INTERNATIONAL JOURNAL OF EXERCISE SCIENCE

Original Research

A Comparison of Brief Resistance and Aerobic Exercise Bouts on Cognitive Processing Speed in Young Adults

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Abstract

International Journal of Exercise Science 18(4): 119-129, 2025. https://doi.org/10.70252/NTHW8907 Research has found even a brief bout of exercise to be beneficial for improving processing speed. However, there is a lack of research directly comparing the effect of exercise modalities on processing speed. The purpose of this study was to compare the effects of a single brief bout of resistance exercise to aerobic exercise on cognitive processing speed in young adults. A total of 29 young adults ranging from 20-34 years of age (22.59±2.86 years) participated in a familiarization session followed by two randomized exercise conditions (aerobic, resistance). Each moderate-intensity exercise condition was followed by completion of a symbol search test to measure cognitive processing speed. A paired-samples t-test was conducted to assess differences in processing speed between aerobic and resistance exercise conditions. Processing speed scores in the aerobic exercise condition (M = 42.97, SD = 9.06) did not significantly differ ($t(28) = -1.701$, $p = 0.100$, $d = 0.316$) from processing speed scores in the resistance exercise condition (M = 44.62, SD = 9.28). Findings from our study suggest that either modality may be used by a healthy young adult population when exercising to improve processing speed. Future research should continue to explore the exercise and processing speed relationship using body weight and resistance band exercises, as used in the present study, on processing speed, because this may be a more attractive strategy for college students who often report time, accessibility, and cost as barriers to exercise.

Keywords: Physical activity, college students, cognitive function

Introduction

Processing speed is the progression by which an individual receives information, begins to understand it, and then responds to it.[1] It impacts various mental functions, including how we take in information through our senses and the speed at which we process information to then compose into feedback.[1] Processing speed affects academic performance, although it is currently unclear if it is a direct or indirect effect.[2] Furthermore, an additional study found that most cognitive abilities peak during an individual's high school years, plateau in their 20s, and then begin to decline during their 30s.[3] Fortunately, research has determined that lifestyle choices such as regular exercise and others can slow the decline of an individual's cognitive abilities associated with aging, including processing speed.[4,5] Most of these lifestyle choices are potentially influenced by the of development of habits during their early adult years when many are transitioning to their post-secondary education. Therefore, college is a potentially ideal time to take proactive steps to prevent or reduce processing speed decline by creating health-enhancing habits.

Research has established a positive relationship between exercise and processing speed.[6,7] For example, one study determined chronic exercise increased performance on any cognitive task by an average of 0.5 standard deviations, considered a large increase, from exercise groups over non-exercise control groups.[6] Though a recent meta-analysis indicated that chronic interventions had greater improvement in cognitive processing speed performance compared to acute exercise interventions.[7] A separate meta-analysis identified that an acute bout of either aerobic or anaerobic exercise produced small improvements in cognitive processing speed performance (d = 0.097).[8] Thus, the research strongly suggests that chronic as well as acute exercise is beneficial to cognitive processing levels. However, the volume of exercise participation declines by 40-50% when students begins college.[9] As cognitive processing speed levels are associated with higher academic performance in young adults,[2] strategies that increase the number of college students who meet physical activity guidelines are warranted to improve both academic performance and health.

While there have been many studies that determined exercise affects cognitive performance, most of this research has focused on aerobic exercise. Fewer research studies have examined the impact of resistance exercise on cognitive processes but have found promising results. For example, one study observed improvements in executive function and cognitive processing speed after 30 minutes of resistance exercise in healthy young adults.[10] Similarly, another study observed improvements in cognitive control and executive function following an acute 30-minute resistance bout.[11] A meta-analysis identified that interventions utilizing a combination of aerobic and resistance exercises improved attention, processing speed, and working memory greater than aerobic exercise alone.[12] Though resistance exercise alone or combine with aerobic can produce improvements in cognitive performance, it is unclear if aerobic exercise alone is more impactful on cognitive processing speed than resistance exercise alone via direct comparison. Further, research exploring resistance exercise and cognitive functioning has focused on more traditional resistance training involving free weights or machines and typically for a duration of 30 minutes or longer, creating a need for research exploring shorter bouts of exercise and using body weight or resistance bands.

