no particular populations participating in training programs as far as participants' age, education levels and cognitive status are concerned.[13] Currently, there is a lively scientific debate regarding the potential role of placebo effects[14] as well as methods for maintaining or enhancing cognitive performance at all ages: these include cognitive training, physical exercise, multidomain interventions, nutritional strategies and social engagement. Conflicting results concern all of these interventions including multidomain ones, likely due to the fact that standardized strategies with fixed amounts of interventions do not reach the same level of efficacy in every participant - being age-related process in general and cognitive deterioration in particular typically heterogeneous both inter- and intra-individually.[15] However, cognitive training has been rather consistently shown to be moderately effective on overall cognitive function,[16,17] on executive functions,[16] on reasoning, speed[18] and working memory.[13] Also the new WHO guideline from 2019 *reducing dementia risk* recommends cognitive training, physical

Correspondence: Maria Cristina Polidori, Ageing Clinical Research, CECAD, University of cologne, Faculty of Medicine and University Hospital Cologne, Cologne, Germany.
Tel.: 0221.478.32753.
E-mail: maria.cristina-polidori@uk-koeln.de

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activity as well as social interaction as an important part of effective prevention.[19]

Although the adoption of public health strategies to identify cognitive disturbances as early as possible during life and start adequate intervention programs is mandatory, the current scientific debate about cognitive training poses important methodological questions.[20] Therefore, research is needed to identify the most effective way to expose populations to adequate goal-oriented, person-centered and culture-tailored lifestyle interventions. To further address these questions, data was retrospectively analyzed from healthy individuals participating in a cognitive training program between 2013 and 2017. The program was developed by the non-profit German Association for Memory Training (Bundesverband Gedächtnistraining e.V., BVGT).

Materials and Methods

Data from 289 persons undergoing a cognitive training program between 2013 and 2017 was retrospectively analyzed. At the time of the investigation, participants were asked to give informed consent to the transmission and analysis of their personal data. The only exclusion criterion was unwillingness to confirm. The present analysis was approved by the Ethics Committee of the University Hospital of Cologne.

After signing informed consent, information was collected in all participants regarding sociodemographic variables (age, gender, years of education, family status, *etc*.), reasons for participation in the cognitive training program, state of health (self-perception: 1-6, with 1 representing best health perception).

BrainProtect® 1.0 is designed to stimulate as many cognitive abilities as possible through a multidomain intervention strongly centered on cognitive training. BrainProtect® consists of both team-based and individual exercises in 90-minute-sessions once a week for 8 weeks performed in small groups up to 12 persons. The sessions include a broadly-based cognitive training as described below, spaced out by simple physical workout units, nutritional counseling and social stimulation through interactive exercises. Nutritional counseling include short informative sessions spacing out the cognitive exercises and aim at improving health consciousness and self-competence by providing knowledge on the benefits of a balanced nutrition as well as practical advices and recipes adhering to a Mediterranean-type diet.

The structure of the multidomain program and its contents are presented at session begin. Each session consists of 9 cognitive tasks guided by trainers certified by the BVGT who also conduce the nutritional counseling and the workout intervals.

For the evaluation of the program whose analysis is the object of the present study, all participants underwent a pretest prior to the beginning of the sessions. This consisted of a series of assessments addressing thinking flexibility, concentration, working memory, perception, logical thinking, structure, fantasy and creativity. All participants underwent a posttest at the end of the 8-week intervention to evaluate changes in the above cited cognitive abilities. To avoid learning effects, pretest and posttest consisted of the same assignment of tasks, but differed in the content (for example different pictures, maps and sums). All exercises have been developed by the BVGT e.V.; the pre- and posttests have not been validated to date.

During the pre/posttest, participants were asked to select in two minutes from a box containing letters a maximum number of identical pairs (concentration, max. 12 points). To test learning, participants memorized a city map in two minutes, after which they underwent the task of recognizing in one minute 10 sites missing in a new map (learning, max. 10 points). To test working memory (max. 5 points), the trainer read out overall 5 calculations, consisting of additions Participants were asked to solve the sums in head with the opposite arithmetic operator (for example: 1+2-4=? > 1-2+4=?). To measure perception, participants were given two nearly identical pictures and were asked to find out the differences in one minute (perception, max. 10 points). To assess logical reasoning, participants were asked to identify in one minute 10 different associations between concepts (example: *small* relates to *big* like *short* to ….? (logical reasoning, max. 10 points). Creation of respectively 10 sentences in two minutes based upon initials of car license numbers (fantasy and creativity, max. 10 points) was given as a sixth task, followed by the structured allocation task of 12 food items in a shelf (structuring, max. 12 points). Each exercise has a maximum score. The total sum of all points adds to a maximum score of 69.

