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Effect of high-intensity interval exercise on pain, disability, and autonomic balance in patients with nonspecific chronic low back pain

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Abstract

Aim: To evaluate the effect of six weeks of high-intensity interval exercise (HIIE) program on pain, disability, and autonomic balance in patients with nonspecific chronic low back pain (NSCLBP). **Materials and methods:** Eighty patients with mild to moderate NSCLBP of either sex, with ages of 18-65 years, were recruited from the physiotherapy department at King Fahd University Hospital, AlKhobar. They were randomly assigned to the control group (n=40), which received standard regular physiotherapy, or the experimental group (n= 40), which received HIIE in addition to the standard regular physiotherapy. Pre- and post-intervention (after 6 weeks) assessments included pain intensity through Numerical Rating Scale (NRS), disability through Oswestry Disability Index (ODI), and autonomic balance through heart rate variability (HRV) parameters and baroreceptor sensitivity (BRS) at rest and in response to an orthostatic challenge. **Results:** There was a significant improvement in pain as well as disability in both groups, with a greater improvement in both variables in favor of the HIIE group. For the HRV parameters after 6 weeks of intervention, the control group had a statistically significant reduction in high frequency (HF), and in response to the orthostatic challenge, a significantly higher rise in the normalized low frequency (LFnu) compared to the baseline. BRS showed a significant reduction and heart rate recovery was significantly faster post-intervention in the HIIE group in the 2nd and 3rd minutes, compared to the baseline values. **Conclusions:** HIIE can be a useful addition to the exercise regimens in practice for NSCLBP patients, as adding HIIE to the standard physiotherapy caused greater improvement in pain and disability compared to standard physiotherapy alone, with better autonomic regulation after six weeks of treatment.

Keywords
Chronic low back pain, Oswestry disability index, autonomic balance, heart rate variability.

Introduction

Chronic low back pain (CLBP) is defined as "a back pain problem that has persisted for at least 3 months and has resulted in pain on at least half of the days in the past six months". It is a highly prevalent condition with great socio-economic impact. Most LBP cases have unclear pain origin and mechanism and are, therefore, classified as non-specific LBP [1]. Aberrant autonomic nervous system (ANS) regulation is hypothesized to contribute to the production and persistence of muscle chronic pain [2]. Regular exercise can avert the development of chronic pain and autonomic dysfunction [3,4]. Conversely, pain-induced physical inactivity leads to deconditioning, which causes an imbalance in autonomic activity. Increased sympathetic tone, in turn, leads to regional ischemia that further aggravates the pain [5].

The cardiac baroreflex system responsible for blood pressure beat-to-beat control is interconnected with body analgesia systems, giving rise to links between cardiovascular parameters such as blood pressure, and baroreceptor sensitivity (BRS) with acute pain reactions [6]. These closely interlinked cardiovascular/ pain modulatory systems are modified in individuals with chronic pain [7]. Patients suffering from chronic pain were reported to have a reduction in high-frequency heart rate variability (HRV), suggestive of reduced parasympathetic activity [8]. The ANS activity in humans can be monitored by measuring HRV and BRS which, compared to the simple routine measurements of heart rate and blood pressure, provides a better and more sensitive means for early indication of autonomic complications [9].

Exercise therapy is an effective strategy to treat CLBP [10]. Though there are no clear recommendations for a particular type of exercise for managing CLBP, some studies are in favor of intense exercise [11], especially, high-intensity aerobic exercise, with positive results [12]. High-intensity interval exercise (HIIE) is where short spurts of high-intensity exercise are interposed with rest intervals [13]. According to which HIIE protocol is applied, different benefits could be gained (e.g., increased blood flow, improved metabolic function, vs. regenerating creatine phosphate) [13].

There are hardly any studies in Saudi Arabia addressing the effects of HIIE on patients suffering from nonspecific CLBP, especially from the autonomic aspect. Therefore, this study explored the effects of six-week training with HIIE on pain, disability, and autonomic regulation in patients with nonspecific CLBP.

Materials and methods

Design and study settings

This study was designed as a randomized controlled trial. The practical aspect lasted from 17th August 2018 to 6th January 2019 and was conducted in the Physiology department at Imam Abdulrahman Bin-Faisal University while the patients' recruitment was carried out at the physiotherapy department of King Fahd University hospital.

