Effects of an acute bout of localized resistance exercise on cognitive performance in middle-aged adults: A randomized controlled trial

By: Yu-Kai Chang and Jennifer L. Etnier

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Abstract:

Objectives. To examine the effect of an acute bout of resistance exercise on cognitive performance in healthy middle-aged adults. **Design.** A randomized controlled trial design. **Methods.** Forty-one adults (M_{age} = 49.10 years, SD = 8.73) were randomly assigned to either resistance exercise or a control condition. The resistance exercise condition consisted of 2 sets of 10 repetitions for 6 exercises, and the control condition involved reading about resistance exercise for a time period approximating the duration of the exercise condition. The Stroop Test and the Trail Making Test (TMT) were completed at baseline and immediately following performance of the treatment. **Results.** Results indicated that resistance exercise significantly benefits speed of processing (Stroop Word and Stroop Color), and that there is a trend towards resistance exercise benefiting performance on an executive function task (Stroop Color–Word) that requires shifting of the habitual response. However, the results for the TMT were not significant which demonstrates that acute resistance exercise has a limited effect on inhibition. **Conclusion.** The present findings extend the literature by indicating that an acute bout of *resistance exercise* has a positive impact on automatic cognitive processes and on particular types of executive function in *middle-aged adults*.

Keywords: Resistance exercise | Cognition | Executive function | Inhibition

Article:

Adults frequently experience deterioration in cognitive functions, such as information processing speed, reasoning, and memory, as a result of advancing age (Albert et al., 1995, Fonda et al., 2005). Fortunately, research indicates that the rate of age-related cognitive decline varies across individuals. People who experience better health and cognition as they age are identified as the “successful aging” group (Rowe & Kahn, 1997) and physical activity is recognized as a candidate for decreasing the risk of dementia and cognitive decline associated with advancing age (Rogers, Meyer, & Mortel, 1990). Although there is evidence to support a beneficial effect of a physical activity program on cognition in older adults (Colcombe and Kramer, 2003, Etnier et al., 1997), evidence related to the beneficial effects of a single bout of exercise on cognitive performance is less clear and research examining the effects of physical activity on cognitive performance by middle-aged adults is sparse. Given that age-related decline in cognitive abilities may appear as early as the 1920 (Salthouse, 2004), it is important for research to test the potential for physical activity (either chronic or acute) to impact the cognitive performance of middle-aged adults. The focus of this study is on the potentially beneficial effects of acute exercise to the cognitive performance of middle-aged adults.

Tomporowski (2003) reviewed the literature on acute exercise and cognitive performance irrespective of age. Although Tomoporowski acknowledged that results from empirical studies examining the effects of aerobic exercise on cognitive performance were inconsistent, he concluded that acute, moderate sub-maximal exercise of 30–60 min generally results in a positive effect on cognitive performance. This conclusion is consistent with findings of a meta-analytic review (Etnier et al., 1997), which demonstrated a significant small positive effect of acute exercise on cognitive performance (effect size = 0.16). Most of the research examining the effects of an acute bout of exercise on cognitive performance has focused on younger adults (Adam et al., 1997, Arcelin et al., 1997, Arcelin et al., 1998, Tomporowski et al., 2005), younger elite athletes (Davranche and Audiffren, 2004, McMorris and Graydon, 2000), and older adults with cognitive impairment (Heyn, Abreu, & Ottenbacher, 2004). Although the findings generally support a beneficial effect of acute exercise, the extant literature is limited by the focus on these three populations, and the effects in "healthy" community-dwelling middle-aged adults have not been sufficiently examined.

A second limitation of the existing research on the cognitive benefits of acute exercise is that the focus has been on continuous exercise modalities, such as jogging or cycling (see Brisswalter et al., 2002, McMorris and Graydon, 2000, Tomporowski, 2003). Research has not yet tested whether or not similar effects can be observed following resistance exercise. Given the mechanisms that have been proposed to underlie the relationship between acute exercise and cognitive performance, there is every reason to expect that resistance exercise might also result in beneficial cognitive effects.

