Can we hit prenatal depression and anxiety through HIIT? The effectiveness of online high intensity interval training on depressive symptoms, fear of childbirth, fear of coronavirus, and perception of quality of life in pregnant women during COVID-19 pandemic – a randomized controlled trial

Dominika Wilczyńska (dominika.wilczynska@awf.gda.pl)
Gdansk University of Physical Education and Sport

Tamara Walczak-Kozłowska
University of Gdansk

Łukasz Radzimiński
Gdansk University of Physical Education and Sport

Miguel Ángel Oviedo-Caro
University of Seville

Rita Santos-Rocha
Polytechnic Institute of Santarém, Sport Sciences School of Rio Maior (ESDRM)

Anna Szumilewicz
Gdansk University of Physical Education and Sport

Research Article

Keywords: pregnancy, exercise, high intensity interval training, emotional condition, coronavirus

Posted Date: June 22nd, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1613394/v1

Abstract

Background: In recent years high intensity interval training (HIIT) has grown in popularity, however it rarely represent training interventions in experimental studies in pregnant populations so far. Therefore, in this study we aimed at assessing the changes in depressive symptoms, fear of childbirth, fear of Covid-19, quality of life after an 8-week supervised online HIIT program, compared to an educational (self-performed physical activity) program.

Methods: We conducted a randomized control trial among 54 Caucasian women in uncomplicated, singleton pregnancy (age 32 ± 4 years, 22 ± 4 week of gestation; mean ± SD). There were 34 women in the experimental group, who participated in an 8-week high intensity interval training program (HIIT group). The comparative group was constituted of 20 pregnant women who attended 8-week educational program (EDU group).

Results: The most important finding was that after intervention the mental health improved somewhat in both groups, but only in the HIIT group the improvement was statistically significant. The positive trends in lowering the severity of depressive symptoms, fear of childbirth, and fear of Covid-19 were observed in both groups, however the positive response to the intervention was stronger in the EDU group. As secondary outcome, there was a significant decrease in cardiorespiratory fitness level in the EDU group, while the HIIT group maintained unchanged level of maximal oxygen uptake.

Conclusions: HIIT can be recommended for women with uncomplicated pregnancies to prevent depression and anxiety symptoms. However, more research is needed to determine the effectiveness of prenatal HIIT in pregnant women in various psychological conditions.

Trial registration: We conducted this study in Poland, in 2021. It was approved by the Bioethics Commission at the District Medical Chamber in Gdansk (KB - 8/21). The full study protocol was registered in ClinicalTrials.gov (NCT05009433).

Introduction

Pregnancy is an important phase in a woman's existence, and a woman's physical and mental health status affects both her and her child's life. During this period several anatomical, hormonal, psychological, and also lifestyle and social role changes appear and may potentially affect women's daily life. Related with these changes, there is an increased risks of depressive disorders during pregnancy, which applies to as many as 23% of pregnant women [1]. Another common problem is fear of childbirth, which complicates about 20% of pregnancies [2]. Moreover, the aforementioned changes and the pregnancy-related symptoms [3] have potential consequences on women's health-related quality of life. That makes their perception of quality of life lower compared with nonpregnant women of similar age, especially in the physical function [4]. According to some authors, the physical component of quality of life decreases throughout pregnancy while the mental component remains stable [5].

Research over the past 30 years has shown that regular physical activity during pregnancy has a positive effect on the physical and psychological condition of the pregnant woman, on pregnancy and on fetal development [6–10]. Among mental benefits are reducing stress, anxiety, and depression as well as well-being improvement. Despite the aforementioned benefits, women have the tendency to reduce their physical activity during the course of pregnancy, which is often associated with the intensification of depressive symptoms [11]. Maternal depression can lead to premature birth, increased stress hormones in infants, and may cause difficulties in establishing a bond with the baby (higher risk of developing insecure attachment style in an infant); negatively affecting its physical and mental development [1,12]. Based on a meta-analysis of 131,406 pregnant women, Davenport et al. (2018) showed that physical activity during pregnancy reduces the risk of perinatal depression by as much as 67% [6]. This result corresponds with the works of other authors [13,14]. Guszkowska et al. (2014) demonstrated that women who participated in an exercise program during pregnancy significantly reduced their fear of childbirth compared to those who attended traditional childbirth classes. Women fear childbirth mainly because they are afraid of pain. Exercising can help reduce the childbirth fear by improving the ability to control breathing and muscle tension and decreasing the level of anxiety, both as a trait and as a state [15,16]. In addition, physical activity is associated with better quality of life perception during pregnancy [17,18].

In the COVID-19 pandemic, many future mothers display a visible weakening of the mental condition [19], which results, among others, in the decline of physical activity levels [20]. The restrictions of the COVID-19 pandemic imposed to reduce infection rates, caused pregnant women to experience disruption not just to their daily lives but also their pregnancy healthcare experience, and led to social confinement. As Atkinson et al. (2020) underlined in their work, this also meant substantial changes to how, when, and why pregnant women were involved and practiced physical activity and exercise [21]. Moreover, many pregnant women fear COVID-19 and, therefore, worry about visiting labor and delivery wards and are even delaying or canceling antenatal visits and face-to-face consultations during the pandemic [22–25]. The anxiety increases due to the thought that the virus would be transmitted to their fetus by vertical transmission [26]. Therefore, it is necessary to determine different activities and ways of support for pregnant women to deal with emotions and stress caused by these extraordinary circumstances. Lebel et al. (2020) reported in the studies in 1.987 pregnant women in Canada that regularly practiced physical activity and social support lowered the likelihood of symptoms of anxiety and depression during the pandemic [27]. It seems crucial to popularize pro-health exercises in pregnant women from various social groups, especially those with a low degree of involvement in physical activity before the pandemic. Women should be encouraged to continue exercising until the day of delivery. Physical activity is recommended during pregnancy owing to the significant health benefits for mothers and their offspring [21,28].

While it is well known that physical activity and exercise have health benefits for pregnant women, which kind of training is most suitable for future mothers? According to current guidelines published by credible obstetrics, gynecology, and sports medicine institutions, including the World Health Organization, women

should perform at least 150 minutes of moderate intensity aerobic physical activity throughout the week (ACOG, 2020; ACSM, 2020; Mottola et al., 2018; WHO, 2020). For moderate-intensity exercise, ratings of perceived exertion should be 13–14 (somewhat hard) on the Borg ratings of perceived exertion scale [33]. According to some researchers, aerobic exercises such as walking, especially in nature, are most beneficial for revitalizing feelings of well-being of pregnant women [6,34]. Rodrigues-Ayllon et al. (2021) demonstrated that the moderate-to-vigorous physical activity was negatively associated with depression in pregnant women. However, little is known so far about the effects of high-intensity exercise on psychosocial condition of mothers-to-be [35].

In recent years, high intensity interval training (HIIT) has grown in popularity [36], inter alia due to its health benefits. There is a variety of HIIT protocols: they are based on short work intervals (< 60 s – 8 min) of vigorous (70–90% maximal heart rate or 14–16 of the 6–20 Borg's rate of perceived exertion scale - RPE) to high intensity (≥ 90% maximal heart rate or ≥ 17 of the 6–20 RPE) interspersed with active (40–70% maximal heart rate or 8–13 of the 6–20 RPE) or passive (cessation of movement) recovery periods (of 1–5 min) [37]. Some authors observed that HIIT used as an acute intervention improved well-being and reduced distress and state of anxiety in patients with depression and schizophrenia [38]. Other researchers found that the HIIT intervention seemed to be more beneficial to reduce depression and anxiety than a moderate intensity training [39,40]. Contrary to these results, in another study, although HIIT decreased depressive symptoms, it also increased perceived stress [41]. Therefore, the authors suggested that moderate intensity exercise may be an optimal intensity of exercise for the promotion of mental health. Based on a literature review, Kleinert & Bassek (2019) concluded that the positive effects of HIIT on the quality of life, depression, anxiety and fatigue are inconsistent. However, they did not find proof of the negative psychological effects of HIIT [42].

Until now, HIIT programs rarely represent training interventions in experimental studies in pregnant populations [43], although the upper limit for the intensity of physical effort for the perinatal period has not been set so far (ACOG, 2020; Davenport, Meah, et al., 2018; Skow et al., 2018). All the evidence shows that pregnant women can benefit from HIIT programs in the same way, as other populations. Therefore, in this study we decided to investigate the effectiveness of HIIT intervention on selected psychological characteristics among pregnant women. We aimed at: first, to assess the changes in depressive symptoms, fear of childbirth, coronavirus anxiety, and perception of quality of life after an 8-week supervised online HIIT program compared to an educational and self-performed physical activity program; second, to determine the predictors of these changes. We also measured the modifications in maximal oxygen uptake (VO_{2max}).

