

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

The relationship between the mode of conception and pregnancy-related pelvic girdle pain, anxiety and physical activity behaviors: a cohort study

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022508
Article Type:	Research
Date Submitted by the Author:	28-Feb-2018
Complete List of Authors:	Lardon, Emeline; Universite du Quebec a Trois-Rivieres; Institut Franco-Européen de Chiropraxie St-Laurent, Audrey; Universite du Quebec a Trois-Rivieres Babineau, Véronique; Department of Obstetrics and Gynaecology, Centre intégré universitaire de santé et de services sociaux de la Mauricie-et-du-Centre-du-Québec, affiliated to the University of Montreal Descarreaux, M; Universite du Quebec, Human kinetics Ruchat, Stephanie-May; Universite du Quebec a Trois-Rivieres,
Keywords:	pregnancy, fertility treatments, pelvic girdle pain, anxiety, physical limitation, physical activity

SCHOLARONE™
Manuscripts

1
2
3 **Manuscript title:** The relationship between the mode of conception and pregnancy-related
4 pelvic girdle pain, anxiety and physical activity behaviors: a cohort study
5
6

7 Emeline Lardon^{1,2}, Audrey St-Laurent¹, Véronique Babineau³, Martin Descarreaux¹,
8 Stephanie-May Ruchat¹
9
10

11
12 **Authors Institutional Information**

13
14 ¹ Département de Human Kinetics, Université du Québec à Trois-Rivières, Trois-Rivières,
15 Canada
16

17 ² Institut Franco-Européen de Chiropraxie, Paris, France
18

19 ³ Département de Obstetrics and Gynaecology, Centre intégré universitaire de santé et de
20 services sociaux de la Mauricie-et-du-Centre-du-Québec, affiliated to the University of
21 Montreal, Trois-Rivières, Canada
22
23

24
25
26
27 **Corresponding author:**

28 Stephanie-May Ruchat, PhD,
29 Professor, Department of Human Kinetics
30 Université du Québec à Trois-Rivières
31 3351, Boul Des Forges, Trois-Rivières, QC G9A 5H7
32
33 E-mail : stephanie-may.ruchat@uqtr.ca
34
35
36
37
38

39 **Key words:** pregnancy; fertility treatments; pelvic girdle pain; anxiety; physical activity.
40

41 **Word count:** 2873
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

ABSTRACT

Objectives: Pregnancy-related pelvic girdle pain (PPGP) is a frequent condition known to significantly affect women's daily life. The etiology of PPGP is still not clearly established but the mode of conception has been suggested to contribute to PPGP. Anxiety related to fertility treatments may be one of the contributing factors. The primary objectives were to determine the evolution of PPGP prevalence and severity, and anxiety, throughout pregnancy in women who conceived spontaneously (SP) or after fertility treatments (FT). We also examined the relationship between PPGP severity and anxiety. The secondary objective was to determine the evolution of physical limitations and physical activity and their correlation with the severity of PPGP.

Design: Prospective cohort study.

Setting: Pregnant women were recruited through physicians' referrals, posters and newspaper advertisements in the local communities.

Participants: Fifty-nine pregnant women (33 SP and 26 FT) were assessed during the 1st, 2nd and 3rd trimester of pregnancy.

Primary and secondary outcome measures: PPGP prevalence and severity (primary), trait and state anxiety, physical limitations and physical activity levels (secondary).

Results: There was no relationship between the mode of conception and our outcomes. The prevalence and severity of PPGP increased over the course of pregnancy (time effect, $p < 0.0001$) whereas trait anxiety decreased from early to mid-pregnancy (time effect, $p = 0.03$). Physical limitations increased throughout pregnancy (time effect, $p < 0.0001$) and physical activity levels decreased (time effect, $p < 0.0001$). The severity of PPGP was positively correlated with physical limitations ($r = 0.51$ to 0.55) but negatively with physical activity levels ($r = -0.39$ to -0.41).

1
2
3 **Conclusions:** Maternal health-related factors, such as PPGP, anxiety and physical activity,
4 are not different in women who conceived spontaneously or after fertility treatments. The
5 more PPGP was severe, the more the women were physically limited and inactive, suggesting
6 that the clinical management of PPGP might decrease physical limitation during pregnancy.
7
8
9
10
11 (299)

12 13 14 15 **Strengths and limitations of this study**

- 16
17
18 • This is a prospective cohort study of pregnant women who were assessed at each
19 trimester of pregnancy, allowing to assess the evolution of several maternal health-related
20 factors that are known to change over the course of pregnancy;
21
22
23
- 24 • Primary and secondary outcomes were collected using validated tools;
25
26
- 27 • One third of our sample achieved a pregnancy after *in vitro* fertilization, which may have
28 limited our ability to find higher anxiety levels and PPGP incidence in women who
29 conceived after fertility treatments compared to those who conceived naturally;
30
31
- 32 • More than half of the participants had a university degree and the results may not be
33 generalizable to a wider population of pregnant women.
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

INTRODUCTION

Pregnancy-related pelvic girdle pain (PPGP) is defined by pain “experienced between the posterior iliac crest and the gluteal fold, particularly in the vicinity of the sacroiliac joint. The pain may radiate in the posterior thigh and can also occur in conjunction with/or separately in the symphysis”¹. Using this definition, large prospective studies with objectively measured symptoms reported a PPGP prevalence between 16% and 25%². The onset of PPGP varies considerably, between the end of the first trimester to the first month post-delivery, with a peak of symptoms generally occurring between the 24th and 36th weeks of pregnancy². Pelvic girdle pain (PGP) is a debilitating condition during pregnancy that is known to affect women’s quality of life. For instance, sleep, physical functioning, social life and hobbies are affected^{3,4}. Importantly, PPGP represents the main cause of sick leave^{5,6} and has therefore significant socioeconomic impact. Pregnant women experiencing PGP are also less likely to be physically active⁷, thereby preventing them to benefit from the numerous positive health effects of prenatal exercise⁸.

Several factors are believed to be involved in PPGP development^{1,2}. One factor of interest is the mode of conception, in other words, naturally or after fertility treatments. A study reported that pregnant women who underwent *in vitro* fertilization (IVF) treatments had a two times higher prevalence rate of sacral pain in early and late pregnancy, as well as a higher prevalence of positive results on pelvic pain provocation tests in late pregnancy⁹. One of the reasons that might explain higher PPGP prevalence in women who conceived after IVF is higher anxiety levels. As reported by a systematic review, women who conceived following fertility treatments had greater pregnancy-specific anxiety than those who conceived naturally¹⁰ and higher levels of anxiety have been found to be among the most notable factors associated with a higher likelihood of reporting PPGP¹¹. However, additional studies are

1
2
3 needed to confirm the relationship between the mode of conception and PPGP, and whether
4
5 anxiety is a contributing factor.

6
7 The primary objectives of this prospective cohort study were to determine the evolution of
8
9 PPGP prevalence and severity, as well as anxiety, over the course of pregnancy in women
10
11 who conceived naturally or after fertility treatments, and to examine the possible relationship
12
13 between PPGP severity and anxiety levels. As PPGP has a significant impact on the women's
14
15 daily life, the secondary objective of our study was to determine the evolution of physical
16
17 limitations and physical activity behaviors throughout pregnancy and whether the severity of
18
19 PPGP was correlated to these factors. Our primary hypotheses are that PPGP prevalence and
20
21 severity, as well as anxiety levels will increase over the course of pregnancy but more
22
23 strongly in women who conceived after fertility treatments, and that PPGP severity will be
24
25 positively correlated with anxiety levels. As a result, our secondary hypotheses are that
26
27 physical limitations will increase whereas physical activity behaviors will decrease over the
28
29 course of pregnancy but more significantly in women who conceived after fertility treatments,
30
31 and that the severity of PPGP will be positively correlated with physical limitations but
32
33 negatively with physical activity behaviors.
34
35
36
37
38

39 **MATERIALS AND METHODS**

40 **Study design and participants' selection**

41
42
43 Between October 2015 and September 2016, women who achieved a spontaneous pregnancy
44
45 (SP group) and women who achieved pregnancy following fertility treatments (FT group)
46
47 were recruited through physicians' referrals, posters and newspaper advertisements in the
48
49 local and surrounding communities. Women under 14 weeks of gestation, with a singleton
50
51 pregnancy and able to understand, speak and write French were considered eligible to
52
53 participate in the study. The study was approved by the local Research Ethics Committees
54
55
56
57
58
59
60

1
2
3 (CER-2015-003 and CER-15-214-07.10) and all participants provided their written informed
4
5 consent.

6 7 **Outcome measures and measurement tools**

8
9 Women were followed from the 1st trimester of pregnancy until delivery through three
10
11 evaluations (1st trimester [TR1]: 10–16 weeks, 2nd trimester [TR2]: 24–28 weeks and 3rd
12
13 trimester [TR3]: 32–36 weeks of gestation). In each trimester, women were asked if they have
14
15 had PPGP over the last 7 days or were having PPGP presently. If a woman had had or was
16
17 having PPGP, she was asked to evaluate pain intensity using a visual analog pain scale
18
19 (VAS). This scale is a self-reported measurement tool used by health professionals allowing
20
21 the patient to rate pain from 0 (no pain) to 10 (extreme pain) ¹². We used a picture to localize
22
23 the woman's pain to make sure that it was located in the lumbo-pelvic region.

24
25 The levels of anxiety was assessed during TR1, TR2 and TR3 using the French-Canadian
26
27 version ¹³ of the State-Trait Anxiety Inventory (STAI) ¹⁴. It is a self-reported questionnaire
28
29 assessing the presence and severity of current symptoms of anxiety (state anxiety scale) and a
30
31 generalized propensity to be anxious (trait anxiety scale). Each scale is based on 20 items on a
32
33 four-point response scale. The range of score for each scale is 20-80, the higher score
34
35 indicating greater anxiety levels.

36
37 Physical limitations and symptoms associated with PPGP were assessed in TR2 and TR3
38
39 using the completed the French-Canadian version of the PGQ was used ¹⁵. The PGQ is a
40
41 condition-specific measure developed for pregnant and postpartum women. It consists of 20
42
43 activity items and five symptom items on a four-point response scale and assess physical
44
45 limitations and symptoms associated with PGP. The range of score is 0-100%, with a higher
46
47 score indicating greater physical limitations and symptoms. The PGQ is reliable and valid for
48
49 both pregnant and postpartum women with PGP ¹⁶.

