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Reproductive history, maternal anxiety and past physical activity practice predict physical activity levels throughout pregnancy

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ABSTRACT

We compared physical activity (PA) levels between pregnant women who conceived naturally (NC) or after fertility treatments (FT) and determined factors predicting prenatal moderate-to-vigorous intensity physical activity (MVPA).

The study was conducted in Trois-Rivières (Canada) between October 2015 and July 2018. MVPA and anxiety levels were assessed at each trimester of pregnancy (TR1, TR2 and TR3) using an accelerometer and the State-Trait Anxiety Inventory, respectively. Sociodemographic and reproductive history data were self-reported or collected from medical files. Repeated measures analysis of variance and regression analyses were conducted.

Ninety-six women were included in the analyses (58 NC and 38 FT). MVPA levels and daily step counts decreased significantly throughout pregnancy (time effect: $F = 28.68$, $p < 0.0001$ and $F = 39.18$, $p < 0.0001$, respectively), but NC and FT women presented similar MVPA and daily step counts (no group effect). The decline in PA practice throughout pregnancy was similar in both groups (no interaction effect). At TR1, State ($\beta = -0.272$, $p = 0.012$) and Trait ($\beta = -0.349$, $p = 0.001$) anxiety and past PA ($\beta = 0.483$, $p < 0.0001$) were correlated with MVPA. Past MVPA was also correlated with MVPA at TR2 ($\beta = 0.595$, $p < 0.0001$) and TR3 ($\beta = 0.654$, $p < 0.0001$). Past PA was the strongest predictors of MVPA levels at TR1, TR2, and TR3, predicting 17% ($p = 0.0002$), 34% ($p < 0.0001$) and 42% ($p < 0.0001$), respectively. Overall, our findings suggest that MVPA practice throughout pregnancy is built on past PA practice. Therefore, to be effective at promoting PA throughout pregnancy, obstetric health care providers and fitness professionals should reinforce the importance of being active as early as possible during pregnancy.

1. Introduction

Several recent literature reviews and meta-analyses confirm that regular physical activity (PA) during pregnancy is not only safe for the mother and the fetus but also improves key pregnancy outcomes. For example, women who are physically active during pregnancy have 32% reduced odds of excessive gestational weight gain (Ruchat et al., 2018), 40% reduced odds of gestational diabetes and hypertensive disorders of pregnancy (Davenport et al., 2018c) and 25% reduced odds of prenatal depression (Davenport et al., 2018a). Moreover, physically active pregnant women are less likely to give birth to a large baby (i.e. > 4000 g, 39% decreased odds) (Davenport et al., 2018b). The safety of prenatal PA has been confirmed as no increased odds of preterm birth, altered fetal growth (Davenport et al., 2018b), miscarriage (Davenport et al., 2019a) or cesarean section (Davenport et al., 2019b) have been reported. According to the 2019 Canadian Guideline for Physical Activity throughout Pregnancy, pregnant women without contra-indications to PA should accumulate at least 150 min per week of moderate-intensity physical activity (MPA) (Mottola et al., 2018). However, more than 85% of pregnant women do not meet these recommendations (Evenson and Wen, 2010). Prospective studies using accelerometer showed that PA levels are significantly lower during the first and third trimesters of pregnancy compared to the second trimester (Evenson and Wen, 2011; Rousham et al., 2005).

Many barriers to prenatal PA have been identified, such as fatigue, nausea, physical discomforts, lack of time and social support as well as a low socio-economic status (Gaston and Cramp, 2011; Harrison et al., 2018). Moreover, the fear that PA may compromise fetal safety and the progress of pregnancy is frequently reported by pregnant women and has been suggested to predict their engagement in prenatal PA

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(Harrison et al., 2018). Concern about fetal safety and the progress of pregnancy has been reported to be greater in pregnant women who had difficulties conceiving naturally and needed to use fertility treatments (FT) to become pregnant. Indeed, a systematic review showed that women who conceived after *in vitro* fertilization (IVF) experienced more anxiety, especially fear to lose their baby, than those who conceived naturally (Gourounti, 2016). However, whether women who conceived after FT are less likely to be active during pregnancy is still unclear. To our knowledge, four studies evaluated the association between the mode of conception and prenatal PA practice and reported mixed results (Evenson et al., 2009; Fisher et al., 2013; Hegaard et al., 2011; Juhl et al., 2012). Therefore, additional studies are needed to clarify whether the mode of conception, but also the number of FT cycles before achieving pregnancy, are associated with prenatal PA levels at each trimester of pregnancy. Noteworthy, other factors related to reproductive history, such as history of miscarriage and/or induced abortion, might negatively affect prenatal PA but results are mixed (Foxcroft et al., 2011; Jukic et al., 2012; Zhang and Savitz, 1996). Because many barriers to PA practice may be different as pregnancy progresses (Harrison et al., 2018), it is important to identify factors that might influence prenatal PA practice at each trimester of pregnancy in order to effectively promote prenatal PA throughout pregnancy, and thereby maternal and neonatal health.