Methods

The present study was a randomized control trial among 54 Caucasian women in uncomplicated, singleton pregnancy (age 32 ± 4 years, 22 ± 4 week of gestation; mean ± SD) who responded to our mass media invitation and volunteered for the study. We conducted promotional activities towards recruitment

for the research in the spring of 2021. We recruited 69 women, who were allocated by the principal researcher in one of the interventional groups: experimental or educational, using simple randomization with 1:1 ratio. Each of the interventions lasted 8 weeks and ended in the fall of 2021. There were 34 women in the experimental group, who completed the high intensity interval training program (HIIT group). The comparative group was constituted of 20 pregnant women who completed educational program on a healthy lifestyle and physical activity in the perinatal period (EDU group). The eligibility criterion was a course of pregnancy allowing participation in physical activities adapted to pregnant women, confirmed by the routine obstetric consultation. Exclusion criteria were contraindications to increased physical effort or other conditions that, according to the researchers, could threaten the health or safety of the participants or could significantly affect the quality of the collected data.

Before and after the intervention all women were assessed with following tools:

Beck Depression Inventory – II (BDI-II)

The occurrence and severity of depression symptoms using BDI-II (Beck Depression Inventory – II) The BDI-II is a patient-rated 21-item inventory to evaluate depressive symptoms. For each item, the participants are required to rate on a scale of 4 ranging from 0 to 3 the severity of the symptoms in the last two weeks. Scores can range from 0 to 63. BDI-II classification is as follows: 0–13: no depression; 14–19: mild depression; 20–28: moderate depression; 29–63: severe depression. The BDI-II has established psychometric properties [45]. In the current study, the Cronbach alpha for the HIIT group and EDU group (for depressive symptoms was 0.78 and 0.73, respectively.

Fear of childbirth

The fear of childbirth was measured with the Childbirth Attitudes Questionnaire (CAQ) (Lowe, 2000), developed from a questionnaire designed to measure fear of childbirth by Areskog et al. [46]. The CAQ is a 16-item questionnaire, with a 4-point Likert scale. The item scores are summed to provide a total score (range: 16–64) with higher scores indicating higher levels of fear of childbirth. The Cronbach alpha for both HIIT group and EDU group was 0.90.

12-item Short Form Health Survey (SF-12)

Health-related quality of life was assessed with 12-item Short Form Health Survey (SF-12) instrument which includes a physical (PCS) and a mental (MCS) scale [47]. The SF-12 is a self-administered questionnaire, which measures health status. Responses to questions are dichotomous (yes/no), ordinal (excellent to poor), or expressed by a frequency (always to never). The answers to this 12-item questionnaire allow calculation of Physical Component Summary (PCS) and a Mental Component Summary (MCS) scores. In the absence of response to a single question of these subscales, the score cannot be calculated. The higher the score, the better the health status. The SF-12 reliability from the study of Ware et al. (1996) is .93 Cronbach alpha [47]. In the current study, the Cronbach alpha for HIIT group and EDU group was 0.75 and 0.67, respectively.

Fear of COVID-19 Scale (FCV-19S)

The authors used the Fear of COVID-19 Scale (FCV-19S) of Ahorsu et al., [48]. The scale consists of 7 items, which are ranged on 5-point Likert scale from 1 - strongly disagree to 5- strongly agree. The scale has single factor structure, with internal consistency α= .82 [48]. Scores range from 7 to 35, and the higher the score the worse the outcome. In the current study, the Cronbach alpha for HIIT group and EDU group for coronavirus fear was 0.84 and 0.87, respectively.

International Physical Activity Questionnaire (IPAQ)

The level of physical activity was measured by the short form of International Physical Activity Questionnaire [49]. This questionnaire, which has shown acceptable measurement properties, provides information on weekly PA levels in multiples of the resting metabolic rate (METs). Based on IPAQ outcomes, we categorized the pregnant women using three levels (categories) of PA: low (inactive women), moderate (accumulating a minimum recommended level of PA) and high (exceeding the minimum recommended level of PA) [50,51].

Progressive maximal exercise test

Maternal oxygen consumption during exercise was measured during a progressive maximal test on a cycloergometer with electronically regulated load (Viasprint 150P) and respiratory gas analyzer (Oxycon Pro, Erich JAEGER GmbH, Germany). We presented the test protocol in our previous study (Szumilewicz et al., 2019). As maximal oxygen capacity (VO_{2max}) we treated the highest value of oxygen uptake, which was maintained for 15 seconds. The anaerobic threshold (AT) values, such as oxygen uptake at AT (VO_2/AT) and heart rate at AT (HR/AT) were established using the V-slope method [52].

Experimental training and educational interventions

The HIIT intervention consisted of attending three 60-minute training sessions a week for eight weeks. The warm-up together with educational tips on how to perform exercises in the main part lasted 7-10 minutes. The main part (15-20 min) was conducted in the form of high intensity intervals. Based on the progressive maximal exercise test we determined the individual heart rate at anaerobic threshold (HR/AT) for each woman. On average, the HR/AT was set at 87% ± 5 of maximal heart rate. Using a heart rate monitor (Polar RS400, Finland) women were supposed to exceed the value of HR/AT in workout intervals for as long as they felt comfortable. The exercise intensity was also monitored with the use of the 0-10 Borg Rating of Perceived Exertion (RPE) [33] and the Talk Test [53].

The workout intervals consisted of exercises involving the main muscle groups (e.g., squats, lunges, jumps, combined with the upper body movements). They lasted for 30-60 seconds, alternating with a 30-60 second rest break, in the ratio of exercise time to rest 1:2, 1:1 or 2:1, according to the individual capabilities of the participant and taking into account the training progression and stage of pregnancy. Following the interval part of the training, women performed resistance, postural, neuromotor (e.g., body

balance) and stretching exercises (5-10 min). The cool down included pelvic floor muscle exercises and preparation-for-birth exercises, e.g., birth position and breathing exercises (5-10 min) and also relaxation and visualization of pregnancy and childbirth (5-15 min). No equipment was used during exercises and only resistance of own body was applied. Women could participate in the exercise program regardless of their level of fitness or exercise capacity, as well as the level of motor skills (based on the diagnostic exercise tests, the exercise program was tailored to the individual needs and capabilities of a woman [54,55].

Group HIIT sessions were held online, from 9.30-10.30 a.m. using the MS Teams® platform on Mondays, Wednesdays and Fridays, except one Monday which was a holiday (23 sessions in total). Women attended 19 ± 4 sessions on average (80% of the entire training program). Before the start of the program, the women were trained how to use the MS Teams® application, as well as about the safety rules for exercising at home (including the safe organization of space at home, rules of communication in the event of an accident or deterioration of well-being). The HIIT intervention was supplemented by educational class once a week. The sessions were conducted by the principal researcher, who is a graduated fitness professional certified Pregnancy and Postnatal Exercise Specialist according to the European educational standard for this profession [56]. We used email and phone contact to monitor the adherence to the program.

The comparative group (EDU group) was constituted of 20 pregnant women who attended educational sessions on a healthy lifestyle, physical activity in the perinatal period and selected aspects of pregnancy and motherhood. The educational program was the same as for the HIIT group. Educational classes ware conducted online in real time, once a week for 8 weeks. We encouraged women from the EDU group to individually undertake exercise and fulfil at least the recommended level of physical activity (minimum 150 minutes per week of moderate to vigorous intensity). We asked them to keep a diary of all their physical activity (including both structured exercise sessions and daily activities lasting at least 10 minutes, such as cleaning the house, gardening, shopping). The educational group did not monitor the intensity with heart rate monitors, but used the RPE scale and Talk Test. We recommended exercise intensity at a level in which they felt a marked increase in breathing frequency, but until their breathing interfered with their conversation. On average, the women reported 19 bouts of physical activity with an average intensity of 6 ± 1 on the 0-10 RPE scale.

During the entire experiment, all study women remained under standard obstetric care. Both interventions were not associated with any negative effects on the course of pregnancy or on childbirth parameters. Data on obstetric and neonatal outcomes were collected postpartum, using an online questionnaire and based on medical documentation, approximately 2 months after delivery. Because the requirement for the trial implementation was that the experimental group attended exercise sessions three times a week, while the educational group had the educational classes once a week, it was impossible to blind the study participants to the group allocation. However, the people collecting the data and the statistician were kept blinded to the allocation.

The sample size was predetermined by using a power calculation with the software G∗power version 3.1.3. The estimated values of the mean and SD from preliminary tests with 9 women form the HIIT group allowed us to predetermine the minimal sample size of 44 (22 for each group) with an allocation ratio 1:1, a power of 0.8 and alpha of 0.05. The flow of participants through the study is presented in Figure 1.

The study was conducted in the Laboratory of Physical Effort and Genetics in Sport, at the Gdansk University of Physical Education and Sport in Poland in 2021.. It was performed according to the principles of the WMA Declaration of Helsinki and with the approval of the Bioethics Commission at the District Medical Chamber in Gdansk (KB - 8/21). The participants signed the informed consent before testing. The full study protocol was registered in ClinicalTrials.gov (NCT05009433) on 17/08/2021. No important methodological changes were done after trial commencement. In this study we followed standards for transparency, openness and reproducibility of research [57] and also adhered to the BMC Sports Science, Medicine and Rehabilitation methodological checklist and CONSORT standards [58]. We performed no data manipulations. Materials for this study are available in the supplementary materials. The data analysis presented in this work was not preregistered.