1
2
3 Finally, physical activity levels were objectively measured at each trimester of pregnancy
4 using the ActiGraph GT3X (ActiGraph, Pensacola, FL), a triaxial accelerometer measuring
5 data in a 60-s epoch. The women were instructed to wear the monitor over the hip on an
6 elastic belt for seven consecutive days from wake-up time to bedtime. They were allowed to
7 remove the accelerometer when sleeping, showering or engaging in water activities.
8
9 According to the method used in the Canadian Health Measures Survey, valid data were
10 defined as \geq four days of monitoring for \geq 10 hours of wear time per day¹⁷. Pregnant women
11 were encouraged to maintain their usual activities. Data were processed using the Actilife
12 software version 6.13.2 (ActiGraph, LLC, FL, USA). The accelerometer data obtained were
13 averaged across valid wear days. To derive the activity frequency, intensity and duration of
14 the measured activity in counts per minute per day, the Freedson equation was used:
15 sedentary (<100 counts), light (100–1951 counts), moderate (1952–5724), vigorous (5725–
16 9498), and very vigorous (>9498)¹⁸, as previously used in pregnant women¹⁹. Non-wear time
17 was defined as a period of zero counts for \geq 60 consecutive minutes, admitting a maximum of
18 two consecutive minutes between 1 and 100 counts/min. When a third observation was
19 between 1 and 100 counts or one observation was more than 100 counts, the non-wear period
20 was ended. Bouts of moderate-to-vigorous physical activity (MVPA) was defined as a
21 minimum of 10 consecutive minutes above 1952 counts and ended with more than two
22 consecutive records below this threshold.
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43

44 **Patient and Public Involvement**

45 Patients and public were not involved in the design and conduct of this study. The results will
46 not be disseminated to study participants.
47
48
49
50

51 **Statistical analysis**

52 Means and standard deviations, as well as percentages, were computerized for variables of
53
54
55
56
57
58
59
60

1
2
3 interest. Student t-test was used to compare socio-demographic and anthropometric
4 characteristics between SP and FT women. For categorical variables, the χ square test was
5 used. Analysis of variance (ANOVA) for repeated measures was used to assess the evolution
6 of the severity of PPGP, anxiety levels, physical limitations and physical activity behaviors
7 throughout pregnancy in SP and FT women. To test whether the severity of PPGP was
8 correlated to the levels of anxiety, physical limitations and physical activity behaviors at each
9 trimester of pregnancy, Pearson's correlation analyses were used. Finally, exploratory logistic
10 regression analyses were conducted to identify potential predictors of PPGP in TR3.
11 Statistical analyses were performed by using the SAS software (version 9.4) and the level of
12 significance was set to $p\text{-value} \leq 0.05$.
13
14
15
16
17
18
19
20
21
22
23
24
25

26 RESULTS

27
28 Between October 2015 and May 2016, the study was presented to 117 eligible pregnant
29 women, among which 62 women accepted to participate. Three women (1 in SP group and 2
30 in FT group) were excluded due to several missing data, leaving 59 women (33 SP and 26
31 FT) for the statistical analyses.
32
33
34
35
36

37 The characteristics of pregnant women are presented in **Table 1**. No significant difference in
38 socio-demographic and pre-pregnancy anthropometric characteristics was found between the
39 groups ($p > 0.05$). Women were on average in their early thirties and approximately half of
40 them were nulliparous. More than half were of normal weight pre-pregnancy (BMI 18.5-24.9
41 kg/m²) and had a university degree. Women's PGP history, related or not to a previous
42 pregnancy, was also similar between the groups, with approximately 50% of the women
43 reporting a history of PGP (**Table 1**). Finally, the prevalence and severity of PPGP, anxiety
44 and physical activity levels were not different between SP and FT pregnant women at study
45 entry (**Table 1**). Data showed that on average, women considered PPGP as uncomfortable
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

(4/10) and were slightly anxious (35/80). Moreover, based on daily steps and physical activity recommendations^{20,21}, our population was considered inactive.

The prevalence of PPGP was similar in both groups during each trimester of pregnancy (TR1: $\chi^2 = 2.19$, $p=0.33$; TR2: $\chi^2 = 2.13$, $p=0.33$; TR3: $\chi^2 = 0.01$, $p=0.92$); the pooled prevalence of PPGP increased from 42% during TR1 to 65% during TR2 to 68% during TR3 ($\chi^2 = 8.45$; $p=0.01$) (**Fig 1**). Among women presenting PPGP at one time point during pregnancy ($n=44$, 26 SP and 18 FT), pain severity significantly increased over the course of pregnancy in both groups (time effect, $p<0.0001$. **Fig 2**), with pain severity being significantly higher during TR2 and TR3 compared to TR1. Trait anxiety decreased over the course of pregnancy in both groups (time effect, $p<0.03$. **Fig 3A**), with lower levels during TR2 compared to TR1, whereas state anxiety did not significantly change (**Fig 3B**). Finally, physical limitations associated with PPGP increased (time effect, $p<0.0001$. **Fig 4A**) whereas daily steps decreased over the course of pregnancy in both groups (time effect, $p<0.0001$. **Fig 4B**). The only time by group interaction effect was found for daily MVPA which decreased only in SP women (time effect, $p<0.0001$; time*group interaction effect, $p=0.04$. **Fig 4C**).

Since changes in the severity of PPGP, levels of anxiety, physical limitations and physical activity behaviors were similar between the groups, result from SP and FT women were pooled in the correlation analyses. Among women who presented PPGP, no correlation was found during TR1 between the severity of PPGP and anxiety or physical activity levels. During TR2, the severity of PPGP was positively correlated with physical limitations ($r=0.51$, $p=0.001$, **Fig 5A**) but negatively with daily steps ($r=-0.39$, $p=0.03$, **Fig 5B**). No correlation was found with daily MVPA (**Fig 5C**). During TR3, we found a positive correlation between the severity of PPGP and physical limitations ($r=0.55$, $p=0.0002$, **Fig 6A**) but a negative correlation with daily MVPA ($r=-0.41$, $p=0.02$, **Fig 6B**). No correlation was found with daily steps (**Fig 6C**).

1
2
3 Finally, exploratory logistic analyses revealed that among the potential predictors of PPGP
4 during TR3 (mode of conception, parity, pre-pregnancy BMI, PPGP, anxiety and physical
5 activity levels during TR1, and weight gain until TR3), PPGP during TR1 was the only
6
7 significant predictor (odds ratio: 7.33, 95% confidence interval 1.82–29.48, $p=0.005$).
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

DISCUSSION

To the best of our knowledge, this is the first cohort study assessing the course of PPGP prevalence and severity in pregnant women who conceived naturally and after fertility treatments, and possible association with anxiety levels and physical activity behaviors. Overall, our primary results showed no relationship between the mode of conception and PPGP prevalence and severity, or anxiety levels. As expected, the prevalence and severity of PPGP increased over the course of pregnancy, whereas anxiety levels decreased from early to mid-pregnancy and were not correlated to the severity of PPGP.

Only one study examined the evolution of the prevalence and severity of PPGP according to the mode of conception. This study was conducted in 31 women who conceived after IVF and 200 women who conceived spontaneously and assessed PPGP at 12, 24 and 34 weeks of pregnancy⁹. The authors found an increase in PPGP prevalence and severity over the course of pregnancy in all women, as we and other authors did²². However, they reported a two times higher rate of PPGP in early and late pregnancy in women who achieved a pregnancy after IVF compared to those who achieved a pregnancy naturally but similar severity of PPGP⁹. Our hypothesis was that higher anxiety levels reported in women who conceived after fertility treatments¹⁰ would contribute to higher PPGP prevalence and severity in this population of pregnant women. However, we did not find any difference in anxiety levels between women who conceived after fertility treatments and those who conceived naturally. Several reasons may explain our result. First, the majority of women included in our sample conceived after ovarian stimulation (OS, n=7) or intrauterine insemination (IUI, n=12), whereas the majority of studies included in Gourounti's review reporting higher anxiety in women who conceived following fertility treatments were conducted in the context of IVF¹⁰. It is very likely that OS and IUI generate less anxiety than IVF treatments, which might explain why we found no differences in anxiety levels in our sample. Second, the

1
2
3 questionnaire we used evaluated state and trait anxiety whereas Gourounti's review reported
4 on pregnancy-specific anxiety¹⁰. It is possible that fertility treatments specifically affect
5 anxiety related to pregnancy but not general anxiety, in which case the questionnaire we used
6 may not have been specific enough to identify differences in anxiety between women who
7 conceived after fertility treatment and those who conceived naturally.
8
9

10
11
12
13 When examining anxiety levels over the course of pregnancy, we found a U-shaped curve,
14 with a significant decrease in anxiety from TR1 to TR2 and a non-significant trend toward an
15 increase from TR2 to TR3. These findings are similar to those of previous studies^{23,24}. In
16 contrast, whereas some studies reported higher anxiety in pregnant women with PPGP^{11,25},
17 we found no correlation between anxiety levels and PPGP severity. Our findings suggest that
18 in our sample, anxiety and PPGP were two independent phenomena.
19
20
21
22

23
24
25
26 Likewise, our secondary results showed no relationship between the mode of conception and
27 physical limitations and physical activity behaviors, except for MVPA during TR3. The
28 decrease in MVPA observed only in women who conceived naturally needs further
29 investigation. Similarly to previous studies²⁶⁻²⁹, we found that with advancing pregnancy,
30 physical limitations increased²⁸⁻³⁰ and physical activity behaviors decreased^{26,27,31}. Our data
31 further showed that the greater PPGP severity the greater physical limitation and lower
32 physical activity levels in mid- and late pregnancy. These results are also in accordance with
33 previous studies reporting decreased physical activity levels as physical limitations and low
34 back pain increase with advancing pregnancy^{28,32}.
35
36
37
38
39
40
41
42
43
44
45

46
47 Despite the high prevalence of PPGP, little is known about the risk factors for PPGP. Clinical
48 management would benefit from an early identification of women at risk of developing PPGP
49 later in pregnancy. Exploratory univariate logistic regression analyses were carried out and
50 revealed that the presence of PPGP during TR1 was a significant predictor of PPGP in TR3.
51
52
53
54 This finding is in accordance with those of Robinson et al.²⁹ who reported an association
55
56
57
58
59
60

1
2
3 between pain and positive pain provocation test in early pregnancy and disability and pain
4
5 intensity in late pregnancy.
6
7

8 **Limitations**

9
10 The current study has a few limitations that should be acknowledged. First, as previously
11 mentioned, our sample was heterogeneous with regards to fertility treatments used to achieve
12 a pregnancy, with the majority of women having conceived after OS or IUI. This may have
13 limited our ability to find higher PPGP prevalence and anxiety levels in women who
14 conceived after fertility treatments. Third, general anxiety was assessed whereas the type of
15 anxiety that may be influenced by the mode of conception may be more specific to pregnancy.
16
17 We had missing physical activity data, suggesting that several women did not wear the
18 accelerometer for at least 10 hours per day for four days. Some women with PPGP reported
19 discomfort when wearing the accelerometer, suggesting that we may have under-evaluated
20 physical activity levels. Finally, more than half of the women we recruited had a university
21 degree. This suggests a possible recruitment bias and limits the generalizability of our results
22 to a wider population of pregnant women. However, the strength of our study is its
23 longitudinal design that allowed us to examine the evolution of several maternal health-
24 related factors that are known to change over the course of pregnancy. Moreover, our study
25 clarifies the relationship between PPGP severity and physical activity behaviors using
26 accelerometers, which is an objective measurement tool frequently used in pregnant women
27 to assess physical activity levels and sedentary behaviors ¹⁹.
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

CONCLUSION

In conclusion, our findings suggest that maternal health-related factors, such as PPGP, anxiety and physical activity behaviors, are not different in women who conceived after fertility treatments and those who conceived spontaneously. The lack of correlation between PPGP severity and anxiety levels suggests that they are two independent phenomena. The increase in PPGP severity and physical limitations, and decrease in physical activity behaviors with advancing gestation, and the fact that the more severe PPGP the greater physical limitations and physical inactivity in mid- and late pregnancy underlie the importance of PPGP management to allow pregnant women performing their daily activities.

