Research Square

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Acute Autonomic and Cognitive Responses to High-Intensity Interval Training With vs. Without a Stroop Task in Male Recreational Athletes

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Abstract

The acute autonomic response to high-intensity interval training (HIIT) is well established, yet it remains unclear whether adding a concurrent cognitive stressor during recovery intervals further perturbs cardiac autonomic control. Sixty-three recreational male young athletes (24.3 ± 4.2 years) were randomly allocated to HIIT (n = 32) or HIIT plus Stroop task (n = 31). Both groups completed 8 × 45 s burpees with 45 s passive recovery; the HIIT plus Stroop task group performed a colour-word Stroop test during recoveries. Pre- and post-exercise assessments included heart-rate variability (HRV) (time/frequency/Poincaré indices), Stroop performance (words, colors, total, interference, estimation), critical flicker fusion threshold, handgrip strength, and horizontal jump. Two-way mixed ANOVAs (Group × Time) tested effects (α = 0.05). Robust time effects emerged in HRV consistent with acute sympathetic activation (↑HR, ↑SI; ↓RR, ↓HRV triangular index in both groups), with small effect sizes; no Group × Time interactions were detected for HRV metrics. For cognition, both groups improved on several Stroop components from pre to post; a main effect of group appeared for the colour's subtest ($F = 5.216$, $p = 0.029$, $\eta^2 = 0.130$), with no interaction. Neuromuscular and arousal measures showed no between-group differences. Adding a Stroop task to HIIT does not further alter acute HRV beyond the effect of HIIT itself, suggesting a ceiling in autonomic perturbation under high physical load. Cognitive work can be integrated during HIIT recoveries without additional autonomic strain, although monitoring of mental fatigue remains advisable.

Introduction

The scientific literature has shown the efficacy of high-intensity interval training (HIIT) in enhancing metabolic function and promoting overall health in diverse population groups (1–4). The distinctive characteristic of HIIT is its structure, which combines periods of intense effort (generally at 80–95% of maximum heart rate) during brief intervals (ranging from 10 seconds to 4 minutes) with periods of low intensity or rest. This alternation enables the body to function under conditions of high energy demand, thereby promoting metabolic and cardiorespiratory adaptations (5). Gibala et al., (2012) (6) postulate that high-intensity interval training (HIIT) can generate adaptations in aerobic capacity like those achieved with moderate-intensity endurance training. Yet these enhancements are attained in a considerably shorter timeframe. A typical protocol might consist of four to six intervals of 30 seconds of maximum-intensity sprinting, followed by four minutes of active recovery (walking). This particular format, referred to as the Tabata protocol, has shown to enhance both aerobic and anaerobic capacity (7).

HIIT also affects cardiovascular measures like Heart Rate Variability (HRV). HRV is a non-invasive measure that reflects the variation in the time interval between consecutive heartbeats (R-R intervals) and is used as an indicator of autonomic nervous system (ANS) function, specifically the balance between the sympathetic and parasympathetic nervous systems (8). The effects of HIIT on HRV can be observed in the short term: a HIIT session can induce a transient decrease in HRV due to physiological stress, followed by a recovery that improves HRV indices (9). In the long term, HIIT programmes lasting several weeks increase HRV at rest, suggesting positive autonomic adaptations (10). Previous research suggested that physical stress is not the sole factor capable of inducing alterations in HRV (11). Research has shown the capacity of HRV to serve as an objective indicator of psychological stress, given its responsiveness to both induced stimuli, such as laboratory tests, and real-life stressors, including those associated with professional environments (12, 13). The non-invasive nature of its measurement, facilitated by electrocardiograms or wearable devices, further ensures its practical applications (14).