The primary objective of this study was to compare PA levels among pregnant women who conceived naturally (CN group) and after FT (FT group) throughout pregnancy. Our hypotheses were that 1) pregnant women are less active during the first and third trimesters of pregnancy (main effect – time effect); 2) FT women are less active than CN women (main effect – group effect) and 3) the decline in PA levels throughout pregnancy is greater in FT women compared to CN women (interaction effect). Our secondary objective was to identify factors related to reproductive history, as well as other maternal characteristics, that predict prenatal MVPA levels at each trimester of pregnancy. Our hypothesis was that several factors, among which factors related to reproductive history, predict prenatal PA levels and that predictors are different according to the trimester of pregnancy.

2. Methods

2.1. Study sample and design

This is a prospective cohort study. The recruitment of pregnant women was conducted between October 2015 and February 2018 and the follow-up extended until July 2018. Women who conceived naturally or after FT were recruited in the city of Trois-Rivières (Canada) through referrals by maternity care clinic coordinators and physicians, as well as poster advertisements in the local and surrounding communities (maternity care clinics, hospital, prenatal centers, sports centers and local university).

Women were eligible to participate to the study if they conceived with a partner of opposed sex, were < 14 weeks of gestation, with a singleton pregnancy, had a pregnancy follow-up and planned to give birth in the Trois-Rivières region and were able to understand, speak and write French. This study was approved by the local Research Ethics Committees. The written informed consent was provided by all participants. Women were followed from the first trimester of pregnancy until delivery, with three evaluations (first trimester [TR1]: 10–14 weeks, second trimester [TR2]: 24–28 weeks and third trimester [TR3]: 32–36 weeks).

2.2. Data collection

At study entry, self-reported socio-demographic and anthropometric information, such as maternal age, gestational age, height, weight and education levels were collected. Information about reproductive history (parity, miscarriage, induced abortion, mode of conception and number of FT cycles [when appropriate]) were collected from medical records.

At each trimester of pregnancy, anxiety and PA levels were assessed. Levels of PA over the three months before enrollment in the study were evaluated using questions from the Canadian Community Health Survey (PAQ) (Statistics Canada, 2014) whereas PA levels at each trimester of pregnancy were objectively assessed using the accelerometer ActiGraph GT3X (ActiGraph, Pensacola, Florida, USA). The ActiGraph GT3X is a triaxial accelerometer that measures data in a 60-s epoch and is frequently used in studies with pregnant women (Harrison et al., 2011; Mizgier et al., 2018). The women were instructed to wear the accelerometer on an elastic belt over their hip for seven consecutive days, from wake-up to bedtime. When sleeping, showering or engaging in water activities, they were asked to remove the monitor. A daily diary was given to each woman to document wear and non-wear periods as well as participation to structured activities. For more details about PA data analysis, see Lardon et al. (2018). To define sedentary time and each intensity of PA, we used Freedson cut-points (sedentary: < 100 cut-points per minute [CPM], light: 100–1951 CPM, moderate: 1952–5724 CPM and vigorous: > 5725 CPM) (Freedson et al., 1998).

Anxiety levels were assessed using the French version of the Spielberger State-Trait Anxiety Inventory (Gauthier and Bouchard, 1993). This self-reported questionnaire is one of the most used in studies with pregnant women (Brunton et al., 2015). It includes two subscales evaluating Trait and State anxiety. The Trait anxiety subscale evaluates the frequency of feelings referring to the generalized propensity to be anxious while the State anxiety subscale measures the intensity of current feelings, referring to the presence and severity of current symptoms of anxiety. Each subscale includes 20 items rated with a 4-level Likert scale. The global range score is 20–80, with a higher score indicating greater levels of anxiety. In clinical practice, a score equal or greater than 40/80 is considered as a high anxiety level score (Leach et al., 2017).

2.3. Statistical analyses

The normality of each variable was assessed using the Shapiro-Wilk and the Kolmogorov-Smirnov tests. A logarithmic transformation was performed to normalize variables abnormally distributed. Descriptive statistics were computerized. Student *t*-test for continuous variables and chi-squared test for dichotomous variables were used to compare baseline characteristics between NC and FT women. Repeated measures analysis of variance (MIXED procedure of SAS software) was used to test main effects (the evolution of PA over the trimesters of pregnancy [time effect] and the difference in PA levels between women who conceived naturally or after FT [group effect]) and potential interaction effect (the decline in PA levels throughout pregnancy according to the mode of conception). Mauchly's test of sphericity was used to test the assumption of sphericity. Variables that did not meet the sphericity assumption were analysed following a Huynh-Feldt correction. When a significant time, group or interaction effect was found, post-hoc analyses were conducted using the Turkey test. To determine factors that predict MVPA levels at each trimester of pregnancy (objective 2), univariate and multivariate (stepwise method) linear regression analyses were conducted. All variables considered clinically relevant from the literature were included in the univariate and multivariate analyses. The objective to perform multivariate regression analyses was to identify the best linear model to predict MVPA levels at each trimester of pregnancy. The collinearity between independent variables included in the multivariate analyses was tested and State and Trait anxiety were highly correlated. Trait anxiety was dropped from the multivariate analyses as we considered that State anxiety better reflected anxiety experienced by pregnant women at the time their PA levels were evaluated. Variables were retained in the best model if they predicted MVPA levels at $p \leq 0.15$, as suggested by Bursac et al. (2008). Bursac et al. (2008) and the model fit was assessed by the R^2 statistic.