Ethical approval and patients' consent

The research related to human use complied with all the relevant national regulations and institutional policies followed the tenets of the Declaration of Helsinki and had been approved by the Research Ethics Committee of Imam Abdurrahman Bin-Faisal University (IRB-PGS-2018-01-076). Each participant was informed about the nature, purpose, and benefits of the study, the right to refuse or withdraw at any time, and the confidentiality of any obtained data. Then, informed consent had been obtained from all participants included in this study before starting.

Participants

To avoid a type II error, a preliminary power analysis [power (1−α error P) = 0.95, α = 0.05, effect size = 0.32, with a two-tails for a comparison of 2 independent groups] determined a sample size for each group in this study. This effect size was calculated accordingly after a pilot study on 12 participants (6 in each group) considering HRV at a lying position as a primary outcome. A sample size of 33 participants per group was necessary. The sample size was increased to 40 per group to allow for dropouts and missing data.

Consequently, a convenient sample of both sexes with nonspecific CLBP was recruited from the physiotherapy department at King Fahad University Hospital. All CLBP patients had mild to moderate lumbar pain with no evidence of specific origin that lasted > 3 months. Their ages were from 18 to 60 years and their body mass index (BMI) was from 18.5 to 34.9 kg/m^2.

Secondary LBP, osteoporosis, osteoarthritis, sciatica, generalized neuromuscular problem, deformities, fractures, walking with assistive devices, any diagnosed disease likely to interfere with exercise on bicycle ergometer or safety of the subject (e.g., cardiac, or respiratory diseases), any disease with known autonomic complications (e.g., diabetes), pregnancy, and lactation were all exclusion criteria. Patients receiving medications that could interfere with heart rate variability (HRV) variables (e.g., beta blockers and calcium antagonists) were also excluded.

Randomization

After screening for eligibility, the participants were randomly assigned into two equal groups; control group and experimental group, each had forty participants, with the use of a computer-based randomization program., and no dropouts occurred after randomization, Figure 1.

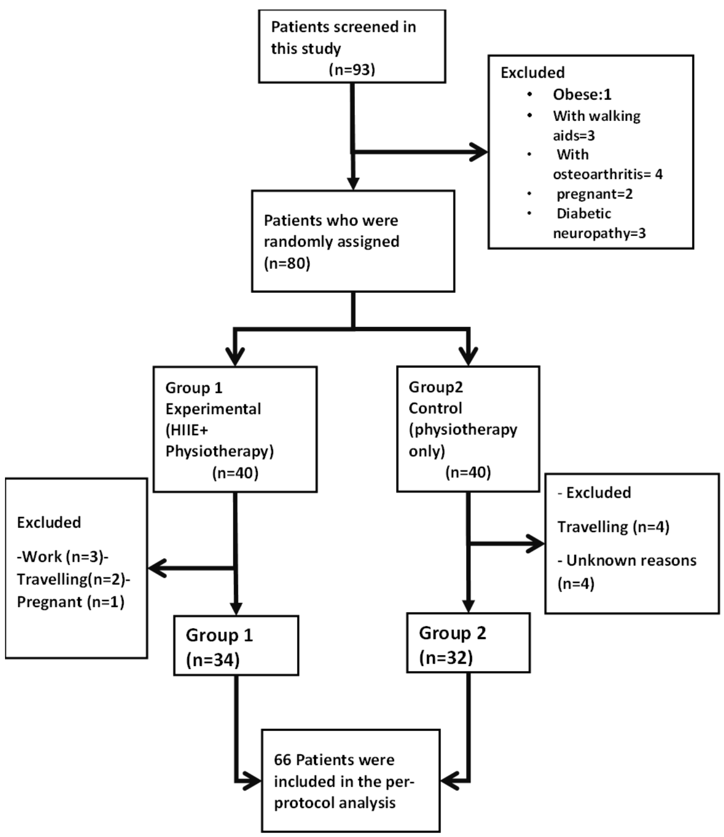

Figure 1. Study design flow chart

Interventions

The CLBP patients of the control group received a 45-minute standard physiotherapy program consisting of heat therapy and interferential electrical current, twice per week for 6 weeks. For the study group, patients received a supervised exercise program of HIIE for 20 minutes, two sessions per week, for six weeks using a computerized controlled ergometer bicycle, in addition to the standard physiotherapy program as the control.

