Journal of Science and Medicine in Sport 17 (2014) 51–55

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Effects of acute resistance exercise on cognition in late middle-aged adults: General or specific cognitive improvement?

Yu-Kai Chang[a,*], Chia-Liang Tsai[b], Chi-Chang Huang[c], Chun-Chih Wang[a], I-Hua Chu[d]

[a] Graduate Institute of Athletics and Coaching Science, National Taiwan Sport University, Taoyuan, Taiwan
[b] Institute of Physical Education, Health and Leisure Studies, National Cheng Kung University, Tainan, Taiwan
[c] Graduate Institute of Sports Science, National Taiwan Sport University, Taoyuan, Taiwan
[d] Department of Sports Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan

ARTICLE INFO

Article history:
Received 30 November 2011
Received in revised form 4 February 2013
Accepted 15 February 2013

Keywords:
Cognitive ageing
Executive function
Neuropsychological assessment
Strength training

ABSTRACT

Objectives: To evaluate the effect of acute resistance exercise on multiple cognitive measures in late middle-aged adults and to address the question of whether general or selective cognitive improvements occur.
Design: A counterbalanced repeated-measures experimental design.
Methods: Thirty adults (mean age = 58.1 ± 3.0 years) were administered five different Stroop test conditions before and after a single bout of resistance exercise and after a no-treatment control. The resistance exercise protocol involved two sets of seven exercises performed at 70% of a 10-repetition maximum, with 30 and 60 s between each set and each exercise, respectively.
Results: The exercise treatment resulted in significantly enhanced performance across all Stroop conditions when compared with the control ($p < .001$). Furthermore, the effect of the exercise treatment on Stroop incongruent performance corresponded to the largest positive influence compared to the performance observed under the other four Stroop test conditions.
Conclusions: These findings extend the current knowledge base by demonstrating that acute resistance exercise facilitates general cognition but has a more beneficial effect on cognition that involves executive control.

1. Introduction

With advancing age, adults frequently experience cognitive declines and brain decay.[1,2] However, there are several interventions that may reverse age-related cognitive declines, and acute exercise is one such intervention that has received particular attention over the last decade.[3,4]

While emerging research has suggested that acute exercise facilitates cognitive performance, most of these studies have only tested the effects of aerobic forms of exercise.[3,4] However, it is important to consider the possibility that resistance exercise may also benefit cognitive performance. This is particularly relevant because resistance exercise is considered an important component of exercise programmes designed to improve health.[5] Additionally, the benefits of resistance exercise have recently been proposed to extend to cognition with the conclusions of two reviews indicating that chronic resistance training enhances cognitive performance in older adults.[6,7] Nonetheless, research examining the effects of acute resistance exercise on cognitive performance is more limited,[8–10] and substantially more research is needed to facilitate our understanding of whether acute resistance exercise benefits different types of cognitive performance equally.

In reviewing the literature on exercise and cognition, Colcombe and Kramer[11] used a theoretical framework to divide cognitive performance into four primary categories, speed, visuospatial, controlled and executive control, and suggested that chronic exercise affects executive function in particular. Executive function is a higher-order cognitive function involved in goal-directed behaviour and includes multiple aspects of cognition that are essential for daily life, including planning, inhibition, updating, scheduling and initiation.[12] In contrast to the stronger effects observed for executive function measures in the chronic exercise literature, there is a lack of consensus regarding the magnitude of the effects of acute exercise on specific types of cognition. For example, Hillman and colleagues examined the effects of moderately intense acute exercise on cognitive performance on a task that included conditions that allowed for an examination of the effects on basic information processing as compared to executive

* Corresponding author.
E-mail address: yukaichangnew@gmail.com (Y.-K. Chang).

1440-2440/$ – see front matter © 2013 Sports Medicine Australia. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jsams.2013.02.007

function. Their results showed that the benefits of acute exercise were greater for the executive function condition than for the basic information processing condition.[13,14] In contrast, a recent meta-analysis by Lambourne and Tomporowski indicated that acute exercise has similar positive effects on both executive function and basic information processing.[3] The controversy over whether the effects of acute exercise are general or have a selective benefit for particular types of cognitive performance is difficult to resolve because inconsistent cognitive tasks have been employed across previous studies.[15] Thus, a task involving multiple cognitive processes might allow further exploration of this issue.

In the present study, we applied a widely used task, the Stroop test. This is a colour-naming task that includes various conditions that allow for the assessment of performance on several different cognitive processes.[16] Additionally, the Stroop test has been demonstrated to show more pronounced results in older adults[17] and to be responsive to both acute aerobic exercise[8,9] and resistance exercise.[18] While a few studies have investigated the effects of acute exercise on Stroop test performance, the present study extends these findings by exploring the effects on the performance of five Stroop test conditions (i.e., congruent, word, colour, neutral and incongruent). The inclusion of these five conditions allows for an examination of the effects of acute exercise on the cognitive processes of facilitation, interference, basic information processing and executive function.

