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 d, 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

A R T I C L E   I N F O
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

A B S T R A C T

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.

© 2013 Sports Medicine Australia. Published by Elsevier Ltd. All rights reserved.

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 Kramer11 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
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 adults17 and to be responsive to both acute aerobic exercise8,9 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.13 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, $f^2 = 0.31$.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 Treynery 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,6 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] × 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
exercise on the Stroop test, a two-way (2 treatment × 5 Stroop test condition) repeated-measures ANOVA was performed, where the dependent variable was the time difference between the pre- and post-tests.

Follow-up simple main effects analyses were performed when significant interactions were detected. Greenhouse–Geisser corrections were applied to tests when Mauchly’s test of sphericity was violated. Bonferroni adjustments were applied to control the alpha inflation. Estimates of effect were also calculated size using Cohen’s d and partial eta-squared ($\eta_p^2$).

3. Results

The results of the 2 × 3 repeated-measures ANOVA revealed a significant treatment × condition interaction ($F[2,58]=181.85, p<.001$, $\eta_p^2 = .86$) that accounted for 86% of the variance in HR. A breakdown of the interaction into simple treatment effects at each time point revealed that there were differences in HR as a function of treatment for the measures of treatment HR ($F[1,29]=192.31, p<.001$, $\eta_p^2 = .87$) and post-test HR ($F[1,29]=186.41, p<.001$, $\eta_p^2 = .87$), but no difference emerged for pre-test HR.

There was a main effect for treatment on HR ($F[1,29]=158.98, p<.001$, $\eta_p^2 = .85$) that accounted for 85% of the variance in HR. Pairwise comparisons revealed that HR was higher for participants in the exercise treatment as compared to those in the control treatment ($p<.001$). There was also a main effect for time ($F[2,58]=102.81, p<.001$, $\eta_p^2 = .78$), which accounted for 78% of the variance in HR. Pairwise comparisons revealed that both treatment HR and post-test HR were significantly higher than pre-test HR ($p's<.001$). The average RPE value assessed during the exercise treatment was 14.90 ± 1.30.

The one-way repeated-measures ANOVA revealed significant differences among the five Stroop conditions ($F[4,116]=408.10$, $p<.001$, $\eta_p^2 = .93$). A post hoc analysis with Bonferroni adjustment revealed significant differences among all conditions, with performance in the incongruent condition being the slowest (45.09 ± 7.50) and with performance becoming significantly faster across the remaining conditions: neutral (28.49 ± 4.10), colour (25.47 ± 4.13), word (21.43 ± 3.46) and congruent (19.80 ± 3.51) ($p's<.001$; see Table 2).

The results of the 2 × 3 repeated-measures ANOVA showed a significant treatment × condition interaction ($F[4,116]=.644$, $p<.001$, $\eta_p^2 = .18$) that accounted for 18% of the variance in reaction time. Within-participants contrasts for the interaction of treatment by condition revealed that the exercise treatment resulted in a significantly larger differences in reaction time scores between pre-test and post-test than the control treatment in all Stroop conditions: incongruent ($F[1,29]=21.33, p<.001$, $\eta_p^2 = .42$), neutral ($F[1,29]=17.20, p<.001$, $\eta_p^2 = .37$), colour ($F[1,29]=27.06, p<.001$, $\eta_p^2 = .48$), word ($F[1,29]=25.18, p<.001$, $\eta_p^2 = .47$) and congruent ($F[1,29]=38.13, p<.001$, $\eta_p^2 = .57$). Additionally, a significant effect was found for the exercise treatment ($F[4,116]=24.89, p<.001$, $\eta_p^2 = .46$), wherein pairwise comparisons revealed that incongruent condition (−11.36 ± 1.52) was associated with larger difference scores for reaction times than the neutral (−3.78 ± 0.48), colour (−3.11 ± 0.53), word (−3.71 ± 0.66) and congruent (−2.90 ± 0.41) conditions ($p's<.001$). A significant effect was also found in the control treatment ($F[4,116]=11.95, p<.001$, $\eta_p^2 = .29$), where the incongruent (−3.94 ± 1.02) and neutral (−1.43 ± 0.42) conditions resulted in significantly larger difference scores in reaction times than the colour (−0.38 ± 0.42), word (0.53 ± 0.41) and congruent conditions (0.77 ± 0.36) ($p's<.029$). The difference scores between

