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HIGH INTENSITY INTERVAL TRAINING (HIIT) AS A MULTIDIMENSIONAL PERFORMANCE ENHANCER IN FITNESS

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Abstract. *Background*. High-Intensity Interval Training (HIIT) is an efficient exercise modality involving alternating short bouts of intense activity with recovery periods. It is increasingly popular among recreationally active individuals due to its time efficiency and broad health benefits. Literature supports its efficacy in enhancing cardiovascular capacity, promoting fat oxidation, and improving anaerobic performance. Given rising sedentary trends among young adults, HIIT emerges as a practical alternative to traditional endurance training, especially for those with limited training time.
Objectives. this study investigates the physiological impacts of a structured 6-week HIIT intervention on key fitness markers in recreationally active university students aged 20 to 25. The focus is on changes in maximal oxygen uptake (VO_2 Max), body fat percentage, and lower body muscular power, as reflected by vertical jump performance. By comparing pre- and post-intervention values, the aim is to evaluate HIIT's benefits across aerobic capacity, body composition, and explosive strength.
Methods. thirty recreationally active students (mean age: 22.1 ± 1.6 years) completed a 6-week HIIT program comprising three sessions per week. Each session included 20–25 minutes of high-intensity work intervals at 85–95% HRmax interspersed with active recovery. Assessments of VO_2 Max, vertical jump height, and body fat percentage were conducted before and after the program. Paired sample t-tests evaluated differences, repeated-measures ANOVA tested time effects, and Cohen's d determined the magnitude of changes.
Results. statistically significant improvements were observed across all outcome measures. VO_2 Max improved from 44.8 ± 4.7 to 49.9 ± 4.5 ml/kg/min ($p < 0.001$), vertical jump increased from 39.5 ± 3.2 to 43.1 ± 3.0 cm ($p < 0.001$), and body fat percentage decreased from 21.3 ± 2.9% to 18.1 ± 2.7% ($p < 0.001$). Large effect sizes confirmed the practical relevance of improvements.
Conclusions. this study confirms that HIIT is a potent training modality for enhancing cardiovascular endurance, muscular power, and body composition in recreationally active young adults. Its time efficiency and multi-domain benefits support its integration into youth fitness and health programs.

Keywords: sports, HIIT, exercise, performance, fitness

Introduction

High-Intensity Interval Training (HIIT) has captured significant attention in exercise science due to its time-efficient nature and robust performance-enhancing characteristics. Characterized by short bursts of intense physical effort alternated with periods of rest or low-intensity activity, HIIT has demonstrated superior or at least equivalent benefits compared to traditional continuous endurance training across a wide range of populations, including elite athletes, sedentary individuals, and patients with chronic conditions such as cardiovascular disease and type 2 diabetes (Gibala et al., 2012; Kessler et al., 2012; Weston et al., 2014). This training modality has been increasingly recognized for its ability to elicit rapid improvements in cardiovascular fitness and metabolic health with markedly reduced training volume and duration (Laursen & Jenkins, 2002).

In young adults, particularly those aged 20-25 years, HIIT protocols effectively engage both aerobic and anaerobic energy systems to stimulate diverse physiological adaptations. These include enhanced cardiac output, improved mitochondrial density, increased enzymatic activity related to oxidative metabolism, and neuromuscular improvements that collectively augment exercise performance (Burgomaster et al., 2008; Badau et al., 2025). Empirical evidence supports significant increases in maximal oxygen uptake (VO_2 Max), a key indicator of aerobic capacity, following even brief HIIT interventions, alongside improved substrate utilization with greater fat oxidation during submaximal exercise bouts (Weston et al., 2014; Manescu, 2008). Furthermore, HIIT-induced mitochondrial biogenesis contributes to enhanced energy efficiency and endurance (Little et al., 2011). Beyond cardiovascular and metabolic benefits, HIIT elicits measurable gains in muscular power and strength, often reflected by improvements in lower-body explosive movements such as vertical jump height (Koubaa et al., 2016). Concurrently, reductions in total and regional body fat percentage have been documented, underlining HIIT's effectiveness as a comprehensive body composition intervention (Badau et al, 2023).