The 90-minute training during the 8-week sessions consisted of similar cognitive games and included anagrams, riddles, painting, groping, sums and rebus. The exercises were spaced by brief coordination, relaxing and breathing exercises as well as by brief lifestyle counseling sessions in plenum (nutrition, diet, physical activity, health-conscious behavior).

Data were statistically analyzed with SPSS 25.0. Descriptive statistics are expressed using absolute and relative frequencies for description of categorical variables and mean or median +/– standard deviation (SD) and quartiles for quantitative variables depending on distribution. A significance of the training effect was examined with a non-parametric comparison (Wilcoxon-test) between pretest and posttest of values of variables. Influencing factors for the change after training were analyzed by backward linear regression. Kruskal-Wallis tests and Mann-Whitney-U tests (for binary variables) were used for a comparison of independent samples, supplemented by post-hoc-tests for variables with more than two categories. A P-value <0.05 was classified as significant.

Change of cognitive assessments was evaluated as absolute difference from pretest or ratio posttest/pretest.

Results

The demographic characteristics of the study participants are displayed in Table 1. The mean age of the 289 participants was 67 years with 80% female (229 females, 67.2±12 years, 60 males, 65.7±11.6 years), 4/5 not employed, half of the group married and 48% having taken part in a cognitive training program before. Participants had 10 years of education on average and considered their own health status between good and satisfactory[2,6] (Table 1). Reasons for participation in the cognitive training program included improving memory performance, disease prevention, improving knowledge and self-assessment.

Seventy-nine% (change post- to pretest >0) of the study participants showed better posttest scores with respect to pretest. All subscores improved significantly from pre- to posttest (P=0.001) except for the subscore structured thinking (P=0.11). Age was shown to be significantly associated with the perception component amont the cognitive abilities (P=0.031).The significance was detected between age group 3 (66-80 years of age) and age group 4 (over 80 years of age). The highest improvement (best change post- to pretest) was shown in the oldest participants over 80 years of age (age group 4). In general, the younger participants showed better pretest results, the older persons showing higher changes after training (Figure 1). Education appeared to influence the sub category perception as well (P=0.042).The significance was detected between secondary school and junior high school, with graduates from the secondary

school showing better pretest results. Participants with a lower educational level displayed higher improvements in the test subcategories, especially the graduates of the junior high school.

Finally, having taken part in a cognitive training program before was associated to higher pretest performances in concentration (P=0.005) and with total scores at posttest (P=0.006) with respect to first-time participants. Again, the highest improvement was observed in first-time participants (Figure 1). No other significant results were observed.

Discussion

All cognitive abilities improved to a significant extent after 8 weeks of training. Larger pre- to posttest improvements occurred in older and less educated participants. The detected tendency that less educated persons and/or persons with a lower initial baseline score in pretest seem to profit more from cognitive training are in agreement with the findings of Meyer[19] and Kalbe *et al.*[21] Although Mewborn could not identify age and education as significant mediators of cognitive training effect,[13] the present results suggest that older persons may profit to a more significant extent from cognitive interventions as compared to younger persons although the latter start with a better cognitive performance. This

Table 1. Demographic characteristics of the participants.