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>15</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Age (years)</td>
<td>59.07 ± 2.96</td>
<td>57.20 ± 2.83</td>
<td>58.13 ± 3.00</td>
</tr>
<tr>
<td>Education (years)</td>
<td>14.13 ± 2.33</td>
<td>11.73 ± 3.17</td>
<td>12.93 ± 2.99</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>168.00 ± 6.15</td>
<td>157.50 ± 6.56</td>
<td>162.75 ± 10.62</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.47 ± 7.72</td>
<td>58.33 ± 10.38</td>
<td>63.90 ± 10.62</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.62 ± 2.50</td>
<td>23.43 ± 3.32</td>
<td>24.02 ± 2.95</td>
</tr>
<tr>
<td>IPAQ (METs/wk)</td>
<td>836.53 ± 489.32</td>
<td>854.80 ± 722.45</td>
<td>845.67 ± 606.34</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>65.27 ± 9.90</td>
<td>67.20 ± 8.74</td>
<td>66.23 ± 9.22</td>
</tr>
<tr>
<td>MMSE</td>
<td>28.33 ± 1.35</td>
<td>28.80 ± 1.32</td>
<td>28.57 ± 1.33</td>
</tr>
<tr>
<td>10 Repetition maximal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps curl-right (lb)</td>
<td>25.92 ± 5.55</td>
<td>15.56 ± 3.48</td>
<td>20.21 ± 6.84</td>
</tr>
<tr>
<td>Biceps curl-left (lb)</td>
<td>25.00 ± 5.99</td>
<td>16.84 ± 4.78</td>
<td>20.50 ± 6.68</td>
</tr>
<tr>
<td>Back lat pull down (lb)</td>
<td>83.92 ± 10.44</td>
<td>56.63 ± 10.74</td>
<td>68.86 ± 17.31</td>
</tr>
<tr>
<td>Chest fly (lb)</td>
<td>51.46 ± 8.77</td>
<td>28.88 ± 7.28</td>
<td>39.00 ± 13.86</td>
</tr>
<tr>
<td>Chest press (lb)</td>
<td>87.46 ± 21.98</td>
<td>55.63 ± 18.67</td>
<td>69.90 ± 25.56</td>
</tr>
<tr>
<td>Leg curl (lb)</td>
<td>64.38 ± 16.78</td>
<td>47.56 ± 12.34</td>
<td>55.10 ± 16.57</td>
</tr>
<tr>
<td>Leg press (lb)</td>
<td>154.23 ± 24.43</td>
<td>130.19 ± 20.38</td>
<td>140.97 ± 25.03</td>
</tr>
</tbody>
</table>

BML, body mass index; bpm, beats per min; IPAQ, International Physical Activity Questionnaire; METs/wk, metabolic equivalents per week; Resting HR, resting HR assessed in occasion One; MMSE, mini-mental state examination.

**Table 2**

Means (±1 SD) and effect sizes for Stroop test results in control and exercise treatments.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Control treatment</th>
<th>Exercise treatment</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test</td>
<td>Post-test</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ES</td>
</tr>
<tr>
<td>Congruent</td>
<td>19.11 ± 3.61</td>
<td>19.88 ± 3.85</td>
<td>0.21</td>
</tr>
<tr>
<td>Word</td>
<td>20.85 ± 3.73</td>
<td>21.34 ± 3.81</td>
<td>0.14</td>
</tr>
<tr>
<td>Colour</td>
<td>25.21 ± 4.22</td>
<td>25.17 ± 4.27</td>
<td>−0.01</td>
</tr>
<tr>
<td>Neutral</td>
<td>29.68 ± 4.52</td>
<td>28.25 ± 4.43</td>
<td>−0.32</td>
</tr>
<tr>
<td>Incongruent</td>
<td>46.89 ± 8.36</td>
<td>43.95 ± 7.26</td>
<td>−0.38</td>
</tr>
</tbody>
</table>