One potential mechanism that has been proposed to explain the benefit of acute exercise on cognitive performance is physiological arousal induced by aerobic exercise, and studies have been designed to identify the nature of the relationship between exercise-induced physiological arousal (typically assessed using heart rate) and cognitive performance. Studies have supported both a linear facilitative effect (Aks, 1998, Allard et al., 1989, Tenenbaum et al., 1993) and an inverted-U relationship (Arent and Landers, 2003, Brisswalter et al., 1995, Chmura et al., 1994, Reilly and Smith, 1986) between heart rate and cognitive performance. Recently, using a causal design with eight levels of exercise-induced physiological arousal, Arent and Landers (2003) indicated that exercise-induced physiological arousal benefits cognitive performance in a quadratic trend, and that optimal performance occurs at 60 and 70% of maximal heart rate reserve.

Other authors (Chmura et al., 1994) have proposed that plasma catecholamines might underlie the relationship between exercise and cognition. Using lactate, adrenaline, and noradrenaline as indices of exercise intensity, an inverted-U relationship has been demonstrated between plasma catecholamines as induced by aerobic exercise and choice reaction time to visual stimuli. Similar results have also been demonstrated for speed of decision-making tasks (McMorris et al., 1999, McMorris et al., 2003). Although the relationship between a single bout of resistance exercise and cognitive performance has not been examined, several researchers have shown that acute resistance exercise can be used to induce arousal changes as indexed by heart rate (Bloomer, 2005, Rezk et al., 2006), plasma catecholamines (French et al., 2007, Pullinen et al., 1999, Ramel et al., 2004), and total energy expenditure (Bloomer, 2005). Since resistance exercise is an important exercise modality that is a central component of current exercise guidelines for middle-aged adults (American College of Sports Medicine, 2007), and because resistance exercise can be used to induce arousal changes that are similar to those observed during aerobic exercise, it is important to explore the effects of an acute bout of resistance exercise on cognitive performance by middle-aged adults.

Thus, the purpose of this study was to use a randomized controlled trial design to examine the effect of an acute bout of resistance exercise on cognitive performance in healthy middle-aged adults. Performance on the Stroop Test and the Trail Making Test was assessed prior to and following acute exercise. We hypothesized that for both tests: (a) performance would improve from the pre-test to the post-test as a function of learning the task; and (b) the resistance exercise group would show a greater improvement in cognitive function from pre-test to post-test than would the control group.

Method

Participants

Fifty community-dwelling men and women, between the ages of 35 and 65 years, were recruited as unpaid volunteers using flyers posted at local nursing homes, churches, and senior community centers and through advertisements in local newspapers. Inclusion criteria were assessed using the Physical Activity Readiness Questionnaire (PARQ) to insure that it was safe for the participant to perform the resistance exercise bout. The PARQ consists of seven questions regarding the presence of conditions that would contraindicate exercise and participants were only included if they answered “NO” to all of the questions. This approach followed the American College of Sports Medicine's Guidelines for Exercise Testing (ACSM, 2007). After meeting the inclusion criteria, participants were randomly assigned into the resistance exercise group or the control group by drawing lots.

Assessment of independent variables

This was a randomized controlled trial with two independent variables: group (resistance exercise group vs. control group) and time (pre-test vs. post-test). The resistance exercise group was instructed to conduct an acute resistance exercise bout that conformed to ACSM guidelines. The control group was instructed to read a pamphlet related to resistance exercise for a period of time similar to the duration that it took for the exercise group to conduct the exercises (this was determined based upon pilot testing). The pre-test data were collected immediately before performance of the treatment, and the post-test data were collected immediately after the treatment.

Assessment of dependent variables

Heart rate monitor. Heart rate (HR) was monitored using a short-range radio telemetry device (Sport Tester Polar Electro Mode PE 3000) that was worn during the entire exercise session. The HR monitor consisted of an elastic band that was strapped around the participant's chest to hold a rubber pad (that contained the heart rate measuring device with the transmitter) in place just below the sternum. In addition, a wristband receiver monitor was also placed on each participant. Data from the HR monitor were checked and recorded before the testing session and also immediately after either the resistance exercise or reading protocol ended. Heart rate data were assessed as an indicant of the physiological arousal induced by the resistance exercise.