Preliminary results indicate an acute, shorter duration bout of aerobic exercise (10 minutes) observed improvements in processing speed.[12] This brief amount of exercise is an attractive strategy to utilize with college students, as many are not engaging in sufficient levels of physical activity and reporting time as a major barrier to exercise.[9,13] Further, using body weight and resistance bands is more practical, cost-effective, and eliminates other common barriers to exercise, including access to facilities and resources.[9,13] Therefore, a short bout of resistance exercise that utilizes body weight and resistance band exercises would be a potentially more feasible approach for this population compared to the traditional approach of using free weights or machines. To date, only a limited number of studies use body weight and light resistance bands to impact cognitive processing speed but did so in children or in an older adult population and most employed an exercise duration of 30 minutes or more.[14,15] No study to our knowledge has used a short duration protocol (10 minutes) with body weight and resistance bands in college students.

Thus, the purpose of this study was to explore if an acute 10-minute bout of resistance exercise, consisting of body weight and resistance band exercises, compared to aerobic exercise for improvements in cognitive processing speed in a college-age population. Based on previous research it is understood that exercise improves cognitive processing speed, therefore the primary focus of this study is to compare the two modes of exercise (aerobic and resistance). We hypothesized that there would be no difference in cognitive processing speed between the resistance exercise condition and aerobic exercise condition.

Methods

Participants

Eligible participants were between 18 and 35 years of age and cleared for moderate-to-vigorous-intensity exercise, as defined by the American College of Sports Medicine (ACSM).[16] Participants were excluded if they met one or more of the following criteria: 1) currently pregnant, 2) regularly used nicotine (defined as six months or more of nicotine product use and/or high exposure to environmental tobacco), 3) took medication that altered exercise heart rate, or 4) had visual impairments that could not be corrected by wearing eyeglasses or contact lenses. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science.[17]

An *a priori* power analysis was performed using G*Power 3.1 to determine the approximate sample size. Given the effect sizes (i.e., η_p^2 between .16 and .36) identified from previous studies[11,18,19] and desired power of 80%, it was determined a sample size of 28 or more participants was needed. A total of 35 participants volunteered to complete the first data collection session; however, six participants were unable to complete the entire study either because they were unable to schedule the additional two data collection sessions (n = 3) or they were deemed ineligible for the study as they were taking medication that altered exercise heart rate (n = 3). Therefore, a total of 29 individuals completed this study. Participant characteristics are reported in Table 1.

Protocol

The study used a randomized crossover design with one familiarization period and two experimental conditions (aerobic and resistance). The familiarization period took place in the same session as the initial screening protocol, if participants met the inclusion criteria and signed the informed consent. This design was selected to best control for the effect of learning or practice and examining within and between-person variation in processing speed.[20] Each condition was separated by 48 hours but no more than 72 hours to allow for the physiological and cognitive effects of the exercise sessions to washout. Participants were required to abstain from caffeine, nicotine, alcohol, and moderate-to-vigorous physical activity for eight hours prior to each visit. Participants were randomly assigned in a 2:2 allocation for exercise condition order to do either aerobic exercise or resistance on training on days two and three.

Table 1. Participant characteristics (*n*=29)

Variable	Mean ± SD or *f* (%)	Range
Age (years)	22.59 ± 2.96	20 – 34
Height (cm)	168.72 ± 8.55	153 – 184
Weight (kg)	78.00 ± 18.84	51 – 125
Body mass index (kg/m^2)	27.23 ± 5.52	19.55 – 41.29
Gender		
Male	15 (51.7%)	
Female	14 (48.3%)	
Race/ethnicity		
Hispanic/Latino	22 (75.9%)	
African American	4 (13.8%)	
Caucasian	3 (10.3%)	

Following institutional review board approval, participants were recruited with posted flyers in buildings throughout a regional university in south Texas. Additionally, several professors informed their classes of the opportunity to participate in the research by sharing the flier. Snowball sampling was also used to encourage other participants to recruit individuals to participate. Individuals who were interested in participating in the study scheduled an initial eligibility appointment via email with the principal investigator (PI). These appointments were held within a human performance laboratory located on the campus of the regional university. Before their appointment, participants were informed that proper exercise attire was required. During the initial assessment visit, participants provided informed consent and completed demographic and health screening questions, which were used to describe the study sample and determine eligibility. The health history questionnaire was based on the ACSM pre-participation screening algorithm.[16]

Once all questionnaires were complete, the PI collected resting heart rate along with height and weight using a physician's beam scale and a wall-mounted stadiometer. Resting heart rate along with predicted maximal heart rate (220-age) was used to calculate the corresponding heart rate reserve (HRR) that would elicit a moderate intensity workload for both the aerobic and resistance visits (50 to 59% of HRR). HRR was determined by using the following formula: ((Predicted heart rate max-resting heart rate) x 0.50 or 0.59) + resting heart rate. This determined the lower and upper limits of the heart rate range for each exercise bout. Next, the Symbol Search test[21] was administered, which served to familiarize participants with the measure. At the end of the initial visit, participants were shown the body weight exercises for the resistance day and asked to complete one repetition of each exercise to ensure they were capable of completing each movement. Following this first condition, participants were scheduled for their next two follow up experimental conditions.