Table 1
Baseline characteristics of women who conceived naturally or after fertility treatments.

Variables	Natural conception		Conception after fertility treatments		p-value
Maternal age (years)	n = 58	30.0 ± 3.8 (22.0–40.0)	n = 38	32.3 ± 3.3 (26.0–38.0)	**0.003**
Aborta	n = 57	34 (59.6%)	n = 38	27 (71.1%)	0.48
0		15 (26.3%)		8 (21.0%)	
1		8 (14.0%)		3 (7.9%)	
> 1					
Parity	n = 58	30 (51.7%)	n = 38	22 (57.9%)	0.55
0		25 (43.1%)		16 (42.1%)	
1		3 (5.2%)		0 (0%)	
> 1					
Pre-pregnancy BMI (kg/m^2)	n = 57	25.2 ± 6.3 (18.1–48.7)	n = 38	25.0 ± 6.2 (18.8–46.1)	0.90
Underweight (< 18.5)	n = 57	1 (1.8%)	n = 38	0 (0%)	0.77
Normal weight (18.5–24.9)		36 (63.2%)		25 (65.8%)	
Overweight (25.0–29.9)		10 (17.5%)		8 (21.1%)	
Obesity (≥30.0)		10 (17.5%)		5 (13.1%)	
Education level	n = 58		n = 38		0.88
University		39 (67.2%)		26 (61.9%)	
Others		19 (32.8%)		16 (38.1%)	
Pregnancy achieved by	N/A	N/A	n = 38		N/A
In vitro fertilization				7 (18.4%)	
Intrauterine insemination				16 (42.1%)	
Ovarian stimulation				15 (39.5%)	
Number of FT cycles before achieving current pregnancy	n = 58	0	n = 38	3.5 ± 3.3 (1–12)	N/A
PAQ score (kcal/kg/day)	n = 54	1.9 ± 1.6 (0.05–8.8)	n = 36	1.6 ± 1.5 (0.08–7.9)	0.35
Activity level according to PAQ score (kcal/kg/day)	n = 54		n = 36		0.60
Inactive (< 1.5)		26 (48.1%)		24 (61.5%)	
Moderately active (1.5 to < 3)		21 (38.9%)		12 (30.8%)	
Active (≥3)		7 (13.0%)		3 (7.7%)	

Data are presented as mean ± standard deviation (min–max) or N (%).
BMI: Body mass index, FT: Fertility treatments, N/A: Non-applicable, PAQ: Physical activity questionnaire. Student *t*-test was used to calculate p-values for continuous variables; chi-squared test was used to calculate p-values for dichotomous variables.
Number in bold represents a significative value at the threshold $p < 0.05$.

Statistical analyses were performed with SPSS statistical software version 24.0 (IBM Corporation, Armonk, USA) and SAS software V9.4 (North Carolina, USA). The results were considered significant at the threshold of $p < 0.05$.

3. Results

Between October 2016 and February 2018, physicians presented the study to 213 eligible pregnant women, among which 102 accepted to participate (recruitment rate: 48%). The two principal reasons for not agreeing to participate in the study were lack of time and/or lack of interest. Six women (two in NC group and four in FT group) were excluded due to loss to follow up (n = 5) or miscarriage (n = 1), leaving 96 women (58 NC and 38 FT) for the statistical analyses.

3.1. Sample characteristics

Baseline characteristics were similar in NC and FT women (Table 1), except for maternal age (NC: 30.0 ± 3.8 versus FT: 32.3 ± 3.3, p = 0.003). In the whole sample, women experienced zero to two aborta (including miscarriages). The majority of women was nulliparous, of normal weight before achieving their current pregnancy and held a university degree. Among FT women, 41.1% achieved their current pregnancy after intrauterine insemination (IUI), 39.5% after ovarian stimulation (OS) and 18.4% after IVF. On average, they underwent 3.5 ± 3.3 FT cycles before achieving pregnancy. According to the PAQ scores, women were predominantly inactive before enrollment in the study.

3.2. Water activities and missing physical activity data

Data about PA levels was missing for 10 (10.4%), 7 (7.3%) and 11 (11.5%) women at TR1, TR2 and TR3, respectively. A total of 13 (13.7%), 20 (22.0%) and 20 (22.7%) women removed the accelerometer to do water activities (aqua-gym or swimming) at TR1, TR2 and TR3, respectively. During the evaluation period, the accelerometer was removed between one and five times for a total of 20–510 min. At each trimester of pregnancy, no significant difference was found between the two groups regarding water exercises in terms of prevalence (%), frequency (times per week) and length (minutes).