Statistical analysis

Statistical tests were performed using the IBM Statistical Package for the Social Sciences version 26.0 (IBM Corp., Armonk, New York, USA), with the statistical significance set to $p < 0.050$. The analysis of the normality of the distribution of study variables was developed using the Kolmogorov-Smirnov test (K-S test). Inter- and intra-group mean differences were analyzed by the Student's t-test or analysis of variance (ANOVA) test when appropriate. In the case of distributions which were significantly different from the normal distribution, we used the non-parametric Mann-Whitney U test and the Wilcoxon T test for the assessment of inter- and intra-group differences, respectively. Additionally, Chi-square was used to evaluate the differences in frequencies.

Results

The characteristics of the participants are gathered in Table 1. The HIIT and EDU groups in terms of age, BMI, physical fitness, and PA levels presented values not statistically different. The EDU group was at slightly higher week of pregnancy. However, we have considered the observed statistically significant difference of 4 weeks between groups of no clinical significance. In the pre-intervention assessment, we did not observe any significant differences between both groups in any of the measured psychosocial parameters (Table 1).

Table 1 The characteristics of the study participants.

	Group				
Variable	**HIIT** **n = 34, M±SD**	**EDU** **n = 20,** **M±SD**	**Statistics[1]**	**p-value**	**Effect size[2]**
Age (years)	31 ± 4	32 ± 4	*Z* = -0.675	0.500	0.185
BMI (height/weight^2)	24.4 ± 2.8	25.4 ± 3.2	*t* = -1.141	0.259	0.322
Week of gestation	20 ± 4	24 ± 4	*Z* = -2.741	**0.006**	0.780
Initial VO_2max (kg/ml/min)	25.6 ± 4.4	23.7 ± 3.6	*Z* = -1.505	0.132	0.417
Initial weekly PA (METs)	2625.3 ± 1823.2	2266.0 ± 1816.5	*Z* = -0.752	0.452	0.206

[1] In case of variables with the distribution close to normal distribution we used parametric testing with Student t test and in case of variables with a distribution significantly different from the normal distribution we used non-parametric testing with Mann-Whitney *U* test.

[2] In case of variables with the distribution close to normal distribution we used Cohen's d for the evaluation of effect sizes and in case of variables with a distribution significantly different from the normal distribution we used rank-biserial correlation.

Bold type indicates significant difference in the outcome variable.

As additional information, 91% of women from the HIIT group and 90% from the EDU group had higher educational level. The remaining women had secondary education. 44% of women from the HIIT group and 50% from the EDU group had moderate level of physical activity. 38% of women from the HIIT group and 30% from the EDU group reported high level of physical activity. The remaining 18% of women from the HIIT group and 20% from the EDU group presented low level of physical activity. Groups did not differ either in their educational level (χ^2 = 0.021, p = .885) or as a category of physical activity measured with the IPAQ (χ^2 = 0.374, p = .829). Of note, the clinical score for depression symptoms was obtained by 5.9% of women form the HIIT group and 10% of women in the EDU group at baseline; and by 5.9% of women form the HIIT group and none of women in the EDU group during second assessment.

The severity of depressive symptoms

The results obtained in the ANOVA with repeated measures revealed a significant main effect (F = 6.530, p = .014, η^2 = 0.112, observed power = 0.708), in the absence of an interaction effect (F = 0.878, p = .353, η^2 = 0.017, observed power = 0.151), in case of the severity of depressive symptoms. However, when

controlling for the week of birth (variable entered as a covariate in ANOVA) neither interaction effect (F = 1.506, p = .225, η^2 = 0.029, observed power = 0.226) nor main effect remained to be significant (F = 2.010, p = .162, η^2 = 0.038, observed power = 0.285). Further post-hoc analyzes showed that the groups did not differ in the severity of depressive symptoms, both in the first measurement (t = 0.277, p = .783, 95% CI: LL = -2.039, UL = 2.692, Cohen's d = 0.078; HIIT group: M = 5.68, SD = 4.44; EDU group: M = 5.35, SD = 3.69) as well as in the second measurement (t = 1.620, p = .111, 95% CI: LL = -0.289, UL = 2.713, Cohen's d = 0.399; HIIT group: M = 4.91, SD = 3.49; EDU group: M = 3.70, SD = 2.01). The change over time was non-significant in both the HIIT group (t = 1.620, p = .115, 95% CI: LL = -0.196, UL = 1.725, Cohen's d = 0.278), as well as in the EDU group (t = 1.759, p = .095, 95% CI: LL = -0.314, UL = 3.614, Cohen's d = 0.393).

Additional analysis with the Chi-square test showed that the groups (HIIT and EDU) did not differ in the presence or absence of clinical symptoms of depression (comparison of the observed and expected frequencies in each category: "occurrence of depressive symptoms", "no depressive symptoms") both in the pre-test (χ^2 = 21.205, p = .130) and in the post-test (χ^2 = 10.796 p = 0.460).

In the next step, we evaluate the associations between the severity of depression symptoms in the final assessment and age, BMI, level of education, week of birth, VO_{2max} (at baseline and final), category of PA level (at baseline and final) as well as IPAQ METs (at baseline and final) in both groups. We found no significant correlations in the EDU group. However, in the HIIT group we found significant correlations between the severity of depression symptoms and category of PA level (at baseline) as well as IPAQ METs (at baseline and final). Based on the results of the correlation analysis, we performed series of regression analyses. The details for the significant correlations are presented in the Table 2.

Table 2 Predictors of the severity of depression symptoms during second assessment for HIIT group.

	Severity of depression symptoms			
	R^2	*F*	**p-value**	***Beta***
Baseline PA in METs	0.224	9.244	.005	-0.473
Baseline category of PA	0.219	8.990	.005	-0.468
Final PA in METs	0.230	9.548	.004	-0.479

METs- metabolic equivalents of tasks

PA-physical activity

Fear of childbirth

In case of the fear of childbirth, the ANOVA with repeated measure revealed that there is a significant main effect (F = 6.956, p = .011, η^2 = 0.118, observed power = 0.735), in the absence of an interaction

effect (F = 1.710, p = .197, η^2 = 0.032, observed power = 0.250); see Figure 2. Additional, post-hoc analyses pointed that the groups did not differ in the case of the severity of fear of childbirth, both in the first measurement (t = -1.908, p = .061, 95% CI: LL = -5.160, UL = 0.118, Cohen's d = 0.471; HIIT group: M = 32.29, SD = 5.09; EDU group: M = 34.81 SD = 5.64), as well as in the second measurement (t = 0.445, p = .658, 95% CI: LL = -3.211, UL = 5.041, Cohen's d = 0.125; HIIT group: M = 30.76, SD = 7.52; EDU group: M = 29.85, SD = 6.89). The change (decrease in fear of childbirth) between pre- and post-intervention was significant in the EDU group (t = 3.060, p = .006, Cohen's d = 0.684), but not in the HIIT group (t = 0.999, p = .325, Cohen's d = 0.171). However, when controlling for the week of birth (variable entered as a covariate in ANOVA) neither interaction effect (F = 2.256, p = .139, , η^2 = 0.042, observed power = 0.314) nor main effect remained to be significant (F = 1.584, p = .214, η^2 = 0.030, observed power = 0.235).

In the next step, we evaluated the associations between the severity of fear of childbirth in the final assessment and age, BMI, level of education, week of birth, VO_{2max} (at baseline and final), category of PA (at baseline and final) as well as Pa in METs (at baseline and final) in both groups. We found no significant correlations in the EDU group. However, in the HIIT group we found significant correlations between the severity of fear of childbirth and category of PA (at baseline) as well as PA in METs (at baseline). Based on the results of the correlation analysis, we performed regression analyses. The details for the significant correlations are presented in Table 3.

Table 3 *Predictors of the fear of childbirth during final assessment for the HIIT group.*

	Fear of childbirth			
	R^2	F	p-value	*Beta*
Baseline PA level in METs	0.145	5.439	.026	-0.381
Baseline category of PA	0.234	10.294	.003	-0.493
METs- metabolic equivalents of tasks PA-physical activity				

Physical and mental health

For the assessment of the differences in the physical aspect of health (reflected by the "Physical health" subscale's score of the SF-12) between groups in the two measurements, repeated ANOVA measures revealed no significant main effect (F = 0.015, p = .903, η^2 = 0.00, observed power = 0.052) nor interaction (F = 0.25, p = .876, η^2 = 0.00, observed power = 0.053). Non-significant results were also observed when the week of birth was entered as a covariate in repeated ANOVA measures.