|            | Pre-test           | Post-test          | ES |
|            |                   |                    |    |
|            | 21.55 ± 3.89       | 18.65 ± 3.92       | −0.74|
| Word       | 23.59 ± 4.47       | 19.88 ± 3.41       | −0.93|
| Colour     | 27.30 ± 5.27       | 24.19 ± 4.34       | −0.64|
| Neutral    | 30.91 ± 5.01       | 26.13 ± 4.41       | −1.01|
| Incongruent| 50.94 ± 11.78      | 39.59 ± 7.75       | −1.14|

Effect size (ES) is calculated using Cohen’s d. Higher negative values represent better performance.
the post-test and pre-test for both treatments under each Stroop test condition are illustrated in Fig. 1.

There were also significant main effects for treatment ($F[1,29]=44.98, p<.001, \eta^2_p = .61$) and condition ($F[4,116]=27.30, p<.001, \eta^2_p = .49$), which accounted for 61% and 49% of the variance in reaction time, respectively. Pairwise comparisons revealed a significantly larger difference in reaction time scores in exercise treatment compared to control treatment ($p<.001$). Pairwise comparisons also revealed significant differences on condition, with incongruent and neutral condition show significantly larger differences in reaction time scores than the other three conditions ($p's<.001$).

4. Discussion

Previous exercise-cognition research using the Stroop test has not examined multiple cognitive functions using a similar cognitive test. The results of this study not only demonstrated standard “facilitation”, in the form of a shorter reaction time in congruent tests compared with neutral ones, but also revealed facilitation under the word and colour conditions. In contrast, the incongruent condition was associated with an “interference” effect, as a longer reaction time was observed under the incongruent condition compared with the neutral condition; the reaction time for the incongruent condition was approximately twice as long as that for the other conditions. This last finding supported the notion that the incongruent condition involved executive function, which has been shown in previous studies.17,24

The improved difference scores obtained across all Stroop test conditions for the resistance exercise treatment relative to the control treatment suggest general cognitive improvements. These findings are consistent with those of recent studies indicating that acute resistance exercise involving upper body exercises has advantageous effects on the results of the word, colour and incongruent conditions.8,9 The present findings broaden the literature by focusing on resistance exercises involving whole body exercise and include additional Stroop test conditions (i.e., the congruent and neutral conditions). However, the results lie in contrast with those of a study conducted by Pontifex et al.,10 who indicated that facilitative effects on working memory and executive function were only found for aerobic exercise and not resistance exercise. Given the multifaceted constructs within executive function, these inconsistent results might be attributed to the sub-types of executive function emphasised by these studies. Etter and Chang12 have argued that both the exercise modality and the specific aspect of executive function tested might influence the relationship detected between acute exercise and cognition and that these potential moderators should be considered.

Previous researchers have suggested that exercise-induced arousal, as indicated by heart rate and catecholamine levels, may be a mechanism that mediates the relationship between acute aerobic exercise and cognition.25 Recently, Winter et al.26 proposed that plasma brain-derived neurotrophic factor (BDNF) and catecholamine levels induced by aerobic exercise are associated with superior learning. Similar to findings related to aerobic exercise, changes in heart rate and catecholamine levels have also been associated with resistance exercise.8,9,27 The catecholamines secreted during resistance exercise are believed to provide optimal force and energy supplementation.28 Our behavioural measurements do not permit direct conclusions to be made regarding potential psycho-biological mechanisms. Nonetheless, changes in arousal and specific physiological mechanisms might explain the general facilitation of performance for all Stroop test conditions associated with resistance exercise.