1
2
3 **Acknowledgments:** The authors would like to acknowledge and thank Sophie Drouin, the
4 coordinator of the fertility clinic, as well as the medical team who assisted with the
5 recruitment, and all the women who participated to the project.
6
7
8
9

10
11 **Funding:** This study was funded by a start-up grant from the Univeristé du Québec à Trois-
12 Rivières (Institutional funds for research).
13
14
15

16
17
18 **Declaration of conflicting interests:** The authors declare that there is no conflict of interest.
19
20
21

22 **Author Contributions:** SMR, MD, VB contributed to the study concept and design; EL and
23 ASStL acquired the data; SMR, MD, EL performed the statistical analysis and interpreted the
24 data; EL and SMR drafted the manuscript; MD, ASStL and VB critically reviewed the
25 manuscript for important intellectual content. All authors read and approved the final
26 manuscript.
27
28
29
30
31
32
33
34

35 **Competing interests:** None declared.
36
37
38

39 **Ethics approval:** The study was approved by the local Research Ethics Committees (CER-
40 2015-003 and CER-15-214-07.10)
41
42
43
44

45
46 **Data sharing statement:** No additional data are available.
47
48
49
50
51
52
53
54
55
56
57
58
59
60

References

1. Vleeming A, Albert HB, Ostgaard HC, Sturesson B, Stuge B. European guidelines for the diagnosis and treatment of pelvic girdle pain. *Eur Spine J*. 2008;17(6):794-819.
2. Kanakaris NK, Roberts CS, Giannoudis PV. Pregnancy-related pelvic girdle pain: an update. *BMC Med*. 2011;9:15.
3. Olsson C, Nilsson-Wikmar L. Health-related quality of life and physical ability among pregnant women with and without back pain in late pregnancy. *Acta Obstet Gynecol Scand*. 2004;83(4):351-357.
4. Gutke A, Ostgaard HC, Oberg B. Pelvic girdle pain and lumbar pain in pregnancy: a cohort study of the consequences in terms of health and functioning. *Spine (Phila Pa 1976)*. 2006;31(5):E149-155.
5. Mogren I. Perceived health, sick leave, psychosocial situation, and sexual life in women with low-back pain and pelvic pain during pregnancy. *Acta Obstet Gynecol Scand*. 2006;85(6):647-656.
6. Moore K, Dumas GA, Reid JG. Postural changes associated with pregnancy and their relationship with low-back pain. *Clin Biomech (Bristol, Avon)*. 1990;5(3):169-174.
7. Owe KM, Nystad W, Bo K. Correlates of regular exercise during pregnancy: the Norwegian Mother and Child Cohort Study. *Scand J Med Sci Sports*. 2009;19(5):637-645.
8. Mudd LM, Owe KM, Mottola MF, Pivarnik JM. Health benefits of physical activity during pregnancy: an international perspective. *Med Sci Sports Exerc*. 2013;45(2):268-277.
9. Kristiansson P, Nilsson-Wikmar L, von Schoultz B, Svardsudd K, Wramsby H. Back pain in in-vitro fertilized and spontaneous pregnancies. *Hum Reprod*. 1998;13(11):3233-3238.

10. Gourounti K. Psychological stress and adjustment in pregnancy following assisted reproductive technology and spontaneous conception: A systematic review. *Women Health*. 2015:1-21.
11. Kovacs FM, Garcia E, Royuela A, Gonzalez L, Abraira V. Prevalence and factors associated with low back pain and pelvic girdle pain during pregnancy: a multicenter study conducted in the Spanish National Health Service. *Spine (Phila Pa 1976)*. 2012;37(17):1516-1533.
12. Ostelo RW, Deyo RA, Stratford P, et al. Interpreting change scores for pain and functional status in low back pain: towards international consensus regarding minimal important change. *Spine (Phila Pa 1976)*. 2008;33(1):90-94.
13. Gauthier J, Bouchard S. Adaptation canadienne-française de la forme révisée du State-Trait Anxiety Inventory de Spielberg. *Canadian Journal of Behavioral Sciences*. 1990;25 (4):559-589.
14. Spielberger CD. *Manual for the State-Trait Anxiety Inventory (Form Y)*. Palo Alto: Consulting Psychologist Press; 1983.
15. Girard MP, Marchand AA, Stuge B, Ruchat SM, Descarreaux M. Cross-cultural Adaptation of the Pelvic Girdle Questionnaire for the French-Canadian Population. *J Manipulative Physiol Ther*. 2016;39(7):494-499.
16. Stuge B, Garratt A, Krogstad Jenssen H, Grotle M. The pelvic girdle questionnaire: a condition-specific instrument for assessing activity limitations and symptoms in people with pelvic girdle pain. *Phys Ther*. 2011;91(7):1096-1108.
17. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Activité physique des adultes au Canada: résultats d'accélérométrie de l'Enquête Canadienne sur les mesures de la santé de 2007-2009. *Statistique Canada Rapports sur la santé*. 2011.

18. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc.* 1998;30(5):777-781.
19. Harrison CL, Thompson RG, Teede HJ, Lombard CB. Measuring physical activity during pregnancy. *Int J Behav Nutr Phys Act.* 2011;8:19.
20. Tudor-Locke C, Bassett DR, Jr. How many steps/day are enough? Preliminary pedometer indices for public health. *Sports Med.* 2004;34(1):1-8.
21. Evenson KR, Mottola MF, Owe KM, Rousham EK, Brown WJ. Summary of international guidelines for physical activity after pregnancy. *Obstet Gynecol Surv.* 2014;69(7):407-414.
22. Kristiansson P, Svardsudd K, von Schoultz B. Back pain during pregnancy: a prospective study. *Spine (Phila Pa 1976).* 1996;21(6):702-709.
23. Lee AM, Lam SK, Sze Mun Lau SM, Chong CS, Chui HW, Fong DY. Prevalence, course, and risk factors for antenatal anxiety and depression. *Obstet Gynecol.* 2007;110(5):1102-1112.
24. Teixeira C, Figueiredo B, Conde A, Pacheco A, Costa R. Anxiety and depression during pregnancy in women and men. *J Affect Disord.* 2009;119(1-3):142-148.
25. Elden H, Gutke A, Kjellby-Wendt G, Fagevik-Olsen M, Ostgaard HC. Predictors and consequences of long-term pregnancy-related pelvic girdle pain: a longitudinal follow-up study. *BMC Musculoskelet Disord.* 2016;17:276.
26. Evenson KR, Wen F. Prevalence and correlates of objectively measured physical activity and sedentary behavior among US pregnant women. *Prev Med.* 2011;53(1-2):39-43.
27. Rousham EK, Clarke PE, Gross H. Significant changes in physical activity among pregnant women in the UK as assessed by accelerometry and self-reported activity. *Eur J Clin Nutr.* 2006;60(3):393-400.

- 1
2
3 28. Cramp AG, Bray SR. A prospective examination of exercise and barrier self-efficacy
4 to engage in leisure-time physical activity during pregnancy. *Ann Behav Med.*
5 2009;37(3):325-334.
6
7
8
9 29. Robinson HS, Veierod MB, Mengshoel AM, Vollestad NK. Pelvic girdle pain--
10 associations between risk factors in early pregnancy and disability or pain intensity in
11 late pregnancy: a prospective cohort study. *BMC Musculoskelet Disord.* 2010;11:91.
12
13
14 30. Chang HY, Lai YH, Jensen MP, et al. Factors associated with low back pain changes
15 during the third trimester of pregnancy. *J Adv Nurs.* 2014;70(5):1054-1064.
16
17
18 31. Downs DS, LeMasurier GC, DiNallo JM. Baby steps: pedometer-determined and self-
19 reported leisure-time exercise behaviors of pregnant women. *J Phys Act Health.*
20 2009;6(1):63-72.
21
22
23 32. Poston L, Briley AL, Barr S, et al. Developing a complex intervention for diet and
24 activity behaviour change in obese pregnant women (the UPBEAT trial); assessment
25 of behavioural change and process evaluation in a pilot randomised controlled trial.
26 *BMC Pregnancy Childbirth.* 2013;13:148.
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Table 1: Baseline characteristics of the 59 pregnant women included in study.

Variables	FT (n=26) Means \pm SD	SP (n=33) Means \pm SD	P values
Fertility treatments	OS=7 IUI=12 IVF=7	-	
Age (years)	32.2 \pm 3.6	30.9 \pm 4.2	0.23
Parity	0.4 \pm 0.6	0.6 \pm 0.6	0.36
0 (n)	57.7% (15)	45.5% (15)	0.35
\geq 1 (n)	42.3% (11)	54.6% (18)	
Pre-pregnancy BMI (kg/cm ²)	26.3 \pm 7.3	25.2 \pm 6.6	0.54
Underweight <18.4	0% (0)	3.1% (1)	0.81
Normal weight (18.5-24.9)	60.0 (15)	62.5% (20)	
Overweight (25.0-29.9)	20.0 (5)	18.8% (6)	
Obese \geq 30.0	20.0%(5)	15.6% (5)	
Education levels			
Non-university degree	42.3% (11)	33.3% (11)	0.48
University degree	57.7% (15)	66.7% (22)	
PGP history (yes) ¹	46.2% (12)	54.6% (18)	0.52
Prevalence of PGP over the last week (yes)	34.6% (9)	48.5% (16)	0.33
Severity of PGP over the last week	2.9 \pm 1.9	4.1 \pm 2.3	0.18
State anxiety	37.4 \pm 11.6	34.2 \pm 9.1	0.28
Trait anxiety	39.8 \pm 10.0	37.1 \pm 9.4	0.26
Daily steps	5328 \pm 1551	5569 \pm 1552	0.80
Daily MVPA (min)	16.3 \pm 10.0	17.4 \pm 13.2	0.97

FT: fertility treatment; SP: spontaneous conception; OS: ovarian stimulation; IUI: intrauterine insemination; IVF: *in vitro* fertilization; BMI : body mass index; PGP : pelvic girdle pain; MVPA: moderate-to-vigorous physical activity

¹ PGP history includes history of pregnancy-related PGP and PGP not related to pregnancy

Missing data: pre-pregnancy BMI: 1 FT, 1 SP; state and trait anxiety : 1 SP; accelerometer data: 4 SP; 6 FT

1
2
3 **Figure legend**
4
5
6

7 **Figure 1:** Prevalence of PPGP in FT and SP pregnant women over the course of pregnancy.
8
9

10
11 **Figure 2:** Evolution of PPGP severity in FT and SP pregnant women over the course of
12 pregnancy.
13
14

15
16
17 **Figure 3:** Evolution of (A) trait anxiety and (B) state anxiety in FT and SP pregnant women
18 over the course of pregnancy.
19
20

21
22
23 **Figure 4:** Evolution of (A) physical limitations, (B) daily step counts an (C) daily moderate-
24 to-vigorous physical activity in FT and SP pregnant women over the course of pregnancy.
25
26
27

28
29
30 **Figure 5:** Correlation between the severity of PPGP and (A) physical limitations, (B) daily
31 step counts and (C) daily moderate-to-vigorous physical activity at TR2.
32
33

34
35
36 **Figure 6:** Correlation between the severity of PPGP and (A) physical limitations, (B) daily
37 step counts and (C) daily moderate-to-vigorous physical activity at TR3.
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

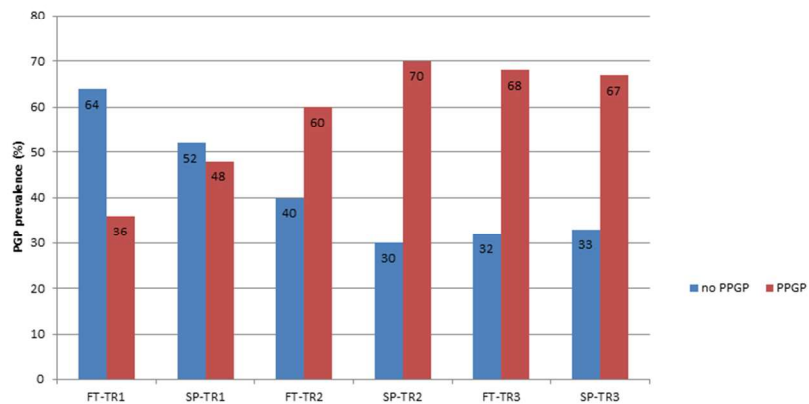


Figure 1: Prevalence of PPGP in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

