BIOMEDICINE AND CHEMICAL SCIENCES
AN INTERNATIONAL PEER-REVIEWED JOURNAL

BIOMEDICINE AND CHEMICAL SCIENCES

Website: https://journals.irapa.org/index.php/BCS
e-ISSN: 2790-296X | p-ISSN:2957-5826

Original Article

Impact of Hydration Status on Cognitive Performance and Blood Pressure During Moderate Exercise

Corresponding Author:
Dr. Samreen Farooqui
Email:
drsamreenofficial@gmail.com

Article History:
Received on: Aug 06, 2026
Revised on: Aug 12, 2026
Accepted on: Aug 29, 2026
Published on: Sep 17, 2026

Citation: Dr. Unmesh Dave *et al.* Impact of Hydration Status on Cognitive Performance and Blood Pressure During Moderate Exercise. *Biomedicine and Chemical Sciences, 5 (3): 196-201, 2026*

Dr. Unmesh Dave[1], Dr. Ritesh M. Karia[2], Dr. Samreen Farooqui[3]*

[1]Professor and Head, Department of Physiology, Matushri Prabhaben Khodabhai Boghara Medical College and Research Centre, Atkot, Gujarat, India

[2]Associate Professor, Department of Physiology, GMERS Medical College, Sola, Ahmedabad, Gujarat, India

[3]Associate Professor, Department of Physiology, Tripura Santiniketan Medical College and Hospital, Madhuban, Ranirkhamar, Tripura, India

ABSTRACT

Background: Small fluid deficits can have an impact on cardiovascular regulation and mental performance during exercise, but the magnitude and time course of these effects are unclear. The aim of the study was to assess the effects of mild hypohydration on cognitive performance and blood pressure responses to moderate exercise.

Method: Forty-two healthy adults (20–40 years old) participated in both euhydrated and hypohydrated trials in a randomized, counterbalanced crossover design with a minimum separation of 7 days. Hypohydration was induced by controlled exercise and fluid restriction to induce a 1.5%-2.0% loss of body-mass. The participants then rode for 45 minutes at 60% of their HRR. Psychomotor vigilance, Stroop inhibition, digit span working memory, blood pressure, heart rate, core temperature, perceived exertion and thirst were measured before, during, and after exercise.

Results: Body-mass loss before the exercise test was 1.8±0.4% in the hypohydrated trial, and 0.2±0.2% in the euhydrated trial ($p<0.001$). During exercise, hypohydration increased heart rate (148±12 versus 140±11 beats/min; $p<0.001$), systolic blood pressure (153±12 versus 146±11 mmHg; $p=0.002$), diastolic blood pressure (79±8 versus 74±7 mmHg; $p=0.006$), and perceived exertion (14.8±1.5 versus 13.4±1.4; $p<0.001$). Post-exercise psychomotor reaction time was slower (356±42 versus 328±35 ms; $p<0.001$), Stroop errors were greater (5.1±2.4 versus 3.2±1.7; $p<0.001$), and digit-span scores were lower (8.7±1.6 versus 9.5±1.4; $p=0.004$).

Conclusion: Hypohydration modestly affected attention and executive control and increased cardiovascular strain during moderate exercise. When cognitive demands are added to exercise, maintaining fluid balance could enhance physiological safety and task performance.

Keywords: hydration; hypohydration; cognitive performance; blood pressure; moderate exercise; physiology

INTRODUCTION

Water is crucial to circulatory stability, thermoregulation, cellular metabolism and neural function. Sweating during exercise decreases plasma volume and increases the effort needed to maintain skin and skeletal-muscle blood flow. If fluid losses are not replaced, heart rate and perceived exertion will increase, thermal strain will increase, and endurance performance may decrease. Therefore, reviews of exercise physiology recognize hydration as a modifiable determinant of performance and safety, especially in the warm environment or during prolonged activity [1].

The cognitive consequences are less consistent than physical consequences, as they are influenced by the extent of dehydration, heat exposure, task complexity, participant expectations, and timing of testing. A meta-analysis found that dehydration negatively affects cognitive functioning in general, and that the magnitude of this effect is greater with increasing levels of body-mass loss for executive function, attention, and motor coordination tasks [2]. Mild dehydration has been shown to impair vigilance and mood in controlled studies of young men, even in the absence of serious hyperthermia [3], and changes in mood, concentration and perceived task difficulty have been found following modest dehydration in healthy women [4].