However, in case of the mental aspect of health (reflected by the "Mental health" subscale's score of the SF-12) the analysis pointed at the significant main effect (F = 8.669, p = .005, η^2 = 0.153, observed power = 0.823), in the absence of an interaction effect (F = 0.099, p = .755, η^2 = 0.002, observed power = 0.061)

(see Figure 3). Post-hoc analyses showed that the groups did not differ in the mental aspect of health in the first measurement (t = -1.995, p = .051, 95% CI: LL = -7.87, UL = -0.02, Cohen's d = 0.562; HIIT group: M = 48.46, SD = 7.23; EDU group: M = 52.38, SD = 6.53), and in the second measurement (t = -1.791, p = .080, 95% CI: LL = -6.09, UL = 0.35, Cohen's d = 0.522; HIIT group: M = 51.90, SD = 6.06; EDU group: M = 54.77, SD = 4.43). Of note, the increase in the mental aspect of health was significant only in the HIIT group (t = -2.652, p = .013, 95% CI: LL = -5.85, UL = -0.76, Cohen's d = 0.476) and non-significant in the EDU group (t = -1.661, p = .114, 95% CI: LL = -6.04, UL = 0.71, Cohen's d = 0.381). However, when controlling for the week of birth (variable entered as a covariate in ANOVA) neither interaction effect (F = 1.236, p = .272, η^2 = 0.026, observed power = 0.193) nor main effect remained to be significant (F = 2.271, p = .106, η^2 = 0.055, observed power = 0.366).

In the next step, we evaluated the associations between the physical and mental health in the final assessment and age, BMI, level of education, week of birth, VO_{2max} (at baseline and final), category of PA (at baseline and final) as well PA in METs (at baseline and final) in both groups. We found no significant correlations in the control group. However, in the HIIT group we found significant correlations between the physical health and IPAQ (final) as well as between mental health and category of PA (at baseline and final) and PA in METs (at baseline and final). Based on the results of the correlation analysis, we performed regression analyses. The details are presented in Table 4.

Table 4 *Predictors of the physical and mental health during final assessment for the HIIT group.*

	Physical health			
	R^2	*F*	p-value	*Beta*
Final PA in METs	0.157	5.947	.020	0.396
	Mental health			
Baseline category of PA	0.160	5.533	.026	0.400
Baseline PA in METs	0.212	7.799	.009	0.460
Final category of PA	0.127	4.200	.050	0.356
Final PA in METs	0.167	5.818	.022	0.409

PA-physical activity

METs- metabolic equivalents of tasks

Covid-19-related fear

In case of the Covid-19-related fear, the results revealed that there were no significant differences between groups in the first assessment (F = 0.075, p = .785, η^2 = 0.001, observed power = 0.058; HIIT group: M = 12.94, SD = 0.69; EDU group: M = 13.25, SD = 0.90). Of note, lack of significant results was observed

when controlling for the week of birth as well. The analysis with the Mann-Whitney *U* pointed to non-significant results as well (Z = -0.535, p = .593; HIIT group: M = 11.41, SD = 0.76; EDU group: M = 10.30, SD = 0.97). The decrease in the fear of Covid-19 (measured with the Wilcoxon *T* test) between the initial assessment and final measurement was significant in the HIIT group (Z = -3.328, p < .001) as well as for the EDU group (Z = -2.661, p = .008); see Figure 4.

In the next step, we evaluated the associations between the COVID-19-related fear in the final assessment and age, BMI, level of education, week of birth, VO_{2max} (at baseline and final), category of PA (at baseline and final) as well as PA in METs (at baseline and final) in both groups. We found no significant correlations in the HIIT as well as EDU group.

The exercise capacity (expressed as VO_{2max})

The analysis conducted with repeated measures ANOVA revealed both the significant main effect (F = 20.387, p < .001, η^2 = 0.290, observed power = 0.993) as well as interaction effect (F = 16.928, p < .001, η^2 = 0.253, observed power = 0.981), in case of the VO_{2max}; see Figure 5. Post-hoc analyzes showed that the groups (HIIT and EDU) did not differ in the VO_{2max} in the first measurement (t = -1.631, p = .109, 95% CI: LL = -4.241, UL = 0.439, Cohen's d = 0.465; HIIT group: M = 25.59, SD = 4.37; EDU group: M = 23.69, SD = 3.58), however they differed in the second measurement (t = -4.076, p < .001, 95% CI: LL = -8.191, UL = -2.786, Cohen's d = 1.149; HIIT group: M = 25.21, SD = 5.11; EDU group: M = 19.72, SD = 4.14). The change (decrease in VO_{2max}) between pre- and post-intervention was significant in the EDU group (t = 5.125, p < .001, 95% CI: LL = 2.348, UL = 5.591, Cohen's d = 1.146), but not in the HIIT group (t = 0.339, p = .737, 95% CI: LL = -0.924, UL = 1.292, Cohen's d = 0.060).

The level of physical activity (based on IPAQ)

Further analysis with Mann-Whitney *U* test revealed that groups did not differ in the IPAQ MET in the first assessment (Z = 0.752, p = .452; HIIT group: M = 2625.27, SD = 1823.21; EDU group: M = 2266.00, SD = 1816.46). Similarly, no between-group differences were observed in the second measurement (Z = -1.506, p = .132; HIIT group: M = 3118.31, SD = 1995.15; EDU group: M = 23.69, SD = 3.58). The within-group analyses with the Wilcoxon *T* test revealed, that the differences between initial assessment and second measurement were statistically insignificant for both the HIIT group (Z = -1.410, p = .158) and EDU group (Z = -0.037, p = .970).

Discussion

The authors investigated two aspects of the current study. Firstly, the researchers aimed to estimate the effects of the 8-week supervised online HIIT program on depressive symptoms, fear of childbirth, fear of Covid-19, and perception of quality of life compared to the 8-week educational and self-performed physical activity program. Secondly, the authors goal was to determine the predictors of the changes in these parameters. It is worth mentioning that women in both groups were generally in good mental and

physical conditions entering the programs, as these were in the inclusion criteria in the project invitation. The study results revealed that the level of depressive symptoms at the beginning of the program was low. Since the women had satisfactory conditions before starting the program, significantly improving these outcomes was not expected. Nevertheless, we observed a significant reduction of anxiety (fear of childbirth) among EDU group women and significant decrease in fear of Covid-19 in both groups. According to Filippetti et al. (2022), pregnant women for whom coronavirus had a more significant psychological impact were more likely to suffer from anxiety and depressive symptoms also associated with reduced attachment to the unborn baby. Therefore, reducing Covid-19 -related fear could work as a protective factor from affective problems.

However, the current study's findings revealed no significant intergroup differences in depression symptoms in the first and second assessments and no changes over time. As long as participants were non-clinical samples, the depressive symptoms were hard to change; nonetheless, the authors observed a substantial improvement in mental health among HIIT group women. The body of studies underlines that mental health is a strong predictor of anxiety, especially pregnant women are vulnerable to anxiety disorders compared to non-pregnant women. Consequently, all the interventions which are proved to improve mental health seem to be very valuable [60,61]. Those results are remarkable findings considering previous studies that pregnancy has been established as period of vulnerability for psychological and social status changes, which increase the potential risk of impaired physical and mental health [1]. Furthermore, the severity of depression symptoms in the HIIT group was associated with a category of physical fitness and physical activity levels pre- and post-intervention. The observations of other authors confirm that regular physical activity leads to the reduction of depressive and anxiety disorders in women in the perinatal period, especially among women experiencing mild or moderate depressive conditions [62,63]. While interpreting the above results, one can refer to other authors who observed that moderate-intensity programs were more effective in treating depression and reducing anxiety. Following this interpretation, moderate intensity continuous training programs would be a better recommendation for women with depression. Nonetheless, Ong et al. (2016), while investigating the influence of continuous cycling exercise at a steady power output compared to interval cycling consisting of continuous cycling at the same power output as continuous cycling but with the addition of six 15-s self-paced higher intensity efforts proved that interval cycling significantly increased enjoyment among pregnant women at late pregnancy. One the other hand, the results might have been influenced by aspects of (even unconscious) social pressure and perhaps the fear of women that they exercise too hard, that it could lead to a miscarriage or harm the baby [65]. Hence, it could reduce the therapeutic effectiveness of exercises in reducing depression-anxiety states through exercise.

Moreover, compared to the educational one, the HIIT program allowed to maintain cardiorespiratory fitness levels (CRF), which is undoubtedly an added value of the investigated program. Similarly to Stubbs et al. (2016), who underlined in the meta-analysis that people with depression, including major depressive disorder, could increase CRF in response to exercise interventions. With such a positive change in VO_{max}, HIIT programs should be recommended for pregnant women in good physical and mental

health. An important and novel result, mentioned before, is that all respondents significantly decreased their level of fear of Covid-19. Neither age, level of education, week of birth, nor physical activity characteristics were the predictors of those changes. However, it is not clear which part of the programs (exercise or education) was more effective in this respect. What is more, we assume that day-to-day adaptation to the pandemic situation could influence the increase of emotional resilience among studied women. Hillyard et al. (2021) in the studies on 553 pregnant women with gestational diabetes, underlined the urgent need for targeted public health initiatives to increase physical activity and reduce sedentary behaviors as the pandemic continues and for future lockdowns. Rabiepoor et al. (2019) emphasize that pregnant women, in general, need to know how safe and beneficial it is to engage in physical activity. Pregnant women should be encouraged to participate in online classes, prepared by qualified exercise professionals and coaches, which could be beneficial in lowering Covid-19 anxiety by reducing face-to-face meetings [67,68].