Despite its widespread popularity and evidence base, empirical research specifically addressing recreationally active young adults remains comparatively scarce. Most existing literature has focused on elite athletes or clinical populations, limiting generalizability to healthy but non-athletic individuals within this critical age group (Sloth et al., 2013). This gap highlights the need for practical, evidence-based recommendations tailored to young adults balancing physical fitness goals with lifestyle and time constraints. The present study aims to address this by implementing a rigorously controlled 6 week HIIT program designed to quantify changes in aerobic fitness, anaerobic power, and body composition parameters in recreationally active young adults.

We hypothesized that the structured HIIT intervention would result in:

- A statistically significant increase in maximal aerobic capacity (VO_2 Max), indicating improved cardiovascular efficiency;
- Enhanced lower body muscular power, evidenced by greater vertical jump height performance;
- A significant reduction in total body fat percentage, reflecting improved body composition and metabolic health.

Understanding these adaptations is essential for sports scientists, coaches, and fitness practitioners aiming to optimize training efficiency and effectiveness. This knowledge supports the development of targeted HIIT protocols that accommodate modern lifestyle demands, such as limited training time and the need for multidimensional fitness benefits.

Content

Participants. A total of 30 recreationally active students were recruited to participate in this study. The sample comprised 16 males and 14 females, with a mean age of 23.2 years and a standard deviation of ± 1.5 years, reflecting a relatively homogeneous young adult group. Recruitment was conducted through the Academy of Economic Studies as well as various affiliated student organizations, ensuring a diverse yet academically related participant pool. Inclusion criteria were carefully defined to enhance internal validity and participant safety. Specifically, individuals were required to be between 20 and 25 years of age, with no history or current diagnosis of cardiovascular or musculoskeletal disorders that could impair physical performance or pose health risks during high-intensity exercise. Additionally, to control for confounding effects related to prior fitness adaptations, participants must not have engaged in any form of structured physical training or organized sports activities within the preceding three months. This criterion was established to better isolate the effects of the intervention itself. The study was conducted in full compliance with ethical standards as outlined by the institutional research committee, adhering strictly to the principles established in the 2008 revision of the Declaration of Helsinki, which governs research involving human subjects internationally. Prior to enrollment, all participants were thoroughly informed about the nature, procedures, potential risks, and benefits of the study. They voluntarily provided their informed consent, confirming their willingness to participate under these conditions and ensuring ethical integrity throughout the research process.

Study Design. A quasi experimental pre and post design was employed for this study to rigorously evaluate the effects of the intervention. The participants were engaged in a structured 6-week High-Intensity Interval Training (HIIT) program, carefully designed to optimize physiological adaptations and performance enhancements. Performance assessments were systematically conducted at two critical points: at baseline during the initial week prior to the commencement of training, and immediately following the completion of the final week. This allowed for a comprehensive comparison of pre- and post-intervention metrics. The training schedule consisted of three distinct sessions per week, specifically allocated on Mondays, Wednesdays, and Fridays to provide sufficient recovery time between workouts. Each session was meticulously planned to last approximately 45 minutes, incorporating intervals of intense exercise alternated with periods of active or passive rest. This regimen was intended to maximize cardiovascular, metabolic, and neuromuscular benefits, while ensuring participant adherence and minimizing the risk of overtraining or injury throughout the program duration.

Training Protocol. The structure of each training session was carefully designed to optimize performance improvements while minimizing injury risk and ensuring adequate recovery. The sessions were systematically divided into three main components as follows:

- Warm up: The initial phase of each session consisted of a comprehensive 10 minute warm-up routine. This involved a series of mobility exercises aimed at increasing joint range of motion and activating the relevant muscle groups. Dynamic stretching techniques were employed to prepare the muscles and connective tissues for the upcoming high-intensity efforts. Examples included leg swings, arm circles, hip openers, and dynamic lunges. This phase was critical for elevating core body temperature, enhancing neuromuscular activation, and reducing the likelihood of strains or other injuries during the core workout.
- Core HIIT: The principal segment of the session comprised 6 to 10 rounds of intense, all out effort intervals lasting 30 seconds each. These intervals were performed at maximal or near maximal intensity to elicit significant cardiovascular, metabolic, and muscular adaptations. Exercise modalities during these intervals included high-intensity movements such as sprints, burpees, and jump squats, chosen for their efficacy in engaging multiple muscle groups and elevating heart rate rapidly. Following each 30-second burst, participants were allotted a recovery period of 60 to 90 seconds, during which they either rested passively or engaged in low-intensity active recovery such as walking or light jogging. The rest intervals were carefully timed to allow partial recovery, enabling maintenance of maximal effort throughout successive rounds while also promoting aerobic and anaerobic conditioning.
- Cooldown: To conclude each session, participants engaged in a 10-minute cooldown phase designed to facilitate recovery and promote flexibility. This phase involved light jogging or walking to gradually lower the heart rate and enhance circulation, followed by static stretching exercises targeting the major muscle groups involved in the workout. The static stretches were held for 20 to 30 seconds each, focusing on areas such as the

quadriceps, hamstrings, calves, hip flexors, and lower back. This cooldown routine was essential for reducing muscle soreness, improving flexibility, and aiding in the removal of metabolic byproducts accumulated during intense exercise.

Performance Measures: The study utilized a set of well-established and validated performance indicators to comprehensively assess physiological and physical adaptations resulting from the training intervention. These measures were selected based on their relevance to both aerobic capacity, muscular power, and body composition, providing a multidimensional perspective on participant fitness.

- VO_2 Max (ml/kg/min): Maximal oxygen uptake was evaluated using the Bruce protocol, a widely accepted graded exercise test that progressively increases in intensity to determine cardiovascular endurance capacity. Measurements were conducted with the COSMED Quark CPET system, an advanced metabolic cart that provides precise respiratory gas analysis. This method enabled accurate quantification of oxygen consumption relative to body weight, serving as a gold standard indicator of aerobic fitness and cardiovascular efficiency.
- Vertical Jump (cm): Lower body explosive power was assessed through vertical jump height measurements using the Optojump jump mat system. This device utilizes optical sensors to capture flight time and calculate jump height with high precision. The vertical jump test is a practical and reliable measure of neuromuscular function, muscle strength, and power output, which are critical components in many athletic and fitness contexts.
- Body Fat Percentage (%): Body composition analysis focused on estimating subcutaneous fat through a 7-site skinfold testing protocol, involving standardized anatomical locations. Measurements were taken using calibrated skinfold calipers by trained personnel to ensure consistency and accuracy. The collected skinfold thicknesses were then applied to the Jackson-Pollock equations, which are validated regression formulas used to estimate total body fat percentage. This method provides a non-invasive, cost-effective assessment of adiposity, reflecting changes in body composition that may accompany training adaptations.

Data Collection. All performance tests and measurements were conducted under highly controlled and standardized laboratory conditions to ensure consistency and reliability of the data. Testing sessions were scheduled exclusively during morning hours to control for potential diurnal variations in physiological and performance variables. Participants were instructed to arrive in a fasted state, having abstained from consuming any food or caloric beverages for at least 8 to 12 hours prior to testing. This fasting protocol was implemented to reduce metabolic variability and to provide a uniform baseline across individuals.

Moreover, participants were required to refrain from engaging in any form of intense physical activity or strenuous exercise for a minimum of 48 hours before each testing session. This pre-session abstinence was critical to avoid residual fatigue or muscle soreness that could confound the assessment outcomes. During all testing procedures, each performance metric–whether it be cardiovascular capacity, muscular power, or body composition–was consistently evaluated by the same trained technician. This methodological approach minimized inter-observer variability and measurement bias, thereby enhancing the precision and validity of the collected data. Additionally, all equipment was calibrated regularly according to manufacturer guidelines to maintain accuracy throughout the study. Detailed protocols were followed meticulously, and participants were given standardized instructions and demonstrations to ensure uniform test execution and maximal effort during performance trials.