3.3. Comparison of prenatal physical activity levels between NC and FT women

Table 4 shows that 53.9%, 41.1% and 23.4% of women achieved PA recommendations at TR1, TR2 and TR3, respectively. As many NC women as FT women were meeting PA recommendations at each trimester of pregnancy (TR1: p = 0.19, TR2: p = 0.54, TR3: p = 0.61). Figs. 1 and 2 show that MVPA levels and daily step counts decreased

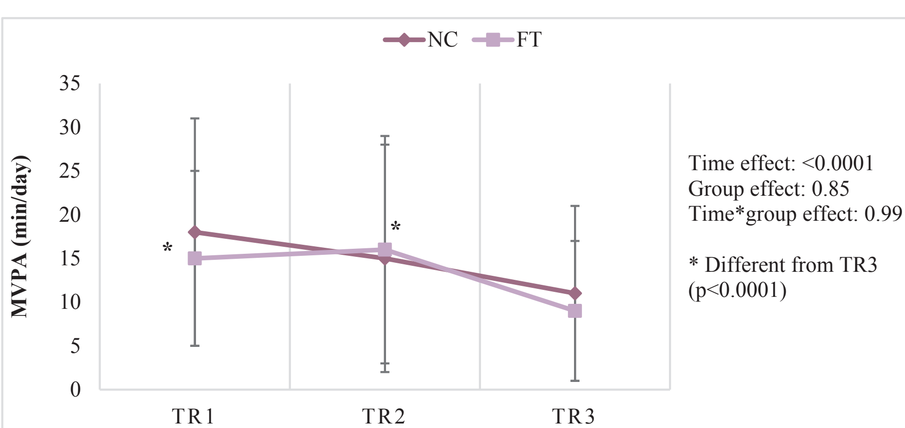

Fig. 1. Evolution of moderate-to-vigorous intensity physical activity (MVPA) levels in women who conceive naturally (NC) or after fertility treatments (FT) over the course of pregnancy (results from repeated measures analysis of variance). TR1: First trimester of pregnancy, TR2: Second trimester of pregnancy, TR3: Third trimester of pregnancy.

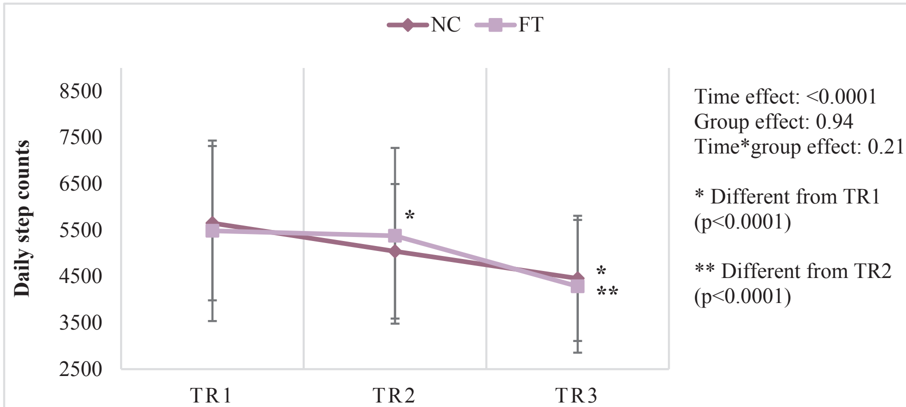

Fig. 2. Evolution of daily step counts in women who conceive naturally (NC) or after fertility treatments (FT) over the course of pregnancy (results from repeated measures analysis of variance). TR1: First trimester of pregnancy, TR2: Second trimester of pregnancy, TR3: Third trimester of pregnancy.

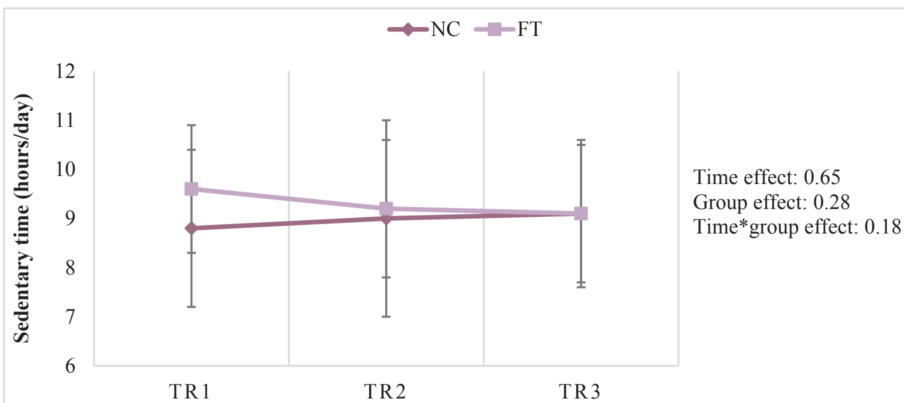

Fig. 3. Evolution of sedentary time in women who conceive naturally (NC) or after fertility treatments (FT) over the course of pregnancy (results from repeated measures analysis of variance). TR1: First trimester of pregnancy, TR2: Second trimester of pregnancy, TR3: Third trimester of pregnancy.