Our findings highlight that both interventions seem to be an efficient way to preserve the quality of life along the course of pregnancy. Despite not only the lower level of quality of life reported by pregnant women when compared with non-pregnant women of the same age [4] and the decrease of the physical aspect of quality of life along the course of pregnancy [5], both the HIIT program and the educational program could be considered in the antenatal care, at least to maintain quality of life perceived by women throughout pregnancy. The improvements obtained in the mental aspect of quality of life by the HIIT program group, which is consistent with meeting physical activity guidelines [69], can be explained not only by its stable behavior during pregnancy [5], but also by the role of exercise practice on the promotion of social interactions [1] and also by the positive influence of exercise on several mental disorders like depression or anxiety [6]. Despite the limitations in aerobic work capacity, caused by an increase in the ventilatory response related to the elevated metabolic costs of exercise, which lead to a cardiorespiratory fitness decline as pregnancy advances [70], the HIIT interventions may be an excellent way to preserve a proper cardiorespiratory fitness level throughout pregnancy. Moreover, the HIIT program could be more enjoyable for women who prefer to be physically active (with supervision by an exercise professional) than the EDU program. Many participants in the EDU group resigned from completing the program, probably because the intervention was educational only.

Limitations And Directions For Future Research

There are limitations of the study. Self-reported assessment of PA may be subject to social desirability bias; however, PA was collected using a validated questionnaire, which minimized potential bias. Some women missed the second assessment. Thus, missing data led to a lower sample size and therefore reduced power to detect differences in change between groups. The educational and social characteristics of both groups were pretty similar, not allowing the extrapolation of data for other groups. The Fear of COVID-19 questionnaire is very recent and was neither previously validated for pregnant women nor do we have reference data yet.

Future experiments on HIIT program efficiency should consider both pregnant women without affective problems where HIIT program would be a form of prevention from emotional difficulties during pregnancy and future mothers with higher levels of anxiety and depression as a form of intervention to reduce mental problems. Future experiments on HIIT program should include pregnant women with more diverse mental health and psychological characteristics.

Conclusions

The study revealed that all the outcomes progress along with the interventions. Very positive trends in the decrease in the severity of depressive symptoms, fear of childbirth, fear of Covid-19, and the increase of physical activity level and mental health among future mothers were observed in the current study, not to mention the significant increase in cardiovascular fitness levels of the HIIT group. High intensity interval training can be recommended for healthy women as a form of physical activity that is safe and beneficial for an uncomplicated pregnancy and has a preventive effect on depression and anxiety symptoms. However, more research is needed to determine the effectiveness of prenatal HIIT in pregnant women in various psychological conditions.

Abbreviations

BMI – body mass index

EDU – educational program

HIIT – High Intensity Interval Training

MET – metabolic equivalent of task

SF-12 – 12-item Short Form Health Survey

IPAQ – International Physical Activity Questionnaire

VO2max - maximal oxygen uptake

Declarations

Ethics approval and consent to participate

We conducted this study in the Laboratory, in 2021. It was performed according to the principles of the WMA Declaration of Helsinki and with the approval of the Bioethics Commission at the District Medical Chamber in Gdansk (KB - 8/21). The participants signed the informed consent before testing. The full study protocol was registered in ClinicalTrials.gov (NCT05009433). No important methodological changes were done after trial commencement. In this study we followed standards for transparency, openness and reproducibility of research (Nosek et al., 2015) and also adhered to the BMC Sports

Science, Medicine and Rehabilitation methodological checklist and CONSORT standards (Moher et al., 2012).

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. It was financed from the statutory research funds of the Faculty of Physical Culture of the Gdansk University of Physical Education and Sport, Poland.

Contributions

Each author has contributed individually and significantly to the development of the manuscript. DW participated in the design of the study, contributed to data collection, manuscript writing and interpretetion of the results; TWK participated in data reduction/analysis and interpretation of results; ŁR participated in the design of the study and contributed to data collection; MAOC contributed to data reduction/analysis and final manuscript corrections; RSR contributed to final manuscript corrections; AS, head of the project, participated in the design of the study, contributed to data collection, manuscript writing and interpretetion of the results. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Acknowledgements

We greatly appreciate the financial support of Gdansk University of Physical Education and Sport and the opportunity to conduct the study there.

References

1. Marcus SM. Depression during pregnancy: rates, risks and consequences–Motherisk Update 2008. *Can J CCinical Pharmacol J Can Pharmacol Clin*. 2009;16(1):e15-22.
2. Saisto T, Halmesmäki E. Fear of childbirth: a neglected dilemma. *Acta Obstet Gynecol Scand*. 2003;82(3):201–208. doi:10.1034/j.1600-0412.2003.00114.x

3. Oviedo-Caro MA, Bueno-Antequera J, Munguía-Izquierdo D. The associations of pregnancy-related symptoms with health-related quality of life at midpregnancy: the PregnActive project. *J Matern Fetal Neonatal Med*. Published online 2021:1–9. doi:10.1080/14767058.2021.1879040
4. Chang SR, Chen KH, Lin MI, Lin HH, Huang LH, Lin WA. A repeated measures study of changes in health-related quality of life during pregnancy and the relationship with obstetric factors. *J Adv Nurs*. 2014;70(10):2245–2256. doi:10.1111/jan.12374
5. Lagadec N, Steinecker M, Kapassi A, et al. Factors influencing the quality of life of pregnant women: a systematic review. *BMC Pregnancy Childbirth*. 2018;18(1):455. doi:10.1186/s12884-018-2087-4
6. Davenport MH, McCurdy AP, Mottola MF, et al. Impact of prenatal exercise on both prenatal and postnatal anxiety and depressive symptoms: a systematic review and meta-analysis. *Br J Sports Med*. 2018;52(21):1376–1385. doi:10.1136/bjsports-2018-099697
7. Davenport MH, Meah VL, Ruchat SM, et al. Impact of prenatal exercise on neonatal and childhood outcomes: a systematic review and meta-analysis. *Br J Sports Med*. 2018;52(21):1386–1396. doi:10.1136/bjsports-2018-099836
8. Davenport MH, Ruchat SM, Poitras VJ, et al. Prenatal exercise for the prevention of gestational diabetes mellitus and hypertensive disorders of pregnancy: a systematic review and meta-analysis. *Br J Sports Med*. 2018;52(21):1367–1375. doi:10.1136/bjsports-2018-099355
9. Davenport MH, Ruchat SM, Sobierajski F, et al. Impact of prenatal exercise on maternal harms, labour and delivery outcomes: a systematic review and meta-analysis. *Br J Sports Med*. 2019;53(2):99–107. doi:10.1136/bjsports-2018-099821
10. Okafor UB, Goon DT. Physical activity and exercise during pregnancy in Africa: a review of the literature. *BMC Pregnancy Childbirth*. 2020;20(1):732. doi:10.1186/s12884-020-03439-0
11. Haßdenteufel K, Feißt M, Brusniak K, et al. Reduction in physical activity significantly increases depression and anxiety in the perinatal period: a longitudinal study based on a self-report digital assessment tool. *Arch Gynecol Obstet*. 2020;302(1):53–64. doi:10.1007/s00404-020-05570-x
12. Murray L, Arteche A, Fearon P, Halligan S, Goodyer I, Cooper P. Maternal postnatal depression and the development of depression in offspring up to 16 years of age. *J Am Acad Child Adolesc Psychiatry*. 2011;50(5):460–470. doi:10.1016/j.jaac.2011.02.001
13. Kołomańska D, Zarawski M, Mazur-Bialy A. Physical activity and depressive disorders in pregnant women—A systematic review. *Medicina (Mex)*. 2019;55(5):212. doi:10.3390/medicina55050212
14. Vargas-Terrones M, Barakat R, Santacruz B, Fernandez-Buhigas I, Mottola MF. Physical exercise programme during pregnancy decreases perinatal depression risk: a randomised controlled trial. *Br J Sports Med*. 2019;53(6):348–353. doi:10.1136/bjsports-2017-098926
15. Guszkowska M. The effect of exercise and childbirth classes on fear of childbirth and locus of labor pain control. *Anxiety Stress Coping*. 2014;27(2):176–189.
16. Guszkowska M, Langwald M, Zaremba A, Dudziak D. The correlates of mental health of well-educated Polish women in the first pregnancy. *J Ment Health Abingdon Engl*. 2014;23(6):328–332. doi:10.3109/09638237.2014.971144