For the aerobic exercise condition, participants were asked to complete a short 10-minute bout of moderate-intensity aerobic exercise on a treadmill, corresponding to the HRR determined during the initial visit. Heart rate during the exercise was monitored using a Polar H10 Heart Rate Sensor. Before beginning the exercise bout, participants were familiarized with the Borg Rating of Perceived Exertion (RPE) Scale[22] which was administered during the exercise bout. RPE was collected to confirm the exercise intensity manipulation via HRR, consistent with other studies assessing exercise and cognitive function.[11,18]

The participants began with a brief warmup on the treadmill for safety considerations, starting at 1.34 m/s and 3% incline. During the warmup, speed was quickly increased until the participant reached the appropriate work rate to elicit the predetermined heart rate zone to begin the 10-minute aerobic period. During the exercise bout participant's heart rate and their RPE were record at 0, 2.5, 5.5, and 8.5 minutes and treadmill speed was increased or decreased throughout the exercise to ensure participants remained in their target heart rate zones for the duration of the exercise protocol. Following the 10-minute bout, participants were asked to sit down. The Symbol Search Test[21] was completed 11 minutes post-exercise, as previous research has determined that to be the ideal length of time to optimize results.[10,23]

The resistance day used a similar protocol to the aerobic day. The participants performed 10 different body weight and resistance band resistance exercises. Each exercise was done for 30 seconds followed immediately by a 30 second rest period that was used to also transition into the next exercise. This equates to a total exercise duration of 10 minutes. Heart rate and RPE were also recorded during 0, 2.5, 5.5, and 8.5 minutes. The 10 exercises were completed at a rate to elicit the predetermined heart rate zone and consisted of the following exercises (in order): push-ups, leg lifts, body weight squats, seated overhead shoulder press with resistance band, side bends with resistance band, box step-ups, triceps dips on step, glute bridge, bent over resistance band row, and side to side lunges. These exercises were chosen due to ease of implementation, with minimal space or equipment requirement. Eleven minutes after completing the resistance exercises the participant took the Symbol Search test.[21]

The Symbol Search subtest from the WAIS-IV[21] was administered to participants via Inquisit software (www.millisecond.com) to assess cognitive processing speed. During this test, participants were presented with 10 rows of symbols. Within each row, there were two symbols on a gray background (on the left) and five symbols on a light blue background (on the right). Participants were instructed to look for a match amongst the five symbols on the right for either one of the two symbols on the left. If they found a match, they were instructed to click it. If no match was found, participants were instructed to click a NO button next to the row. Participants' performance was recorded as the total number of correct responses within the two-minute test. Psychometric data for the computerized Symbol Search is not available, however, both the WAIS-IV and a computerized version of the Wechsler Intelligence Scale for Children (WISC-IV) have been found to have good reliability and validity.[24,25] With the Symbol Search test taking two minutes to complete, participants completed the processing speed assessment 13 minutes post exercise, well within the recommended time frame post-exercise to optimize cognitive performance results.[20]

The Borg Rating of Perceived Exertion (RPE) Scale[22] is a 15-point scale with verbal descriptions to standardize perceived exertion across tasks and individuals. The full 15-point scale ranges from 6 (no exertion at all) to 20 (absolute maximum). Participants verbally reported a number during each assessment period, which was recorded by the PI.

Statistical Analysis

Data were first screened for normality, outliers, and independence, and then participant characteristics were also calculated for all variables of interest using SPSS v. 26 (see Table 1). Independent samples t-tests were conducted to assess for any differences in processing speed by gender, as suggested by some studies[26] and order (whether participants completed aerobic exercise or resistance exercise the second day of data collection). Cohen's d was calculated for the independent samples t-tests to determine effect sizes, where 0.8 is considered a large effect, 0.5 a medium effect, and 0.2 a small effect.[27] Paired samples t-tests were also calculated to examine any differences in heart rate and RPE between the aerobic and resistance exercise sessions. Finally, a paired-samples t-test was conducted to assess differences in processing speed between the conditions (aerobic, resistance). An alpha level of 0.05 was used for indication of statistical significance.