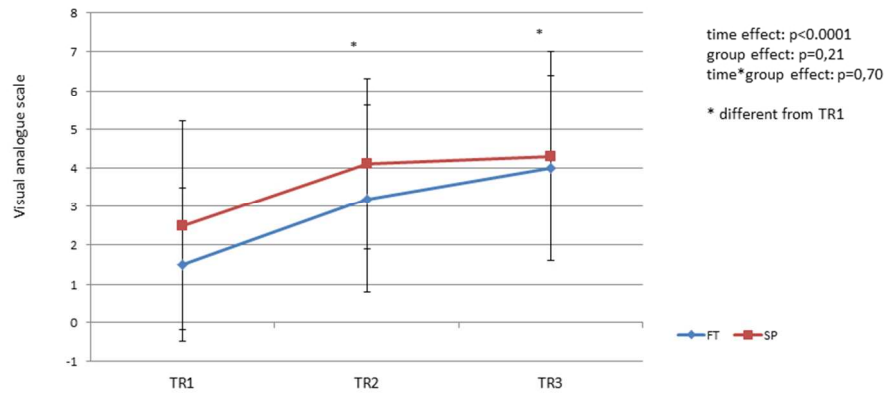


Figure 2: Evolution of PPGP severity in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

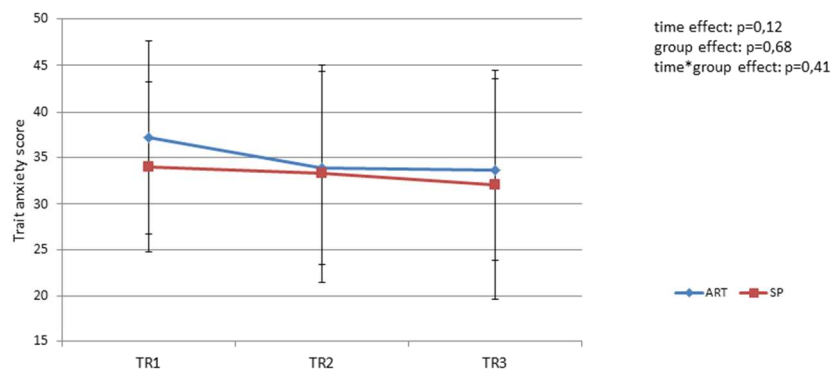


Figure 3: Evolution of trait anxiety in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

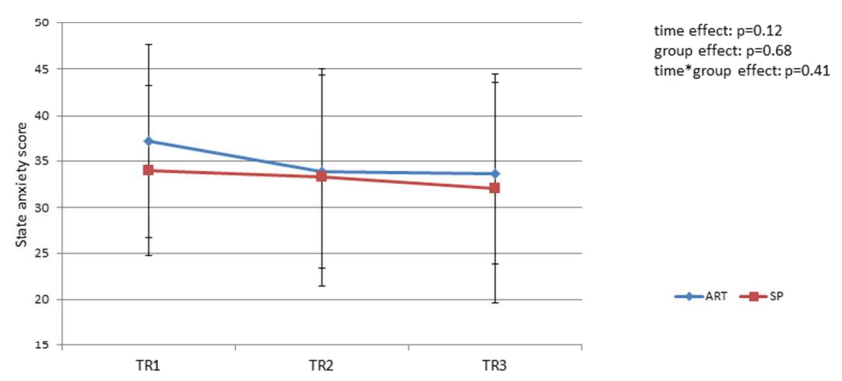


Figure 3: Evolution of state anxiety in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

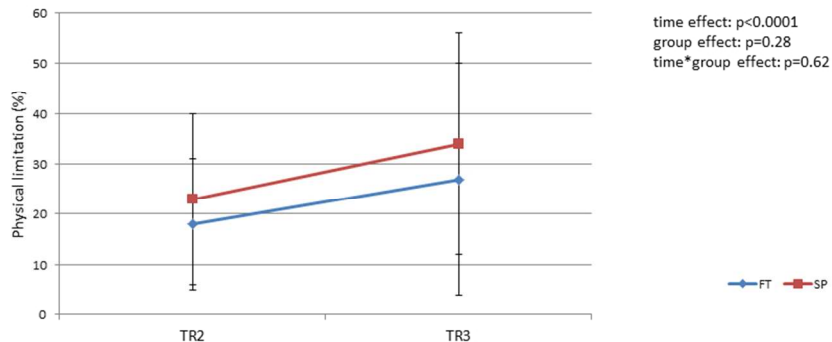


Figure 4: Evolution of physical limitations in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

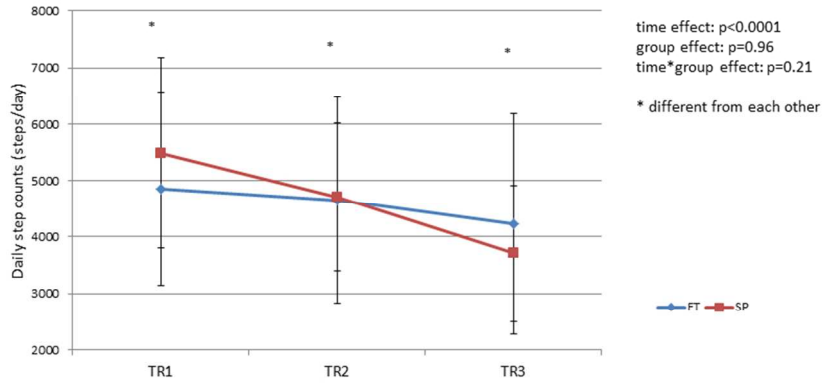


Figure 4: Evolution of daily step counts in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

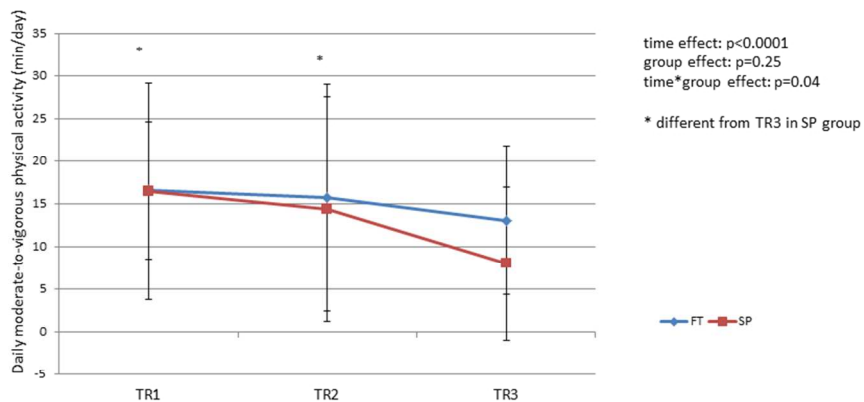


Figure 4: Evolution of daily moderate-to-vigorous physical activity in FT and SP pregnant women over the course of pregnancy.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

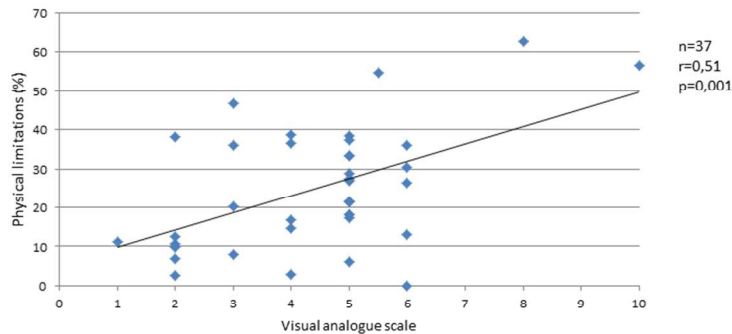


Figure 5: Correlation between the severity of PPGP and physical limitations at TR2.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

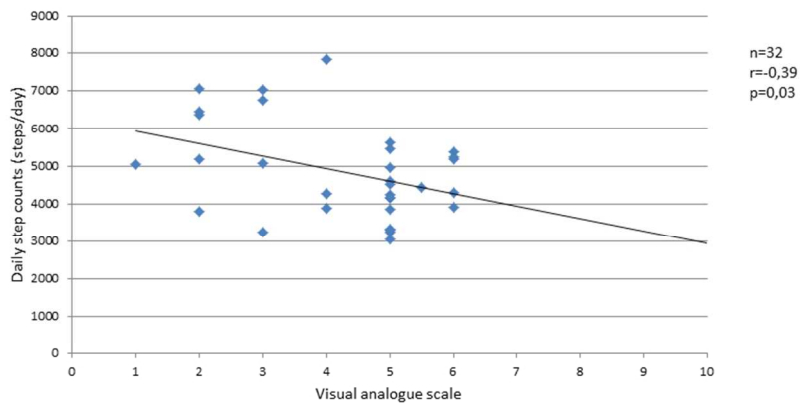


Figure 5: Correlation between the severity of PPGP and daily step counts at TR2.

254x190mm (96 x 96 DPI)

Peer Review Only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

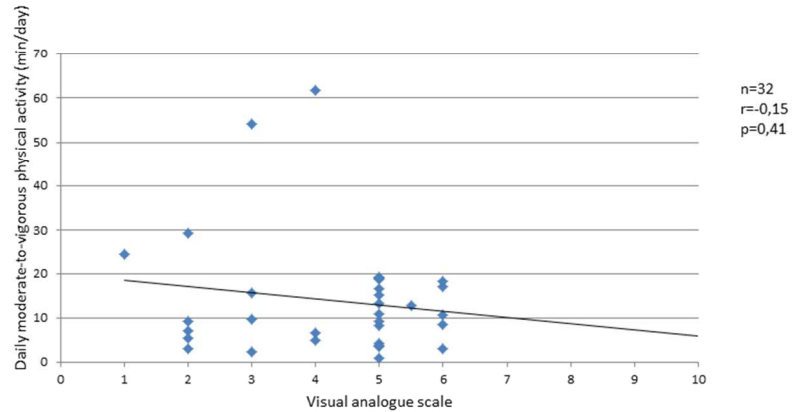


Figure 5: Correlation between the severity of PPGP and daily moderate-to-vigorous physical activity at TR2.

254x190mm (96 x 96 DPI)

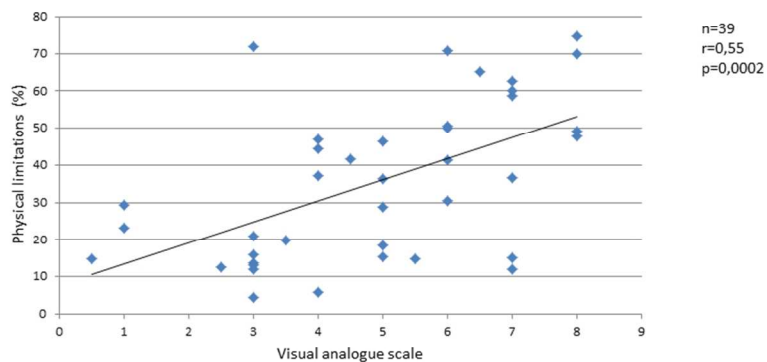


Figure 6: Correlation between the severity of PPGP and physical limitations at TR3.

254x190mm (96 x 96 DPI)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

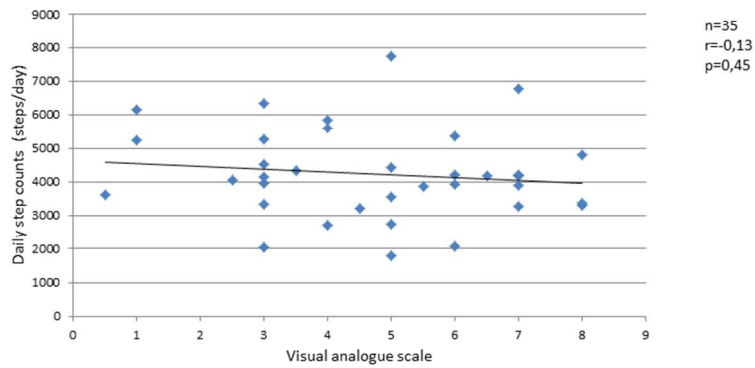


Figure 6: Correlation between the severity of PPGP and daily step counts at TR3.