The Stroop Test is a widely used tool for assessing physiological stress in scientific research. The Stroop Test is based on assigning a colour to each word, where the colour of the ink in which the word is printed is different from the background colour (e.g., the word "pink" written in green). This procedure creates a conflict between the automatic processing of reading and colour identification, resulting in slower response times and greater mental effort (15). The Stroop test acts as a mental stressor, inducing changes in heart rate variability (HRV) by activating sympathetic responses and reducing variability (15). The purpose of this instrument is to assess stress response, autonomic dysfunctions, and disorders such as post-traumatic stress disorder or somatisation. Research has demonstrated that during the administration of the Stroop

test, HRV in the HF components diminishes, signifying heightened levels of arousal. For instance, in patients diagnosed with somatic symptom disorder, an association has been observed between performance on emotional Stroop tasks and HRV characteristics (16). This differentiates affected individuals from healthy controls, particularly in female subjects (17).

Another analysis based on ECG and HRV signals during the Stroop test has been shown to accurately detect human stress, thus suggesting its use in physiological monitoring (18). Furthermore, HRV variations during the test differ by gender, with greater sympathetic regulation observed in men (17–19). In systematic reviews, HRV under conditions of Stroop stress has been demonstrated to be associated with general physiological impacts, thus highlighting its role in the early detection of chronic stress (20). Physical exertion is rarely experienced in isolation; athletes frequently perform under concurrent cognitive loads. Emerging evidence suggests that combining physical and cognitive stressors may amplify autonomic perturbations beyond those of isolated stressors. This phenomenon may be due to competition for central resources within the central autonomic network or heightened allostatic load (21, 22). For instance, recent studies incorporating Stroop tasks during HIIT rests in athletes reported increased subjective mental fatigue without altering physical workload or basic HR metrics, hinting at differential autonomic impacts not captured by traditional cardiovascular measures alone (23). A number of recent investigations have made a direct comparison between acute autonomic responses and HIIT performed with versus without a simultaneous cognitive interference task, such as the Stroop test, in recreational athletes. The autonomic responses were measured using comprehensive HRV analysis. Existing literature has primarily examined isolated physical or cognitive stressors, or dual-task effects on performance, rather than autonomic dynamics (24). This finding indicates a significant gap in the existing knowledge, as a better understanding of how cognitive demands modulate the autonomic response to HIIT could inform the development of optimised training protocols that enhance resilience to combined stressors.

This relationship underscores the utility of the Stroop test in measuring cognition and revealing autonomic dynamics, which are of significant value in the fields of clinical psychology and neuroscience.

Thus, this study aimed to analyse the acute effect of HIIT exercise and compare it with the acute effect of HIIT exercise alongside the Stroop Test. It was hypothesized that both groups will decrease their HRV during the tests, with a greater decrease in the HIIT plus Stroop test group, due to a higher level of mental stress.

Methods

Participants

63 male recreational athletes (24.3 ± 4.2 years, 175.5 ± 8.2 cm, 71.0 ± 11.7 kg) were analysed. The present study employed a descriptive research method. Convenience sampling was employed due to the existence of logistical constraints and limitations in accessing clinical populations. Participants were recruited among volunteers that agreed to participate in the study. The term "recreational athletes" was defined as individuals who engaged in structured physical exercise on a regular basis, with a minimum training frequency of ≥ 3 sessions per week and a total weekly training volume of ≥ 150 minutes of moderate-to-vigorous physical activity (or ≥ 75 minutes of vigorous-intensity activity). This definition was in accordance with the World Health Organization physical activity guidelines for adults and in line with recent studies (25). This type of individuals was specifically selected as the target population because training status substantially modulates autonomic nervous system (ANS) regulation, cardiovascular stress responsiveness, and post-exercise recovery dynamics. Highly trained endurance athletes typically exhibit enhanced baseline parasympathetic tone and faster HRV recovery post-exercise due to chronic adaptations from high-volume training, which may blunt acute autonomic perturbations during high-intensity interval training (HIIT) combined with cognitive stressors (26, 27). This group represents a large segment of the exercising population who frequently perform dual-task activities in daily life or training. Results from this group may thus better inform training prescription, fatigue management, and rehabilitation protocols for non-elite individuals. In order to address the potential confounding of HRV by preceding measurements, neuromuscular tests were brief and separated by short rests. Participants were instructed to remain in a seated position during the HRV recordings to ensure that posture effects