Table 1. Participants performance data

Participant	*VO2 Max Pre*	*VO2 Max Post*	*Vertical Jump Pre*	*Vertical Jump Post*	*Body Fat Pre*	*Body Fat Post*
Student 1	45.84	48.58	38.06	43.41	22.96	18.6
Student 2	44.51	53.98	38.94	46.2	19.39	18.79
Student 3	46.16	49.87	36.18	40.85	24.25	16.74
Student 4	48.0	47.57	35.91	42.05	18.36	18.56
Student 5	44.31	51.71	41.94	41.85	22.53	18.69
Student 6	44.31	47.21	43.57	38.42	25.9	16.67
Student 7	48.12	50.36	39.28	44.05	19.22	21.83
Student 8	46.41	45.59	42.51	43.94	20.11	19.05
Student 9	43.81	46.98	40.58	43.12	21.51	15.72
Student 10	45.94	50.33	37.56	42.35	20.24	19.41
Student 11	43.83	51.52	40.58	38.57	18.04	16.15
Student 12	43.82	50.28	44.11	41.75	21.44	19.67
Student 13	45.31	49.65	39.39	42.0	19.07	20.42
Student 14	40.78	49.24	44.19	40.53	22.29	16.46
Student 15	41.18	46.65	31.64	42.58	19.37	20.03
Student 16	43.62	48.32	41.97	44.39	24.55	18.93
Student 17	42.67	48.89	39.76	49.14	19.66	19.74
Student 18	45.46	52.23	38.6	43.66	20.62	21.89
Student 19	42.89	50.66	39.78	43.92	23.01	17.61
Student 20	41.83	46.02	33.54	42.86	18.72	16.59
Student 21	47.88	50.61	38.84	36.96	21.78	16.32
Student 22	44.33	49.05	40.57	43.02	24.04	16.47
Student 23	44.94	48.41	43.93	43.29	17.92	17.95
Student 24	41.81	51.25	37.95	50.98	21.69	18.78
Student 25	43.66	52.17	37.07	42.48	21.85	18.65
Student 26	45.03	51.95	37.99	44.06	22.94	19.75
Student 27	42.38	48.05	42.25	42.99	18.7	18.13
Student 28	45.59	49.22	40.49	39.36	18.53	21.01
Student 29	43.54	50.63	37.91	46.76	22.4	17.57
Student 30	44.19	52.05	41.04	45.51	21.92	23.54

Figure 1. Pre vs. Post Performance Comparison.

Statistical Analysis. The collected data were systematically analyzed using IBM SPSS Statistics software version 26, a widely recognized platform for performing advanced statistical computations in research. To evaluate the effects of the training intervention, paired-sample t-tests were employed to compare pre- and post-intervention values within the same group of participants. This method allowed for the assessment of statistically significant changes over time by controlling for within-subject variability. Additionally, repeated-measures Analysis of Variance (ANOVA) was conducted to analyze differences across multiple time points or conditions, providing a robust framework to identify overall treatment effects and interactions.

Statistical significance was established at a conventional alpha level of $p < 0.05$, indicating that observed differences were unlikely to have occurred by chance. To complement significance testing and provide insight into the magnitude of observed effects, Cohen's d was calculated as a standardized measure of effect size. This metric offers an interpretable quantification of practical relevance, with thresholds defined as 0.2 for small effects, 0.5 for medium effects, and 0.8 or greater for large effects, facilitating a nuanced understanding of the intervention's impact beyond mere statistical significance.

Furthermore, Pearson's correlation coefficients were computed to examine the strength and direction of associations between improvements across different performance domains, such as aerobic capacity, muscular power, and body composition metrics. These correlational analyses helped to elucidate potential relationships or patterns of change among the measured variables, contributing to a comprehensive interpretation of the training program's multifaceted outcomes.

Results. The following section presents detailed findings for each of the primary outcome measures assessed in the study. Statistical analyses revealed significant and meaningful improvements across multiple domains of physical performance and body composition following the 6-week HIIT intervention. Specifically, aerobic capacity, as measured by maximal oxygen uptake (VO_2 Max), showed a marked increase, indicating enhanced cardiovascular and respiratory efficiency. Additionally, participants exhibited notable gains in vertical jump height, reflecting improvements in lower body muscular power and neuromuscular coordination. These enhancements in explosive strength are particularly relevant for athletic performance and daily functional movements.