Cognitive tasks. Executive function tasks were selected to assess cognitive performance. These tasks were selected because evidence from the literature on chronic exercise (Colcombe & Kramer, 2003) suggests that the largest effects of exercise programs are observed on executive function tasks (effect size = 0.68). In addition, executive functions, which include working memory, response inhibition, attention capacity, self-regulation, behavioral sequencing, cognitive flexibility, planning, and organization of behavior, are essential for daily living (Eslinger, 1996, Wecker et al., 2000). Lastly, Salthouse, Atkinson, and Berish (2003) indicated that some specific executive functions (i.e., inhibition, updating, and time sharing) are potential mediators of age-related cognitive decline in normal adults, supporting the hypothesis that physical activity might serve to delay typical age-related declines in cognition.

The Stroop Test (Stroop, 1935), also referred to as the Color–Word Task, was used to assess executive abilities, selective attention, and the ability to inhibit a habitual response (Pachana, Thompson, Marcopulos, & Yoash-Gantz, 2004). The test–retest reliability of the Stroop Test is 0.84 (Siegrist, 1997). Three conditions are included in the Stroop Test. In the Word condition, participants see color names written in black ink and are asked to read the word aloud. In the Color condition, participants see rectangles printed in different colors of ink and are instructed to verbally identify the color of each rectangle. In the Color–Word condition, participants see a color name printed in a different color ink (such as RED printed in green ink) and are instructed to verbally identify the color of the ink.

The Trail Making Test (TMT) was refined from the Army Individual Test Battery and has become one of the most commonly used tests in the assessment of general brain function, executive processing, concentration, and attention (Soukup, Ingram, Grady, & Schiess, 1998). It is a timed paper and pencil task which consists of two separate parts. Part A (TMT-A) involves drawing a line to connect consecutively numbered dots from 1 to 25 which are set in a random pattern on a piece of paper. Part B (TMT-B) requires the participant to connect numbers and letters in a progressive sequence (i.e., 1 to A–2 to B).

Exercise protocol and procedures

Participants were invited to come to the laboratory on two separate days. Each participant was tested individually and completed both the resistance exercise and the cognitive testing in the same room on both days. In session one, the participant was presented with a brief introduction to the experiment, was given an informed consent that had been approved by the University's Institutional Review Board, and was asked to complete the PARQ and a medical health history survey. Following confirmation that participants could safely participate in the study, participants were randomly assigned into either the resistance exercise group or the control group. To determine an optimal weight for a set of 10–15 repetitions, one repetition maximum (1-RM) was tested indirectly for each participant in the exercise group. Because of the age of the participants and in light of concerns that a participant might be injured if he or she were to perform a true 1-RM, the 1-RM for each exercise was assessed using a theoretical 1-RM approach. In this approach, participants were instructed to perform a single lift of a dumbbell (or more than one dumbbell) to identify a weight that they would feel comfortable lifting for 5–15 repetitions. Once a comfortable weight was identified, the participant lifted the weight for 5–15 repetitions. The weight and the number of repetitions were then used to estimate the participant's 1-RM for each exercise (Baechle, Earle, & Wathen, 2000).

During the second session, participants were equipped with Polar Heart Rate monitors. After sitting quietly in a comfortable chair in a dimly lit room for 15 min, the investigator recorded the participant's baseline HR. The participant was given instructions for the Stroop Test and a practice session for the TMT to get familiarized with these tests. The participant was then asked to complete the cognitive tests in the following order: TMT-A, TMT-B, Stroop Word (SW), Stroop Color (SC) and the Stroop Color–Word (SCW). After collecting the pre-test data, the participant performed the assigned treatment condition. Participants in the resistance exercise group performed a resistance exercise bout consisting of 2 sets of 10 repetitions for 6 exercises. The dumbbell weight for the second session was determined by calculating 75% of their theoretical 1-RM assessment and this was recognized as an appropriate estimate of a weight that can be lifted for 10 repetitions (Baechle et al., 2000). The six exercises were the right-arm curl, left-arm curl, dumbbell rowing-right hand, dumbbell rowing-left hand, dumbbell lateral raise, and bench press. The exercise protocol was designed to be consistent with Tomporowski's (2003) conclusions that moderate exercise conducted for 30–60 min benefits cognition. This exercise session lasted approximately 45 min and would be described as moderate intensity based on classifications proposed by ACSM (2007) and Pollock et al. (1998). Participants in the control group were asked to read materials on resistance exercise for a period of time that was similar to the duration, 45 min, which the exercise group took to conduct the actual exercises. Following their respective treatments, HR was recorded and participants were asked to conduct the cognitive tests again (post-test) in the same order as at the pre-test.