17. Krzepota J, Sadowska D, Biernat E. Relationships between physical activity and quality of life in pregnant women in the second and third trimester. *Int J Environ Res Public Health*. 2018;15(12):2745. doi:10.3390/ijerph15122745
18. Oviedo-Caro MA, Bueno-Antequera J, Munguía-Izquierdo D. Explanatory factors and levels of health-related quality of life among healthy pregnant women at midpregnancy: A cross-sectional study of The PregnActive Project. *J Adv Nurs*. 2018;74(12):2766–2776. doi:10.1111/jan.13787
19. Davenport MH, Meyer S, Meah VL, Strynadka MC, Khurana R. Moms Are Not OK: COVID-19 and Maternal Mental Health. *Front Glob Womens Health*. 2020;1:1. doi:10.3389/fgwh.2020.00001
20. Gildner TE, Laugier EJ, Thayer ZM. Exercise routine change is associated with prenatal depression scores during the COVID-19 pandemic among pregnant women across the United States. *PLOS ONE*. 2020;15(12):e0243188. doi:10.1371/journal.pone.0243188
21. Atkinson L, De Vivo M, Hayes L, et al. Encouraging physical activity during and after pregnancy in the COVID-19 era, and beyond. *Int J Environ Res Public Health*. 2020;17(19):7304. doi:10.3390/ijerph17197304
22. Ding W, Lu J, Zhou Y, Wei W, Zhou Z, Chen M. Knowledge, attitudes, practices, and influencing factors of anxiety among pregnant women in Wuhan during the outbreak of COVID-19: a cross-sectional study. *BMC Pregnancy Childbirth*. 2021;21(1):80. doi:10.1186/s12884-021-03561-7
23. Kahyaoglu Sut H, Kucukkaya B. Anxiety, depression, and related factors in pregnant women during the COVID-19 pandemic in Turkey: A web-based cross-sectional study. *Perspect Psychiatr Care*. 2021;57(2):860–868. doi:10.1111/ppc.12627
24. Mappa I, Distefano FA, Rizzo G. Effects of coronavirus 19 pandemic on maternal anxiety during pregnancy: a prospectic observational study. *J Perinat Med*. 2020;48(6):545–550. doi:10.1515/jpm-2020-0182
25. Verweij EJ, M'hamdi HI, Steegers E a. P, Reiss IKM, Schoenmakers S. Collateral damage of the covid-19 pandemic: a Dutch perinatal perspective. *BMJ*. 2020;369:m2326. doi:10.1136/bmj.m2326
26. Saccone G, Florio A, Aiello F, et al. Psychological impact of coronavirus disease 2019 in pregnant women. *Am J Obstet Gynecol*. 2020;223(2):293–295. doi:10.1016/j.ajog.2020.05.003
27. Lebel C, MacKinnon A, Bagshawe M, Tomfohr-Madsen L, Giesbrecht G. Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. *J Affect Disord*. 2020;277:5–13. doi:10.1016/j.jad.2020.07.126
28. Zilver SJM, Broekman BFP, Hendrix YMGA, et al. Stress, anxiety and depression in 1466 pregnant women during and before the COVID-19 pandemic: a Dutch cohort study. *J Psychosom Obstet Gynecol*. 2021;42(2):108–114. doi:10.1080/0167482X.2021.1907338
29. ACOG Committee Opinion Summary, Number 804: Physical Activity and Exercise During Pregnancy and the Postpartum Period: *Obstet Gynecol*. 2020;135(4):991–993. doi:10.1097/AOG.0000000000003773
30. ACSM. ACSM information on Pregnancy Physical Activity. In: American College of Sports Medicine. Published online 2020.

31. Mottola M, Davenport M, Ruchat SM, et al. 2019 Canadian guideline for physical activity throughout pregnancy. *Br J Sports Med*. 2018;52:1339–1346. doi:10.1136/bjsports-2018-100056
32. WHO. WHO guidelines on physical activity and sedentary behaviour. Geneva: World Health Organization. In (Vol. 57). Geneva: World Health Organization. Published online 2020.
33. Borg G. *Borg's Perceived Exertion and Pain Scales*. Human Kinetics; 1998:viii, 104.
34. Davenport MH. Exercise during pregnancy: A Prescription for Improved Maternal/Fetal Well-being. *ACSMs Health Fit J*. 2020;24(5):10–17. doi:10.1249/FIT.0000000000000602
35. Rodriguez-Ayllon M, Acosta-Manzano P, Coll-Risco I, et al. Associations of physical activity, sedentary time, and physical fitness with mental health during pregnancy: The GESTAFIT project. *J Sport Health Sci*. 2021;10(3):379–386. doi:10.1016/j.jshs.2019.04.003
36. Thompson WR. Worldwide Survey of Fitness Trends for 2022. *ACSMs Health Fit J*. 2022;26(1):11–20. doi:10.1249/FIT.0000000000000732
37. Wood G, Murrell A, Touw T van der, Smart N. HIIT is not superior to MICT in altering blood lipids: a systematic review and meta-analysis. *BMJ Open Sport Exerc Med*. 2019;5(1):e000647. doi:10.1136/bmjsem-2019-000647
38. Heggelund J, Kleppe KD, Morken G, Vedul-Kjelsås E. High Aerobic Intensity Training and Psychological States in Patients with Depression or Schizophrenia. *Front Psychiatry*. 2014;5:148. doi:10.3389/fpsyt.2014.00148
39. Borrega-Mouquinho Y, Sánchez-Gómez J, Fuentes-García JP, Collado-Mateo D, Villafaina S. Effects of High-Intensity Interval Training and Moderate-Intensity Training on Stress, Depression, Anxiety, and Resilience in Healthy Adults During Coronavirus Disease 2019 Confinement: A Randomized Controlled Trial. *Front Psychol*. 2021;12:643069. doi:10.3389/fpsyg.2021.643069
40. Plag J, Ergec DL, Fydrich T, Ströhle A. High-Intensity Interval Training in Panic Disorder Patients: A Pilot Study. *J Nerv Ment Dis*. 2019;207(3):184–187. doi:10.1097/NMD.0000000000000944
41. Paolucci EM, Loukov D, Bowdish DME, Heisz JJ. Exercise reduces depression and inflammation but intensity matters. *Biol Psychol*. 2018;133:79–84. doi:10.1016/j.biopsycho.2018.01.015
42. Kleinert J, Bassek M. Psychological aspects of high intensity interval training (HIIT) in therapy: A literature review. [in German] Psychologische Aspekte von Hochintensivem Intervalltraining (HIIT) in der Therapie: Eine Übersicht der Literatur. *BG Bewegungstherapie Gesundheitssport*. 2019;35(2):79–87. doi:10.1055/a-0860-1694
43. Szumilewicz A, Santos-Rocha R, Worska A, et al. How to HIIT while pregnant? The protocol characteristics and effects of high intensity interval training implemented during pregnancy – A systematic review. *Balt J Health Phys Act*. 2022;14(1). https://dcgdansk.bepress.com/journal/vol14/iss1/1
44. Skow R, Davenport M, Mottola M, et al. Effects of prenatal exercise on fetal heart rate, umbilical and uterine blood flow: A systematic review and meta-analysis. *Br J Sports Med*. 2018;53:bjsports-2018. doi:10.1136/bjsports-2018-099822

45. Beck AT, Steer RA, Brown GK. *BDI-II, Beck Depression Inventory: Manual*. Second edition. Harcourt Brace; 1996.
46. Areskog B, Kjessler B, Uddenberg N. Identification of Women with Significant Fear of Childbirth during Late Pregnancy. *Gynecol Obstet Invest*. 1982;13(2):98–107. doi:10.1159/000299490
47. Ware J, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: Construction of scales and preliminary tests of reliability and validity. *Med Care*. 1996;34(3):220–233. doi:10.1097/00005650-199603000-00003
48. Ahorsu DK, Lin CY, Imani V, Saffari M, Griffiths MD, Pakpour AH. The Fear of COVID-19 Scale: Development and initial validation. *Int J Ment Health Addict*. Published online 2020. doi:10.1007/s11469-020-00270-8
49. Craig CL, Marshall AL, Sj??Str??M M, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity: *Med Sci Sports Exerc*. 2003;35(8):1381–1395. doi:10.1249/01.MSS.0000078924.61453.FB
50. Cheng HL (Helen). *A Simple, Easy-to-Use Spreadsheet for Automatic Scoring of the International Physical Activity Questionnaire (IPAQ) Short Form.*; 2016. doi:10.13140/RG.2.2.21067.80165
51. IPAQ. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ)-Short and Long Forms. *Int Phys Act Quest*. Published online 2005. Accessed April 2, 2022. https://ci.nii.ac.jp/naid/10030318551/
52. Beaver WL, Wasserman K, Whipp BJ. A new method for detecting anaerobic threshold by gas exchange. *J Appl Physiol*. 1986;60(6):2020–2027. doi:10.1152/jappl.1986.60.6.2020
53. Persinger R, Foster C, Gibson M, Fater DCW, Porcari JP. Consistency of the talk test for exercise prescription. *Med Sci Sports Exerc*. 2004;36(9):1632–1636.
54. Santos-Rocha R, Gutiérrez IC, Szumilewicz A, Pajaujiene S. Exercise Testing and Prescription for Pregnant Women. In: Santos-Rocha R, ed. *Exercise and Sporting Activity During Pregnancy: Evidence-Based Guidelines*. Springer International Publishing; 2019:183–230. doi:10.1007/978-3-319-91032-1_8
55. Szumilewicz A, Santos-Rocha R. Exercise Selection and Adaptations During Pregnancy. In: Santos-Rocha R, ed. *Exercise and Sporting Activity During Pregnancy: Evidence-Based Guidelines*. Springer International Publishing; 2019:231–308. doi:10.1007/978-3-319-91032-1_9
56. Santos-Rocha R, Szumilewicz A, Perales M, Pajaujiene S. EuropeActive Standards EQF Level 5 - Pregnancy and Postnatal Exercise Specialist. *EuropeActive*. Published online 2016.
57. Nosek BA, Alter G, Banks GC, et al. Promoting an open research culture. *Science*. 2015;348(6242):1422–1425. doi:10.1126/science.aab2374
58. Moher D, Hopewell S, Schulz KF, et al. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *Int J Surg Lond Engl*. 2012;10(1):28–55. doi:10.1016/j.ijsu.2011.10.001
59. Filippetti ML, Clarke ADF, Rigato S. The mental health crisis of expectant women in the UK: effects of the COVID-19 pandemic on prenatal mental health, antenatal attachment and social support. *BMC*