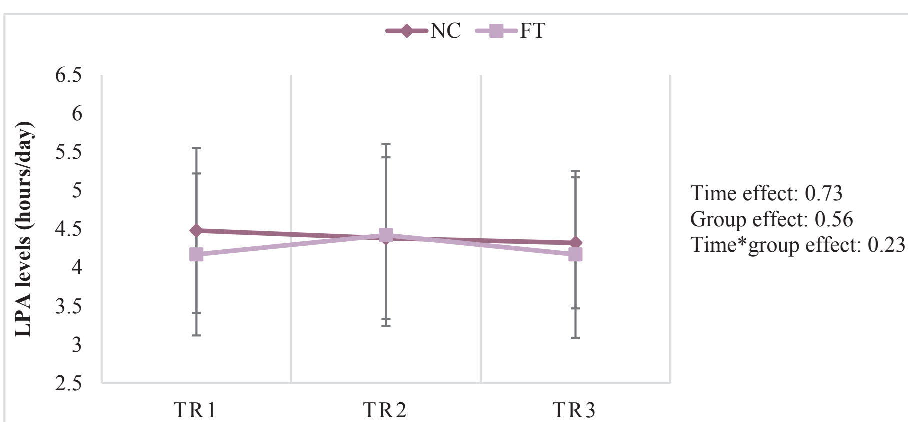

Fig. 4. Evolution of light-intensity physical activity (LPA) levels in women who conceive naturally (NC) or after fertility treatments (FT) over the course of pregnancy (results from repeated measures analysis of variance). TR1: First trimester of pregnancy, TR2: Second trimester of pregnancy, TR3: Third trimester of pregnancy.

significantly throughout pregnancy (time effect: $F = 28.68$, $p < 0.0001$ and $F = 39.18$, $p < 0.0001$, respectively), but that NC and FT women presented similar MVPA levels and daily step counts (no group effect [MVPA: $F = 0.04$, $p = 0.85$; Daily step counts: $F = 0.01$, $p = 0.94$]). Moreover, the decline in MVPA and daily step counts throughout pregnancy was similar in both groups (no interaction effect [MVPA: $F = 0.01$, $p = 0.99$; Daily step counts: $F = 1.61$, $p = 0.21$]). Finally, sedentary time and light-intensity PA levels were similar across the three trimesters of pregnancy and in both groups (Figs. 3 and 4).

3.4. Predictors of prenatal physical activity levels

Results from univariate linear regression analyses are presented in Table 2. Variables significantly correlated with MVPA levels at TR1 were: State anxiety levels ($\beta = -0.272$, $p = 0.012$), Trait anxiety levels ($\beta = -0.349$, $p = 0.001$) and self-reported PA levels practiced in the previous three months ($\beta = 0.483$, $p < 0.0001$). MVPA levels at TR2 and TR3 were significantly correlated with past MVPA levels (MVPA practiced at TR1: $\beta = 0.595$, $p < 0.0001$ and MVPA practiced at TR2: $\beta = 0.654$, $p < 0.0001$, respectively). Results from multivariate linear

Table 2
Predictors of physical activity at each trimester of pregnancy (results from univariate linear regression analyses).

Variables	TR1			TR2			TR3		
	R^2	Beta	p-value	R^2	Beta	p-value	R^2	Beta	p-value
Maternal age	< 0.0001	0.007	0.946	0.001	0.025	0.818	0.032	−0.178	0.104
Aborta	0.014	−0.118	0.284	0.008	−0.092	0.393	0.002	−0.046	0.675
Parity	0.001	−0.032	0.769	0.002	−0.042	0.695	< 0.0001	−0.019	0.861
Pre-pregnancy BMI	−0.005	0.071	0.518	0.008	0.088	0.415	0.001	0.022	0.839
Education level	0.025	0.157	0.152	0.004	0.064	0.553	0.019	0.137	0.210
Mode of conception	0.001	0.031	0.777	< 0.0001	−0.020	0.852	0.003	0.052	0.638
Number of FT cycles before achieving current pregnancy	0.007	0.084	0.446	0.002	0.042	0.699	0.005	0.071	0.518
State anxiety	**0.074**	**−0.272**	**0.012**	0.009	−0.094	0.382	0.043	−0.208	0.057
Trait anxiety	**0.122**	**−0.349**	**0.001**	0.004	−0.061	0.573	0.001	−0.028	0.799
PAQ score	**0.233**	**0.483**	**< 0.0001**	–	–	–	–	–	–
MVPA (min/week), TR1	–	–	–	**0.353**	**0.595**	**< 0.0001**	–	–	–
MVPA (min/week), TR2	–	–	–	–	–	–	**0.428**	**0.654**	**< 0.0001**

BMI: Body mass index, FT: Fertility treatments, MVPA: Moderate-to-vigorous intensity physical activity, PAQ: Physical activity questionnaire, R^2: Coefficient of determination, TR1: First trimester of pregnancy, TR2: Second trimester of pregnancy, TR3: Third trimester of pregnancy.
Number in bold represents a significative value at the threshold $p < 0.05$.

Table 3
Predictive models of physical activity practice at each trimester of pregnancy (results from multivariate linear regression analyses).