Data analysis

Because age is predictive of cognitive performance on executive function tests, an independent-samples *t*-test was used to compare age between the exercise and control groups. In the event of significant differences in age between the groups, age would be used as a covariate in all subsequent analyses. A 2×2 mixed analysis of variance (ANOVA) for group (exercise, control) by time (pre-test, post-test) was conducted with HR as the dependent variable. Separate 2×2 mixed multivariate analyses of variance (MANOVAs) for group (exercise, control) by time (pre-test, post-test) were conducted to test the effects of the exercise on each group of cognitive tests (Stroop: SW, SC, and SCW; Trail Making: TMT-A and TMT-B). In the event of a significant multivariate effect, separate 2×2 ANOVAs were used to identify the significant univariate effects. In the event of significant interaction effects, figures are presented and interpreted to identify the significant differences. Effect sizes (ESs) are presented using Hedges's approach (the mean difference of the groups divided by the pooled standard deviation). An alpha of 0.05 was used as the level of statistical significance for all statistical analyses which were conducted using SPSS 15.0.

Results

After confirming the inclusion criteria, 41 adults (14 men, 27 women, M_{age} = 49.10 years, SD = 8.73) were included in the study. Although our participants were randomly assigned, there were significant differences, $t(38) = 2.21$, $p < 0.05$, effect size (ES) = 0.96, in age between the resistance exercise group ($n = 22$, $M = 52.28$ years, SD = 8.92) and the reading group ($n = 19$, $M = 46.00$ years, SD = 8.52). Thus, age was used as a covariate in subsequent analyses.

Heart rate

Descriptive data for HR are provided in Table 1. A two-way mixed ANCOVA with age as a covariate revealed that there was a significant main effect for group, $F(1, 36) = 9.72$, $p < 0.005$, partial $\eta^2 = 0.21$, and a significant interaction effect for group by time, $F(1, 36) = 44.84$, $p < 0.001$, partial $\eta^2 = 0.56$. Univariate analyses indicated that there was no significant difference between groups in HR at baseline, $F(1, 39) = 0.54$, $p > 0.05$, partial $\eta^2 = 0.15$. In contrast, HR was significantly higher for the exercise vs. the control group at the post-test, $F(1, 40) = 24.23$, $p < 0.001$, partial $\eta^2 = 0.40$, which indicated that arousal increased as a result of participation in the acute exercise bout (see Fig. 1).

Table 1. Means, standard deviations, and effect sizes (from Pre-test to Post-test) for heart rate and cognitive performance as a function of treatment condition

	Exercise					**Control**				
	Pre-test		**Post-test**			**Pre-test**		**Post-test**		
Source	***M***	**SD**	***M***	**SD**	**ES**	***M***	**SD**	***M***	**SD**	**ES**
HR (bpm)	82.00	12.20	96.90	14.25	1.12	79.70	9.16	78.00	8.96	−0.19
% HR max	48.90	6.00	58.30	6.90	1.45	45.90	4.30	44.80	4.30	−0.26
SW	21.27	3.19	19.95	3.56	−0.39	20.63	3.36	20.22	4.12	−0.11
SC	26.80	4.23	24.70	4.02	−0.51	25.29	3.79	25.36	5.59	0.01
SCW	45.74	10.37	39.36	7.94	−0.69	41.13	8.65	38.47	7.29	−0.33
TMT-A	23.21	9.25	19.82	7.40	−0.40	22.36	5.12	21.12	7.24	−0.20
TMT-B	55.72	18.04	46.80	16.76	−0.51	57.59	14.88	51.52	16.13	−0.39

Note. Values for the Stroop Tests and for the Trail Making measures are in msec, thus for all of the cognitive measures, a negative ES is indicative of an improvement in performance from pre-test to post-test. HR = Heart rate; SW = Stroop Word; SC = Stroop Color; SCW = Stroop Color–Word; TMT-A = Trail Making Test Part A; TMT-B = Trail Making Test Part B; %HR max was calculated using Karvonen's method which is based on an age-predicted HR max of 220-age.