Results

Independent samples t-tests were conducted to assess for any differences in processing speed by gender. No significant difference was found ($t(27) = 0.19$ $p = 0.852$, $d = 0.07$) between males ($M = 37.87$, $SD = 7.34$) and females ($M = 37.29$, $SD = 9.27$) for processing speed in the familiarization period. No significant difference was found ($t(27) = -1.09$, $p = 0.285$, $d = 0.40$) between males ($M = 41.20$, $SD = 8.12$) and females ($M = 44.86$, $SD = 9.92$) for processing speed in the aerobic exercise condition. Finally, no significant difference was found ($t(27) = -0.53$, $p = 0.603$, $d = 0.19$) between males ($M = 43.73$, $SD = 8.11$) and females ($M = 45.57$, $SD = 10.62$) for processing speed in the resistance exercise condition.

Independent samples t-tests were next calculated to assess for any differences in processing speed by order (whether participants completed aerobic exercise or resistance exercise on the second day of data collection). No significant difference was found ($t(27) = -0.71$, $p = 0.483$, $d = 0.26$) between the aerobic exercise first condition ($M = 36.53$, $SD = 8.05$) and the resistance exercise first condition ($M = 38.71$, $SD = 8.46$) for processing speed in the familiarization period. No significant difference was found ($t(27) = -1.49$, $p = 0.149$, $d = 0.55$) between the aerobic exercise first condition ($M = 40.60$, $SD = 8.40$) and the resistance exercise first condition ($M = 45.50$, $SD = 9.35$) for processing speed in the aerobic exercise condition. Finally, no significant difference was found ($t(27) = 0.07$, $p = 0.948$, $d = 0.02$) between the aerobic exercise first condition ($M = 44.73$, $SD = 8.78$) and the resistance exercise first condition ($M = 44.50$, $SD = 10.13$) for processing speed in the resistance exercise condition.

A paired samples t-test was calculated to examine any differences in heart rate between the aerobic and resistance exercise sessions. No significant difference was found ($t(28) = -1.77$, $p = 0.087$, $d = 0.31$) between heart rate in the aerobic exercise condition ($M = 141.97$, $SD = 5.33$) and the heart rate in the resistance exercise condition (*M* = 144.24, *SD* = 8.85). Lastly, a paired samples *t*-test was calculated to examine any differences in RPE between the aerobic and resistance exercise sessions. No significant difference was found ($t(28) = 0.43$, $p = 0.672$, $d = 0.05$) between RPE in the aerobic exercise condition (*M* = 11.06, *SD* = 1.82) and RPE in the resistance exercise condition (*M* = 10.96, *SD* = 1.66).

Finally, a paired-samples *t*-test was conducted to assess differences in processing speed between the aerobic and resistance conditions. On average, processing speed scores in the aerobic condition (*M* = 42.97, *SD* = 9.06) did not significantly differ ($t(28) = -1.701$, $p = 0.100$, $d = 0.316$) from processing speed scores in the resistance condition (*M* = 44.62, *SD* = 9.28). See Table 2 for processing speed means and standard deviations between conditions.

Table 2. Processing speed means and standard deviations by condition

Condition	Mean	SD
Familiarization	37.59	8.18
Aerobic Exercise*	42.97	9.06
Resistance Exercise*	44.62	9.28

*Indicates statistical significance compared to familiarization period ($p<0.001$)

Discussion

The purpose of the present study was to compare the effects of a single brief bout of resistance exercise to aerobic exercise on cognitive processing speed in young adults. No significant differences were found in processing speed between the aerobic and resistance exercise conditions. Previous research has already established that aerobic exercise can improve cognitive functioning, including processing speed.[28] There is less research exploring the effects of resistance exercise on cognitive processing speed, however, studies have found an acute bout of resistance exercise can produce cognitive functioning benefits in middle and older adult populations.[10]

We anticipated finding differences between aerobic and resistance exercise bouts in processing speed given the mechanisms for effecting processing speed differ between aerobic and resistance exercise. Aerobic exercise has been found to increase blood flow to the brain, which increases brain-derived neurotrophic factor (BDNF) and promotes neurogenesis, cell survival, synaptic plasticity, and vascular function.[13,29] Several hypothesized mechanisms exist for the benefit of resistance exercise on processing speed. Some studies suggest that resistance exercise improves cognitive functioning by stimulating the release of BDNF, considered to be essential for cognitive functioning.[30] Other research has found moderate intensity resistance exercise increased tissue oxygen levels, indicating increased cerebral blood flow.[31] Finally, structural changes in grey and white matter following resistance exercise have been observed.[32] However, the existing research on resistance exercise and cognitive functioning has primarily used free weights or machines and followed a more traditional approach to resistance training. This more traditional approach to resistance training has been found linked to a decreased rate of participation in resistance training due to low motivation and lack of time.[33]