Variables	Trimester	Estimated parameter (b)	Partial R^2	R^2 of the model	p-value
PAQ score	1	0.26	0.17	0.17	< 0.0001
Number of FT cycles before achieving current pregnancy	1	0.07	0.03	0.20	0.03
State anxiety	1	−0.66	0.04	0.24	0.04
Maternal age	1	−1.11	0.02	0.26	0.15
MVPA (min/week), TR1	2	0.58	0.34	0.34	< 0.0001
MVPA (min/week), TR2	3	0.71	0.42	0.42	< 0.0001
Maternal age	3	−2.04	0.03	0.45	0.004
Education level	3	0.40	0.03	0.48	0.02
State anxiety	3	−0.55	0.03	0.51	0.06
Number of FT cycles before achieving current pregnancy	3	0.04	0.02	0.53	0.12

PAQ: Physical activity questionnaire, FT: Fertility treatments, MVPA: Moderate-to-vigorous intensity physical activity, NC: Natural conception, R^2: Coefficient of determination.
Explanatory variables included in the multiple linear regression models were:
TR1: Maternal age, aborta, parity, pre-pregnancy body mass index, education (university degree vs other), mode of conception (NC vs. FT), Nb of FT cycles achieved before the current pregnancy, state anxiety, PAQ score.
TR2: Maternal age, aborta, parity, pre-pregnancy body mass index, education (university degree vs other), mode of conception (NC vs. FT), Nb of FT cycles achieved before the current pregnancy, state anxiety, MVPA (min/week) practiced in TR1.
TR3: Maternal age, aborta, parity, pre-pregnancy body mass index, education (university degree vs other), mode of conception (NC vs. FT), Nb of FT cycles achieved before the current pregnancy, state anxiety, MVPA (min/week) practiced in TR2.

regression analyses are presented in Table 3. The best linear model to predict MVPA levels at TR1 included the following predictive variables: self-reported PA levels practiced in the previous three months (estimated parameter [b] = 0.26, $R^2 = 0.17$, $p < 0.0001$), the number of FT cycles before achieving the current pregnancy (b = 0.07, $R^2 = 0.03$, p = 0.03), State anxiety levels (b = −0.66, $R^2 = 0.04$, p = 0.04), and maternal age (b = −1.11, $R^2 = 0.02$, p = 0.15). The best linear model to predict MVPA levels at TR2 included only MVPA practiced at TR1 (b = 0.58, $R^2 = 0.34$, $p < 0.0001$). Finally, the best linear model to predict MVPA levels at TR3 included the following predictive variables: MVPA practiced at TR2 (b = 0.71, $R^2 = 0.42$, $p < 0.0001$), maternal age (b = −2.04, $R^2 = 0.03$, p = 0.004), education level (b = 0.40, $R^2 = 0.03$, p = 0.02), State anxiety levels (b = −0.55, $R^2 = 0.03$, p = 0.06), and the number of FT cycles before achieving the current pregnancy (b = 0.04, $R^2 = 0.02$, p = 0.12). Our data showed that PA practiced in the previous three months had the greatest contribution to each predictive model; it predicted 17% of MVPA levels at TR1 (p = 0.0002, the final model predicted 26%), 34% of MVPA levels at TR2 ($p < 0.0001$, the final model predicted 34%) and 42% MVPA levels at TR3 ($p < 0.0001$, the final model predicted 53%).

4. Discussion

To the best of our knowledge, this is the first prospective cohort study documenting objectively PA levels in pregnant women according to their mode of conception. Our data revealed that MVPA levels and daily step counts decreased significantly over the course of pregnancy but to the same magnitude in women who conceived naturally and in those who conceived after FT (see Figs. 1–4). Our hypothesis was that PA levels at TR1 and TR3 would be lower compared to TR2, based on previous transversal and prospective studies using accelerometers (Evenson and Wen, 2011; Hayes et al., 2015). However, we found a linear decrease in PA levels throughout pregnancy. Our result is still consistent with those reported in previous prospective and retrospective studies using subjective or objective measures of prenatal PA (Hayes et al., 2015; Hegaard et al., 2011; Owe et al., 2009). The decrease in PA levels over the course of pregnancy can be explained by different factors, such as the increase in physical discomforts and pelvic girdle pain as pregnancy progresses (Lardon et al., 2018; Owe et al., 2009). We were also expecting to find a greater decline in PA levels over the course of pregnancy in women who conceived after FT compared to those who conceived naturally. This hypothesis was based on the fact that the former would experience more anxiety, especially fear to lose their baby, than the latter (Gourounti, 2016) and that greater anxiety would

Table 4
Distribution of physical activity assessed by accelerometer at each trimester of pregnancy in women who conceived naturally or after fertility treatments.