254x190mm (96 x 96 DPI)

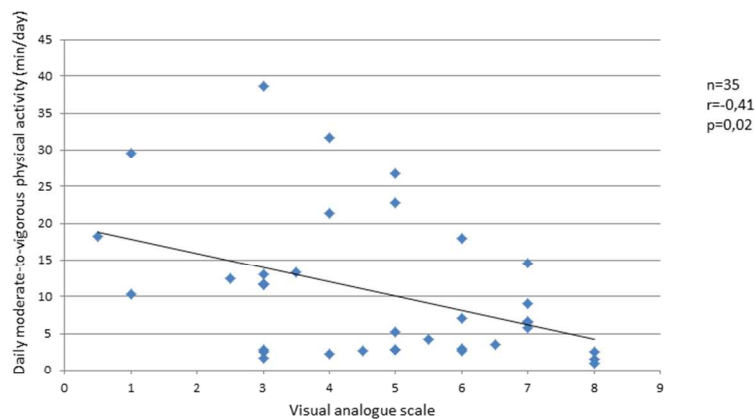


Figure 6: Correlation between the severity of PPGP and daily moderate-to-vigorous physical activity at TR3.

254x190mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	na
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	-
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	na
		(d) If applicable, explain how loss to follow-up was addressed	na
		(e) Describe any sensitivity analyses	na
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19 (table 1)
		(b) Indicate number of participants with missing data for each variable of interest	na
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-9, 20-28 (figures)
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	na
		(b) Report category boundaries when continuous variables were categorized	na
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	na
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Lumbopelvic pain, anxiety, physical activity and mode of conception: A prospective cohort study of pregnant women

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022508.R1
Article Type:	Research
Date Submitted by the Author:	12-Jul-2018
Complete List of Authors:	Lardon, Emeline; Universite du Quebec a Trois-Rivieres; Institut Franco-Européen de Chiropraxie St-Laurent, Audrey; Universite du Quebec a Trois-Rivieres Babineau, Véronique; Department of Obstetrics and Gynaecology, Centre intégré universitaire de santé et de services sociaux de la Mauricie-et-du-Centre-du-Québec, affiliated to the University of Montreal Descarreaux, M; Universite du Quebec, Human kinetics Ruchat, Stephanie-May; Universite du Quebec a Trois-Rivieres,
Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Sports and exercise medicine
Keywords:	pregnancy, fertility treatments, anxiety, physical activity, lumbopelvic pain

SCHOLARONE™
Manuscripts

Only

1
2
3 1 **Manuscript title:** Lumbopelvic pain, anxiety, physical activity and mode of conception: A
4 2 prospective cohort study of pregnant women
5
6 3

7 4 Emeline Lardon^{1,2, *}, Audrey St-Laurent¹, Véronique Babineau³, Martin Descarreaux¹,
8 5 Stephanie-May Ruchat^{1, *}
9
10 6

11 7 **Authors Institutional Information**

12 8 ¹ Département de Human Kinetics, Université du Québec à Trois-Rivières, Trois-Rivières,
13 9 Canada

14 10 ² Institut Franco-Européen de Chiropraxie, Paris, France

15 11 ³ Département de Obstetrics and Gynaecology, Centre intégré universitaire de santé et de
16 12 services sociaux de la Mauricie-et-du-Centre-du-Québec, affiliated to the University of
17 13 Montreal, Trois-Rivières, Canada

18 14 * these authors contributed equally to the work
19
20
21
22
23
24
25
26

27 16 **Corresponding author:**

28 17 Stephanie-May Ruchat, PhD,
29 18 Professor, Department of Human Kinetics
30 19 Université du Québec à Trois-Rivières
31 20 3351, Boul Des Forges, Trois-Rivières, QC G9A 5H7

32 21 E-mail : stephanie-may.ruchat@uqtr.ca
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

22 24 **Key words:** pregnancy; lumbopelvic pain; anxiety; physical activity; fertility treatments.

23 25
24 26 **Word count:** 3636

1 ABSTRACT

2 **Objectives:** Pregnancy-related lumbopelvic pain (LPP) is a frequent condition known to
3 significantly affect women's daily life. The etiology of pregnancy-related LPP pain is still not
4 clearly established but the mode of conception has been suggested to contribute LPP. Anxiety
5 related to fertility treatments may be one of the contributing factors. The primary objectives
6 were to determine the evolution of LPP prevalence and severity, and anxiety, throughout
7 pregnancy in women who conceived spontaneously (SP) or after fertility treatments (FT). A
8 further aim was to examine the relationship between pregnancy-related LPP severity and
9 anxiety. The secondary objective was to determine the evolution of physical activity and their
10 correlation with the severity of pregnancy-related LPP.

11 **Design:** Prospective cohort study.

12 **Setting:** Pregnant women were recruited through physicians' referrals, posters and newspaper
13 advertisements in the local and surrounding communities (hospital, maternity care clinic,
14 prenatal centers, sports centers, local university).

15 **Participants:** Fifty-nine pregnant women (33 SP and 26 FT) were assessed during the 1st, 2nd
16 and 3rd trimester of pregnancy.

17 **Primary and secondary outcome measures:** Pregnancy-related LPP prevalence and severity
18 (primary), trait and state anxiety, and physical activity levels (secondary).

19 **Results:** There was no relationship between the mode of conception and the outcome
20 measures. The prevalence and severity of LPP increased over the course of pregnancy (time
21 effect, $p < 0.0001$) whereas trait anxiety decreased from early to mid-pregnancy (time effect,
22 $p = 0.03$). Activity limitations increased throughout pregnancy (time effect, $p < 0.0001$) and
23 physical activity levels decreased (time effect, $p < 0.0001$). The severity of LPP was positively
24 correlated with activity limitations ($r = 0.51$ to 0.55) but negatively with physical activity
25 levels ($r = -0.39$ to -0.41).

1
2
3 1 **Conclusions:** Maternal health-related factors, such as LPP, anxiety and physical activity, are
4
5 2 not different in women who conceived spontaneously or after fertility treatments. The more
6
7 3 LPP was severe, the more the women were physically limited and inactive.
8
9 4

10
11 5 **Strengths and limitations of this study**
12

- 13
14 6 • This is a prospective cohort study of pregnant women who were assessed at each
15
16 7 trimester of pregnancy, allowing to determine the evolution of several maternal health-
17
18 8 related factors that are known to change over the course of pregnancy;
19
20 9 • Primary and secondary outcomes were collected using validated tools;
21
22 10 • The low number of women who achieved a pregnancy following *in vitro* fertilization
23
24 11 prevented us to fully test our hypotheses; thus larger studies are needed to better
25
26 12 understand whether IVF contribute to pregnancy-related LPP.
27
28 13 • More than half of the participants had a university degree, which is not representative of
29
30 14 our local population. The results may therefore not be broadly generalizable.
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 INTRODUCTION

2 More than 50% of women experience pain in the lumbopelvic area during pregnancy ¹. Low
3 back pain (LBP) is defined as pain localized below the ribs, but above the gluteal folds, with
4 or without radiation down the legs ², whereas pelvic girdle pain (PGP) is defined as pain
5 “experienced between the posterior iliac crest and the gluteal fold, particularly in the vicinity
6 of the sacroiliac joints. The pain may radiate in the posterior thigh and can also occur in
7 conjunction with/or separately in the symphysis” ¹. The term lumbopelvic pain (LPP) is used
8 when no distinction is made between PGP and LBP ³. Thus the wide range in the reported
9 prevalence of LPP in the literature (45–73%) ^{4 5} has been attributed to the different criteria
10 used to classify types and severity of pain, and the different periods during pregnancy LPP
11 was assessed. The onset of LPP varies considerably, between the end of the first trimester to
12 the first month post-delivery, with a peak of symptoms generally occurring between the 24th
13 and 36th weeks of pregnancy ⁶. Pregnancy-related LPP is a debilitating condition that is
14 known to affect women’s quality of life ⁷, with repercussions such as disruption of sleep,
15 increased psychological stress, social and sexual life and work capacity ^{4 7-10}. Pregnant women
16 experiencing LPP are also known to be less physically active during pregnancy ¹¹. Prenatal
17 physical activity is an important component of a healthy pregnancy ¹² and all women without
18 contraindication to exercise are encouraged to be regularly active throughout pregnancy to
19 benefit from it ^{13 14}. On the other hand, pregnancy-related LPP can contribute to maternal
20 physical inactivity and its associated maternal, fetal and neonatal complications ¹².

21 Several factors are believed to be involved in pregnancy-related LPP development, such as
22 degenerative metabolic, genetic, hormonal, and biomechanical factors/non-optimal joint
23 stability ^{1 6}. Another factor of interest is the mode of conception, in other words, naturally or
24 after fertility treatments. A study reported that pregnant women who underwent *in vitro*
25 fertilization (IVF) treatments had a two times higher prevalence rate of sacral pain in early

1 and late pregnancy, as well as a higher frequency of positive results on pelvic pain
2 provocation tests in late pregnancy¹⁵. The authors concluded that relaxin causes pelvic pain
3 because relaxin is higher in IVF pregnancies¹⁶. Another reason that might explain higher
4 pregnancy-related LPP prevalence in women who conceived after IVF is higher anxiety
5 levels. As reported by a systematic review, women who conceived following fertility
6 treatments had greater pregnancy-specific anxiety than those who conceived naturally¹⁷.
7 Based on a multi-center study including 1,158 women, higher levels of anxiety was reported
8 to be among the most notable factors associated with a higher likelihood of reporting LBP¹⁸.
9 However, to the best of our knowledge, no study has examined pregnancy-related LPP among
10 women who achieve pregnancy naturally or after fertility treatment, and whether anxiety is a
11 contributing factor to the development of LPP.

12 The primary objectives of this prospective cohort study were to determine the evolution of
13 LPP prevalence and severity, as well as anxiety, over the course of pregnancy in women who
14 conceived naturally or after fertility treatments, and to examine the possible relationship
15 between pregnancy-related LPP severity and anxiety levels. As pregnancy-related LPP has a
16 significant impact on the women's daily life, the secondary objective of our study was to
17 determine the evolution of physical activity behaviors throughout pregnancy and whether the
18 severity of LPP was correlated to these factors. Our primary hypotheses are that LPP
19 prevalence and severity, as well as anxiety levels will increase over the course of pregnancy
20 but more strongly in women who conceived after fertility treatments, and that pregnancy-
21 related LPP severity will be positively correlated with anxiety levels. As a result, our
22 secondary hypotheses are that activity limitations will increase whereas physical activity
23 behaviors will decrease over the course of pregnancy but more significantly in women who
24 conceived after fertility treatments, and that the severity of pregnancy-related LPP will be
25 positively correlated with activity limitations but negatively with physical activity behaviors.

1 MATERIALS AND METHODS

2 Study design and participants' selection

3 This is a prospective cohort study of pregnant women who were recruited between October
4 2015 and September 2016. Women who achieved a spontaneous pregnancy (SP group) and
5 women who achieved pregnancy following fertility treatments (FT group) were recruited
6 through physicians' and a clinic coordinator's referrals, posters and newspaper advertisements
7 in the local and surrounding communities (hospital, maternity care clinic, prenatal centers,
8 sports centers, local university). Women under 14 weeks of gestation, with a singleton
9 pregnancy and able to understand, speak and write French were considered eligible to
10 participate in the study. The study was approved by the local Research Ethics Committees
11 (CER-2015-003 and CER-15-214-07.10) and all participants provided their written informed
12 consent.

14 Outcome measures and measurement tools

15 Women were followed from the 1st trimester of pregnancy until delivery through three
16 evaluations (1st trimester [TR1]: 10–16 weeks, 2nd trimester [TR2]: 24–28 weeks and 3rd
17 trimester [TR3]: 32–36 weeks of gestation). In each trimester, a member of the research team
18 asked the women if they have had pregnancy-related LPP over the last 7 days or if they were
19 having LPP presently using the illustration provided in the French version of the Pelvic Girdle
20 Questionnaire (PGQ) ¹⁹. If a woman had or was having pregnancy-related LPP, she was asked
21 to rate pain intensity using a visual analog pain scale (VAS). This scale is a self-reported
22 measurement tool used by health professionals allowing the patient to rate pain from 0 (no
23 pain) to 10 (extreme pain) ²⁰.

