Original Research Article

Investigating the Effectiveness of High-Intensity Continuous Training in Trained Recreational Athletes

Michael Xu and Adem Tareen

Green Level High School, 7600 Roberts Rd, Cary, NC, 27519, United States

ABSTRACT

High-Intensity Continuous Training (HICT), introduced by Joel Jamieson in *Ultimate MMA Conditioning*, involves sustained slow-cadence, high-resistance repetitions for 10-20 minutes to improve aerobic abilities such as fatigue resistance in Type II muscle fibers. Despite its proposed benefits for athletes in sports which require repeated, near-maximal explosive efforts, HICT has yet to be scientifically evaluated. This matched-subjects pilot study examined the effectiveness of a 10-week HICT intervention on fatigue resistance in two 17-year-old recreational athletes (172.72 ± 2.54 cm, 140 ± 3 lbs), measured via performance across Repeated Sprint Ability (RSA) and Cooper 12-minute run-walk tests. One subject performed HICT twice weekly on a commercially available spin bike; the other served as a control. Test analyses used Wilcoxon signed-rank and paired sample t-tests for between-subjects comparisons, and Kendall's tau correlations for within-subject performance trends. The experimental subject exhibited a negative trend in RSA sprint times ($\tau = -0.764$, $p = 0.002$), indicating improved fatigue resistance, while the control showed a positive trend ($\tau = 0.556$, $p = 0.029$), suggesting that HICT improved fatigue resistance and recovery in Type II fibers. These effects may reflect enhanced phosphocreatine (PCr) resynthesis, mitochondrial biogenesis, and lactate clearance. Cooper test results showed no significant trends in either subject, leaving maximal oxygen uptake (VO2max) effects inconclusive. These limited findings suggest HICT may be a viable technique for developing fatigue resistance in the fast-twitch muscles of teenage athletes. Further research should incorporate larger samples, extended intervention periods, formal measurement of external variables, and direct physiological measurements of aerobic adaptations.

Keywords: Sports Science; HICT; High-Intensity Continuous Training; Aerobic Training; Exercise; Aerobic Adaptations

INTRODUCTION

Within the human body, there are two types of muscle fibers: Type I, or "Slow-Twitch" fibers, and Type II, or "Fast-Twitch" fibers. Type I fibers possess slow contraction velocities, relying primarily on oxidative phosphorylation for Adenosine Triphosphate (ATP) resynthesis and being highly dense in mitochondria (1). Type II fibers possess higher contraction velocities and lower mitochondrial levels, separated into sub-fibers IIa and IIx.1,2 IIa and IIx exhibit moderate to fastest contraction velocities respectively, with IIa having more mitochondrial content than IIx but with significantly less power output (1, 3). Additionally, IIa fibers can utilize both the oxidative and glycolytic pathways for ATP resynthesis, while IIx uses the Phosphocreatine

Corresponding author: Michael Xu, E-mail: mcxu@students.wcpss.net.

Accepted May 21, 2026
https://doi.org/10.70251/HYJR2348.43208219

(PCr) and glycolytic pathways, fatiguing quickly in high intensity or maximal efforts (3).

Because of the higher oxidative capacity of Type I fibers, they are slower to fatigue than their Type II counterparts (4). However, in sports with high, repeated explosive demand such as combat sports (e.g. Wrestling, Boxing), there is a need to improve the aerobic ability of the Type II fibers to meet corresponding performance demands of generating as much power as possible interspersed with short rest periods (5). Indeed, recovery from muscular fatigue, which is defined as an "exercise-induced reduction in maximal voluntary muscle force," (6) has been shown to positively correlate with greater aerobic ability such as increased mitochondrial content through accelerated PCr resynthesis, enhanced lactate clearance, and improved oxidative ATP regeneration (7, 8, 9).

There exists a variety of methods for increasing mitochondrial content and fatigue resistance in Type II muscle fibers, among them being Sprint Interval Training (SIT) and High-Intensity Interval Training (HIIT) (10, 11). Strength and conditioning coach and founder of 8 Weeks Out, Joel Jamieson, in his book Ultimate MMA Conditioning proposes a novel method for this purpose: High-Intensity Continuous Training (HICT). Accredited to Russian health and human performance specialist Val Nasedkin, HICT involves the continuous performance of slow-cadence repetitions with high resistance for up to 10–20 minutes at a time (12). This differentiates itself from both SIT and HIIT, which sustain high intensities for only brief bursts with intermittent rest periods. According to Jamieson, it is purported to allow the Type II fibers to generate ATP for longer periods, delaying performance fatigability (12). If true, this presents a promising aerobic conditioning technique not previously assessed in scientific literature. In lieu of access to advanced testing equipment such as muscle biopsies or a cycle ergometer, this matched subjects design study aims to infer the effectiveness of HICT in increasing the fatigue resistance of Type II fibers in two trained teenage athletes via practical performance fatigability testing.

METHODS AND MATERIALS

Given the exploratory nature of this research with the absence of prior studies on HICT, as well as limited access to testing subjects, a two-subject pilot design was selected, aiming to establish preliminary effects and inform the design of future larger studies. The two subjects in this study were both 17-year-old male athletes (172.72 ± 2.54 cm, 140 ± 3 lbs.) with prior experience performing resistance and aerobic training multiple times a week (3 ± 1.3 yrs, 4 ± 1 days/week). Approval was granted by a school ethics committee comprising of a current health professional with expertise in Sports and Exercise Science, a school administrator, and a school educator. Informed consent was obtained from both participants and their parents, briefed on the methods and objectives of the study. Assignment of subjects to the experimental or control condition was determined by coin flip, with the experimental subject performing HICT two times a week for the study duration of 10 weeks. Personally identifiable information was not recorded, with either subject being simply labeled as the experimental subject or the control subject and the only data collected being their performance across testing. The subjects were instructed to abstain from their regular training, while maintaining their diet and sleep patterns for the duration of the study and to report any deviations such as weight gain or consistent disrupted sleep. No formal monitoring of these variables was conducted, a significant limitation of this study's design.