The purpose of this study was to extend the current literature by focusing on changes in Stroop test performance following acute resistance exercise conducted by ageing adults. More specifically, this study attempted to investigate the magnitude of the effects of acute exercise on multiple cognitive processes to determine whether the results represent general or selective cognitive improvements. On the basis of meta-analytical data,[3] we anticipated that general improvement would be observed following acute resistance exercise.

2. Method

Thirty community-dwelling adults, aged 55–70 years, from Taoyuan, Taiwan, were recruited. These participants satisfied two criteria: (a) they met the requirements of the physical activity readiness questionnaire (PAR-Q), ensuring their safety when performing a single bout of exercise and (b) they achieved a score on the Chinese version of the mini-mental state examination (MMSE) of more than 26, verifying that they were considered to be cognitively normal.[19] They also completed several other questionnaires, including the international physical activity questionnaire (IPAQ), which is an international surveillance questionnaire used to assess levels of physical activity.[20] Detailed characteristics of the participants are presented in Table 1. The number of participants was determined by means of a power analysis (G*Power 3.0) using a 2×2 mixed design with alpha = 0.05, power = 0.80 and the effect size, $f = 0.31$.[9] The protocol was approved by the National Taiwan Sport University Institutional Review Board for human investigation.

The Stroop test was specifically applied to measure multiple cognitive functions. During the test, each participant was instructed to identify verbally, as quickly as possible, the ink colour of the stimulus presented in each condition. The Stroop test in the present study was modified from that of Trenerry and colleagues (reliability of 0.90)[21] and consisted of five conditions: congruent, word, colour, neutral and incongruent. All of the conditions included 50 stimuli, but they contained different stimuli. The stimuli for the congruent condition were colour names written in the same colour of ink (e.g., BLUE written in blue ink, RED written in red ink). For the word condition, the stimuli were colour names written in black ink (e.g., BLUE written in black ink, RED written in black ink). For the colour condition, the stimuli were rectangles drawn in coloured ink (e.g., a blue rectangle, a red rectangle). For the neutral condition, the stimuli were words unrelated to colour written in coloured ink (e.g., TABLE written in blue ink, BOOK written in red ink). For the incongruent condition, the stimuli were colour names printed in a different colour ink (e.g., BLUE written in red ink, RED written in blue ink). Participants were asked to identify the colour of ink in all of the conditions. The stimuli for each condition were displayed on a sheet of paper presented by an experimenter, and the participants were asked to name the conditions from top to bottom (10 stimuli) and left to right (5 columns). Performance on the Stroop conditions was indexed based on reaction times, which were assessed using a hand-held stopwatch.

The participants came to the laboratory individually on three different occasions, at least 48 h apart, over a 10-day period. Visit 1 entailed the baseline assessment. Each participant was presented with a brief introduction to the experiment and was required to provide written informed consent. The participant then completed the PAR-Q, MMSE, IPAQ and a health history questionnaire and provided demographic details. They were subsequently instructed to attach a heart rate (HR) monitor (Mode S 610i; Polar Electro, Finland) and sit quietly in a dimly lit room for 15 min. At the conclusion of the 15-min period, their resting HR was assessed. A warm-up was then performed (e.g., a specific warm-up involving stretches for all of the major muscle groups), and the participant's 10-repetition maximum (RM) for each of seven exercises was determined by a trained fitness instructor. The seven exercises were a biceps curl-right, biceps curl-left, lat pull down, chest press, chest fly, leg curl and leg press. The 10-RM for each exercise was determined following the guidelines of the 10-RM testing protocol.[22]

Participants were tested during two additional visits with the particular treatment on each day counterbalanced across the participants to minimise order and practice effects. At both of these visits, participants were given instructions for the Stroop test and performed all five conditions of the Stroop (pre-test). Participants then performed their assigned treatment and were administered all five conditions of the Stroop test again (post-test).

In the resistance exercise treatment, participants warmed up for 10 min and conducted the resistance exercises for 20–25 min. The resistance exercises included two sets of the seven resistance exercises performed at 70% of the 10-RM for each exercise. The rest periods for each set and for each exercise were 30 and 60 s, respectively. The protocol design was based on a previous study,[8] which indicated that this protocol had an positive influence on cognitive performance. In the no-treatment control, participants were asked to read materials related to physical activity and mental health for approximately 30 min.

The HR monitor was worn during visits 2 and 3. Three HR measurements were taken: the pre-test HR, treatment HR and post-test HR. The pre-test HR was determined 60 s before performance of the first Stroop test (pre-test); the treatment HR was the average HR during the treatment (resistance exercise or reading); and the post-test HR was assessed 60 s before each participant performed the Stroop test for the post-test. Ratings of Perceived Exertion (RPE)[23] were also assessed at the end of each physical exercise. Following the three visits, participants were given US$30 for compensation and debriefed by a member of the research team.

As a manipulation check, a two-way (2 [treatment] $\times$ 3 [time]) repeated-measures analysis of variance (ANOVA) was carried out to determine the effect of exercise on HR. A one-way repeated-measures ANOVA for the average reaction time (pre-test and post-test in both treatments) was initially performed to determine if there were differences in terms of Stroop test performance between the five Stroop test conditions. To analyse the effect of