Moderate exercise is a useful model for studying the interplay between fluid status and cognition, as cognitive testing is performed during sympathetic activation, cardiovascular redistribution, increasing temperature, and fatigue. Active hypohydration can be different from the passive restriction of fluid intake since the exercise and the heat stress the body. Systematic evaluation has suggested that the direction of cognitive change is most consistent when hypohydration is in excess of ~2% of body mass, though susceptible domains may be affected at lower hypohydration deficits [5]. In athletes, the lack of fluid replacement can also impair decision making and reaction time at the end of exercise when they need to make accurate decisions [6].

Blood pressure responses are additional information. In dynamic exercise, the rise in blood pressure is related to the increase in cardiac output, and the diastolic pressure is relatively unchanged or increases slightly due to peripheral vasodilation. Hypohydration decreases central blood volume and stroke volume, which can be compensated by tachycardia and vasoconstriction, but which also increases cardiovascular strain. For recreational exercisers, industrial workers, military personnel and athletes who may be required to perform cognitively demanding tasks in a fluid depleted state, it is clinically relevant. However, recent studies are still investigating the effects of prolonged moderate exercise with sustained mild dehydration, and the variability of the protocols makes it difficult to translate this into simple thresholds [7].

This is a present crossover study to evaluate cognitive and blood pressure responses in a standardized euhydrated and mildly hypohydrated state. The main hypothesis was that moderate exercise would impair psychomotor vigilance and induce greater inhibitory-control errors with a body-mass deficit of about 1.5%-2.0%. The second hypothesis was that hypohydration would cause an increase in exercise SBP, DBP, RPE, and thermal strain.

MATERIALS AND METHODS

Study design and participants

A randomized, counterbalanced crossover experiment was performed in a temperature-controlled human performance laboratory. Two conditions, euhydration and hypohydration were completed by 42 volunteers between the ages of 18-35 years. Trials were separated by 7-14 days and conducted at the same time of day for each participant to minimize the circadian variation. The participants were not endurance-trained but were recreationally active. Patients were excluded if they had cardiovascular, renal, neurologic, endocrine, or psychiatric disease, or were currently ill with a fever, pregnant, smoked, taking antihypertensive or psychoactive medication, had a resting blood pressure greater than or equal to 140/90 mmHg, or failed to pass the familiarization exercise test.

The use of pretrial standardization and manipulation of hydration status.

The subjects abstained from alcohol, heavy exercise, and foods that are unusually salty for 24 hours prior to each trial. Caffeine was banned for 12 hours. A standard evening meal and morning snack were given, and the amount consumed before the first trial was recorded to be able to duplicate it. For euhydrated, water was given the previous day (35 mL/kg) and 2 hours prior to testing (5 mL/kg). During hypohydration, participants performed intermittent cycling in a warm room on the evening prior to testing and were given a limited, standardized volume of fluid afterwards. The goal was to achieve 1.5%-2.0% body-mass loss without symptoms of heat illness.

Body mass (nude or light clothing) was determined on a calibrated scale and urine specific gravity was determined by refractometry. The criteria for the trials were urine specific gravity of < 1.020 for euhydration and urine specific gravity ≥ 1.020 and body-mass loss of 1.5%-2.2% for hypohydration. Those who were not within the specified range were rescheduled. A normal light breakfast was eaten 2 hours prior to the exercise session.

The exercise and cognitive testing protocol will be used in the following manner.

Following 15 minutes of seated rest, baseline blood pressure was measured 3 times with an automated validated monitor and cuff size appropriate for the patient. Participants then rode for 45 minutes at 60% of their individually determined heart-rate reserve in a laboratory with a temperature of 24±1°C and a relative humidity of 45%-55%. Workload was modified in the first 5 minutes and then modified only to keep within the target heart-rate range. During the test no fluid was taken in. Heart rate was measured continuously and blood pressure, rating of perceived exertion, thermal sensation and thirst were measured at 15, 30 and 45 minutes.

Cognitive tests consisted of a 5-minute psychomotor vigilance task, a computerized color-word Stroop test, and forward-plus-backward digit span. Different alternate equivalent versions were used for the different conditions. Testing was done prior to and 8 minutes following exercise in a quiet room. The main cognitive results were mean reaction time, lapses > 500 ms, Stroop incongruent-trial errors and total digit-span score. To minimize learning effects, familiarity was achieved at least 48 hours prior to the first experimental trial.

Physiological measurements and safety

Tympanic temperature was recorded using a standard method and capillary blood samples were drawn for hematocrit and plasma osmolality. Rate-pressure product was defined as the product of systolic blood pressure and heart rate. Symptoms were observed during testing and stopping criteria were defined as chest pain, presyncope, confusion, systolic pressure >220 mmHg, diastolic pressure >110 mmHg, or core-temperature concern. No stopping criteria was reached by any participant.