Baseline characteristics	N	
Age (years)	283	66.9±12
Gender (%female)	289	229 (79.2%)
Education (years)	283	10.4±1.5
Employment (%yes)	289	61 (21.1%)
Marital status (%married)	288	145 (50.3%)
Previous participation in cognitive training (%yes)	289	139 (48.1%)
Self-perception of health	284	2.6±0.83

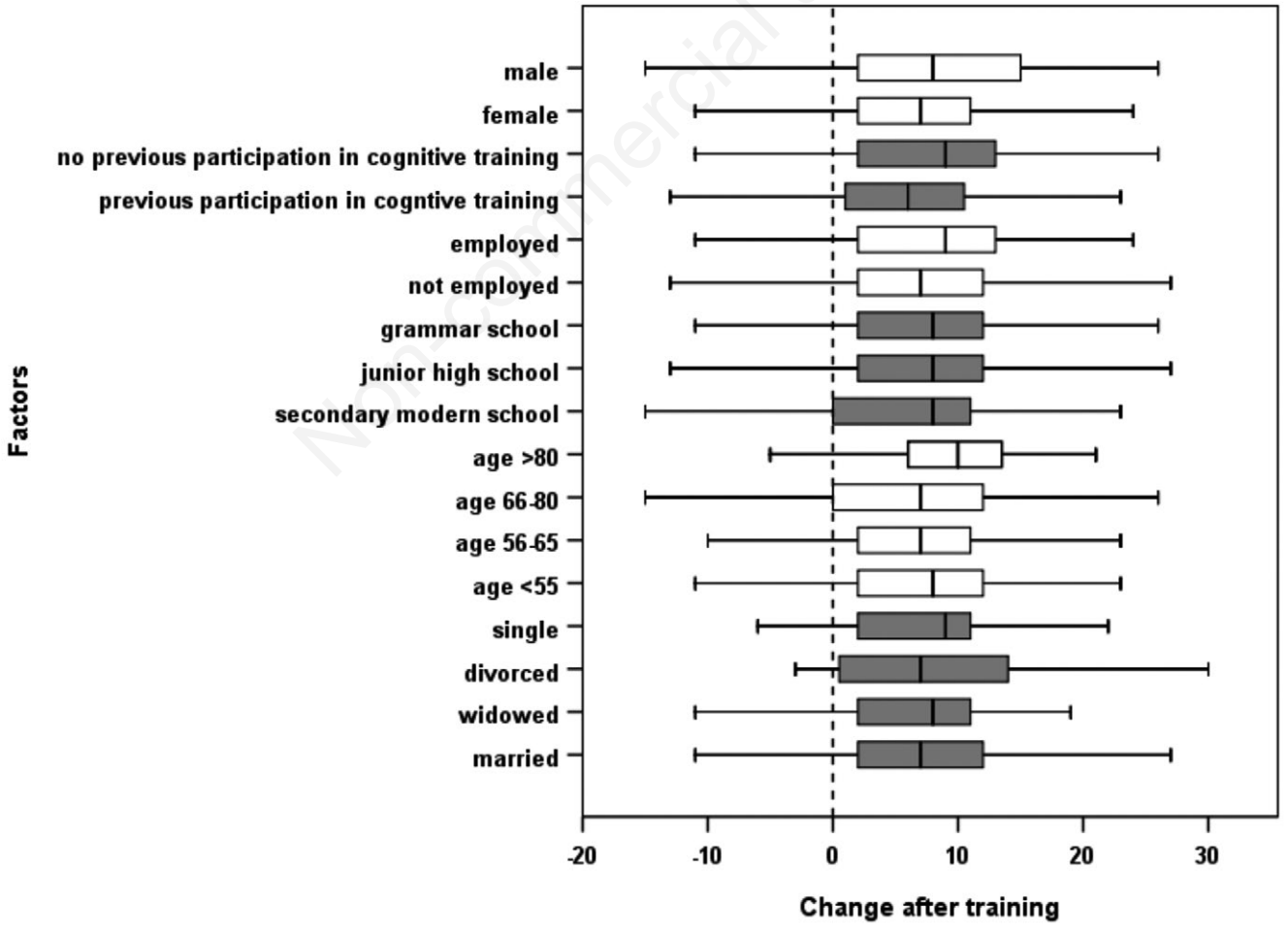

Figure 1. Boxplot; absolute change post- to pretest in total score in dependency of different factors.

finding conforms to the compensation theory of Lövden, *that baseline performance within age groups correlates negatively with instruction gains*.[22]

In addition, previous participation to a cognitive training program did not hinder the further improvement of the performance at specific subtests. These results are in agreement with the training effect on specific tests according to specific cognitive ability addressed.[17]

The two sub-categories with the greatest change from pre- to posttest were fantasy and creativity (+46.4%) and perception (+35.13%) (Table 2).These abilities are usually not trained daily, neither are they usually required in common professional or in daily living activities, in contrast for instance to structured thinking or concentration. This observation is in agreement with the knowledge that the brain possesses much more potential than is actually stimulated. This may also explain the strong change shown after the training in the relative subscores.