Our current study utilized a brief bout of body weight and resistance band exercises, which may be a more attractive strategy for college students who often report time, accessibility, and cost as a barrier to exercise.[13,34] Findings from the current study also add to the existing literature on the cognitive benefits of short acute bouts of exercise as we found significant differences in processing speed between the familiarization period and aerobic exercise condition and also between the familiarization period and the resistance exercise condition. Research has found that even an exercise bout as short as 10 minutes can improve an individual's processing speed.[10,23] For example, one study found that women with breast cancer saw increases in their cognitive processing speed and performance in spatial working memory following a walk at a duration of either 10, 20, or 30 minutes.[23] Whereas in the non-exercise group the individuals remained seated for the same allotted time periods. This group experienced a decline in processing speed and performance in spatial working memory when compared to the control group. It should be noted though that regular participation in physical activity produces more cognitive benefits[28] and general physical and psychological well-being benefits than a single bout of exercise.

Though the benefit of such a short bout of activity may be less than a more extended exercise bout, a short bout such as the one used in this study does have advantages. For example, a short bout of exercise could be more attractive to individuals with limited time or can be used to provide "breaks" during their daily lives at work or school. Along with this, these short bouts during the day that could be used a work or school could potentially appear less obtrusive to their work, allowing for supervisors or instructors to be more receptive to their implementation. Lastly, this activity may be attractive to those with limited resources compared to more traditional forms of activity.

Our study was not without limitations. We had initially planned to compare processing speed across three conditions (control, aerobic, resistance), however, given the control condition was the first day of testing for all participants, changes in processing speed from the control condition to either the aerobic or resistance conditions could have been simply due to the learning effect. Therefore, researchers should consider utilizing a counterbalanced design on future studies to address this issue.

Our study sample, though recruited from a young healthy adult population at a regional university, does not necessarily reflect the entire college-aged population and future studies should look to recruit more diverse populations in regard to race, fitness level, age, health status, and other characteristic markers. While participants were all healthy, cleared for moderate-to-vigorous physical activity, and required to abstain from moderate-to-vigorous physical activity prior to each visit, we did not collect data on their typical physical activity modality. For example, some participants may have been only engaging in aerobic exercise, while others may have been doing both aerobic and resistance exercise. Furthermore, our protocol utilized prediction equations to determine appropriate work rate ranges to elicit moderate-intensity physical activity based on HR response. However, this decision was made to ease burden on participants so that they did not have to undergo a maximal exercise test to determine true maximal HR, allowing for a potentially more diverse study population, including those not cleared for maximal-intensity physical activity participation.

Future research should also further explore the effects of mode of exercise used with a young healthy population. For example, studies have generally focused on using repetitive aerobic activities such as walking, running, or cycling, however, research has highlighted the need to explore aerobic tasks that are less repetitive or involve more task complexity, such as the inclusion of novel motor coordination patterns.[20,35,36] Further, while the present study utilized 30 seconds of rest in between each resistance exercise and incorporated resistance exercises that targeted a variety of muscle groups, the rest period between resistance-based exercises and the specific muscle groups targeted should also continue to be examined. Finally, research should continue to explore the optimal dose of exercise to produce the greatest cognitive benefits.

This study advances the research regarding brief bouts of resistance exercise and its effect on cognitive processing speed. There is a lack of research directly comparing the effect of exercise modalities on cognitive functioning or processing speed. Our study compared aerobic exercise to resistance exercise and found no difference in processing speed between the two exercise conditions. Thus, this suggests that mode of exercise may not be an important factor when using exercise to improve processing speed in healthy college-aged students. The current study also helps advance the research on the effects of exercise on cognition in the healthy college-aged population, who have been studied much less than older adults or children. Given the large number (40-50%) of college students in the U.S. who are inactive[9] and report time as a barrier to exercise,[13] the 10-minute bout of body weight resistance exercises used in the current study may be a feasible option for healthy young adults to engage in prior to performing tasks in which processing speed is essential, for example, timed exams.

Acknowledgements

This study was supported by the McNair Scholars Program at Texas A&M University-Kingsville.

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