The experimental subject, performing HICT 2x a week, did so on a commercially available Spin Bike (13). As displayed in Table 1, the subject sits on the Spin Bike grasping the handles, pedals in a vertical alignment. They make one rotation of the pedals, bringing each pedal to the previous position of the opposite pedal, pausing for approximately one second before performing another rotation. This is performed continuously for the twenty-minute duration, sustaining only 20–30 Rotations Per Minute of the Spin Bike wheel. Two sets per session were performed, with 10 minutes of walking at a non-strenuous pace as active recovery between sets (Figure 1).

The performance tests selected for this study were the Cooper walk-run test, and a Repeated Sprint Ability (RSA) test. Before each test, the participants performed a five-minute warm up consisting of jogging, high knees, lunges, and high kicks, each done for 15 meters in immediate succession. The Cooper walk-run test measures the maximum distance (MD) covered during 12 minutes of continuous running on a flat track, recorded in meters with a digital app for the purposes of the study (15), which then is converted to an estimated VO2max via the regression equation (16). The Repeated Sprint Ability test involves six timed 30-meter sprints at maximal effort down a flat track, with 15 seconds of walking at a non-strenuous pace as active recovery between sprints. The mean time (MT) for all six sprints

Table 1. *Baseline RSA test descriptive statistics results in seconds for control and experimental subjects. Three baseline RSA tests were conducted prior to the subject assigned to the experimental condition starting the HICT intervention. Each test required the subjects to complete six maximal effort 30-meter sprints, with 15 seconds of walking as active recovery between sprints and the mean sprint time for each test recorded as the outcome measure. Descriptive statistics include the number of valid observations (n), arithmetic mean, standard deviation (SD), and minimum and maximum values across the three baseline tests. Lower mean sprint times indicate better sprint performance. Test Number refers to the sequential test number (1-3) within this baseline measurement phase.*

Descriptive Statistics	Control Subject Baseline Test Number	Control Subject Baseline Sprint Time	Experimental Subject Baseline Test Number	Experimental Subject Baseline Sprint Time
Valid	3	3	3	3
Mean (arithmetic)		7.224		7.164
Std. Deviation		0.025		0.013
Minimum	1	7.203	1	7.152
Maximum	3	7.252	3	7.178

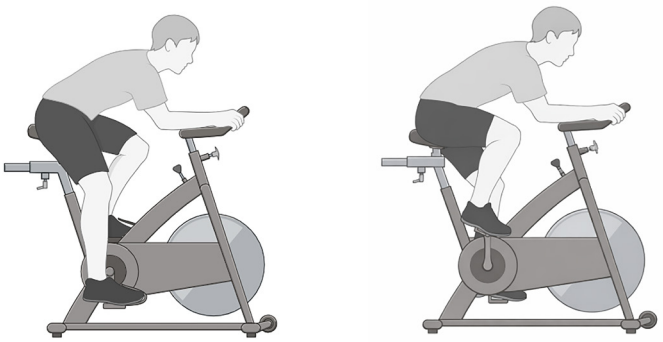

Figure 1. *The procedure for performing HICT on the Spin Bike. The participant starts in Position 1, at a dead stop. One repetition is performed, rotating the pedals and bringing the participant's feet into Position 2 to a dead stop again. The participant will pause 1 second before performing another repetition, back to Position 1.*

were recorded for each test. The Repeated Sprint Ability tests were conducted 1x a week, while the Cooper walk-run test was conducted once every 2 weeks. Results were recorded for both the experimental and control subjects, who tested simultaneously. Three familiarization sessions for each test were carried out prior to testing, and three baseline tests were conducted prior to starting the intervention.

Statistical analyses for both tests were conducted in JASP (version 0.96) adopting an alpha level of $p < 0.05$. Descriptive statistics were calculated for each subject across baseline and intervention period tests, including mean, standard deviation, minimum and maximum values. Shapiro-Wilk tests were conducted for intervention period data to select an appropriate inferential test. For Repeated Sprint Ability test times, as the experimental subject's data violated the assumption of normality, a Wilcoxon signed-rank test was used to characterize the magnitude and direction of differences between subjects across tests, with rank-biserial correlation as the measure of effect size. For Cooper 12-minute run-walk test distances, both participants met the assumption of normality, so a paired samples t-test was used to characterize differences between subjects, with Cohen's d as the measure of effect size. With each condition comprising of a single participant, these tests treat repeated test occasions as the unit of observation, the results being reported descriptively to indicate the consistency and direction of divergence in subject performance across the study rather than attempting to support a generalizable inference across a larger population. The primary evidence for the effects of the HICT intervention was therefore drawn from within-subject Kendall's tau correlations, conducted separately for each subject to determine whether their performance saw a systematic change across the intervention period.

RESULTS

Descriptive baseline statistics for both participants are reported in Table 1. The control subject entered the study with a mean baseline sprint time of 7.224 seconds (SD = 0.025) and the experimental subject with a mean of 7.164 seconds (SD = 0.013), which indicates comparable performance levels pre-intervention. The experimental subject was marginally faster in baseline testing by ~0.06

seconds. There was low variability across both baseline measurements, with standard deviations well below 0.1 seconds.

Descriptive statistics for both participants in the intervention period are reported in Table 2. The control subject's mean of 7.846 seconds (SD = 0.517) when compared with the experimental subject's mean of 7.014 seconds (SD = 0.06) highlights a large mean difference of ~0.83 seconds (Table 2). Additionally, due to the large differences in standard deviations there was a noticeable contrast in variability between subjects.