Analyses revealed that the largest difference between pre-test RT and post-test RT as a function of exercise was observed for the incongruent condition, suggesting a selective improvement in Stroop task performance. When the incongruent condition is performed, task-irrelevant words need to be inhibited and only the colour must be recognised. Given that reading a word is a more automatic task than identifying the colour of ink a word is written in, succeeding in the incongruent poses a challenge, and the task likely engages several executive functions, including selective attention, inhibition and cognitive flexibility.29 Therefore, the improved incongruent condition performance suggests that acute resistance exercise may have a particularly facilitative effect on executive function.

This selective improvement is consistent with that seen in past studies that have observed selective incongruent/executive function benefits following acute aerobic exercise.13,14 These past studies also examined P3, an event-related potential (ERP) component that reflects attention resource allocation, to elucidate the underlying cognitive processes affected by acute exercise. Using the neuroelectric index, Hillman and colleagues observed that acute exercise increased the P3 amplitude, particularly under incongruent conditions, suggesting that acute exercise could alter attention resource allocation to improve performance on tasks involving executive function. Alteration of attention resource allocation may be an appropriate interpretation of the selective effect because the interference effect observed when comparing the performance under the congruent and incongruent conditions is believed to result in competition between attention resources.30 The effect of resistance exercise on performance in the incongruent condition may also be attributed to the activation of specific brain regions. Using functional near-infrared spectroscopy, Yanagisawa et al.31 showed that acute aerobic exercise improves performance under the incongruent condition and increases the activation of the left dorsolateral prefrontal cortex (LDPC), suggesting that the LDPC is an exercise-related neural substrate for Stroop interference aspects of executive function. The similar incongruent effect found in these two studies mentioned provides a basis for examining exercise modality and executive function by applying neuroimaging analysis.

Insulin-like growth factor-1 (IGF-1), an alternative mechanism underlying the effects of resistance exercise on cognition in ageing adults, can be specifically proposed. IGF-1 is inversely related to age.32 Research has provided evidence that this decline in IGF-1 is associated with age-related cognitive impairment.33 Although
aerobic exercise can increase IGF-1, Kraemer and Ratamess have shown that IGF-1 plays a major role in regulating skeletal muscle hypertrophy and stimulating protein synthesis during resistance exercise, which suggests a mechanistic role for IGF-1 in resistance exercise and cognition.

Although the present study revealed approaches for improving cognition, the results were only based on a group of late middle-aged adults with intact cognition and therefore cannot be generalised to other populations. Given that various cognitive functions begin to decline in the early 20s and that ageing adults frequently encounter age-related cognitive impairments (e.g., Alzheimer’s disease and dementia), future investigations regarding the relationships between resistance exercise and various types of cognitive performance and cognitive impediments in older adults are necessary. Furthermore, measurement of mean reaction time is considered to provide a global behavioural index, but does not provide evidence regarding underlying processes. It is possible to explore underlying processes by applying a fractionated reaction time to differentiate between central and peripheral factors, by using the ERP to delineate stimulus and response conflicts within the Stroop test and by using neuroimaging to localise the brain regions involved when completing the Stroop test. Future research should consider examining the effects of acute exercise on the underlying processes by adopting interdisciplinary approaches to further our understanding.

5. Conclusion

This study has extended the literature by providing evidence that acute resistance exercise has positive impacts on multiple cognitive functions, as assessed by the Stroop test in late middle-aged adults. More specifically, acute resistance exercise not only resulted in general cognitive facilitation but also selectively improved cognition related to executive function. As several plausible mechanisms are proposed herein, further research on the relationship between resistance exercise and cognition should be conducted to advance the understanding of how and why resistance exercise influences cognition in ageing adults.

Practical implications

• Acute resistance exercise consisting of two sets of seven exercises performed at 70% 10-RM improves cognition in late middle-aged adults.
• This acute resistance exercise protocol influences a variety of cognitive functions in a positive way.
• The acute resistance exercise protocol is particularly beneficial to executive cognitive functions.

Acknowledgements

We sincerely thank Drs Costas I. Karageorghis and Jennifer L. Etiner for offering comments on earlier drafts of this paper. The research was supported in part by a grant from the National Science Council (NSC 99-2410-H-179-001).

References