Variables	TR1				TR2				TR3			
	Natural Conception		Conception after fertility treatments		Natural Conception		Conception after fertility treatments		Natural Conception		Conception after fertility treatments	
	n	mean ± SD (min–max) or N (%)	n	mean ± SD (min–max) or N (%)	n	mean ± SD (min–max) or N (%)	n	mean ± SD (min–max) or N (%)	n	mean ± SD (min–max) or N (%)	n	mean ± SD (min–max) or N (%)
Valid days (number)	53	6.7 ± 0.9 (4–10)	33	6.7 ± 0.7 (5–8)	53	6.6 ± 0.6 (5–8)	36	6.6 ± 0.8 (4–8)	50	6.6 ± 0.7 (4–8)	35	6.5 ± 0.8 (4–7)
Sedentary time (h/day)	53	8.8 ± 1.6 (5.2–14.0)	33	9.6 ± 1.3 (6.9–12.6)	53	9.0 ± 2.0 (4.8–18.1)	36	9.2 ± 1.4 (5.8–12.6)	50	9.1 ± 1.5 (4.8–12-8)	34	9.1 ± 1.4 (5.8–11.8)
LPA (min/day)	53	269 ± 64 (115–424)	33	250 ± 63 (118–389)	53	262 ± 63 (114–399)	36	265 ± 71 (152–463)	50	259 ± 51 (164–355)	35	250 ± 65 (136–392)
MPA (min/day)	53	17 ± 12 (1–48)	33	14 ± 8 (3–34)	53	15 ± 12 (1–63)	36	16 ± 12 (1–54)	50	10 ± 10 (1–43)	35	9 ± 8 (1–37)
MVPA(min/day)	53	18 ± 13 (1–56)	33	15 ± 10 (3–51)	53	15 ± 13 (1–63)	36	16 ± 13 (1–54)	50	11 ± 10 (1–44)	35	9 ± 8 (1–37)
MVPA (min/week)	53	125 ± 91 (4–391)	33	126 ± 99 (20–489)	53	107 ± 91 (9–445)	36	114 ± 93 (7–380)	50	74 ± 76 (3–313)	35	68 ± 61 (7–258)
MVPA ≥150 min/week	52	17 (32,7%)	33	7 (21.2%)	53	10 (18.9%)	36	8 (22.2%)	50	6 (12.0%)	35	4 (11.4%)
Aquatic activities	58	6	37	7	55	9	36	11	52	14	36	6
YES		(10.3%)52		(18.9%)30		(16.4%)46		(22.4%)25		(26.9%)38		(16.7%)30
NO		(89.7%)		(81.1%)		(83.6%)		(69.4%)		(73.1%)		(83.3%)
Aquatic activities (number/week)	6	1.3 ± 0.5 (1–2)	7	2.1 ± 1.7 (1–5)	9	1.6 ± 1.1 (1–4)	11	1.4 ± 0.9 (1–4)	14	1.7 ± 1.2 (1–5)	6	1.7 ± 0.8 (1–3)
Aquatic activities (min/week)	5	53 ± 40 (20–120)	7	150 ± 150 (60–480)	9	130 ± 148 (55–510)	10	78 ± 52 (40–220)	9	115 ± 114 (35–405)	6	106 ± 50 (55–180)
Steps (per day)	53	5650 ± 1665 (1885–10396)	33	5484 ± 1948 (1092–12408)	53	5042 ± 1451 (1880–9140)	36	5377 ± 1896 (2491–11777)	50	4458 ± 1350 (1970–8397)	35	4286 ± 1433 (1804–7751)

thereby result in lower PA practice among women who conceived after FT. However, our previous data revealed that anxiety levels were not different between women who conceived after FT and those who conceived naturally (Lardon et al., 2018), which could explain, at least in part, our result showing similar PA level in women, independently of their mode of conception. Nevertheless, our results are consistent with those of a prospective cohort study showing no difference in prenatal PA levels between women who conceived naturally (n = 295) and those who conceived after IVF (n = 297) (Fisher et al., 2013). However, in this study, the number of women who had a previous pregnancy were higher, and anxiety levels lower, in women who conceived after IVF. Differences in baseline characteristics of the women that might influence maternal anxiety levels, such as parity and education level, might possibly mask the relationship between the mode of conception and PA practice during pregnancy.