In the Shapiro-Wilk test, the control subject met normality (W = 0.85, p=0.058), while the experimental subject violated normality (W = 0.837, p = 0.041), leading to a Wilcoxon signed-rank test being selected as the inferential comparison (Table 3). The Wilcoxon signed-rank test in Table 4 indicated a consistent, large difference between subjects in RSA times across the 10 tests (z = 2.803, p = 0.002, rank-biserial r = 1), reflecting that the experimental subject recorded faster sprint times

Table 2. *Repeated Sprint Ability (RSA) testing descriptive statistics results for the control and experimental subjects over the 10-week intervention period, with one test per week. The experimental subject performed HICT twice a week during this period, while the control subject performed no intervention. The RSA test consists of six maximal effort 30-meter sprints, with 15 seconds of walking as active recovery between sprints and the mean sprint time for each test recorded as the outcome measure. Descriptive statistics include the number of valid observations (n), arithmetic mean, standard deviation (SD), and minimum and maximum values across the three baseline tests. Lower mean sprint times indicate better sprint performance. Test Number refers to the sequential test number (1-3) within this baseline measurement phase.*

Descriptive Statistics	Control Subject Test Number	Control Subject Mean Sprint Time	Experimental Subject Test Number	Experimental Subject Mean Sprint Time
Valid	10	10	10	10
Mean (arithmetic)		7.846		7.014
Std. Deviation		0.517		0.060
Minimum	1	7.317	1	6.903
Maximum	10	8.763	10	7.073

Table 3. *Shapiro-Wilk test results for the 10 RSA tests conducted during the Intervention Period. The Shapiro-Wilk test assesses whether data is consistent with a normal distribution, with a p-value above 0.05 indicating that the assumption of normality is met. The W statistic ranges from 0-1, values closer to 1 indicate greater normality. The control subject meets normality (W = 0.850, p = 0.058), while the experimental subject violated normality (W = 0.837, p = 0.041), leading to the Wilcoxon signed-rank test being selected for the statistical comparison between the subjects for their RSA sprint times.*

Descriptive Statistics	Control Subject Mean Sprint Time	Experimental Subject Mean Sprint Time
Shapiro-Wilk (W)	0.850	0.837
P-Value of Shapiro-Wilk	0.058	0.041

Table 4. *Wilcoxon signed-rank test comparing the mean RSA sprint times in seconds between the control and experimental subjects across the 10 tests in the intervention period. It was selected because the experimental subject's data violated normality (Table 3). Each of the 10 tests is treated as one paired observation, with W being the sum of positive ranks and effective size reported as rank-biserial correlation (r). r = 1.0 indicates the experimental subject had a faster sprint time in every paired observation. However, given the design of n = 1 per condition, these results serve only to show divergence between the two subjects and do not support an inference across a wider population.*

Measure 1	Measure 2	W	z	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Control Subject Mean Sprint Time	Experimental Subject Mean Sprint Time	55.00	2.803	0.002	1	0.342

than the control subject across the majority of tests (Table 4). However, given the single subject per condition design, the finding only characterizes the divergence between these two subjects and cannot support inference to a larger population.

In the Kendall's tau results for the RSA tests conducted in the intervention period, the experimental participant demonstrated a significant negative correlation (τ = -0.764, p = 0.002) in Table 5, which indicates a consistent decrease in times over the study period. In contrast, the control participant demonstrated a significant positive correlation (τ = 0.556, p = 0.029), indicating a consistent increase in times (Figure 2). Both effects were large, with the two subjects experiencing opposite effects in performance across the intervention period.

Table 5. *Control and Experimental Subject's Kendall's Tau-b (τ) test results of the 10 RSA tests conducted during the Intervention Period. Kendall's Tau-b is a non-parametric rank correlation with a range of -1 to 1. Negative τ values indicate sprint times are decreasing over time, or showing an increase in performance, while positive values indicate sprint times are increasing over time, showing a decrease in performance. The Control Subject shows a significant positive trend (τ = 0.556, p = 0.029), indicating a worsening in cross-test performance, while the Experimental Subject shows a significant negative trend (τ = 0.764, p = 0.002), indicating an improvement in cross-test performance.*

Kendall's Tau Correlations	Kendall's Tau B	P
Control Subject Test Number – Mean Control Subject Sprint Time	0.556	0.029
Experimental Subject Test Number – Mean Experimental Subject Sprint Time	-0.764	0.002

Table 6 displays descriptive statistics for the baseline Cooper 12-minute walk-run tests conducted for the control and experimental subjects. During baseline testing the control subject recorded a mean distance of 2597 meters (SD = 15.04), ranging from 2580 to 2607 meters across the tests. The experimental subject recorded a mean distance of 3146 meters (SD = 9.713), ranging from 3135 to 3154 meters. Like the RSA baseline data, both subjects demonstrated low variability across baseline tests, suggesting that both possessed stable and consistent aerobic states entering the study (Figure

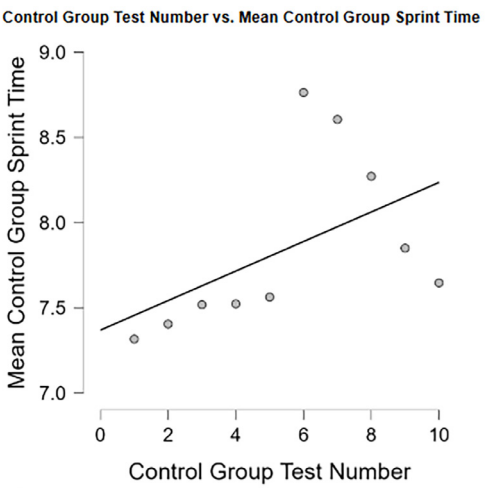

Figure 2. *Scatterplot for the Control Subject Kendall's Tau test results of the 10 RSA tests conducted during the Intervention Period. The RSA test consists of six 30-meter sprints at maximal effort with 15 seconds of walking as active recovery between sprints. The control subject did not perform the HICT training intervention. With a τ of 0.556 and a p-value of 0.029, there is a significant positive trend in mean sprint times across tests, indicating an increase in sprint times over the intervention period, or a decrease in performance.*

Table 6. Baseline Cooper 12-minute run test descriptive statistics results for the experimental and control groups. Three baseline tests were conducted before the 10-week Intervention Period, requiring each subject to run or walk as far as possible in 12 minutes on a flat track. Total distance in meters was recorded as the outcome measure and is used to estimate VO2max using the formula , with higher distances correlating with higher maximal oxygen uptake and subsequently greater aerobic capacity.