Statistical analysis

Linear mixed-effects models with condition, time, and condition × time interaction as fixed effects and participant as random effect were used to analyze the data. The order of the trials was investigated by including trial order and no significant order effect was found. Prespecified post-exercise contrasts were summarized using paired t tests. McNemar tests were used to compare categorical variables. Within-participant standardized mean differences (SMD) and 95% confidence intervals (CI) were presented as effect sizes. Two-sided p-value < 0.05 was considered statistically significant. The sample had over 80% power to detect a difference of 0.45 (standardized) within-participant reaction time..

RESULTS

The sample included 22 men and 20 women, with a mean age of 25.8±4.2 years and body-mass index of 23.4±2.6 kg/m². Trial order was evenly distributed, and all participants completed both conditions. Baseline sleep duration, pretrial carbohydrate intake, resting heart rate, and resting cognitive scores were comparable. The hydration manipulation produced a mean body-mass deficit of 1.8±0.4%, urine specific gravity of 1.025±0.004, and higher plasma osmolality in the hypohydrated condition (Table 1).

Table 1. Participant characteristics and pre-exercise hydration markers

Variable	Euhydrated trial	Hypohydrated trial	p-value
Body mass, kg	68.9±10.7	67.8±10.5	<0.001
Change from reference mass	-0.2±0.2%	-1.8±0.4%	<0.001
Urine specific gravity	1.012±0.005	1.025±0.004	<0.001
Plasma osmolality, mOsm/kg	287.4±4.8	295.6±5.3	<0.001
Hematocrit, %	42.1±3.7	44.0±3.8	<0.001
Resting heart rate, beats/min	68±9	71±10	0.08
Resting SBP, mmHg	116±10	118±11	0.19
Resting DBP, mmHg	72±7	74±8	0.12

Exercise intensity, external workload, and room conditions were equivalent between trials. Hypohydration increased heart rate by an average of 8 beats/min during the final 15 minutes and increased systolic and diastolic pressure despite matched workload. The condition-by-time interactions were significant for heart rate ($p<0.001$), systolic pressure ($p=0.01$), rate-pressure product ($p<0.001$), thirst ($p<0.001$), and perceived exertion ($p=0.002$). Tympanic temperature was 0.3°C higher at exercise completion under hypohydration (Table 2).

Table 2. Physiological responses during moderate cycling

Outcome	Euhydrated trial	Hypohydrated trial	p-value
Mean workload, W	128±28	127±29	0.61

Outcome	Euhydrated trial	Hypohydrated trial	p-value
Heart rate at 45 min, beats/min	140±11	148±12	<0.001
Systolic BP at 45 min, mmHg	146±11	153±12	0.002
Diastolic BP at 45 min, mmHg	74±7	79±8	0.006
Mean arterial pressure, mmHg	98±7	104±8	0.001
Rate-pressure product	20,440±2,660	22,644±3,010	<0.001
Tympanic temperature, °C	37.5±0.3	37.8±0.4	<0.001
Perceived exertion, Borg 6-20	13.4±1.4	14.8±1.5	<0.001
Thirst, 0-10	3.2±1.5	6.8±1.4	<0.001

Cognitive performance was similar before exercise, indicating adequate counterbalancing and familiarization. After exercise, mean psychomotor reaction time was 28 ms slower in the hypohydrated trial, vigilance lapses approximately doubled, Stroop incongruent errors increased, and digit-span performance decreased. Stroop response time also lengthened, while congruent-trial accuracy remained high in both conditions. The largest standardized effect was observed for vigilance lapses (d=0.69), followed by Stroop errors (d=0.63) and reaction time (d=0.61) (Table 3).

Table 3. Cognitive performance before and after exercise

Outcome	Euhydrated	Hypohydrated	p-value
Baseline PVT reaction time, ms	306±31	308±33	0.68
Post-exercise PVT reaction time, ms	328±35	356±42	<0.001
Post-exercise PVT lapses, n	2.1±1.5	4.0±2.4	<0.001
Baseline Stroop errors, n	2.6±1.6	2.7±1.5	0.77
Post-exercise Stroop errors, n	3.2±1.7	5.1±2.4	<0.001
Post-exercise Stroop response time, ms	712±76	754±84	0.003
Baseline digit span, total	9.8±1.5	9.7±1.4	0.74
Post-exercise digit span, total	9.5±1.4	8.7±1.6	0.004

Post-exercise reaction time correlated with percentage body-mass loss (r=0.46; p=0.002), thirst (r=0.39; p=0.01), and rate-pressure product (r=0.34; p=0.03). In an exploratory mixed model, hydration condition remained associated with reaction time after adjustment for temperature and perceived exertion (adjusted mean difference 21 ms; p=0.006). No sex-by-condition interaction was statistically significant, although the study was not powered for sex-specific inference.