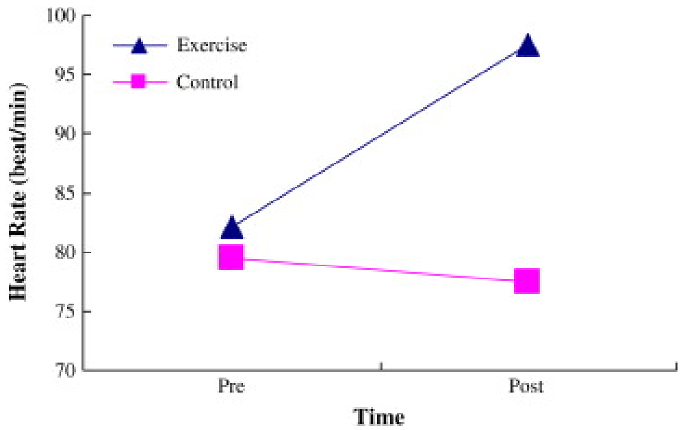

Fig. 1. Heart rate as a function of time and group (adjusted for age).

Effect of resistance exercise on Stroop Test

Because age was significantly different between groups, MANCOVAs were conducted to test the difference between participants in the resistance exercise group vs. the reading group in the amount of change in their scores from pre-test to post-test. The main effect of group was not significant, $F(3, 35) = 0.32$, $p > 0.05$. However, there was a significant main effect for time, $F(3, 35) = 2.90$, $p < 0.05$, partial $\eta^2 = 1.99$, and a significant interaction of group by time, $F(3, 35) = 3.63$, $p < 0.05$, partial $\eta^2 = 0.24$.

Univariate ANCOVAs were conducted to determine the nature of the Group × Time interaction for each of the Stroop tests. Means and standard deviations for Stroop Tests are presented in Table 1. A significant interaction between time and group was found in both the SW condition, $F(1, 37) = 4.46$, $p < 0.05$, partial $\eta^2 = 0.11$, and the SC condition, $F(1, 37) = 4.67$, $p < 0.05$, partial $\eta^2 = 0.11$. The interaction for time by group was nearly significant for the SCW condition, $F(1, 37) = 3.08$, $p = 0.09$, partial $\eta^2 = 0.08$. Effect sizes for SW, SC, and SCW were calculated from pre-test to post-test for participants in the resistance exercise group and showed small to moderate effect sizes for all three conditions (see Table 1).

An examination of these interactions indicated that, after an acute resistance exercise intervention, post-test performance on the SW and SC conditions improved as compared to baseline and this improvement was greater for the resistance exercise group than for the reading group (see Fig. 2a, b). Although findings for the SCW condition did not reach statistical significance, the results for the SCW condition were similar to those observed in the SW and SC conditions (see Fig. 2c).

Effect of resistance exercise on Trail Making Test

Because age was significantly different between groups, a 2 × 2 MANCOVA was conducted to assess if there was a difference between participants in the resistance exercise and reading group in the amount of change in their scores on the TMT-A and TMT-B. Descriptive statistics for the Trail Making Test are presented in Table 1. No significant multivariate effect was found for the main effect of group $F(2, 33) = 1.31$, $p > 0.05$, or time, $F(2, 33) = 1.26$, $p > 0.05$. In addition, the interaction between time and group $F(2, 33) = 0.87$, $p > 0.05$, was also not significant.