Descriptive Statistics	Control Subject Test Number	Control Subject Total Meters Covered	Experimental Subject Test Number	Experimental Subject Total Meters Covered
Valid	3	3	3	3
Mean (arithmetic)		2597		3146
Std. Deviation		15.04		9.713
Minimum	1	2580	1	3135
Maximum	3	2607	3	3154

3). However, it should be noted that the two subjects' baseline normality assessment is limited by the small sample size (n=3) and should be interpreted with caution.

Across the 5 Cooper 12-minute run tests conducted during the intervention period, the experimental subject had a mean distance covered of 3147 meters (SD = 23.08), ranging from 3120 to 3175 meters. The control subject had a mean distance of 2610 meters (SD = 22.85), ranging from 2583 to 2640 meters. A higher value in meters covered indicates improvement, in contrast with the RSA test values representing time. Between the two subjects, the mean difference across the intervention period was approximately 537 meters, exhibiting a substantial gap in aerobic performance. Both subjects had similarly lower levels of variability in test distances (SD = 23 meters for both), which indicates that despite a large absolute difference in distance covered both subjects performed with comparable consistency (Table 7).

Before selecting an inferential test, a Shapiro-Wilk normality test was conducted on the intervention period Cooper 12-minute run-walk test data. Both the experimental participant (W = 0.930, p=0.598) and the control participant (W = 0.975, p = 0.908) met the assumption of normality as both p-values exceeded 0.05. Subsequently, a paired samples t-test was selected as the inferential test (Table 8).

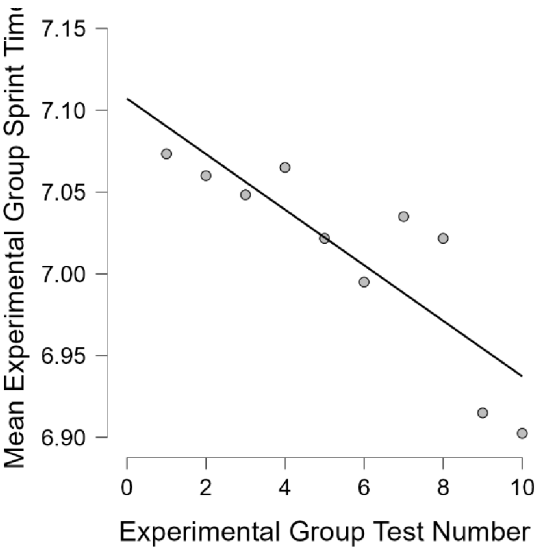

Figure 3. *Scatterplot for Experimental Subject Kendall's Tau test results of the 10 RSA tests conducted during the Intervention Period. The RSA test consists of six 30-meter sprints at maximal effort with 15 seconds of walking as active recovery between sprints. The experimental subject performed HICT two times a week throughout the Intervention Period. A significant negative trend was observed (τ = -0.764, p = 0.002), indicating a decrease in sprint times over the intervention period, or an increase in performance.*

Table 7. *Intervention Period Cooper 12-minute run test descriptive statistics results for the experimental and control groups. Greater total meters covered indicates greater aerobic capacity. The experimental subject performed HICT two times a week during this period, while the control subject performed no intervention. Descriptive statistics include the arithmetic mean, standard deviation, and minimum and maximum.*

Descriptive Statistics	Control Group Test Number	Control Group Total Meters Covered	Experimental Group Test Number	Experimental Group Total Meters Covered
Valid	5	5	5	5
Mean (arithmetic)		2610		3147
Std. Deviation		22.85		23.08
Minimum	1	2583	1	3120
Maximum	5	2640	5	3175

Table 8. *Intervention Period Cooper 12-minute run test Shapiro-Wilk results for the experimental and control groups. Both the experimental subject and control subject met the assumption of normality, having a p-value above 0.05, leading to a paired-samples t-test being selected to compare the subjects' Cooper test distances.*

Descriptive Statistics	Experimental Group Meters Covered	Control Group Meters Covered
Shapiro-Wilk	0.930	0.975
P-Value of Shapiro-Wilk	0.598	0.908

The paired samples t-test reported a large and consistent difference in meters covered between the experimental and control subject across the five tests conducted during the intervention period ($t = 40.65$, $p < 0.001$, $d = 18.18$, 95% CI [6.287, 29.67]). The experimental subject covered greater distances than the control subject in every test, with a mean difference of ~537 meters. As noted in the Methods, this result is interpreted descriptively, given the n = 1 per group design, with the confidence interval and effect size reported to convey the magnitude of difference between the two subjects instead of estimating a population effect. The Cohen's d of 18.18, being exceptionally large, should be interpreted in the context of the small sample size and low within-participant variability, which inflate the d value (Table 9).

To determine whether each subject's Cooper 12-minute run-walk test performance changed systematically across the intervention period, a Kendall's tau-b correlation was conducted for each subject between test number and meters covered. The experimental subject showed a non-significant positive correlation between test number and meters covered ($\tau = 0.200$, $p = 0.817$), while the control participant demonstrated a τ of 0.000 (p=1), showing a total absence of any trend in the meters covered across the five tests (Table 10) (Figures 4 and 5). Scatterplots Figure 4 and Figure 5 illustrate this, with no consistent direction pattern displayed. While the experimental subject's positive τ is expected for an aerobic intervention, due to statistical insignificance an improvement in aerobic capacity cannot be confirmed.