The results of the linear regression analyses indicated that variables associated with prenatal MVPA levels varied from one trimester of pregnancy to another. Univariate analyses revealed that a higher PA levels in the previous three months and lower anxiety levels were significantly correlated with higher MVPA levels at TR1. Higher time spent in MVPA at TR1 and TR2 were also significantly correlated with higher MVPA at TR2 and TR3, respectively. Multiple regression analyses confirmed these results as PA practiced over the past 3 months strongly and consistently predicted MVPA levels during the observation periods (the more PA the women practiced over the past 3 months the higher MVPA levels during the observation periods). More specifically, PA levels at the very beginning of pregnancy predicted 17% in MVPA levels at TR1 (the final model predicted 26%). Along with that, Bacchi et al. (2016) reported that pregnant women who were physically active before pregnancy had approximately 50% higher odds to achieve the recommended PA volume of 150 min per week (Bacchi et al., 2016) and Nascimento et al. (2015) reported a significant association between PA during pregnancy and PA before pregnancy (Nascimento et al., 2015). Similarly, MVPA levels at TR1 and TR2 had the greatest contribution to the predictive model of MVPA levels at TR2 (predicted 34% – the final model predicted 34%) and TR3 (predicted 42% – the final model predicted 53%). Multivariate analyses allowed us to identify the best model to predict MVPA levels at each trimester of pregnancy, although some variables included in these models were statistically non-significant (p-value > 0.05 but ≤0.15) and contributed modestly to the predictive model. We were able to predict 26% in MVPA levels at TR1 (17% predicted by past PA levels, 4% by state anxiety, 3% by the number of FT cycles underwent before achieving current pregnancy, and 2% by maternal age), 34% in MVPA levels at TR2 (predicted completely by past MVPA) and 56% in MVPA levels at TR3 (42% predicted by pas MVPA levels, 3% by maternal age, education level and state anxiety, and 2% by the number of FT cycles underwent before achieving current pregnancy). Our data therefore revealed that 1) MVPA levels in the previous three months were the strongest predictor of current MVPA, predicting a greater proportion of MVPA levels with advancing pregnancy (17% at TR1, 34% at TR2, and 42% at TR3), and 2) with advancing pregnancy, the proportion MVPA levels that was predicted by the best models increased from 26% at TR1, to 34% at TR2 and to 53 at TR3, suggesting that factors that were not assessed in our study, such as motivation or social support (Harrison et al., 2018), might have a stronger effect on MVPA practice in early-mid pregnancy than in late pregnancy. Anxiety was a significant predictor of MVPA levels at TR1, although its contribution to the predictive model was modest. The more anxious the women were the lower MVPA levels they had. This result may be explained by the fact that anxiety, and more specifically anxiety-related to the safety for the fetus and the progress of pregnancy, has been identified as a barriers to prenatal PA (Harrison et al., 2018). The other predictors, such as maternal age, education level or the number of FT cycle before achieving current pregnancy contributed only modestly to the models and were likely included in the final predictive model due to a statistical phenomenon rather than a clinical significance.

Overall, our results, combined to previous ones, suggest that PA practice throughout pregnancy is strongly influenced by past history of PA practice. Promoting PA practice early in pregnancy is therefore critical to encourage women being active throughout pregnancy, and thereby promote maternal and neonatal health. Prenatal anxiety was significantly associated with MVPA levels in early and late pregnancy, suggesting that the psychological status should be taken into account in the promotion of prenatal PA. More specifically, the origin of anxiety should be discussed and if anxiety is related to concern about the risks of PA for the fetus, the safety component of regular PA practice during pregnancy should be emphasized.

4.1. Study limitations and strengths

Some limitations should be acknowledged when interpreting the results of the current study. First, our sample was highly educated. Thus, the possibility of selection bias cannot be completely ruled out. Our sample might therefore not be fully representative of the general pregnant population. Second, our sample size was relatively small and heterogeneous with regard to FT used to achieve a pregnancy. Indeed, a minority of women who achieved pregnancy after FT conceived by IVF (18.4%). The medical procedures are more invasive and the medical surveillance is more frequent in the context of IVF compared to OS and IUI. It is therefore very likely that IVF is more psychologically demanding and lead to higher anxiety and depression levels in the women, as reported by previous studies (Cousineau and Domar, 2007; Greil et al., 2011). The low number of women in our sample who achieved a pregnancy following IVF likely prevented us to fully test our hypothesis of lower prenatal PA levels due to higher anxiety levels in women who achieved a pregnancy after FT. Further studies could benefit from conducting a similar study with a larger and more homogeneous sample, as well as from including women with similar baseline characteristics that could influence anxiety and PA practice, such as maternal age. The use of a self-reported questionnaire to assess prenatal PA levels of women before enrollment in the study could have compromised the validity of the measure. However, it is impossible to objectively assess past PA levels. Importantly, we used a validated questionnaire, what contributes to increase our confidence in the validity of the measure. Finally, two women, one in each group (FT: 5.3% and NC: 3.5%), were told by their doctor to decrease their PA levels in late pregnancy because of complications. Nevertheless, we don't believe that our results were affected by the decrease in PA levels of these two women.

Despite some limitations, our study has several strengths. First, its longitudinal design allowed us to examine the evolution of PA throughout pregnancy. Second, PA levels were assessed objectively using the accelerometer ActiGraph GT3X, allowing more reliable and valid measures than subjective methods (e.g. self-reported PA questionnaires) (Guérin et al., 2018). Despite the numerous benefits of using accelerometers, their use may lead to an underestimation of PA levels due to their non-waterproof properties. Because many women removed the accelerometer to do water exercises (e.g. swimming, aqua-gym, etc.), it is possible that PA levels at TR1, TR2 and TR3 were underestimated. However, when comparing women who conceived naturally and those who conceived after FT, no differences in the prevalence, frequency and length of water activities were found, suggesting that if PA levels were underestimated, it was of the same magnitude in all women. Importantly, our study adds knowledge about new predictors of prenatal PA, which might help in the development of future intervention studies aiming at promoting PA during pregnancy and ultimately improving maternal and neonatal health.

5. Conclusion

In conclusion, the findings of our prospective cohort study suggest that MVPA practice throughout pregnancy is built on past PA practice. Therefore, to be effective at promoting PA throughout pregnancy, obstetric health care providers and fitness professionals should reinforce the importance of being active as early as possible during pregnancy. Moreover, a discussion about anxiety might help overcome barriers to prenatal PA practice, especially in early pregnancy and ultimately improve maternal and neonatal health.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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