on autonomic indices were controlled for. Prior to the commencement of the session, participants were required to abstain from the consumption of caffeine, intense physical exertion, and meals for a period of two hours. It is asserted that these controls align with recommendations for minimising artefacts in acute exercise HRV studies (28). The experimental procedures were explained to all the participants, following the Declaration of Helsinki, and approved by the Ethics Committee of the European University of Madrid (CIPI/18/74).

Procedure

The participants were randomly divided into two groups. The first group (N = 32) performed a high intensity interval training (HIIT) which consisted of 8 repetitions of 45" performing burpees with a resting period of 45" between repetitions. The second group (N = 31) performed the same training, but they had to carry out a Stroop test during the resting periods.

Before and after the training, the following parameters were analysed:

(1) Body mass (to the nearest 0.1 kg) was measured by a bioimpedance analyser (InBody 720, Biospace Co. Ltd., Seoul, South Korea).

(2) Body height (to the nearest 1 cm) was measured by a portable stadiometer (SECA, Leicester, UK).

(3) Cortical arousal was measured through the Critical Flicker Fusion Threshold (CFFT) in a viewing chamber (Lafayette Instrument Flicker Fusion Control Unit Model 12,021) following the procedures conducted in previous studies (29).

(4) Isometric handgrip strength by a grip dynamometer (Takei Kiki Koyo. Japan).

(5) Horizontal jump through a metric scale.

(6) Heart Rate Variability (HRV) through a Polar H10 heart rate chest strap validated to record RR function to analyse heart rate variability (HRV) (30, 31), by the Kubios HRV software (University of Kuopio. Kuopio, Finland) following procedures of previous research (32).

Kubios settings used:

The Kubios HRV Premium software (version 3.5) was used to analyze the RR intervals recorded with the Polar H10 chest strap. The signal was resampled at 4 Hz using cubic spline interpolation to properly capture the high-frequency band. Artifact correction was set to a low threshold, smoothness priors were applied with lambda values between 500 and 1000, and spectral analysis was performed using the Welch method with low-frequency band (0.04–0.15 Hz) and high-frequency band (0.15–0.40 Hz) (33). Each 5-minute RR-interval segment was checked for stationarity using Kubios' reverse arrangement test, and all segments showed $p > 0.05$, confirming adequate stationarity for reliable analysis.

(7) Stroop test through a test of colours and words. The validity of this type of short- task to induce mental fatigue has been previously summarized in previous studies (22, 34).

The inclusion of handgrip strength and horizontal jump performance was justified as markers of upper- and lower-body neuromuscular fatigue, respectively. These are sensitive to acute high-intensity exercise and exacerbated by concurrent cognitive load in dual-task paradigms. These measures provide insight into whether cognitive interference during recovery modulates peripheral fatigue beyond central autonomic effects captured by HRV (35, 36). CFFT was utilized to assess cortical arousal and fatigue, complementing HRV as a proxy for central nervous system recovery. (Fig. 1. HERE)

Statistical analysis

The IBM SPSS statistical package version 21.0 for Windows (IBM Corp., Armonk, NY) was used to analyse the data. Normality assumptions were checked with the Kolmogorov-Smirnov test. Homoscedasticity assumptions were checked with the Levene test. Descriptive statistics were presented as mean and standard deviation. A two-way ANOVA test was used to compare the effect of the group (HIIT, or HIIT with Stroop in the resting periods), the effect of the moment of the measurements (pre, post), and the interaction among the result and the game location. A Bonferroni post hoc test was used to analyse pairwise comparisons. The level of significance for all the comparisons was set at $p < 0.05$. The effect size was assessed by the eta squared value (η^2) as specified in previous research (37).