24 The levels of anxiety was assessed during TR1, TR2 and TR3 using the French-Canadian
25 version ²¹ of the State-Trait Anxiety Inventory (STAI) ²². The STAI is a self-reported

1
2
3 1 questionnaire assessing the presence and severity of current symptoms of anxiety (state
4
5 2 anxiety scale) and a generalized propensity to be anxious (trait anxiety scale). Each scale is
6
7 3 based on 20 items on a four-point response scale. The range of score for each scale is 20-80,
8
9 4 the higher score indicating greater anxiety levels. The STAI has been widely used in research
10
11 5 with pregnant women and it does reflect the anxiety-related experiences of pregnant women.
12
13 6 Its use with pregnant women is therefore appropriate²³.

15 7 Activity limitations and symptoms associated with pregnancy-related LPP were assessed in
16
17 8 TR2 and TR3 using the completed the French-Canadian version of the PGQ was used¹⁹. The
18
19 9 PGQ is a condition-specific measure developed for pregnant and postpartum women. It
20
21 10 consists of 20 activity items and five symptom items on a four-point response scale and
22
23 11 assesses activity limitations and symptoms associated with pain in the lumbopelvic region.
24
25 12 The range of score is 0-100%, with a higher score indicating greater activity limitations and
26
27 13 symptoms. The PGQ is reliable and valid for both pregnant and postpartum women with
28
29 14 pregnancy-related LPP²⁴.

32
33 15 Finally, physical activity levels were objectively measured at each trimester of pregnancy
34
35 16 using the ActiGraph GT3X (ActiGraph, Pensacola, FL), a triaxial accelerometer measuring
36
37 17 data in a 60-s epoch. The women were instructed to wear the monitor over the hip on an
38
39 18 elastic belt for seven consecutive days from wake-up time to bedtime. They were allowed to
40
41 19 remove the accelerometer when sleeping, showering or engaging in water activities.
42
43 20 Furthermore, the women received a daily diary to document wear and non-wear time periods
44
45 21 and water activities. According to the method used in the Canadian Health Measures Survey,
46
47 22 valid data were defined as \geq four days of monitoring for \geq 10 hours of wear time per day²⁵.

48
49
50 23 Pregnant women were encouraged to maintain their usual activities. Data were processed
51
52 24 using the Actilife software version 6.13.2 (ActiGraph, LLC, FL, USA). The accelerometer
53
54 25 data obtained were averaged across valid wear days. To derive the activity frequency,
55
56
57
58
59
60

1 intensity and duration of the measured activity in counts per minute per day, the Freedson
2 equation was used: sedentary (<100 counts), light (100–1951 counts), moderate (1952–5724),
3 vigorous (5725–9498), and very vigorous (>9498)²⁶, as previously used in pregnant women
4²⁷. Non-wear time was defined as a period of zero counts for ≥ 60 consecutive minutes,
5 admitting a maximum of two consecutive minutes between 1 and 100 counts/min. When a
6 third observation was between 1 and 100 counts or one observation was more than 100
7 counts, the non-wear period was ended. Bouts of moderate-to-vigorous physical activity
8 (MVPA) was defined as a minimum of 10 consecutive minutes above 1952 counts and ended
9 with more than two consecutive records below this threshold.

10 **Patient and Public Involvement**

11 Patients and public were not involved in the design and conduct of this study. The results will
12 not be disseminated to study participants.

13 **Statistical analysis**

14 Means and standard deviations, as well as percentages, were computerized for variables of
15 interest. Student t-test was used to compare socio-demographic and anthropometric
16 characteristics between SP and FT women. For categorical variables, the χ square test was
17 used. The MIXED procedure of SAS was used to test the effect of time (trimesters), group
18 (SP and FT women) and potential interaction effects on the outcome measures (i.e. the
19 severity of pregnancy-related LPP and anxiety levels [objective 1], and physical activity
20 behaviors [objective 2]). The assumption of sphericity was tested using Mauchly's Test of
21 Sphericity. Variables that did not meet the sphericity assumption were analyzed following a
22 Geisser Greenhouse correction. When a significant effect of time, group or interaction effect
23 was found, post-hoc analyses were conducted using the Tukey test. To test whether the
24 severity of pregnancy-related LPP was correlated to the levels of anxiety (objective 1), and
25
26

1 physical activity behaviors (objective 2) at each trimester of pregnancy, Pearson's correlation
2 analyses were used. Statistical analyses were performed by using the SAS software (Institute,
3 Cary, NC, version 9.4) and the level of significance was set to $p\text{-value} \leq 0.05$.

4 5 **RESULTS**

6 Between October 2015 and September 2016, the study was presented by physicians or to 117
7 eligible pregnant women, among which 62 women accepted to participate. Reasons for not
8 agreeing to participate to the study were lack of interest or lack of time. Three women (1 in
9 SP group and 2 in FT group) were excluded due to loss to follow-up (n=1), miscarriage (n=1)
10 or missing data (n=1), leaving 59 women (33 SP and 26 FT) for the statistical analyses.

11 The characteristics of pregnant women are presented in **Table 1**. No significant difference in
12 socio-demographic and pre-pregnancy anthropometric characteristics was found between the
13 groups ($p>0.05$). Women were on average in their early thirties and approximately half of
14 them were nulliparous. More than half were of normal weight pre-pregnancy (BMI 18.5-24.9
15 kg/m^2) and had a university degree. Women's LPP history, related or not to a previous
16 pregnancy, was also similar between the groups, with approximately 50% of the women
17 reporting a history of LPP (**Table 1**). Finally, the prevalence and severity of pregnancy-
18 related LPP, anxiety and physical activity levels were not different between SP and FT
19 pregnant women at study entry (**Table 1**). Data showed that on average, women considered
20 LPP as moderate (4/10) and were slightly anxious (35/80). Moreover, based on daily steps
21 and physical activity recommendations^{28 29}, our population was considered inactive.

22 In our study, a total of 8 (13.5%), 8 (13.5%) and 9 (15%) women removed the accelerometer
23 to do water activities (aqua gym, swimming or bathing) during TR1, TR2 and TR3,
24 respectively. The accelerometer was removed between 1 and 5 times during the evaluation
25 period, and for 10 to 225 minutes. Furthermore, physical activity data was missing for 10

1 (17%), 7 (12%) and 8 (14%) women at TR1, TR2 and TR3, respectively, because those
2 women did not wear the accelerometer for at least 10 hours per day for at least four days.
3 The prevalence of pregnancy-related LPP was similar in both groups during each trimester of
4 pregnancy (TR1: $\chi^2 = 2.19$, $p=0.33$; TR2: $\chi^2 = 2.13$, $p=0.33$; TR3: $\chi^2 = 0.01$, $p=0.92$); the
5 pooled prevalence increased from 42% during TR1 to 65% during TR2 to 68% during TR3
6 ($\chi^2 = 8.45$; $p=0.01$) (**Fig 1**). Among women presenting with pregnancy-related LPP at one
7 time point during pregnancy ($n=44$, 26 SP and 18 FT), pain severity significantly increased
8 over the course of pregnancy in both groups (time effect: $F=14.81$, $p<0.0001$. **Fig 2**), with
9 pain severity being significantly higher during TR2 and TR3 compared to TR1. Trait anxiety
10 decreased over the course of pregnancy in both groups (time effect: $F=3.93$, $p<0.03$. **Fig 3**),
11 with lower levels during TR2 compared to TR1, whereas state anxiety did not significantly
12 change (**Fig 4**). Finally, activity limitations associated with pregnancy-related LPP increased
13 (time effect: $F=18.82$, $p<0.0001$. **Fig 5**) whereas daily steps decreased over the course of
14 pregnancy in both groups (time effect: $F=16.03$, $p<0.0001$. **Fig 6**). The only time by group
15 interaction effect was found for daily MVPA (time effect: $F=13.11$, $p<0.0001$; time*group
16 interaction effect: $F=3.38$, $p=0.04$. **Fig 7**), with daily MVPA being lower in TR3 compared to
17 TR1 and TR2 only in SP women.

18 Since changes in the severity of pregnancy-related LPP, levels of anxiety, and physical
19 activity behaviors were similar between the groups, result from SP and FT women were
20 pooled in the correlation analyses. Among women who presented with pregnancy-related
21 LPP, no correlation was found during TR1 between the severity of pregnancy-related LPP
22 and anxiety or physical activity levels. During TR2, the severity of pregnancy-related LPP
23 was positively correlated with activity limitations ($r=0.51$, $p=0.001$, **Fig 8**) but negatively
24 with daily steps ($r=-0.39$, $p=0.03$, **Fig 9**). No correlation was found with daily MVPA (**Fig**
25 **10**). During TR3, we found a positive correlation between the severity of pregnancy-related

1 LPP and activity limitations ($r=0.55$, $p=0.0002$, **Fig 11**) and a negative correlation with daily
2 MVPA ($r=-0.41$, $p=0.02$, **Fig 12**). No correlation was found with daily steps (**Fig 13**).

4 **DISCUSSION**

5 To the best of our knowledge, this is the first cohort study assessing the course of pregnancy-
6 related LPP prevalence and severity in pregnant women who conceived naturally and after
7 fertility treatments, and possible association with anxiety levels and physical activity
8 behaviors. Overall, our primary results showed no differences in LPP prevalence and severity,
9 or anxiety levels between women who achieved a pregnancy naturally or after fertility
10 treatments. As expected, the prevalence and severity of LPP increased over the course of
11 pregnancy and were of similar magnitude than that reported in previous studies^{10,18}. Anxiety
12 levels decreased from early to mid-pregnancy and were not correlated to the severity of LPP.

13 Only one study examined the evolution of the prevalence and severity of pregnancy-related
14 PGP (PPGP) according to the mode of conception¹⁵. This study was conducted in 31 women
15 who conceived after IVF and 200 women who conceived spontaneously and assessed PGP at
16 12, 24 and 34 weeks of pregnancy. The authors found an increase in PPGP prevalence and
17 severity over the course of pregnancy in all women, as we and other authors did³⁰. However,
18 they reported a two times higher rate of PPGP in early and late pregnancy in women who
19 achieved a pregnancy after IVF compared to those who achieved a pregnancy naturally but
20 similar severity of PPGP¹⁵. Importantly, many IVF women carried multiple pregnancies in
21 that study. Given that relaxin levels are higher after IVF¹⁶ and that the number of fetuses is
22 higher after IVF, and given that the mechanical load is higher in twin pregnancies, it is
23 difficult to establish what causes higher rates of PPGP after IVF in this previous study.

24 Our hypothesis was that higher anxiety levels reported in women who conceived after fertility
25 treatments¹⁷ would contribute to higher pregnancy-related LPP prevalence and severity in

1 this population of pregnant women. However, we did not find any difference in anxiety levels
2 between women who conceived after fertility treatments and those who conceived naturally.
3 Several reasons may explain our result. First, the majority of women included in our sample
4 conceived after ovarian stimulation (OS, n=7) or intrauterine insemination (IUI, n=12),
5 whereas the majority of studies included in Gourounti's review reporting higher anxiety in
6 women who conceived following fertility treatments were conducted in the context of IVF¹⁷.
7 Because the medical surveillance is more frequent and the procedure more invasive in the
8 context of IVF, it is likely that IVF generates more anxiety than OS and IUI. This might
9 partially explain why we found no differences in anxiety levels in our sample.