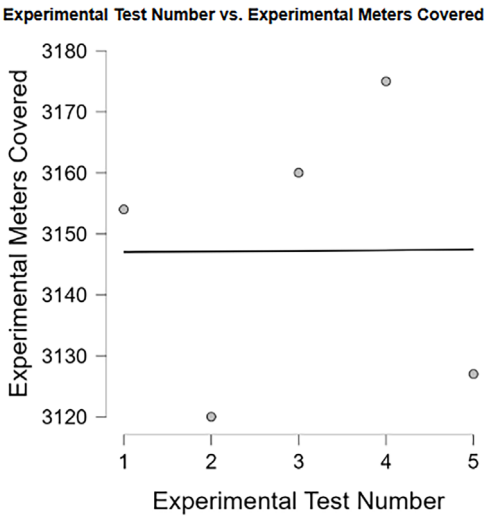

Figure 4. *Scatterplot for Experimental Subject's Kendall's Tau test results of the Cooper 12-minute run tests conducted during the Intervention Period. Higher values on the y-axis indicate greater aerobic performance, with the experimental subject performing HICT 2x a week. The line represents the Kendall's tau-b fit. With a τ of 0.200 and p-value of 0.817, there is no significant trend in meters covered across tests that can't be distinguished from random variation.*

Table 9. *Intervention Period Cooper 12-minute run test Paired Sample T-test results for the experimental and control subjects. Both subjects met the normality assumption (Table 8), with each of the five tests constituting a paired observation. Effect size is reported as Cohen's d with a 95% confidence interval. Because of the design only having n = 1 per condition, results should be interpreted descriptively to show the large difference between the two subjects instead of supporting an inference to a broader population. Subsequently, the Cohen's d of 18.18 is inflated by this single participant per condition design, and should be interpreted with caution.*

Measure 1	Measure 2	t	df	p	Cohen's d	SE Cohen's d	Lower	Upper
Experimental Subject Meters Covered	Control Subject Meters Covered	40.65	4	<.001	18.18	7.420	6.287	29.67

Table 10. *Experimental and Control Group Kendall's Tau test results for the Cooper 12-minute run tests conducted during the Intervention Period. Positive τ values indicate an increase in distance covered over time, or an increase in performance. Correlations were calculated separately for each subject. The experimental subject showed an insignificant positive trend ($\tau = 0.2$, $p = 1$) while the control subject showed an absence of any trend ($\tau = 0$, $p = 1$).*

Kendall's Tau Correlations	Kendall's Tau B	P
Experimental Subject Test Number – Experimental Subject Meters Covered	0.200	0.817
Control Subject Test Number – Control Subject Meters Covered	0.000	1.000

Table 10. *Experimental and Control Group Kendall's Tau test results for the Cooper 12-minute run tests conducted during the Intervention Period. Positive τ values indicate an increase in distance covered over time, or an increase in performance. Correlations were calculated separately for each subject. The experimental subject showed an insignificant positive trend (τ = 0.2, p =1) while the control subject showed an absence of any trend (τ = 0, p = 1).*

Kendall's Tau Correlations	Kendall's Tau B	P
Experimental Subject Test Number – Experimental Subject Meters Covered	0.200	0.817
Control Subject Test Number – Control Subject Meters Covered	0.000	1.000

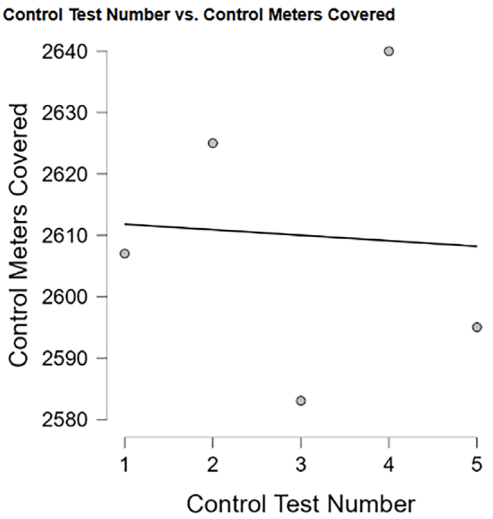

Figure 5. *Scatterplot for Control Subject's Kendall's Tau test results of the Cooper 12-minute run tests conducted during the Intervention Period. Higher values on the y-axis indicate greater aerobic performance, with the control subject performing no intervention. The line represents the Kendall's tau-b fit. With a τ of 0 and p-value of 1, there is a complete absence of any indication of directional trends.*

DISCUSSION

Across both RSA sprint times and Cooper 12-minute run-walk test distances, the experimental subject outperformed the control subject, with highly significant results and large effect sizes on both inferential tests (Wilcoxon, Paired Sample T-Test). The consistency of this pattern across both outcome measures represents a notable strength of the overall findings, with the subject performing the HICT intervention consistently achieving better results than the control subject not performing the intervention. However, due to the experimental subject showing a pre-existing advantage at baseline level than the control subject, demonstrating marginally faster sprint times and greater distances covered, Kendall's trend analyses were therefore examined as the primary assessment for the effectiveness of HICT in improving fatigue reduction of fast-twitch muscle fibers.