DISCUSSION

After 45 minutes of moderate exercise, mild hypohydration (about 1.8% of body mass) caused impairments in vigilance, inhibitory control, and working memory. It also had a positive effect on heart rate, systolic and diastolic blood pressure, rate-pressure product, thermal strain, thirst and perceived exertion for the same external workload. The results suggest that a fluid deficit less than the traditional 2% could have some measurable effects when cognitive testing occurs right after a prolonged exercise. Experimental research on voluntary dehydration in trained athletes has also demonstrated impairments in specific cognitive functions, especially if the task is cognitively challenging or if it occurs towards the end of an exercise session [8].

The psychomotor vigilance result is practically relevant. The mean difference is 28 milliseconds, which might seem negligible, but there is also a doubling of lapses, which would indicate that there is more of a problem with sustained attention than a uniform slowing. This may impact driving, equipment operation, tactical decisions, or sport-specific responses. Changes in cerebral perfusion, neuronal metabolism, discomfort and attentional allocation due to dehydration may contribute. Neuroimaging studies have shown that dehydration can change brain structure, and can require more neural resources to sustain performance on a task, even if overall accuracy is not completely lost [9].

Executive control was also found to be susceptible. The hypohydrated state led to more errors on incongruent Stroop trials, but had little effect on congruent trials that were easier to perform. This pattern is consistent with the notion that tasks involving more conflict monitoring or response inhibition show signs of impairment earlier than simple tasks. Evidence-based meta-analysis has revealed that there are significant dehydration-related effects on executive function and attention, but with a high degree of heterogeneity [2]. Variations between studies may be due to the type of dehydration (active or passive), ambient temperature, pre-dehydration hydration status, expectancy, caffeine status and practice effects. Between-person variability was minimized in the present crossover design, and alternate versions of the tasks were used to minimize learning.

The cardiovascular responses were consistent with a decrease in circulating volume and compensatory sympathetic activity. In dynamic exercise, there is competition between the vascular beds of the skin and muscle for cardiac output while a decrease in plasma volume decreases stroke volume. Cardiac output is maintained by increasing heart rate and/or vasoconstrictor support may raise mean and/or diastolic pressure. Dehydration, hyperthermia, cardiovascular drift and decreased performance capacity are the factors that are highlighted in reviews of exercise under heat stress [10]. The temperature difference in this study did not completely explain the reaction-time effect, implying that the fluid deficit and the perceived strain effect were independent.

Raised blood pressure does not necessarily mean that dehydration always causes hypertension. Responses are dependent on posture, intensity of exercise, environmental temperature, autonomic tone and the interaction of decreased preload and peripheral vasoconstriction. In certain cases, severe dehydration may lead to hypotension and cause presyncope. In this study, moderate exercise was adequate to keep pressure up and the higher rate-pressure product represented higher myocardial workload. The absolute values were within normal ranges for exercise, but the same compensation might not be as easily sustained in older adults or in patients with cardiovascular disease.

Practical implications are to start with euhydrated, to plan for fluid availability during exercise that is likely to result in significant sweat loss, and to use individual fluid replacement instead of a universal amount. The sweat rate, climate, clothing, work-rest cycles and gastrointestinal tolerance are widely variable in team-sport and occupational contexts [11]. Changes in body mass during representative sessions may be used to estimate net fluid deficit. Hypotonic drinks should also be avoided since too much fluid may lead to exercise-associated hyponatremia. The objective is to maintain safe fluid balance and not to force fluids above physiological requirement.

The randomized crossover design, objective hydration criteria, matched workload, controlled environment, and multidomain cognitive assessment are strengths of the study. The young healthy sample, laboratory environment, short duration of exercise, lack of direct measurement of cerebral blood flow, and the use of tympanic instead of ingestible core temperature monitoring are limitations. The participants were not blinded to thirst, which may have led to a possible expectancy effect. The protocol used is for acute mild hypohydration and is not able to define responses to chronic low water intake, severe dehydration, or outdoor heat. Older adults, hypertensive populations, ecologically valid dual tasks, and continuous hemodynamic monitoring should be included in future studies.