Results

Table 1 shows the HRV variables. For the HIIT group, significant differences were found between pre and post samples in the following variables: HR, SI (increased); RR, HRVI (decreased). For the HIIT + Stroop group, significant differences were found in the following variables: HR, SI (increased); RR, SDSD, PNN50, HRVI (decreased). No differences between HIIT and HIIT + Stroop groups were found. The effect size for all variables was small.

Table 1
Heart-rate variability results.

	Pre				Post				Group and prepost effect		
	HIIT		HIIT + Stroop		HIIT		HIIT + Stroop				
	M	SD	M	SD	M	SD	M	SD	F	p	η^2
HR	83.0‡	20.2	77.4‡	12.3	113.5‡	22.7	105.9‡	20.0	0.226	0.637	0.007
RR	753.8‡	162.0	787.4‡	140.4	545.7‡	102.5	557.6‡	165.3	0.062	0.804	0.002
RMSSD	37.2	16.0	40.1	26.0	31.2	18.8	58.4	135.3	0.694	0.411	0.020
SDSD	37.2	16.0	39.9‡	25.8	31.2	18.8	26.5‡	14.0	0.787	0.381	0.023
SDNN	61.3	33.7	55.4	45.5	48.8	52.1	34.5	33.4	0.187	0.668	0.005
PNN50	19.4	15.9	21.5‡	24.6	12.3	17.3	10.2‡	11.8	0.258	0.615	0.008
HRVI	4.50‡	1.85	4.70‡	1.86	2.44‡	1.61	2.05‡	0.93	0.433	0.515	0.013
TINN	178.8	112.4	185.8	94.8	81.1	56.7	73.5	42.4	0.088	0.769	0.003
SI	217.8‡	256.4	137.5‡	180.2	1188.6‡	1657.3	955.8‡	1364.7	0.148	0.703	0.005
SD1	24.8	9.66	28.1	18.1	20.2	10.9	22.8	19.9	0.000	0.991	0.000
SD2	80.7	50.1	71.7	63.7	61.6	76.0	41.4	48.9	0.155	0.697	0.005
SD1/SD2	0.80	1.80	0.48	0.26	0.75	0.69	3.27	3.21	1.756	0.194	0.051
LF	567.2	1410.4	353.5	1157.3	406.7	1383.2	274.6	444.8	0.091	0.764	0.003
HF	95.8	92.8	104.7	142.6	39.2	51.3	126.5	287.1	1.003	0.324	0.030
LF/HF	11.8	32.0	3.16	3.31	15.0	30.9	3.82	3.17	0.210	0.650	0.007
LF (n.u.)	86.3	103.7	58.8	24.0	144.4	231.1	59.3	27.2	1.488	0.231	0.044
HF (n.u.)	31.7	20.5	80.9	158.1	41.4	52.5	36.9	25.6	1.558	0.221	0.046

Note. M: Mean. SD: Standard Deviation. F: Fisher-Snedecor test. η2: Partial eta squared. HIIT: High Intensity Interval Training. HR: Heart Rate. RR: R-R interval. RMSSD: Root mean square of successive RR interval differences. SDSD: Standard Deviation of the differences between successive NN intervals. SDNN: Standard deviation of NN intervals. PNN50: Percentage of successive RR intervals that differ by more than 50ms. HRVI: HRV triangular index. TINN: Baseline width of the RR interval histogram. SI: Stress Index (sympathetic activity). SD1: Poincaré plot standard deviation perpendicular the line of identity. SD2: Poincaré plot standard deviation along the line of identity. SD1/SD2: Ratio of SD1-to-SD2. LF: Low-frequency band (0.04–0.15 Hz). HF: High-frequency band (0.15–0.4 Hz). LF (n.u.): Relative power of the low-frequency band (0.04–0.15 Hz) in normal units. HF (n.u.): Relative power of the high-frequency band (0.15–0.4 Hz) in normal units. *Differences between HIIT and HIIT+Stroop groups ($p < 0.05$). ‡ Differences with pre/post samples ($p < 0.05$).