Each patient in both groups was comfortably placed in a prone lying position, with a cushion below the abdominal area and forefoot zone. The hot pack was wrapped with a towel and applied to the lumber region for approximately 15 minutes. After the removal of the hot pack, the lumber area was dried from excessive water with a paper towel [14]. For applying the interferential current, in the prone lying position, four cutaneous electrode pads (8x6 cm) (Phyaction 787, Uniphy, Eindhoven, NL) were applied on the painful lumbar area using gel and fixation tape. The carrier frequency was 4000Hz, with a frequency amplitude of 20Hz for 30 minutes, and intensity according to patients' tolerance. After the removal of electrodes, the lumber area was cleaned with a paper towel to remove the excessive gel. Following each use, electrodes were washed in running water and then, dried with paper towels [15].

For the HIIE, after instructing the patients to evacuate the bladder and report any symptoms to stop the exercise, the predicted HRmax was calculated according to the formula: heart rate maximum (220-age). Then, a Graded Maximal Exercise test (GME) was done for prescribing exercise intensity using a Polar belt and ECG setup [16]. After determining the suitable intensity, training was performed on a computerized controlled ergometer bicycle. Each session of HIIE consisted of warm-up (3 minutes of cycling with an intensity of 10 watts), interval exercise (10 repetitions of 60-second bursts at 80% of the HRmax interspersed by 60 seconds of recovery), and cool down (5 minutes at a power of 20 watts). The HR was continuously displayed to maintain the exercise intensity level.

Assessment of outcomes

The descriptive data for every patient including age, BMI, baseline heart rate, and blood pressure were taken and recorded. All variables were assessed for each patient at baseline and after six weeks of treatment. The pain intensity was assessed through a numerical rating scale, the LBP-causing disability, through the Oswestry disability index (ODI), the HRV by ECG recording, and BRS by Finometer

To assess pain, each patient was asked to place a mark along the line of the scale to denote his/her level of pain [1]. For identifying disability levels using ODI, the scores of each section were summated, divided by 50 which is the total score and multiplied by 100 to provide a percentage of disability. A percentage of 0-20% indicated minimal disability, 21-40% indicated moderate disability, 41-60% indicated severe disability, 61-80% indicated crippling back pain and 81-100% indicated bedbound [17].

Using the ECG, identifying cardiac cycle was done through the R wave of each QRS complex. The R-R intervals were used to measure the frequency domain parameters of HRV (HF, LF, LF/HF ratio). For measuring BRS using Finometer Pro (FMS, Netherlands), the peaks of the pressure waves were detected, and the peak-to-peak interval was calculated and recorded from the finger cuff. To analyze resting hemodynamic recording, the cardiac BRS (in milliseconds per millimeter of mercury) was measured by the spontaneous baroreflex (SBR) method [18].

Statistical analysis

Data were entered in Microsoft excel and all data analysis was performed using SPSS for windows version 20.0 (SPSS Inc., Chicago, IL). Prior to final analysis, data were screened for normality assumption, homogeneity of variance, and presence of extreme scores, as a pre-requisite for parametric calculations of the analysis of difference. The homogeneity of variance test and test of normality were done using Shapiro-Wilk test. Based on the results, the non-parametric Wilcoxon Signed Rank and Mann-Whitney U tests were used for pain, disability normalized low frequency (LFnu), and BRS within and between groups comparisons, respectively. Continuous independent variables (high frequency (HF), normalized HF (HFnu), LF, LF/HF Ratio, and heart rate recovery (HRR) parameters) were examined by t-test and analysis of variance. For normally distributed data, MANOVA was applied to see the differences within and between the groups. P-value of less than 0.05 was considered significant in all statistical analyses.

Results

Eighty CLBP patients were assigned to either the control group (standard physiotherapy program) or the study group (HIIE added to the standard physiotherapy program). Distribution of gender inside each group was unequal, with 15 males and 19 females in the HIIE group vs. 8 males and 24 females in the control group. Analysis has shown no significant differences between groups for baseline data except for age. The HIIE group's mean age was significantly lower (P=0.000) (Table 1).