Pregnancy Childbirth. 2022;22(1):1–10. doi:10.1186/s12884-022-04387-7

60. Uguz F, Yakut E, Aydogan S, Bayman MG, Gezginc K. Prevalence of mood and anxiety disorders during pregnancy: A case-control study with a large sample size. *Psychiatry Res*. 2019;272:316–318. doi:10.1016/j.psychres.2018.12.129
61. Yang J ping, Qu J, Sun K, Gao LL. Anxiety symptoms and health-related quality of life in mainland Chinese pregnant women: a cross-sectional study. *J Reprod Infant Psychol*. Published online 2021:1–12. doi:10.1080/02646838.2021.1952553
62. Perales M, Refoyo I, Coteron J, Bacchi M, Barakat R. Exercise during pregnancy attenuates prenatal depression: A randomized controlled trial. *Eval Health Prof*. 2015;38(1):59–72. doi:10.1177/0163278714533566
63. Teychenne M, York R. Physical Activity, Sedentary Behavior, and Postnatal Depressive Symptoms: A Review. *Am J Prev Med*. 2013;45(2):217–227. doi:10.1016/j.amepre.2013.04.004
64. Ong MJ, Wallman KE, Fournier PA, Newnham JP, Guelfi KJ. Enhancing energy expenditure and enjoyment of exercise during pregnancy through the addition of brief higher intensity intervals to traditional continuous moderate intensity cycling. *BMC Pregnancy Childbirth*. 2016;16(1):161. doi:10.1186/s12884-016-0947-3
65. Domingues MR, Matijasevich A, Barros AJD. Physical activity and preterm birth: A literature review. *Sports Med*. 2009;39(11):961–975. doi:10.2165/11317900-000000000-00000
66. Stubbs B, Rosenbaum S, Vancampfort D, Ward PB, Schuch FB. Exercise improves cardiorespiratory fitness in people with depression: A meta-analysis of randomized control trials. *J Affect Disord*. 2016;190:249–253. doi:10.1016/j.jad.2015.10.010
67. Hillyard M, Sinclair M, Murphy M, Casson K, Mulligan C. The impact of COVID-19 on the physical activity and sedentary behaviour levels of pregnant women with gestational diabetes. *PLoS ONE*. 2021;16(8):1–18. doi:10.1371/journal.pone.0254364
68. Rabiepoor S, Rezavand S, Yas A, Ghanizadeh N. Influential factors in physical activity amongst pregnant women. *Balt J Health Phys Act*. 2019;11(2). doi:10.29359/BJHPA.11.2.04
69. Oviedo-Caro MA, Bueno-Antequera J, Munguía-Izquierdo D. Meeting physical activity guidelines and its association with health-related quality of life throughout pregnancy: the PregnActive project. *Psychol Health Med*. 2022;0(0):1–8. doi:10.1080/13548506.2022.2029502
70. Davenport MH, Steinback CD, Mottola MF. Impact of pregnancy and obesity on cardiorespiratory responses during weight-bearing exercise. *Respir Physiol Neurobiol*. 2009;167(3):341–347. doi:10.1016/j.resp.2009.06.009

Figures

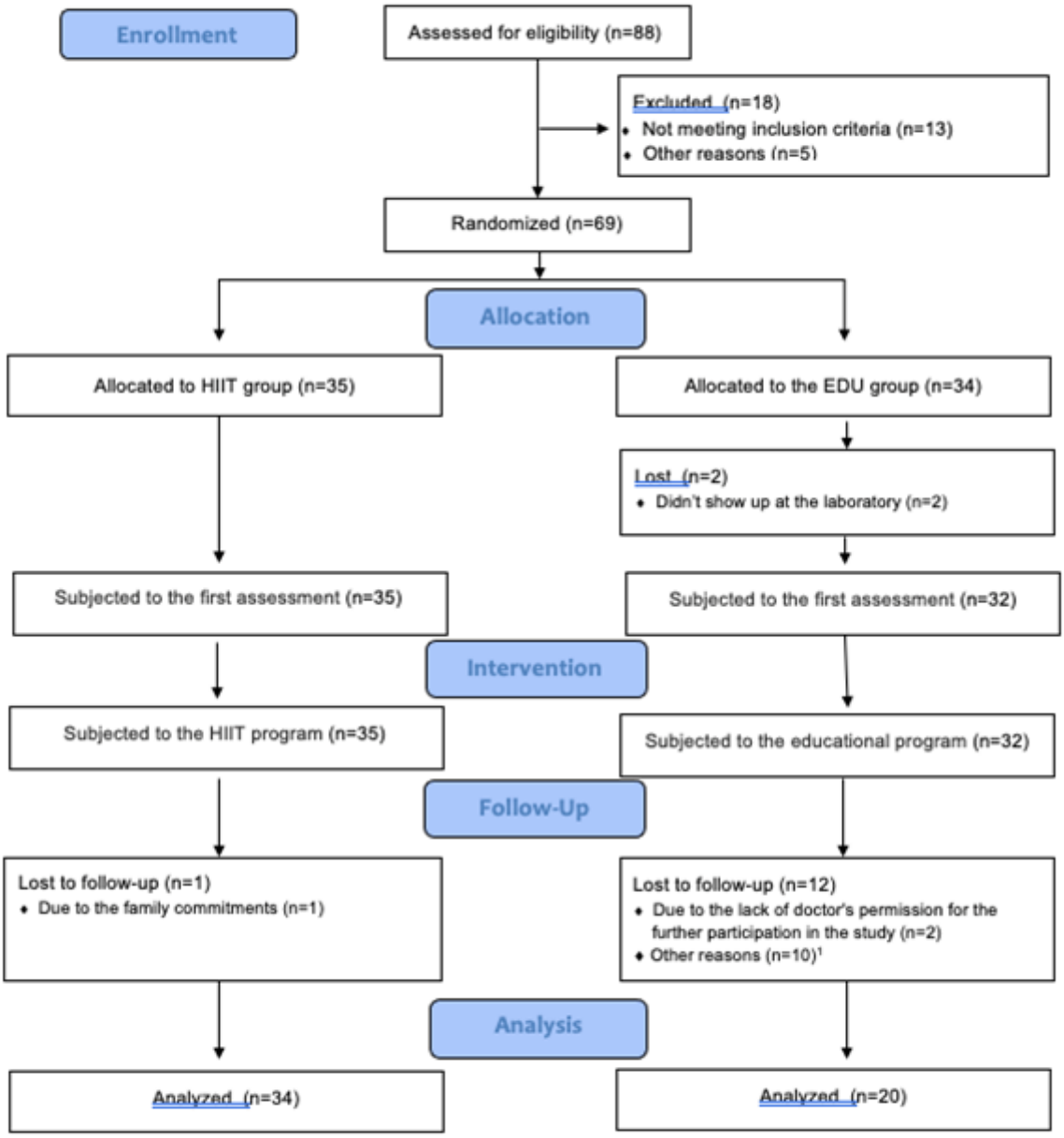

Figure 1

The flow of participants through the study.

Note. HIIT – high intensity interval training; EDU - educational

[1]Due to: no interest to continue the program (n=6); preterm birth (n=1); not feeling well on the day of the second assessment (n=2); did not provide the reason (n=2).