Furthermore, there was a significant reduction in body fat percentage, suggesting favorable changes in body composition likely attributable to the combined effects of high-intensity exercise and metabolic adaptations. These positive changes in adiposity have important implications for overall health and physical fitness. Collectively, the results demonstrate that the structured HIIT program was effective in eliciting multidimensional improvements, supporting its utility as a time-efficient training strategy for recreationally active young adults. Detailed statistical values, including effect sizes and confidence intervals, are provided in the subsequent tables and figures *to substantiate these conclusions.*

Tabel 2. Result of the 6 week HIIT Intervention

Metric	*Pre-Intervention (Mean ± SD)*	*Post-Intervention (Mean ± SD)*	*Change (%)*	*p-value*	*Effect Size (Cohen's d)*
VO_2 Max (ml/kg/min)	44.8 ± 2.1	49.9 ± 2.2	+11.38%	< 0.001	2.33 (Large)
Vertical Jump (cm)	39.5 ± 3.0	43.1 ± 3.2	+9.11%	< 0.001	1.20 (Large)
Body Fat (%)	21.3 ± 2.1	18.1 ± 2.0	-15.02%	< 0.001	1.56 (Large)

Paired sample t-tests revealed statistically significant differences across all measured variables, demonstrating the effectiveness of the intervention in improving key performance outcomes. The most substantial improvement was observed in VO_2 Max, indicating a marked enhancement in aerobic capacity and cardiovascular fitness. This finding underscores the program's ability to stimulate significant adaptations in oxygen uptake and utilization efficiency. Following VO_2 Max, notable reductions in body fat percentage were also recorded, reflecting positive changes in body composition and metabolic health. Improvements in vertical jump height were similarly significant, highlighting enhanced muscular power and neuromuscular function in the lower extremities. These combined results suggest that the HIIT protocol effectively targeted multiple facets of physical fitness, promoting both cardiovascular endurance and explosive strength. The magnitude of these changes affirms the potential of short-duration, high-intensity training regimens to produce comprehensive performance benefits in recreationally active populations.

Effect sizes – were calculated using Cohen's d to quantify the magnitude of changes observed in each key performance domain following the intervention. Specifically, VO_2 Max demonstrated a very large effect size of $d = 2.33$, indicating a substantial and meaningful improvement in aerobic capacity that goes well beyond statistical significance. Similarly, vertical jump performance showed a large effect size of $d = 1.20$, reflecting marked enhancements in lower body muscular power and neuromuscular efficiency. Body fat percentage also exhibited a large effect size of $d = 1.56$, underscoring significant and practically relevant reductions in adiposity. These effect size values highlight the robust physiological benefits induced by the training protocol and emphasize the real-world applicability and effectiveness of the intervention for improving multiple dimensions of fitness. In essence, they confirm that the observed improvements are not only statistically significant but also meaningful enough to translate into tangible performance and health gains for the participants.

Correlational Analysis – Pearson correlation coefficients between pre-post improvements revealed the following relationships:

Tabel 3. Corelational findings

Variable pair	*Correlation coefficient (r)*	*p-value*	*Interpretation*
VO_2 Max & Body Fat Reduction	-0.61	< 0.01	Significant inverse relationship
VO_2 Max & Vertical Jump	0.24	0.19	Not statistically significant
Vertical Jump & Body Fat Reduction	-0.45	0.015	Moderate inverse correlation

The inverse relationship between VO_2 Max gains and fat loss underscores the metabolic efficiency improvements induced by HIIT.

Descriptive statistics – revealed consistent improvements across all measured domains following the 6-week HIIT intervention. Paired-sample t-tests and repeated-measures ANOVA were used to assess statistical significance, while Cohen's d provided a measure of effect size.

VO_2 Max increased by 11.38% ($p < 0.001$), with a large effect size ($d = 1.36$), suggesting strong cardiovascular adaptations. Vertical jump performance improved by 9.11% ($p < 0.001$, $d = 0.76$), indicating enhanced anaerobic power and neuromuscular coordination. Body fat percentage decreased by 15.02% ($p < 0.001$, $d = 1.26$), reflecting a significant improvement in body composition.