In the present analysis, the average test person is a married woman, 67 years old, attended the junior high school, absolved an apprenticeship, but is not employed anymore (Table 2), which might represent a typical target population for cognitive training programs. In addition to prevention purposes, cognitive training has been shown to positively affect wellbeing, and in fact more than 50% of the participants could confirm to feel significantly better after the 8-week intervention. This corresponds to previous results[16] and might partly be related to the training format, in which the interaction in small groups favors the quality of communication and interpersonal verbalization.

In addition, the perception of doing something beneficial for oneself as far as physical and mental health is concerned is an important factor guaranteeing a long-lasting effect of preventive strategies. This might explain the repeated beneficial training effect beyond learning shown in participants who had already undergone training previously, as suggested by previous research showing that a good feeling and motivation do reinforce the effect of exercising.[23]

As mentioned above, studies argue on the real effect of cognitive training[24-29] and criticize study designs not able to capture placebo effects.[14] However, and in light of the current demographic transition, the results of this and other investigations indicate that there is a benefit in participating in cognitive training programs. In the absence of any identified adverse effect, it is difficult to discourage adequate interventions in this sense. For instance, cognitive training was shown to ameliorate functioning of older persons as measured by means of the instrumental activities of daily living,[30] a highly relevant result in light of the average 8 years lived with disability in those countries with life expectancy at birth over 70 years (WHO).

Finally, the BVGT training model (once a week for two months) does not conform to the recommended formats of twice a week for three months[20] and of three times a week for two months.[16,19] However, this could support practicability in older participants, enhance compliance and adherence to the counseling suggestions.

The present investigation has several limitations. First of all, its retrospective nature without a control group and follow-up hinders the full interpretability of the results. However, as mentioned above, cognitive tests showed higher scores and all participants without exclusion subjectively experienced improved wellbeing. A second important limitation of the present study is that the pre- and posttests were not validated before. However, the results are unequivocal and the effects of the intervention pronounced, therefore this preliminary retrospective analysis will constitute the base of the randomized controlled trial BrainProtect® 2.0 which will use validated pre- and post-tests. Third, the recruitment in the study presented here did not follow the classical triaging on the basis of exclusion and inclusion criteria; however, the original aim of the evaluation was to look at the effects of a largely established Nation-wide training under real-life conditions.

Conclusions

In conclusion, the present study, based on a retrospective analysis of preliminary data lacking a robust validated indicator of cognitive performance, suggests that the multidomain, cognitive training-centered

Table 2. Improvement after training in different subcategories.

Subcategory	Absolute change post- to pre-test mean ± standard deviation median (quartiles)	Relative ratio post-/pre-test mean	P value
Concentration (select from a box containing letters a particular one and write down in two minutes the number)	1.1±2.36 1 (0-2)	0.1644	0.001
Learning ability(add in two minutes in an empty city map as many locations as possible previously shown in a separate city map)	1.03±2.24 1 (–0.5-2.5)	0.2401	0.001
Perception(find in one minute as many errors as possible on a picture)	1.17±2.25 1 (0-3)	0.3513	0.001
Logical reasoning(identification of 10 different associations between concepts in one minute)	1.25±2.37 1 (0-3)	0.2765	0.001
Structured thinking(listing of 12 given food items according to geographical origin in two minutes)	0.35±3.79 0 (2-3)	0.5220	0.110
Working memory (8 presented additions and subtractions to solve as the opposite calculation, 1 ½ minute)	0.76±1.49 1 (0-2)	0.2274	0.001
Fantasy & creativity(Creation of sentences based upon initials of car licence numbers, two minutes)	1.61±2.19 1 (0-3)	0.4640	0.001
Total score (sum of scores)	7.26±7.63 8 (2-12)	0.2288	0.001

BrainProtect® program might improve cognitive abilities after 8 weeks of weekly training. The effect seems only partly influenced by factors like age and education and appears to be more prominent in older participants and in those with less education years. More research is mandatory to confirm these observations in randomized studies using validated tests of cognitive function.

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