In the Kendall's tau for the RSA tests, both participants showed significant opposing trends. The experimental subject showed a strong negative correlation between test number and sprint times throughout the 10-week intervention period (τ = -0.764, p = 0.002), while the control subject showed a strong positive correlation between test number and sprint times during the same period (τ = 0.556, p = 0.029). The experimental subject's progressive increases in sprint performance are consistent with previous literature studying improvements in fatigue resistance like mitochondrial biogenesis and PCr resynthesis caused by a similar intervention, HIIT, with meaningful changes being observed even within a 2-week period (17). In addition, because fatigue-induced decreases in power output across repeated sprints are influenced by aerobic processes that enhance inter-effort recovery (18), and such sprints primarily recruit Type II fibers (19), these results are consistent with the possibility that HICT elicited aerobic adaptations that supported fatigue reduction and recovery in the fast-twitch fibers. However, causality cannot definitively be inferred from the single-subject design. Although there is a lack of existing literature surrounding this unique training technique, similar interventions possessing high, prolonged mechanical tension have been shown to activate signaling activators like PGC-1α, a key regulator of mitochondrial growth (20) as well as a transition from Type IIb to more oxidative Type IIa isoforms (21). A transition toward more oxidative Type IIa fibers would be expected to enhance fatigue resistance during repeated sprints, which is consistent with the experimental subject's progressive improvement in sprint times across the intervention period. Conversely, the control subject's significant positive trend (τ = 0.556, p = 0.029) across the intervention period is consistent with progressive neuromuscular fatigue in the absence of an aerobic training intervention, further supporting the proposed

mechanism by contrast.

Regarding the results of the Cooper 12-minute run-walk test, existing literature indicates that progressive aerobic training adaptations, such as mitochondrial density, cardiac output, enhanced oxidative enzyme activity, and VO2max are typically reflected across the intervention period (22, 23). However, within the Kendall's tau analysis for the two subjects' Cooper 12-minute run-walk test distances during the intervention period, neither subject showed a significant within-participant trend across the five tests. The experimental subject's tau of 0.200 ($p=0.817$) indicates that while a small positive trend was present, it was not statistically significant and cannot be distinguished from random variation. In addition, the control subject's tau of 0.000 ($p=1.000$) indicates a complete absence of any directional trend. The experimental subject's variation of distances across the five tests, ranging from 3120 to 3175 meters (SD = 23.08), suggests that performance was static throughout the intervention period instead of progressively improving as expected. The low within-subject variability in the experimental subject's Cooper 12-minute run-walk test distances (SD = 23.08) may indicate that performance had approached a ceiling within the testing conditions, with further aerobic adaptations present physiologically but not being able to be detected through the test at this sample size. In addition, the 5 Cooper test data points collected across the intervention period have limited statistical power for the Kendall's tau analysis, suggesting that an improvement trend may exist but is undetectable given the constraints of the current study design. While there was a statistically significant difference in the meters covered between the two subjects across all five tests ($t(4) = 40.65$, $p < 0.001$), the baseline data shows the experimental subject already demonstrated greater aerobic capacity/meters covered, translating to a higher VO2max prior to the intervention. Thus, this gap should not be interpreted as evidence of HICT's effectiveness at improving VO2max. Using the Cooper formula , the experimental subject's mean distance of 3147 meters corresponds to an estimated VO2max of 59 ml/kg/min, when compared to the control subject's 47 ml/kg/min, has a difference of 12 ml/kg/min that as argued above is better attributed to pre existing differences in aerobic capacity than to adaptations induced by the intervention.

This study's findings suggest that HICT may support sprint performance across repeated intervals and testing occasions, as well as possibly producing underlying biological adaptations to aerobic training such as increased mitochondrial density accelerated phosphocreatine (PCr) resynthesis, enhanced lactate clearance, and improved oxidative ATP regeneration typically associated with performance effects such as muscular fatigue reduction and resistance in Type II muscle fibers. For coaches and athletes in sports that demand near-maximal explosive efforts, like combat sports, team field sports, and racket sports, the findings of this pilot study carry numerous implications. The Kendall's tau sprint time trends suggest that HICT has the possibility of being an effective method for developing fatigue resistance in fast twitch muscle fibers, supporting the maintenance and improvement of sprint performance across repeated efforts over an intervention period. For combat sport athletes, experiencing repeated bouts of maximal effort separated by brief recovery times such as rounds/periods, a training intervention that enhances recovery between these efforts through adaptations like increased PCr resynthesis and lactate clearance can prove valuable, translating directly into performance benefits in later stretches when fatigue induced performance is the most pronounced. However, the absence of a trend in the Cooper test distances advises against HICT as a possibly effective intervention for developing VO2max. Practitioners should be aware that while the experimental subject maintained a higher aerobic capacity throughout the study, due to exhibiting similarly higher values at baseline it cannot be confirmed from the data that HICT was responsible for elevating aerobic capacity within the study's timeframe. In addition, these implications should be treated as exploratory in nature, with the design of this pilot study such as its limited sample size preventing both generalizability to larger populations and definitive evidence of elicited adaptations.

Future research assessing the effectiveness of HICT as an aerobic training intervention should incorporate direct physiological measurement tools capable of detecting underlying aerobic adaptations proposed to strengthen the performance changes observed in this study. Specifically, muscle biopsies analyzed for mitochondrial density markers like citrate synthase activity and PGC-1α would provide more direct biological evidence of whether HICT produced the mitochondrial adaptations inferred from the RSA data but not detected in the Cooper 12-minute run-walk test (24). Biopsy samples taken pre and post intervention from the vastus lateralis, the primary muscle group recruited during sprints, would allow for direct quantification of changes in Type IIa to Type IIb fibers, as well as mitochondrial density and oxidative enzyme activity that performance-based tests

alone can't produce (25). VO2max laboratory testing would also provide a measure of aerobic capacity that is more sensitive to improvements induced by training than field tests like the Cooper 12-minute run-walk test, which is susceptible to motivational/pacing variability and has an inherent measurement error due to its inferential nature (26). Finally, extending the intervention period and subject count beyond the scope of this study would allow researchers to better assess whether observed aerobic adaptations continue to progress or plateau, or even manifest at all within a larger sample size, as well as determine the minimum effective dose for HICT required to produce detectable changes in performance and physiological markers.