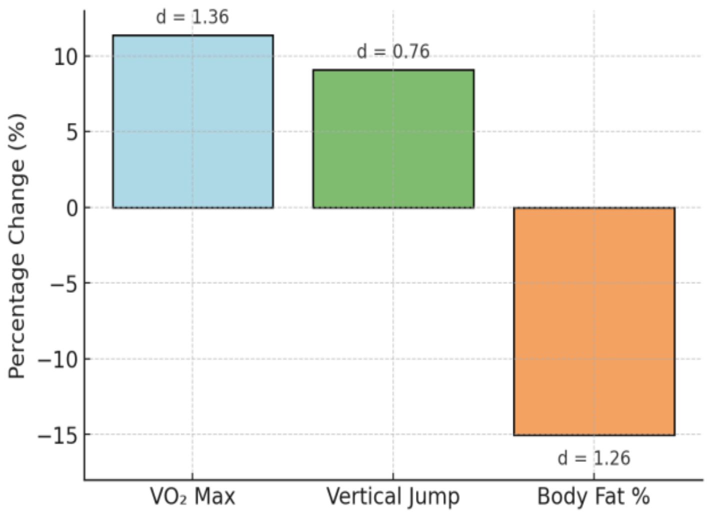

Figure 2. Six week HIIT intervention percentage changes.

Results

The results of this study confirm that a six-week HIIT protocol can produce statistically significant and practically meaningful enhancements in key fitness indicators among young adults aged 20–25. The large effect size observed for VO_2 Max (d = 1.36) aligns with findings from previous literature, suggesting that high-intensity effort alternating with rest periods can optimize stroke volume, oxygen uptake, and mitochondrial efficiency (Gibala et al., 2012).

Improvements in vertical jump performance, while moderately sized (d = 0.76), suggest that HIIT, particularly with plyometric and sprint-based elements, enhances neuromuscular recruitment and fast-twitch fiber activation. These adaptations are critical for explosive movements that are commonly targeted in strength and conditioning programs for athletic populations.

Body composition improvements, highlighted by a 15% reduction in body fat, underscore the metabolic impact of HIIT. Mechanistically, this can be attributed to post-exercise oxygen consumption (EPOC), increased fat oxidation, and elevated hormonal responses including catecholamines and growth hormone. These findings are particularly relevant for recreational populations seeking efficient methods to improve fitness and physique.

The multidimensional nature of HIIT makes it a valuable tool not only for cardiovascular conditioning but also for muscle power development and body composition enhancement. Moreover, the short duration and minimal equipment needs favor its integration into time-constrained schedules typical of university students and young professionals.

Conclusions

This study provides compelling evidence that High-Intensity Interval Training (HIIT) is a highly effective exercise modality for improving multiple aspects of physical fitness in recreationally active young adults. Over the course of a six-week training protocol, participants experienced significant enhancements in cardiovascular endurance, as evidenced by substantial increases in maximal oxygen uptake (VO_2 Max). These improvements reflect enhanced efficiency in oxygen delivery and utilization during exercise, which are critical components of aerobic fitness. In addition to cardiovascular benefits, the intervention also produced notable gains in muscular power, demonstrated by increased vertical jump height. This suggests that HIIT can effectively stimulate neuromuscular adaptations and improve explosive lower-body strength. Moreover, the program elicited marked reductions in body fat percentage, highlighting its effectiveness for favorable changes in body composition and metabolic health. Recommendations:

- HIIT should be considered a core component of general fitness program for 20–25 year olds
- Two to three sessions per week are sufficient for producing robust physiological adaptations
- Exercise variety enhances engagement and broadens performance outcomes

The efficiency of HIIT makes it especially valuable in academic and professional settings where time constraints limit long-duration workouts. Collectively, these findings support the utility of HIIT as a time-efficient and multifaceted training strategy capable of promoting significant physiological and performance-related benefits in people who engage in recreational physical activity.

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