Pain intensity and disability

Within groups, there was a significant decrease ($p<0.05$) in both pain intensity and disability in both groups. Mann-Whitney U tests showed insignificant differences ($p>0.05$) between both groups at baseline in both pain intensity and ODI. However, there was a significant decrease ($p<0.05$) after six weeks of treatment for HIIE group in comparison to control group in both variables (Table 2).

HRV parameters in Standing Position

Concerning LF, HF, HFnu, and LF/HF Ratio, multiple pairwise comparison tests (Post hoc tests) of two-way MANOVA showed insignificant differences ($p>0.05$) within groups for all these dependent variables except for HF and HFnu. There was a significant reduction ($p<0.05$) in HF and HFnu for control group after six weeks of treatment compared to baseline. Between groups, there were no significant differences ($P>0.05$) in the mean values of all variables at baseline and after six weeks of treatment. For LFnu parameter, tests revealed no significant differences ($p>0.05$) within or between groups ($p>0.05$), comparing baseline results to six weeks of treatment (Table 3).

HRV parameters in response to orthostatic challenge (from lying to standing)

Within groups, there was a statistically significant increase in LFnu post-treatment in the control group compared to baseline (p=0.034), while on comparing both groups, there was a difference between groups though the difference did not reach statistical significance (P= 0.053) (Table3).

HRR parameters after exercise at different periods

Within groups, results have shown a statistically significant increase ($p<0.05$) of mean values for relative HRR at the 2nd minute (%HRR2) and the 3rd minute (%HRR3) for the HIIE group after six weeks post-exercise as compared to baseline. While there were statistically insignificant differences ($p>0.05$) in other dependent variables (maximal heart rate (HRmax), HRR at 1st, 2nd & 3rd minutes, and relative HRR at the 1st minute (%HRR1) in both groups. Between groups, there was no statistically significant ($p>0.05$) mean difference in any of the dependent variables at both measuring periods (baseline and post-intervention) (Table 4).

BRS values in supine and standing

Within groups, there was a significant reduction of BRS in HIIE group after six weeks of treatment in comparison to baseline. On comparing both groups, no significant differences were found ($p>0.05$) in the mean BRS values at baseline or after six weeks of treatment (Table 4).

Discussion

This study was conducted to assess the effect of HIIE added to a standard physiotherapy program of heat and interferential current on the pain, disability, and autonomic function of patients with nonspecific CLBP. The HIIE group showed a significantly greater improvement in pain and disability compared to control group. HIIE group, also, exhibited significantly better autonomic regulation as revealed by better reactivity to orthostatic stress and a faster HR recovery after 6 weeks of treatment compared to control group. The study utilized that type of intervention (HIIE) for the study group as it represents an acceptable exercise type with optimal adaptations and great tolerability because of recovery produced by its intermittent nature. It is considered safe for both young and old aged people as well as persons with certain diseases or disabilities, with no significant adverse effects [19].

The improvement in pain and functional level within the control group could be supported by Rajfur et al. [20], who concluded that selected electrotherapeutic modalities were successful in relieving pain and improving functional disability of patients with CLBP. More significant pain intensity reduction shown in HIIE group could be attributed to controlling the inflammatory markers that are responsible for inflammation and pain sensation in LBP patients [21]. This finding and that regarding the superior improvement of functional disability in the HIIE group were confirmed by Chatzitheodorou et al. [22], who found that 12 weeks of high-intensity exercise resulted in more pain relief and greater improvement in functional ability than passive interventions (electrotherapy).

Similarly, Murtezani et al [12] observed a significant improvement in pain and disability with high-intensity aerobic exercise in CLBP patients whereas the passive group did not show any significant improvement. On the contrary, Verbrugghe et al. [23] reported a non-significant difference in pain level or disability of CLBP patients between the high-intensity group and conventional physical therapy group after 6 weeks of treatment. However, none of these investigators used HIIE; the mode of exercise was high-intensity aerobic exercise which was not easy to maintain for longer periods at a sufficiently high level of heart rate or oxygen consumption.