This study is subject to a variety of important limitations that must be considered when interpreting the findings. The single subject per group design (n = 1 per group) is a constraint on the generalizability and statistical power of all reported findings. With only one subject per condition, the study cannot account for individual variability in response to the intervention, and no definite inference can be drawn regarding the broader population of teen athletes from these results. The small number of data points available for each statistical analysis, such as the five Cooper 12-minute run-walk test measurements and the three baseline tests per participant, also severely limit the statistical power of the Kendall's tau trend analysis. Thus, improvement trends in the Cooper 12-minute run-walk test may exist but are undetectable within the constraints of the current study design. The reliance on performance-based outcome measures represents another limitation, with sprint times and Cooper test distances providing useful indicators of functional performance but being unable to directly quantify underlying physiological adaptations proposed to explain the results, such as mitochondrial biogenesis, PGC-1α signaling activations, and fiber type transitions. Without direct measurement tools such as muscle biopsies or laboratory VO2max testing, the explanations offered in this study remain as inferences rather than confirmed findings. The lack of formal measurement of external variables such as diet and sleep quality poses a final constraint on the generalizability of the data. Although participants were asked to maintain their regular routines throughout the study period, adherence was not strictly verified. It is possible that differences in these variables between or within participants contribute to the observed performance trends, whether independently or in conjunction with the intervention of HICT. Considering these limitations, all findings should be therefore cautiously treated as pilot data that requires another study to replicate with a substantially larger sample size, direct biological monitoring tools and consistent, formal measurement of external variables before any conclusions about HICT's effectiveness can be generalized.

CONCLUSION

This pilot study aimed to examine the effectiveness of High Intensity Continuous Training (HICT) as prescribed in strength and conditioning coach Joel Jamieson's book, *Ultimate MMA Conditioning,* on improving aerobic fitness in a matched subject's design comparing one teenage recreational athlete undertaking the intervention against one control teenage recreational athlete. Using Repeated Sprint Ability (RSA) and the Cooper 12-minute run-walk test as outcome measures, the experimental subject consistently outperformed the control subject, with statistically significant between-participant differences on both the Wilcoxon signed-rank test for sprint times and the paired samples t-test for Cooper test distances. However, due to the experimental subject exhibiting superior performance at baseline for both tests (RSA Sprint Time M (seconds) = 7.164, Cooper Meters Covered M = 3146) than the control subject (RSA Sprint Time M (seconds) = 7.224, Cooper Meters Covered M = 2597), more compelling evidence to assess HICT's effectiveness can be found in the Kendall's tau analyses conducted. The Kendall's tau analysis for the RSA sprint times found that the experimental subject demonstrated a significant and strengthening negative trend in sprint times throughout the intervention period, while the control subject in contrast demonstrated a significant positive trend across the same period. This separation of performance trajectories is consistent with the proposition that HICT elicited meaningful aerobic adaptations supporting fatigue resistance and recovery of fast-twitch muscle fibers across repeated sprint efforts, including mechanisms like accelerated PCr resynthesis, enhanced lactate clearance, and a transition towards more oxidative Type IIa muscle fibers. The RSA test results, while inferential in nature, suggest HICT warrants further investigation as a training tool for athletes in sports requiring repeated near-maximal explosive efforts over a sustained period.

In contrast with the RSA findings, the Kendall's tau analyses for the Cooper 12-minute run-walk test did not provide supporting evidence that HICT produced measurable improvements in aerobic capacity or

VO2max within the intervention's timeframe. Neither subject demonstrated a statistically significant trend in meters covered across the intervention period's five tests. In addition, the significant difference between subjects in the paired t-test is better attributed to pre-existing differences in aerobic fitness than an adaptation caused by HICT. Possible explanations for the absence of a trend include a performance ceiling experienced within the testing conditions, and an insufficient number of data points to determine a gradual trajectory. Together, the two measures present a mixed evaluation of HICT's effectiveness. The RSA data is consistent with the intervention supporting fatigue resistance in fast-twitch muscle fibers, while the Cooper test data does not confirm any measurable VO2max improvement within the current study.

The findings of this pilot study provide preliminary, limited evidence for HICT as an effective training intervention for improving fatigue resistance in the fast-twitch muscle fibers of teenage recreational athletes. Future researchers should address the limitations faced in the study using larger matched samples, collecting more extensive pre-intervention baseline data, an extended intervention period, and direct physiological measurement tools such as muscle biopsies and laboratory VO2max testing to procure the biological evidence that performance-based tests alone cannot produce. Until such research is conducted, the effectiveness of HICT as a method of improving aerobic capacity and fatigue resistance in fast-twitch muscle fibers cannot be confirmed beyond this single pilot study's scope.

CONFLICT OF INTEREST

The author declares that there are no conflicts of interest related to this work.