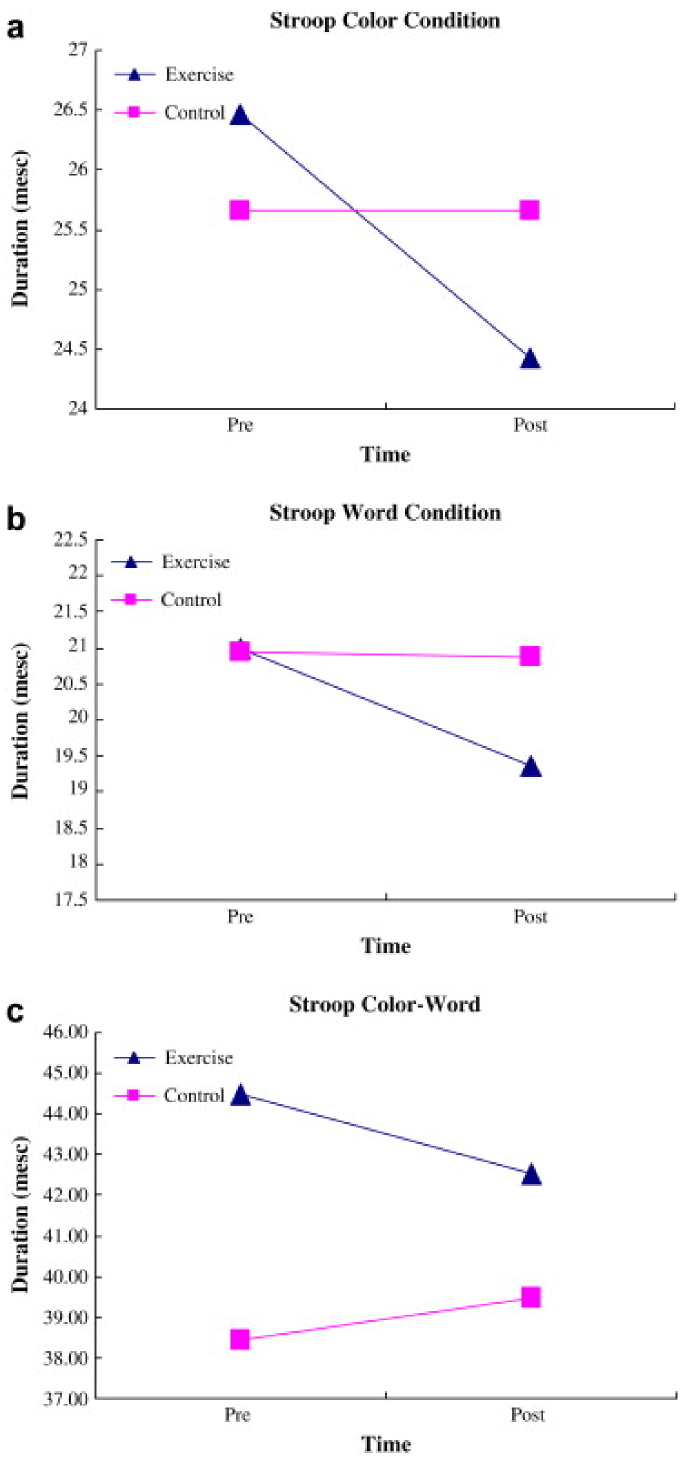

Fig. 2. Cognitive performance as a function of time and group (adjusted for age) on a) Stroop Word Condition; b) Stroop Color Condition; c) Stroop Color–Word Condition.

Discussion

The purpose of this study was to examine the effect of an acute bout of resistance exercise on cognitive performance in healthy middle-aged adults. Before and after undergoing a resistance exercise session or a reading protocol, participants were instructed to complete the TMT and the Stroop Test.

Surprisingly, the results for the TMT did not show any significant effect of acute resistance exercise whereas significant effects were found on the Stroop test. Relatively low statistical power might explain the non-significant results on the TMT. An examination of the multivariate analyses suggests that the proportion of variance explained for the potential effect of physical activity on TMT performance is smaller (partial $\eta^2 = 0.05$) than was observed for the significant interactions observed for the Stroop measures (partial $\eta^2 = 0.24$). We suggest that these differing results might be indicative of the specificity of the effects of acute exercise on cognition. That is, although the TMT and the Stroop test are both described as measures of executive function, they may actually reflect different specific types of executive function. Generally, the TMT is proposed as a measure of cognitive flexibility where TMT-A reflects motor and visual control while TMT-B reflects the additional executive control needed to switch between number and letter sequences. However, Arbuthnott and Frank (2000) suggested that the TMT could also represent another executive function described as task-set inhibition ability. In tests that involve the ability to switch between two or more cognitive tasks, Mayr and Keele (2000) indicated that shifting from one task-set to another requires the ability to shift attention and to inhibit current task goals. Arbuthnott and Frank (2000) demonstrated that performance on the TMT-B is significantly associated with task-set inhibition ability, thus suggesting that the TMT-B might be best categorized as a test assessing inhibition. Thus, our non-significant results and small partial η^2 may be most comparable to the findings of Sibley, Etnier, and Le Masurier (2006). Sibley et al. used the same three versions of the Stroop task that were used in this study; however, they also used a negative priming task to distinguish between interference and inhibition. Since a significant effect for exercise was found in the Stroop interference task and not in the Stroop inhibition condition, it was concluded that acute exercise specifically affects interference and does not have an effect on inhibition. Thus, our findings on the TMT are consistent with those of Sibley et al. in demonstrating that the effect of acute exercise on inhibition is small.