As for HRV parameters, HF was significantly reduced post-treatment only in the control group. HF is thought to represent vagal activity and reduced vagal activity indicates a trend toward reduced autonomic regulation [8]. In other words, the HIIE group had better autonomic regulation compared to control group. Regular physical exercise is known to increase parasympathetic activity and/or reduce sympathetic activity thereby leading to an increase in HF and a reduction in LF components of HRV power [24].

In response to orthostatic challenge, the rise in LFnu was significantly lower in HIIE group compared to control group post-intervention. This was associated with a lower LF/HF ratio with HIIE compared to control. As the person assumes an upright posture there is increased sympathetic activity, manifested as an increase in LFnu and LF/HF ratio and sympathovagal balance would be tilted in favor of sympathetic dominance [25]. The control group exhibited an exaggerated response to orthostatic challenge with heightened sympathetic activity and/or associated reduced parasympathetic activity. This was an indication that autonomic balance was better in the HIIE group at 6 weeks post-treatment.

The same findings were observed by Heydari et al. [26] found a significant improvement in HRV parameters (LF and HF) after 12 weeks of HIIE in young-aged males. Additionally, Fronchetti et al. [27] reported a greater HRV threshold after 3 weeks of HIIE. These changes might be related to delayed parasympathetic withdrawal throughout incremental exercise. In contrast, some studies [28,29] reported a minor improvement, while others [30] did not find any alteration following training for five weeks to five months [28-30]. The lack of improvement could be attributed to inadequate training intensities, meaning that exercises were stopped before reaching supramaximal intensities [31]. Moreover, Hottenrott et al. [32] reported that exercise programs of short durations (less than three months) were not sufficient to induce vagal modulation changes in healthy and unhealthy people. Therefore, the short duration of the present study (6 weeks) could contribute to the non-significant changes in most of the parameters found in HRV measures.

Inconsistencies across HRV studies could be due to variable participants' age and physical activity level; poor reporting, removal and/or correction procedures; use of different frequency bandwidths and normalization methods for spectral measuring of LF and HF; width difference in HRV measures between subjects of the same study; and failure of studies to identify the normal and abnormal values.

Post-treatment, the recovery of heart rate was significantly faster in HIIE group, evidenced by significantly higher %HRR2 and %HRR3, with no significant difference between both groups. Generally, the initial 30-60 seconds of HHR after exercise cessation are dominated by the reactivation of parasympathetic nervous system, whereas the subsequent recovery is the result of parasympathetic activity and sympathetic withdrawal [33]. A faster recovery points towards better autonomic regulation in the sense of faster activation of parasympathetic system coupled with inactivation of sympathetic system [34].

Villelabeitia-Jaureguizar et al. [35] examined the effect of HIIE for 8 weeks on HRR in subjects having coronary heart disease and found a significant increase in HRR at 1st and 2nd minute after training cessation. Also, Stöggl and Björklund [36] evaluated the effect of different training intensities on acute HRR in athletes participating in endurance sports and found that the HIIE group had improvement in acute HRR after 9 weeks of training. Kannankeril et al. [37] have attributed the significant reduction in early HRR following exercise at high intensity to sympathetic withdrawal accompanied by an increased parasympathetic activation.

Conversely, Currie et al. [38] reported that 12 weeks of HIIE in coronary artery disease patients resulted in non-significant changes in HRR in the first two minutes after training cessation. They explained the lack of improvement by the optimum medical management in addition to the normative pre-training status of their sample [38]. The differences among studies regarding HRR after exercise cessation could be related to the variation in the method used for obtaining HRR (passive or active), the definite recovery minute assessed, and the difference in dichotomous cut points identifying normal and abnormal HRR values [16, 35].

The response of BRS in the HIIE to orthostatic challenge was the expected one, i.e., a reduction in BRS value on assuming the standing posture, as standing leads to increased sympathetic activity, manifested as a reduction in the BRS [39]. The BRS measurement in response to HIIE could indicate the alterations in cardiovascular health, in addition to the time efficiency advantages of HIIE [40]. The reduction in BRS observed in the study could probably be because of the reading method of the BRS values, which was the momentary reading at a particular time not averaged.