10 When examining anxiety levels over the course of pregnancy, we found a U-shaped curve,
11 with a significant decrease in anxiety from TR1 to TR2 and a non-significant trend toward an
12 increase from TR2 to TR3. These findings are similar to those of previous studies^{31 32}. In
13 contrast, whereas some studies reported higher anxiety in pregnant women with LBP or PGP
14^{18 33}, we found no correlation between anxiety levels and LPP severity. Our findings suggest
15 that in our sample, anxiety and LPP were two independent phenomena.

16 Likewise, our secondary results showed no relationship between the mode of conception and
17 physical limitations and physical activity behaviors, except for MVPA during TR3. The
18 decrease in MVPA observed only in women who conceived naturally needs further
19 investigation. Similarly to previous studies³⁴⁻³⁷, we found that with advancing pregnancy,
20 physical limitations increased³⁶⁻³⁸ and physical activity behaviors decreased^{34 35 39}. Our data
21 further showed that the greater pregnancy-related LPP severity the greater physical limitation
22 and lower physical activity levels in mid- and late pregnancy. These results are also in
23 accordance with previous studies reporting decreased physical activity levels as physical
24 limitations and low back pain increase with advancing pregnancy^{36 40}.

25 26 **Limitations**

1
2
3 1 The strength of our study is its longitudinal design that allowed us to examine the evolution of
4
5 2 several maternal health-related factors that are known to change over the course of pregnancy,
6
7 3 in the context of spontaneous pregnancies and pregnancies achieved following FT. Moreover,
8
9 4 our study adds knowledge about the relationship between pregnancy-related LPP severity and
10
11 5 physical activity behaviors. However, the current study has limitations that should be
12
13 6 acknowledged. First, our sample was heterogeneous with regards to fertility treatments used
14
15 7 to achieve a pregnancy, with the majority of women having conceived after OS or IUI. This
16
17 8 may explain the lower prevalence of PPGP and anxiety levels in women who conceived after
18
19 9 fertility treatments. The low number of women who achieved a pregnancy following IVF
20
21 10 prevented us to fully test our hypotheses and further larger studies are needed to better
22
23 11 understand whether IVF contribute to pregnancy-related. Second, more than half of the
24
25 12 women we recruited had a university degree, which is more than in our local population
26
27 13 (22.5%)⁴¹. This suggests a possible recruitment bias and limits the generalizability of our
28
29 14 results. Third, although accelerometers provide a valid and objective measure of physical
30
31 15 activity levels, non-waterproof accelerometers underestimate several types of physical
32
33 16 activity, such as water activities. In our data set, several women removed the accelerometer to
34
35 17 do water activities (aqua gym, swimming or bathing) during TR1, TR2 and TR3, suggesting
36
37 18 that we possibly underestimated the level of physical activity of these women. We also had
38
39 19 missing physical activity data because some women did not wear the accelerometer for at
40
41 20 least 10 hours per day for at least four days. Finally, physical activity levels were assessed
42
43 21 only for a seven-day period during each trimester of pregnancy. Given that each trimester
44
45 22 lasts for more than a week, the data obtained and the results reported in relation to physical
46
47 23 activity levels do not truly reflect the evolution of physical activity levels over each trimester
48
49 24 and over the entire course of pregnancy. Nevertheless, the majority of the women stated in the
50
51
52
53
54
55
56
57
58
59
60

1
2
3 1 daily diary that their physical activity behavior over the seven-day period of evaluation
4
5 2 reflected their habitual behaviors.
6

7 3

9 4 **CONCLUSION**

11 5 In conclusion, our findings suggest that maternal health-related factors, such as LPP, anxiety
12
13 6 and physical activity behaviors, are not different in women who conceived after fertility
14
15 7 treatments and those who conceived spontaneously. The lack of correlation between the
16
17 8 severity of pregnancy-related LPP and anxiety levels suggests that they are two independent
18
19 9 phenomena. The increase in LPP severity and activity limitations, and decrease in physical
20
21 10 activity behaviors with advancing gestation, and the fact that the more severe LPP the greater
22
23 11 activity limitations and physical inactivity in mid- and late pregnancy underline the
24
25 12 importance of pregnancy-related LPP management to allow pregnant women performing their
26
27 13 daily activities.
28
29

30
31 14

32
33 15
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 1 **Acknowledgments:** The authors would like to acknowledge and thank Sophie Drouin, the
4
5 2 coordinator of the fertility clinic, as well as the medical team who assisted with the
6
7 3 recruitment, and all the women who participated to the project.
8
9 4

10
11 5 **Funding:** This study was funded by a start-up grant from the Univeristé du Québec à Trois-
12
13 6 Rivières (Institutional funds for research).
14
15 7

16
17
18 8 **Declaration of conflicting interests:** The authors declare that there is no conflict of interest.
19
20 9

21
22 10 **Author Contributions:** SMR, MD, VB contributed to the study concept and design; EL and
23
24 11 AStL acquired the data; SMR, MD, EL performed the statistical analysis and interpreted the
25
26 12 data; EL and SMR drafted the manuscript; MD, AStL and VB critically reviewed the
27
28 13 manuscript for important intellectual content. All authors read and approved the final
29
30 14 manuscript.
31
32 15

33
34
35 16 **Competing interests:** None declared.
36
37 17

38
39 18 **Ethics approval:** The study was approved by the local Research Ethics Committees (CER-
40
41 19 2015-003 and CER-15-214-07.10)
42
43 20

44
45
46 21 **Data sharing statement:** No additional data are available.
47
48 22
49
50
51
52
53
54
55
56
57
58
59
60

1 References

- 1 2 1. Vleeming A, Albert HB, Ostgaard HC, et al. European guidelines for the diagnosis and
3 4 treatment of pelvic girdle pain. *Eur Spine J* 2008;17(6):794-819. doi: 10.1007/s00586-008-
5 6 0602-4 [published Online First: 2008/02/09]
- 7 8 2. van Tulder M, Becker A, Bekkering T, et al. Chapter 3. European guidelines for the
9 10 management of acute nonspecific low back pain in primary care. *Eur Spine J* 2006;15 Suppl
11 12 2:S169-91. doi: 10.1007/s00586-006-1071-2
- 13 14 3. Wu WH, Meijer OG, Uegaki K, et al. Pregnancy-related pelvic girdle pain (PPP), I:
15 16 Terminology, clinical presentation, and prevalence. *Eur Spine J* 2004;13(7):575-89. doi:
17 18 10.1007/s00586-003-0615-y [published Online First: 2004/09/01]
- 19 20 4. Gutke A, Ostgaard HC, Oberg B. Pelvic girdle pain and lumbar pain in pregnancy: a cohort
21 22 study of the consequences in terms of health and functioning. *Spine (Phila Pa 1976)*
23 24 2006;31(5):E149-55. doi: 10.1097/01.brs.0000201259.63363.e1 [published Online First:
25 26 2006/03/02]
- 27 28 5. Mogren IM, Pohjanen AI. Low back pain and pelvic pain during pregnancy: prevalence
29 30 and risk factors. *Spine (Phila Pa 1976)* 2005;30(8):983-91. [published Online First:
31 32 2005/04/19]
- 33 34 6. Kanakaris NK, Roberts CS, Giannoudis PV. Pregnancy-related pelvic girdle pain: an
35 36 update. *BMC Med* 2011;9:15. doi: 10.1186/1741-7015-9-15 [published Online First:
37 38 2011/02/18]
- 39 40 7. Olsson C, Nilsson-Wikmar L. Health-related quality of life and physical ability among
41 42 pregnant women with and without back pain in late pregnancy. *Acta Obstet Gynecol Scand*
43 44 2004;83(4):351-57. [published Online First: 2004/03/10]
- 45 46 8. Elden H, Lundgren I, Robertson E. Life's pregnant pause of pain: pregnant women's
47 48 experiences of pelvic girdle pain related to daily life: a Swedish interview study. *Sex Reprod*
49 50 *Healthc* 2013;4(1):29-34. doi: 10.1016/j.srhc.2012.11.003
- 51 52 9. Mogren I. Perceived health, sick leave, psychosocial situation, and sexual life in women
53 54 with low-back pain and pelvic pain during pregnancy. *Acta Obstet Gynecol Scand*
55 56 2006;85(6):647-56. doi: 10.1080/00016340600607297 [published Online First: 2006/06/06]
- 57 58 10. Wang SM, Dezinno P, Maranets I, et al. Low back pain during pregnancy: prevalence,
59 60 risk factors, and outcomes. *Obstet Gynecol* 2004;104(1):65-70. doi:
10.1097/01.AOG.0000129403.54061.0e [published Online First: 2004/07/02]
11. Owe KM, Nystad W, Bo K. Correlates of regular exercise during pregnancy: the
Norwegian Mother and Child Cohort Study. *Scand J Med Sci Sports* 2009;19(5):637-45. doi:
10.1111/j.1600-0838.2008.00840.x [published Online First: 2008/07/17]

- 1
2
3 1 12. Mudd LM, Owe KM, Mottola MF, et al. Health benefits of physical activity during
4 2 pregnancy: an international perspective. *Med Sci Sports Exerc* 2013;45(2):268-77. doi:
5 3 10.1249/MSS.0b013e31826cebc [published Online First: 2012/08/17]
6
7 4 13. Davies GA, Wolfe LA, Mottola MF, et al. Exercise in pregnancy and the postpartum
8 5 period. *Journal of obstetrics and gynaecology Canada : JOGC = Journal d'obstetrique et*
9 6 *gynecologie du Canada : JOGC* 2003;25(6):516-29. [published Online First: 2003/06/14]
11
12 7 14. ACOG Committee Opinion No. 650: Physical Activity and Exercise During Pregnancy
13 8 and the Postpartum Period. *Obstet Gynecol* 2015;126(6):e135-42. doi:
14 9 10.1097/aog.0000000000001214 [published Online First: 2015/11/26]
15
16 10 15. Kristiansson P, Nilsson-Wikmar L, von Schoultz B, et al. Back pain in in-vitro fertilized
17 11 and spontaneous pregnancies. *Hum Reprod* 1998;13(11):3233-8. [published Online First:
18 12 1998/12/16]
19
20 13 16. Kristiansson P, Svardsudd K, von Schoultz B, et al. Supraphysiological serum relaxin
21 14 concentration during pregnancy achieved by in-vitro fertilization is strongly correlated to the
22 15 number of growing follicles in the treatment cycle. *Hum Reprod* 1996;11(9):2036-40.
23
24 16 17. Gourounti K. Psychological stress and adjustment in pregnancy following assisted
25 17 reproductive technology and spontaneous conception: A systematic review. *Women Health*
26 18 2015:1-21. doi: 10.1080/03630242.2015.1074642 [published Online First: 2015/07/28]
27
28 19 18. Kovacs FM, Garcia E, Royuela A, et al. Prevalence and factors associated with low back
29 20 pain and pelvic girdle pain during pregnancy: a multicenter study conducted in the Spanish
30 21 National Health Service. *Spine (Phila Pa 1976)* 2012;37(17):1516-33. doi:
31 22 10.1097/BRS.0b013e31824dcb74 [published Online First: 2012/02/16]
32
33 23 19. Girard MP, Marchand AA, Stuge B, et al. Cross-cultural Adaptation of the Pelvic Girdle
34 24 Questionnaire for the French-Canadian Population. *J Manipulative Physiol Ther*
35 25 2016;39(7):494-9. doi: 10.1016/j.jmpt.2016.06.002 [published Online First: 2016/08/19]
36
37 26 20. Ostelo RW, Deyo RA, Stratford P, et al. Interpreting change scores for pain and
38 27 functional status in low back pain: towards international consensus regarding minimal
39 28 important change. *Spine (Phila Pa 1976)* 2008;33(1):90-4. doi:
40 29 10.1097/BRS.0b013e31815e3a10 [published Online First: 2008/01/01]
41
42 30 21. Gauthier J, Bouchard S. Adaptation canadienne-française de la forme révisée du State-
43 31 Trait Anxiety Inventory de Spielberg. *Canadian Journal of Behavioral Sciences* 1990;25
44 32 (4):559-89. [published Online First: 1993/10]
45
46 33 22. Spielberger CD. Manual for the State-Trait Anxiety Inventory (Form Y): Palo Alto:
47 34 Consulting Psychologist Press 1983.