[Table 1 HERE]

Table 2 shows the Stroop, arousal, and physical variables. For the HIIT group, significant differences were found between pre and post samples in the following variables: words test, colours test, stroop test, stroop estimation (increased). For the HIIT + Stroop group, significant differences were found in the following variables: words test, stroop test, interference (increased). No differences between HIIT and HIIT + Stroop groups were found. The effect size for all variables was small.

Table 2
Stroop, arousal, and physical results.

	Pre				Post				Group and prepost effect		
	HIIT		HIIT + Stroop		HIIT		HIIT + Stroop				
	M	SD	M	SD	M	SD	M	SD	F	p	η^2
Words test	117.6‡	22.8	121.7‡	15.3	128.4‡	26.0	128.8‡	17.2	0.629	0.433	0.018
Colours test	79.1‡	18.6	90.4	14.7	87.1‡	21.8	90.8	14.0	5.216	0.029	0.130
Stroop test	55.5‡	15.2	58.9‡	15.4	62.0‡	15.4	65.6‡	12.2	0.005	0.944	0.000
Stroop estimation	46.8‡	9.63	51.7	7.10	51.5‡	11.5	53.1	7.10	3.438	0.072	0.089
Interference	8.67	9.71	7.23‡	10.4	10.4	10.4	12.4‡	9.47	1.431	0.240	0.039
Flicker (hz)	39.0	3.31	38.3	2.55	39.5	3.21	38.5	2.94	0.246	0.623	0.007
Horizontal Jump (m)	2.18	0.26	2.21	0.39	2.24	0.25	2.18	0.27	1.591	0.216	0.043
Strength (kg)	44.6	8.91	41.8	10.4	45.3	7.92	41.5	9.43	1.143	0.292	0.032

Note. M: Mean. SD: Standard Deviation. F: Fisher-Snedecor test. η2: Partial eta squared. HIIT: High Intensity Interval Training. *Differences between HIIT and HIIT+Stroop groups ($p < 0.05$). ‡ Differences with pre/post samples ($p < 0.05$).

[Table 2 HERE]

Discussion

The purpose of this analysis was to evaluate the impact of high-intensity interval training (HIIT) alone compared to HIIT combined with the Stroop test on heart rate variability (HRV) parameters, assessed through measurements taken before and after the intervention. Analysis of the results revealed no significant interaction effects between groups and time for any HRV metric, with all p-values greater than 0.05 and small effect sizes ($\eta^2 < 0.05$ for most variables).

Initial hypothesis was that both groups will decrease their HRV values during the tests. The primary hypothesis has been confirmed, demonstrating a decline in HRV values in response to an elevated sympathetic nervous system response. These findings are congruent with the broader literature on acute HRV responses to HIIT, which consistently demonstrates reductions in parasympathetic activity and overall HRV during and immediately following high-intensity efforts (38, 39). However, no significant differences between the two groups could be demonstrated. In contrast, studies examining the Stroop test in isolation report notable autonomic alterations, which tend to manifest as a decrease in HRV indices due to increased cognitive demand and stress-induced sympathetic activation (40, 41). These changes tend to be gender-specific, with some tests showing greater vagal suppression in women. This phenomenon has been linked to an increase in catecholamine release and cardiovascular stress (42). However, when integrating cognitive stress factors, such as the Stroop test, with physical exercise, the literature is more limited and heterogeneous.