REFERENCES

1. Seene T, Alev K, Kaasik P. Changes in fast-twitch muscle oxidative capacity and myosin isoforms modulation during endurance training. *J Sports Med Phys Fitness.* 2007; 47 (1): 142-152.
2. Proctor DN, Sinning WE, Walro JM, Sieck GC, Lemon PW. Oxidative capacity of human muscle fiber types: Effects of age and training status. *J Appl Physiol.* 1995; 78 (6): 2033-2038. https://doi.org/10.1152/jappl.1995.78.6.2033
3. Bogdanis GC. Effects of physical activity and inactivity on muscle fatigue. *Front Physiol*. 2012; 3: 142. https://doi.org/10.3389/fphys.2012.00142
4. Herbison GJ, Jaweed MM, Ditunno JF. Muscle fiber types. *Arch Phys Med Rehabil*. 1982; 63 (5): 227-230.
5. Franchini E. High-intensity interval training prescription for combat-sport athletes. *Int J Sports Physiol Perform*. 2020; 15 (6): 767-776. https://doi.org/10.1123/ijspp.2020-0289
6. Gandevia SC. Spinal and supraspinal factors in human muscle fatigue. *Physiol Rev*. 2001; 81 (4): 1725-1789. https://doi.org/10.1152/physrev.2001.81.4.1725
7. van Oorschot JWM, Schmitz JPJ, Webb A, Nicolay K, Jeneson JAL, Kan HE. 31P MR spectroscopy and computational modeling identify a direct relation between Pi content of an alkaline compartment in resting muscle and phosphocreatine resynthesis kinetics in active muscle in humans. *PLoS ONE*. 2013; 8 (9): e76628. https://doi.org/10.1371/journal.pone.0076628
8. Hashimoto T, Brooks GA. Mitochondrial lactate oxidation complex and an adaptive role for lactate production. *Med Sci Sports Exerc*. 2008; 40 (3): 486-494. https://doi.org/10.1249/MSS.0b013e31815fcb04
9. McDougall RM, Tripp TR, Frankish BP, Doyle-Baker PK, Lun V, Wiley JP, et al. The influence of skeletal muscle mitochondria and sex on critical torque and performance fatiguability in humans. *J Physiol*. 2023; 601 (23): 5295-5316. https://doi.org/10.1113/JP284958
10. Skelly LE, Gillen JB, Frankish BP, MacInnis MJ, Godkin FE, Tarnopolsky MA, et al. Human skeletal muscle fiber type-specific responses to sprint interval and moderate-intensity continuous exercise: Acute and training-induced changes. *J Appl Physiol*. 2021; 130 (4): 1001-1014. https://doi.org/10.1152/japplphysiol.00862.2020
11. Wyckelsma VL, Levinger I, McKenna MJ, Formosa LE, Ryan MT, Petersen AC, et al. Preservation of skeletal muscle mitochondrial content in older adults: Relationship between mitochondria, fibre type and high-intensity exercise training. *J Physiol*. 2017; 595 (11): 3345-3359. https://doi.org/10.1113/JP273950
12. Jamieson J. Ultimate MMA Conditioning. Performance Sports Inc.; 2009. Available from: https://www.8weeksout.com (accessed on 2026-04-12).
13. Best Fitness. BFSB5 chain indoor exercise bike. Available from: https://www.bestfitness.com (accessed on 2026-04-12).
14. 8 Weeks Out. High intensity continuous training method with Mark McLaughlin [Video]. YouTube. 2026 January. Available from: https://youtu.be/q8zcxiucNkY?si=Nl69tPth6Nm8qnzn (accessed on 2026-04-12).
15. Strava. Strava (Version 352.10.0) [Mobile app]. 2024. Available from: https://www.strava.com/ (accessed on

2026-04-12).

16. Mayorga-Vega D, Bocanegra-Parrilla R, Ornelas M, Viciana J. Criterion-related validity of the distance- and time-based walk/run field tests for estimating cardiorespiratory fitness: A systematic review and meta-analysis. *PLoS ONE*. 2016; 11 (3): e0151671. https://doi.org/10.1371/journal.pone.0151671
17. Forbes SC, Slade JM, Meyer RA. Short-term high-intensity interval training improves phosphocreatine recovery kinetics following moderate-intensity exercise in humans. *Appl Physiol Nutr Metab*. 2008; 33 (6): 1124-1131. https://doi.org/10.1139/H08-099
18. Mendez-Villanueva A, Edge J, Suriano R, Hamer P, Bishop D. The recovery of repeated-sprint exercise is associated with PCr resynthesis, while muscle pH and EMG amplitude remain depressed. *PLoS ONE*. 2012; 7 (12): e51977. https://doi.org/10.1371/journal.pone.0051977
19. Simpson CWC, Walter J, Gieseg SP, Lackner S, Holasek S, Hamlin MJ. Central and peripheral nervous system activity and muscle oxygenation in athletes during repeated-sprint exercise in normoxia and normobaric hypoxia. *J Sports Sci.* 2025; 43 (19): 2204-2216. https://doi.org/10.1080/02640414.2025.2461947
20. Mang ZA, Ducharme JB, Mermier C, Kravitz L, de Castro Magalhaes F, Amorim F. Aerobic adaptations to resistance training: The role of time under tension. *Int J Sports Med*. 2022; 43 (10): 829-839. https://doi.org/10.1055/a-1664-8701
21. Seene T, Alev K, Kaasik P. Adaptation of skeletal muscle to prolonged activity: Role of myosin. *Health*. 2019; 11 (2): 195-200. https://doi.org/10.4236/health.2019.112017
22. Moscatelli F, Polito R, Porro C, Eronia S, Sessa F, Monda M, et al. Twelve weeks of aerobic training to increase VO_2max in sedentary young males. *Phys Educ Theory Methodol.* 2022; 22 (3): 333-337. https://doi.org/10.17309/tmfv.2022.3.05
23. Nurulita RF, Yusnadi Y. Aerobic exercise intervention to increase VO_2max capacity of higher students in college environment. *ETDC Indones J Res Educ Rev.* 2025; 4 (3): 532-539. https://doi.org/10.51574/ijrer.v4i3.3284
24. Wright DC, Han D-H, Garcia-Roves PM, Geiger PC, Jones TE, Holloszy JO. Exercise-induced mitochondrial biogenesis begins before the increase in muscle PGC-1α expression. *J Biol Chem*. 2007; 282 (1): 194-199. https://doi.org/10.1074/jbc.M606116200
25. Pollock RD, O'Brien KA, Daniels LJ, Nielsen KB, Rowlerson A, Duggal NA, et al. Properties of the vastus lateralis muscle in relation to age and physiological function in master cyclists aged 55-79 years. *Aging Cell*. 2018; 17 (2): e12735. https://doi.org/10.1111/acel.12735
26. Gönülateş S. Analysis of difference between the VO_2max values in field and laboratory tests. *Univers J Educ Res*. 2018; 6 (9): 1938-1941. https://doi.org/10.13189/ujer.2018.060912