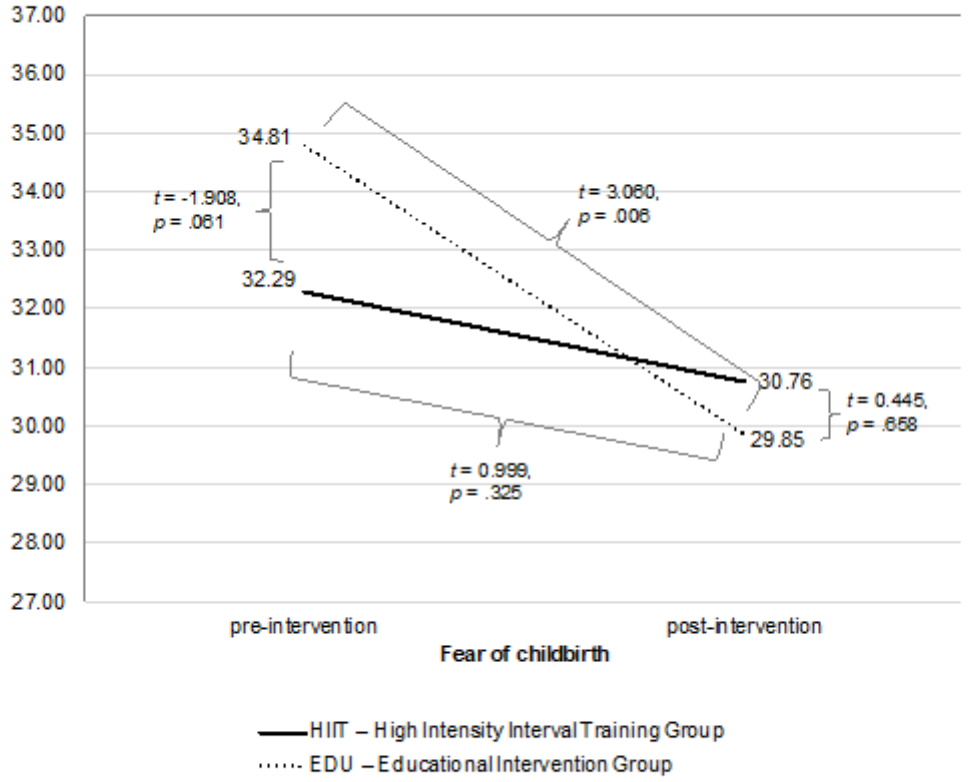

Figure 2

The differences in the severity of fear of childbirth between HIIT and EDU groups pre-and post-intervention the intervention

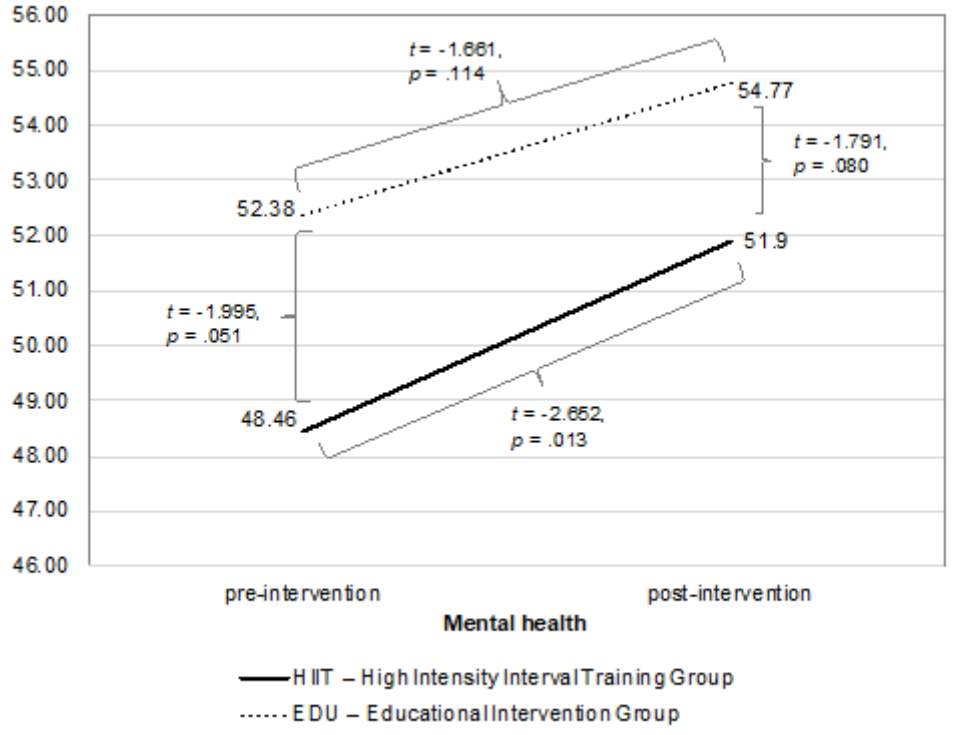

Figure 3

The differences in the mental aspect of health between HIIT and EDU groups pre-and post- intervention

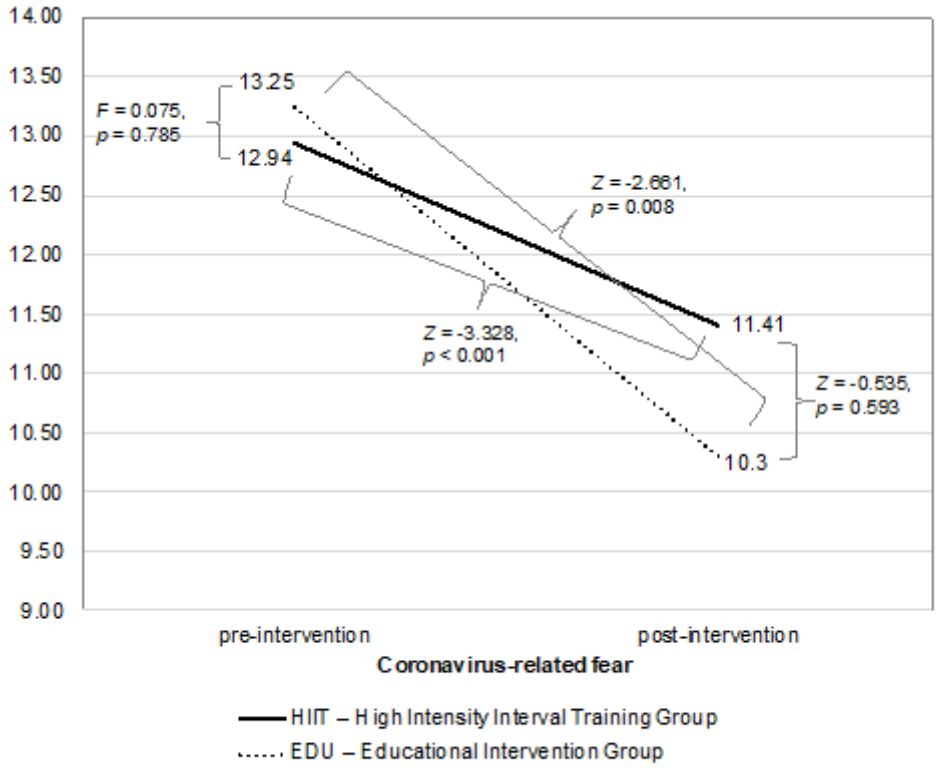

Figure 4

The differences in the severity of the COVID-19-related fear between HIIT and EDU groups pre-and post-intervention

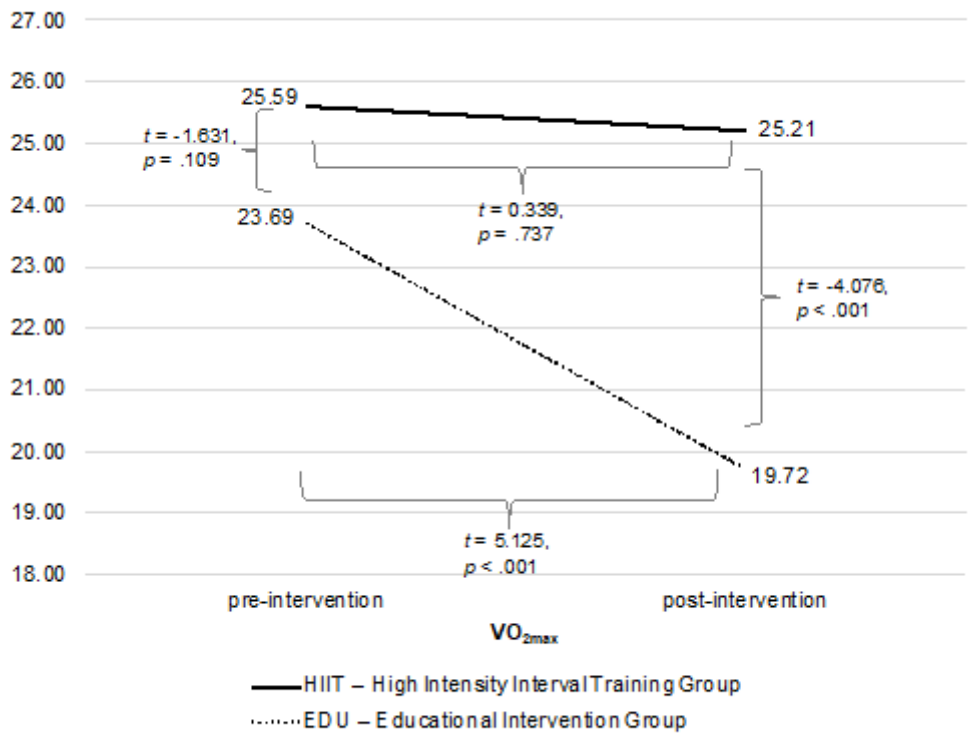

Figure 5

The differences in the VO_{2max} between HIIT and EDU groups pre-and post- intervention (in ml/kg/min)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Rawdatabase.xlsx