This result suggests that the incorporation of the Stroop test did not generate differential responses from the autonomic nervous system beyond those induced by HIIT itself. The results obtained in this study suggest the absence of additive or synergistic effects on HRV, implying that the intense sympathetic drive associated with HIIT may mask or saturate the autonomic impact of cognitive interference. This finding is corroborated by comparable research conducted on trained adults, in which HIIT interspersed with a Stroop task during rest intervals increased perceived mental fatigue and effort but produced equivalent decreases in RMSSD and heart rate responses compared to HIIT alone (43). Similarly, other protocols

combining HIIT with cognitive demands have reported an increase in subjective fatigue without a corresponding increase in physiological workload metrics, such as heart rate or external performance indicators (44, 45). These similarities highlight a possible dissociation between the mental and physical domains under combined stressors, where cognitive tasks amplify perceived stress but do not further alter autonomic balance beyond the threshold of physical exercise. The absence of significant interactions in our study could reflect a ceiling effect in autonomic activation during HIIT, in which the additional cognitive load fails to elicit further sympathetic changes, as evidenced by the non-significant changes in LF/HF and the stress index (SI). This finding contrasts with the results of some meta-analyses using neuroimaging that associate reductions in HRV with broader stress responses, including cognitive interference, but mainly in resting or low-intensity contexts (11). The discrepancies observed could be attributed to variations in the participants' fitness levels, which modulate HRV recovery dynamics (27). Furthermore, the high interindividual variability in the data obtained highlights the influence of factors such as initial physical fitness or stress resistance on responses.

Recent research from the same group has systematically examined the interplay between HIIT and a concurrent Stroop task, offering external validity for the present findings. In recreational tennis players, Clemente-Suárez and colleagues showed that adding an incongruent Stroop test during HIIT recoveries increased perceived exertion and impaired serve accuracy compared with HIIT alone, while cortical arousal (critical flicker fusion threshold) remained unchanged (46). In a follow-up study, the combination of HIIT plus Stroop selectively elevated mental fatigue and the rate of perceived exertion without altering external or internal load markers (speed, heart rate) or RMSSD, suggesting that the added cognitive stress predominantly manifests as subjective strain rather than additional autonomic or mechanical workload (47). Complementarily, when strength outcomes and skill execution were assessed, a HIIT plus Stroop protocol reduced serve speed but preserved accuracy, a pattern interpreted as a central regulation strategy prioritizing precision under cognitive-physical co-stress (22). Taken together, these studies align with our observation of robust time effects in HRV with no Group × Time interaction: the superimposed Stroop challenge appears to magnify mental fatigue and specific motor-skill costs but does not systematically exacerbate acute cardiac autonomic perturbation beyond that induced by HIIT itself.

Limitations and future research

The inherent limitations of this study relate to the possibility that the sample size is limited, as inferred from the variability observed in the measurements. The analysis focused on acute short-term responses, without longer-term follow-up of recovery or control of confounding variables such as hydration or prior sleep. Consequently, it is recommended that future research incorporate larger cohorts, as well as real-time monitoring of HRV during dual tasks and explorations of chronic adaptations to combined HIIT-Stroop protocols. A key limitation of this study is that only male participants were included, so the results cannot be directly applied to women.

Future research should include both men and women to better understand these effects.

Studies show that women often have higher resting parasympathetic activity, stronger vagal responses, and different stress and hormone reactions compared to men (48). A limitation of this study is the lack of controlled breathing during HRV measurements. Participants were instructed to breathe normally without specific guidance on rate or depth, which may have introduced variability in respiratory patterns and influenced high-frequency HRV components (8). Even though this approach reflects more natural conditions, it is recommended that future studies consider standardizing or monitoring respiration. These research studies have the potential to provide clear and compelling answers to the following questions: first, whether repeated exposure has the capacity to enhance autonomic resilience or, conversely, whether such exposure tends to exacerbate fatigue in athletic or clinical populations.