There is additional research on hydration that is not conducted in the exercise laboratory that corroborates the sensitivity of cognition to fluid balance. According to reviews, the area's most prone to decline as a result of the accumulation of fluid loss are attention, executive function, and memory [12]. The American College of Sports Medicine position stand suggests personalized fluid replacement, depending on sweat losses, exercise duration, environmental factors, and tolerance [13]. Physiological studies also indicate that dehydration leads to a decrease in plasma volume, an increase in cardiovascular strain and may affect endurance performance before clinical symptoms become apparent [14].

Longitudinal studies have shown that lower hydration status is linked with increased cognitive decline in at-risk adults [15] and controlled water restriction and supplementation studies have yielded reversible effects on memory, processing speed and mood [16]. Another important point to note from narrative synthesis is that the degree of cognitive impairment is related to the complexity of the task, the degree of heat exposure, the amount of habitual intake, and the method used to induce hypohydration [17]. However, in the broader clinical literature, dehydration is associated with negative physiological effects, but not at the same level in different populations [18].

CONCLUSION

A fluid deficit of around 1.8% of body mass was associated with greater cardiovascular and perceptual strain during moderate exercise and poorer attention, inhibitory control and working memory following exercise. The findings are consistent with the need for proactive, individual hydration approaches in situations where decisions and tasks that demand quick and accurate cognition follow prolonged exercise. Guidance on fluid intake should be a balance between preventing meaningful fluid loss and the potential for unnecessary fluid intake.

REFERENCES

1. Casa DJ, Stearns RL, Lopez RM, et al. Influence of hydration on physiological function and performance during trail running in the heat. J Athl Train. 2010. PMID:20210618.
2. Wittbrodt MT, Millard-Stafford M. Dehydration impairs cognitive performance: a meta-analysis. Med Sci Sports Exerc. 2018;50(11). PMID:29933347.
3. Ganio MS, Armstrong LE, Casa DJ, et al. Mild dehydration impairs cognitive performance and mood of men. Br J Nutr. 2011. PMID:21736786.
4. Armstrong LE, Ganio MS, Casa DJ, et al. Mild dehydration affects mood in healthy young women. J Nutr. 2012. PMID:22190027.
5. Goodman SPJ, Moreland AT, Marino FE. The effect of active hypohydration on cognitive function: a systematic review and meta-analysis. Physiol Behav. 2019. PMID:30876770.
6. Dube A, et al. Effects of hypohydration and fluid balance in athletes on cognitive performance: a systematic review. Sports Med Open. 2022. PMID:36032481.
7. Watanabe H, et al. Effects of sustained mild dehydration on thermoregulatory and cognitive functions during prolonged moderate exercise. Eur J Appl Physiol. 2024. PMID:38985305.
8. D'Anci KE, Vibhakar A, Kanter JH, Mahoney CR, Taylor HA. Voluntary dehydration and cognitive performance in trained college athletes. Percept Mot Skills. 2009. PMID:19831106.
9. Kempton MJ, Ettinger U, Foster R, et al. Dehydration affects brain structure and function in healthy adolescents. Hum Brain Mapp. 2011. PMID:20336685.
10. Périard JD, Eijsvogels TMH, Daanen HAM. Exercise under heat stress: thermoregulation, hydration, performance implications, and mitigation strategies. Physiol Rev. 2021. PMID:33829868.
11. Nuccio RP, Barnes KA, Carter JM, Baker LB. Fluid balance in team sport athletes and the effect of hypohydration on cognitive, technical, and physical performance. Sports Med. 2017. PMID:28508338.
12. Adan A. Cognitive performance and dehydration. J Am Coll Nutr. 2012;31(2):71-78. PMID:22855911.
13. Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS. American College of Sports Medicine position stand: exercise and fluid replacement. Med Sci Sports Exerc. 2007;39(2):377-390. PMID:17277604.
14. Cheuvront SN, Kenefick RW. Dehydration: physiology, assessment, and performance effects. Compr Physiol. 2014;4(1):257-285. PMID:24692140.
15. Nishi SK, et al. Water intake, hydration status and 2-year changes in cognitive performance in older adults with metabolic syndrome. BMC Med. 2023. PMID:36882739.
16. Zhang J, et al. Effects of water restriction and supplementation on cognitive performance and mood among young adults. Int J Environ Res Public Health. 2021. PMID:34684650.
17. Masento NA, Golightly M, Field DT, Butler LT, van Reekum CM. Effects of hydration status on cognitive performance and mood. Br J Nutr. 2014;111(10):1841-1852. PMID:24480458.
18. Manz F. Hydration and disease. J Am Coll Nutr. 2007;26(5 Suppl):535S-541S. PMID:17921462.