In terms of the Stroop Test, results indicated that performance on the SW and SC improved from pre-test to post-test for the resistance exercise group and that this improvement was greater than was observed for the control group. Results for the SCW condition did not reach significance; however, an examination of the results indicated that similar effects were observed but were not of the same magnitude (partial $\eta^2 = 0.08$) as for the SW and SC tasks (partial $\eta^2 = 0.11$). Effect sizes for the pre-test to post-test improvements on the three tasks were similar indicating that resistance exercise had a moderate effect on performance on all three tasks (SW: ES = −0.39, SC: ES = −0.51, SCW: ES = −0.61) as compared to participation in a quiet reading session (SW: ES = −0.11, SC: ES = 0.01, SCW: ES = −0.33). These findings support the hypothesis that 45 min of moderate intensity resistance exercise has a positive impact on particular types of cognitive performance. In particular, the results demonstrate that resistance exercise significantly positively benefits speed of processing tasks (SW and SC) and that there is a trend towards resistance exercise benefiting performance on an executive function task that requires shifting of the habitual response (SCW). These results are consistent with past studies which have demonstrated that an acute bout of aerobic exercise has its greatest impact on the speeded components of cognitive performance tasks and on the ability to shift the habitual response (Hogervorst et al., 1996, Lichtman and Poser, 1983, Sibley et al., 2006).

Thus, the present study indicated that a 45-min bout of moderate intensity resistance exercise benefits both lower level cognitive processes (i.e., speed of processing) and higher level cognitive processes (i.e., the executive functions of shifting the habitual response). Several studies have demonstrated the positive effect of sub-maximal aerobic exercise on cognitive performance in terms of reaction time (Adam et al., 1997, Arcelin et al., 1997, Arcelin et al., 1998, Davranche et al., 2005, Davranche et al., 2006) and executive function (Dietrich and Sparling, 2004, Hillman et al., 2003, Lichtman and Poser, 1983, Tomporowski et al., 2005). Based upon these findings, it has been suggested that exercise-induced physiological arousal might be a potential mechanism to explain the cognitive benefits of an acute bout of aerobic exercise. In this study, acute resistance exercise was effective in increasing heart rate; therefore, the results of this study are consistent with the hypothesis that physiological arousal is a potential mechanism for explaining the benefit of resistance exercise on cognitive function.

As a final consideration, limitations of our study should be addressed. First, although a strength of this study was that we manipulated exercise intensity based upon each individual participant's theoretical 1-RM which was estimated using a standard protocol, individual differences related to muscle fatigue characteristics might impact the relative intensity of the exercise bout. Second, we were reliant upon participation by volunteers who were likely to be comfortable with the prospect of completing an exercise bout, and we did not assess exercise history or fitness in our sample. All of these variables could have impacted the exercise experience and therefore influenced cognitive performance indirectly. In future research, measures of perceived exertion should be assessed to insure that the relative intensities of the exercise bout are equivalent, and exercise history and fitness level should be ascertained so that these variables can be controlled either through recruitment of a homogenous sample or through statistical controls. For ethical reasons, researchers are always reliant on voluntary participation, but measures of psychological arousal, affective responses to the exercise, and self-efficacy for exercise might also improve our understanding of variables that potentially moderate the relationship between acute physical activity and cognition.

In summary, the present findings indicate that a 45-min bout of moderate intensity resistance exercise has a positive impact on both automatic cognitive processes and particular types of executive function in middle-aged adults. This is the first study to our knowledge in which a single bout of resistance exercise has been shown to benefit cognitive function. Further, the results of this study suggest that acute resistance exercise benefits cognitive function in middle-aged adults. Based upon these findings, suggestions for further research in this area are warranted. First, given that this is the first published study in which the effects of an acute bout of resistance exercise on cognition have been tested, further studies should be conducted to insure that these results are replicable and to assess whether or not they generalize to other populations. Second, future research should be designed to further our understanding of dose–response relationships and of the mechanisms underlying these relationships. If the benefits of resistance training on cognitive performance are reliable, it will be important to ascertain the appropriate exercise prescription for maximizing those effects. Lastly, resistance training has proven to be particularly important for older-aged adults, one of the fastest growing segments of the population. Given that older adults often express concern over maintaining their cognitive functioning into advancing age, these findings could be used to encourage older adults to participate in resistance exercise programs.

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