The study results were inconsistent with Heydari et al. [26] and Pichot et al. [41], who found a significant increase in BRS following HIIE training in young males (for 12 weeks) and old males (for 14 weeks), respectively. Additionally, the results of the current study disagreed with Cassidy et al. [42], who reported that 12 weeks of unsupervised HIIE caused non-significant changes in BRS in type 2 diabetic patients. However, the lack of improvement in that study could be related to the lack of supervision of the exercise [42].

The discrepancy in BRS results between the current study and the previous studies could be related to the difference in subjects' age and level of physical activity as both aging and low physical activity level can induce structural and functional alterations of the arteries through decreasing elastin and increasing collagen, resulting in arterial dispensability reduction and arterial stiffness increase [43]. Also, BMI, level of central adiposity and incorporation of low caloric diet could affect BRS results [43]. It is possible that a minimum period of chronic pain persistence is required to affect pain circuits integrating with autonomic centers to exhibit any appreciable effect [6]. Pinna et al. [9] have also warned that within-subject variability is high in the measurements of spontaneous BRS and this fact needs to be kept in mind when BRS measurements are used to detect treatment effects in individual patients.

Study limitations

In the present study, we relied on the HRmax which shows a good correlation with oxygen consumption. Yet, the gold standard for assessing maximal ability/physical fitness is maximal oxygen consumption, but it was not possible because of logistic problems. The study involved both sexes despite the known gender differences in HRV values. Evaluation of the long-term influence of HIIE on pain, disability, and autonomic function (balance) could not be done. Also, the BRS patients' recorded values were momentary while to confirm the findings, the average BRS values should have been considered.

Conclusions

Based on the results, it could be concluded that HIIE intervention with standard physiotherapy for 6 weeks led to a significantly greater improvement in pain, disability, better reactivity to orthostatic stress and a faster HR recovery compared to standard physiotherapy alone in the patients suffering from mild to moderate NSCLBP. Thus, HIIE can be a useful, efficacious addition to the standard regimens in CLBP patients.

Conflict of interest

The authors declared no conflict of interest.

The sources of funding for the study

Not applicable

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Table1. Descriptive statistics of patients in both groups:

Variables	HIIE group (N=40)	Control (N=40)	P value
	Mean (SD)	Mean (SD)	
Age (year)	29.14(8.95)	39.24(13.51)	0.000*
Height (cm)	161.4(10.55)	159.82(9.32)	0.411
Weight (kg)	70.01(12.65)	74.03(11.46)	0.143
BMI (kg/m^2)	27.52(4.73)	28.80(5.04)	0.201
Heart rate (bpm)	80.92(13.38)	81.26(12.61)	0.561
SBP (mmHg)	120.79(16.30)	121.82(15.48)	0.954
DBP (mmHg)	70.21(11.78)	73.44(9.87)	0.054

Data were expressed as mean (SD), N=Number of subjects, BMI=Body Mass Index, SBP: systolic blood pressure, DBP: diastolic blood pressure
*: significant p-value ≤ 0.05

Table 2. Comparison between both groups in pain, and disability

Variables and measuring times	HIIE Group (n= 40)	Control Group (n= 40)	P-value between Group
	Median (IQR)	Median (IQR)	
Pain Intensity (0-10 NRS)			
Baseline	4 (3)	5 (2)	.272
6 Weeks	0 (2)	2.5 (4)	.000*
P-Value within groups	.0005	.0005	
ODI (0-100)			
Baseline	13.5 (10.5)	20 (18.5)	.050
6 Weeks	6 (8)	12.5 (14)	.002
P-Value within groups	.0001	.0001	

IQR: Interquartile range, NRS=Numerical Rating Scale, ODI= Oswestry Disability Index, HVR: heart rate variability *: significant p-value ≤ 0.05.