Practical applications

Integrating a brief Stroop task during HIIT recoveries appears feasible when the objective is to enrich sessions with a cognitive component without adding detectable acute autonomic strain beyond HIIT itself. Coaches and practitioners can use 30–60 s incongruent color–word trials in each recovery bout (e.g., 8 × 45 s work / 45 s recovery) to target attentional

control and inhibitory processes while maintaining the physiological stimulus of the session. In racquet, team, and tactical populations, this pairing can be scheduled 1–2 times per week as a micro-dose of “cognitive load under fatigue,” ideally in technical or conditioning sessions where precision under stress is relevant. Because concurrent Stroop tends to elevate perceived exertion and mental fatigue, staff should monitor session RPE and a simple 0–10 mental-fatigue VAS, adjust total volume accordingly, and avoid stacking additional high-cognitive drills the same day. Implementation details that improve reliability include a short familiarization to minimize learning effects, standardized instructions and timing, and consistent task difficulty (e.g., fixed incongruent ratio). For athlete monitoring, track pre- to post-changes in HR, RMSSD (or a chosen HRV index), and task accuracy/latency to individualize progression. In return-to-play or in-season contexts, this approach can maintain cognitive demands without materially increasing autonomic load, but it should be reduced or omitted in athletes showing excessive mental fatigue or suboptimal recovery.

Conclusion

These findings indicate that incorporating the Stroop test into HIIT does not significantly alter HRV profiles compared to HIIT alone, aligning with emerging evidence that physical demands dominate autonomic responses in dual-task scenarios. This has implications for training design, suggesting that cognitive enhancements can be integrated without compromising physiological recovery, though mental fatigue monitoring remains crucial.

Declarations

Consent for publication

Not applicable

Availability of data and materials

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Competing Interests

The authors declare that they have no competing interests.

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Ethics statement

The studies involving humans were approved by Ethics Committee for Research of the European University of Madrid. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ÁB-S: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. SDLT: Conceptualization, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. VC-S: Conceptualization, Investigation, Validation, Writing – original draft, Writing – review & editing.

Declaration of interest

The authors certify that they are not involved in any organization or entity with any financial interest, or non-financial interest, in the subject discussed in this manuscript. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sector.

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Figures

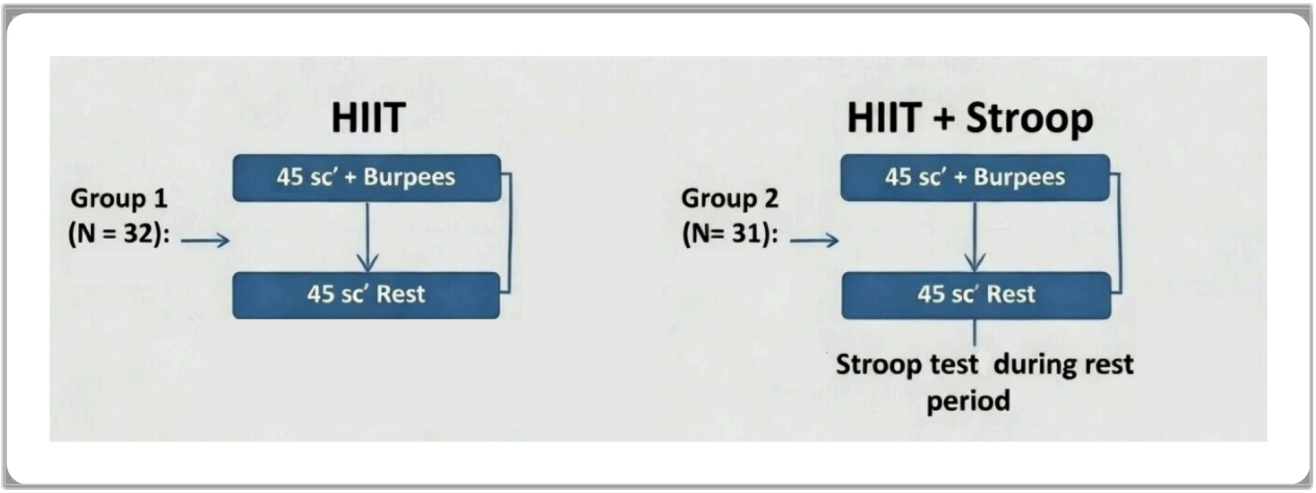


Figure 1

Exercise protocol