Table 3. Comparison of HRV parameters in standing & in response to orthostatic stress between both groups

Variables	HIIE Group (n= 40)	Control Group (n= 40)	P-value between Group
HRV parameters in standing			
	Mean (SD)	Mean (SD)	
High frequency (ms^2)			
Baseline	2.58(0.51)	2.79(0.65)	0.171
6 Weeks	2.62(0.55)	2.51(0.45)	0.409
P-Value within groups	0.762	0.027*	
Normalized high frequency			
Baseline	1.43(0.23)	1.54(0.2)	0.057
6 Weeks	1.42(0.26)	1.43(0.23)	0.824
P-Value within groups	0.777	0.047*	
Low frequency (ms^2)			
Baseline	2.96(0.42)	2.98(0.53)	0.92
6 Weeks	2.99 (0.36)	2.86(0.3)	0.165
P-Value within groups	0.782	0.174	
Normalized low frequency			
Baseline	1.87(0.17)	1.78(0.25)	0.053
6 Weeks	1.84(0.17)	1.86(0.196)	0.697
P-Value within groups	0.806	0.102	
Low-frequency to high-frequency ratio			
Baseline	0.35(0.4)	0.18(0.36)	0.098
6 Weeks	0.36(0.42)	0.36(0.37)	0.944
P-Value within groups	0.853	0.06	
HRV in response to orthostatic stress			
	Delta change	Delta change	
Normalized high frequency			
Baseline	12.16(20.73)[a]	5.58(20.07)	0.170
6 Weeks	11.37(19.38)	17.94(16.45)	0.158
P-Value within groups	0.610	0.074	
Normalized low frequency			
Baseline	-12.41(24.32)[b]	-7.40(20.65)	0.346
6 Weeks	-11.37(24.27)	-22.46(19.15)	0.053
P-Value within groups	0.617	0.034*	
Low-frequency to high-frequency ratio			
Baseline	-2.02(2.95)	-1.09(2.57)	0.156
6 Weeks	-2.27(3.74)	-2.89(4.51)	0.552

P-Value within groups	0.279	0.126

SD: standard deviation, ms: millisecond, ms²: millisecond square, a: a positive value represents a reduction in the value in standing position compared to lying down, b: the negative sign represents an increase in the value during standing compared to the lying down position, *: significant p ≤0.05.

Table 4. Comparison of HRR and BRS parameters between both groups across different measuring times

Variables	HIIE Group (n= 40)	Control Group (n= 40)	P-value between Group
	Mean (SD)	Mean (SD)	
HRR parameters			
HRmax			
Baseline	149 (17)	139 (21)	0.056
6 Weeks	146 (17)	137 (19)	0.057
P-Value within groups	0.271	0.572	
HRR1			
Baseline	25 (10)	25 (14)	0.707
6 Weeks	28 (12)	27 (13)	0.707
P-Value within groups	0.209	0.412	
HRR2			
Baseline	38 (13)	36 (15)	0.181
6 Weeks	43 (11)	39 (14)	0.125
P-Value within groups	0.062	0.442	
HRR3			
Baseline	43 (12)	40 (15)	0.184
6 Weeks	48 (12)	43 (15)	0.130
P-Value within groups	0.136	0.468	
%HRR1			
Baseline	16.6 (7.1)	17.9(9)	0.689
6 Weeks	19.3(8.7)	20.2 (9.3)	0.630
P-Value within groups	0.144	0.215	

%HRR2			
Baseline	25.9 (8.8)	25.8 (9.4)	0.524
6 Weeks	29.5 (7.0)	28.1 (10.2)	0.540
P-Value within groups	0.035*	0.205	
%HHR3			
Baseline	29.3 (7.4)	29 (9.8)	0.511
6 Weeks	33 (8.0)	31.2 (9.5)	0.518
P-Value within groups	0.034*	0.276	
BRS parameters			
BRS msec/mmHg (supine)			
Baseline	0.95(0.25)	0.91(0.31)	0.65
6 Weeks	0.84 (0.32)	0.81(0.31)	0.649
P-Value within groups	0.049*	0.079	
BRS msec/mmHg (standing)			
Baseline	0.84(0.22)	0.72(0.24)	0.065
6 Weeks	0.68(0.29)	0.68(0.27)	0.985
P-Value within groups	0.002*	0.459	

SD: standard deviation, HRmax=maximal heart rate, HRR1: heart rate recovery at 1st min post-exercise, HRR2: heart rate recovery at 2nd min, HRR3: heart rate recovery at 3rd min, %HRR1=relative heart rate recovery at 1st min, %HRR2: relative heart rate recovery at 2nd min, %HRR3: relative heart rate recovery at 3rd min, *: significant p ≤0.05.