- 1
2
3 1 23. Gunning MD, Denison FC, Stockley CJ, et al. Assessing maternal anxiety in pregnancy
4 2 with the State - Trait Anxiety Inventory (STAI): issues of validity, location and participation.
5 3 *Journal of Reproductive and Infant Psychology* 2010;28(3):266-73.
6
7
8 4 24. Stuge B, Garratt A, Krogstad Jenssen H, et al. The pelvic girdle questionnaire: a
9 5 condition-specific instrument for assessing activity limitations and symptoms in people with
10 6 pelvic girdle pain. *Phys Ther* 2011;91(7):1096-108. doi: 10.2522/ptj.20100357 [published
11 7 Online First: 2011/05/21]
12
13 8 25. Colley RC, Garriguet D, Janssen I, et al. Activité physique des adultes au Canada:
14 9 résultats d'accélérométrie de l'Enquête Canadienne sur les mesures de la santé de 2007-2009.
15 10 *Statistique Canada Rapports sur la santé* 2011
16
17
18 11 26. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and
19 12 Applications, Inc. accelerometer. *Med Sci Sports Exerc* 1998;30(5):777-81. [published Online
20 13 First: 1998/05/20]
21
22
23 14 27. Harrison CL, Thompson RG, Teede HJ, et al. Measuring physical activity during
24 15 pregnancy. *Int J Behav Nutr Phys Act* 2011;8:19. doi: 10.1186/1479-5868-8-19
25
26 16 28. Tudor-Locke C, Bassett DR, Jr. How many steps/day are enough? Preliminary pedometer
27 17 indices for public health. *Sports Med* 2004;34(1):1-8.
28
29
30 18 29. Evenson KR, Mottola MF, Owe KM, et al. Summary of international guidelines for
31 19 physical activity after pregnancy. *Obstet Gynecol Surv* 2014;69(7):407-14. doi:
32 20 10.1097/OGX.0000000000000077
33
34 21 30. Kristiansson P, Svardsudd K, von Schoultz B. Back pain during pregnancy: a prospective
35 22 study. *Spine (Phila Pa 1976)* 1996;21(6):702-9. [published Online First: 1996/03/15]
36
37
38 23 31. Lee AM, Lam SK, Sze Mun Lau SM, et al. Prevalence, course, and risk factors for
39 24 antenatal anxiety and depression. *Obstet Gynecol* 2007;110(5):1102-12. doi:
40 25 10.1097/01.AOG.0000287065.59491.70
41
42
43 26 32. Teixeira C, Figueiredo B, Conde A, et al. Anxiety and depression during pregnancy in
44 27 women and men. *J Affect Disord* 2009;119(1-3):142-8. doi: 10.1016/j.jad.2009.03.005
45 28 [published Online First: 2009/04/07]
46
47
48 29 33. Elden H, Gutke A, Kjellby-Wendt G, et al. Predictors and consequences of long-term
49 30 pregnancy-related pelvic girdle pain: a longitudinal follow-up study. *BMC Musculoskelet*
50 31 *Disord* 2016;17:276. doi: 10.1186/s12891-016-1154-0
51
52 32 34. Evenson KR, Wen F. Prevalence and correlates of objectively measured physical activity
53 33 and sedentary behavior among US pregnant women. *Prev Med* 2011;53(1-2):39-43. doi:
54 34 10.1016/j.ypmed.2011.04.014
55
56
57
58
59

- 1
2
3 1 35. Rousham EK, Clarke PE, Gross H. Significant changes in physical activity among
4 2 pregnant women in the UK as assessed by accelerometry and self-reported activity. *Eur J Clin*
5 3 *Nutr* 2006;60(3):393-400.
6
7
8 4 36. Cramp AG, Bray SR. A prospective examination of exercise and barrier self-efficacy to
9 5 engage in leisure-time physical activity during pregnancy. *Ann Behav Med* 2009;37(3):325-
10 6 34. doi: 10.1007/s12160-009-9102-y
11
12 7 37. Robinson HS, Veierod MB, Mengshoel AM, et al. Pelvic girdle pain--associations
13 8 between risk factors in early pregnancy and disability or pain intensity in late pregnancy: a
14 9 prospective cohort study. *BMC Musculoskelet Disord* 2010;11:91. doi: 10.1186/1471-2474-
15 10 11-91
16
17
18 11 38. Chang HY, Lai YH, Jensen MP, et al. Factors associated with low back pain changes
19 12 during the third trimester of pregnancy. *J Adv Nurs* 2014;70(5):1054-64. doi:
20 13 10.1111/jan.12258
21
22
23 14 39. Downs DS, LeMasurier GC, DiNallo JM. Baby steps: pedometer-determined and self-
24 15 reported leisure-time exercise behaviors of pregnant women. *J Phys Act Health* 2009;6(1):63-
25 16 72.
26
27 17 40. Poston L, Briley AL, Barr S, et al. Developing a complex intervention for diet and activity
28 18 behaviour change in obese pregnant women (the UPBEAT trial); assessment of behavioural
29 19 change and process evaluation in a pilot randomised controlled trial. *BMC Pregnancy*
30 20 *Childbirth* 2013;13:148. doi: 10.1186/1471-2393-13-148
31
32
33 21 41. Statistics Canada. Labour Force Survey, special compilation, adapted by the Institut de la
34 22 statistique du Québec., July 14, 2017.
35 23
36
37 24
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Table 1:** Baseline characteristics of the 59 pregnant women included in study.

Variables	FT (n=26) Means \pm SD	SP (n=33) Means \pm SD	P values
Fertility treatments	OS=7 IUI=12 IVF=7	-	
Age (years)	32.2 \pm 3.6	30.9 \pm 4.2	0.23
Parity	0.4 \pm 0.6	0.6 \pm 0.6	0.36
0 (n)	57.7% (15)	45.5% (15)	0.35
\geq 1 (n)	42.3% (11)	54.6% (18)	
Pre-pregnancy BMI (kg/cm ²)	26.3 \pm 7.3	25.2 \pm 6.6	0.54
Underweight <18.4	0% (0)	3.1% (1)	0.81
Normal weight (18.5-24.9)	60.0 (15)	62.5% (20)	
Overweight (25.0-29.9)	20.0 (5)	18.8% (6)	
Obese \geq 30.0	20.0%(5)	15.6% (5)	
Education levels			
Non-university degree	42.3% (11)	33.3% (11)	0.48
University degree	57.7% (15)	66.7% (22)	
LPP history (yes) ¹	46.2% (12)	54.6% (18)	0.52
Prevalence of pregnancy-related LPP over the last week (yes)	34.6% (9)	48.5% (16)	0.33
Severity of pregnancy-related LPP over the last week	2.9 \pm 1.9	4.1 \pm 2.3	0.18
State anxiety	37.4 \pm 11.6	34.2 \pm 9.1	0.28
Trait anxiety	39.8 \pm 10.0	37.1 \pm 9.4	0.26
Daily steps	5328 \pm 1551	5569 \pm 1552	0.80
Daily MVPA (min)	16.3 \pm 10.0	17.4 \pm 13.2	0.97

FT: fertility treatment; SP: spontaneous conception; OS: ovarian stimulation; IUI: intrauterine insemination; IVF: *in vitro* fertilization; BMI : body mass index; LPP : lumbopelvic pain; MVPA: moderate-to-vigorous physical activity

¹ LPP history includes history of pregnancy-related LPP and LPP not related to pregnancy

Missing data: pre-pregnancy BMI: 1 FT, 1 SP; state and trait anxiety : 1 SP; accelerometer data: 4 SP; 6 FT

2

3

1
2
3 **1 Figure legend**
4

5 2

6
7 **3 Figure 1:** Prevalence of pregnancy-related lumbopelvic pain (LPP) in women who conceived
8 spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.
9

10 **5 Figure 1 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
11 trimester of pregnancy.
12
13

14 7

15
16
17
18 **8 Figure 2:** Evolution of pregnancy-related lumbopelvic pain (LPP) severity in women who
19 conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.
20

21
22 **10 Figure 2 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
23 trimester of pregnancy.
24
25

26 12

27
28
29 **13 Figure 3:** Evolution of trait anxiety in women who conceived spontaneously (SP) or after
30 fertility treatments (FT) over the course of pregnancy.
31

32
33 **15 Figure 3 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
34 trimester of pregnancy.
35
36

37 17

38
39
40 **18 Figure 4:** Evolution of state anxiety in women who conceived spontaneously (SP) or after
41 fertility treatments (FT) over the course of pregnancy.
42

43
44 **20 Figure 4 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
45 trimester of pregnancy.
46
47

48 22

49
50 **23 Figure 5:** Evolution of activity limitations in women who conceived spontaneously (SP) or
51 after fertility treatments (FT) over the course of pregnancy.
52
53

54 24

1
2
3 1 **Figure 5 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
4 trimester of pregnancy.
5
6

7 3

8
9 4 **Figure 6:** Evolution of daily moderate-to-vigorous physical activity (MVPA) in women who
10 conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.
11
12

13 6 **Figure 6 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
14 trimester of pregnancy.
15
16

17 8

18
19 9 **Figure 7:** Evolution of daily step counts in women who conceived spontaneously (SP) or
20 after fertility treatments (FT) over the course of pregnancy.
21
22

23 11 **Figure 7 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
24 trimester of pregnancy.
25
26

27 13

28
29 14 **Figure 8:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
30 activity limitations in the 2nd trimester of pregnancy (TR2).
31
32

33 16

34
35 17 **Figure 9:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
36 daily moderate-to-vigorous physical activity (MVPA) in the 2nd trimester of pregnancy (TR2).
37
38

39 19

40
41 20 **Figure 10:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
42 daily step counts in the 2nd trimester of pregnancy (TR2).
43
44

45 22

46
47 23 **Figure 11:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
48 activity limitations in the 3rd trimester of pregnancy (TR3).
49
50

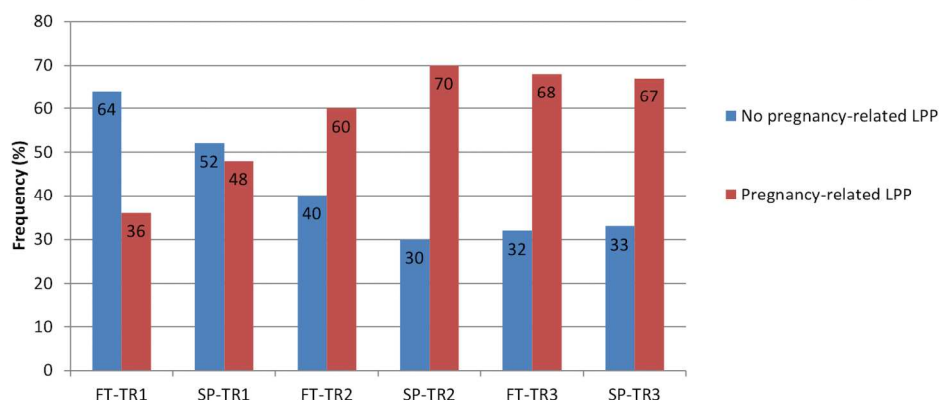
51 25

1
2
3 1 **Figure 12:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
4
5 2 daily moderate-to-vigorous physical activity (MVPA) in the 3rd trimester of pregnancy (TR3).
6

7 3
8
9 4 **Figure 13:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
10
11 5 daily step counts in the 3rd trimester of pregnancy (TR3).
12

13 6
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

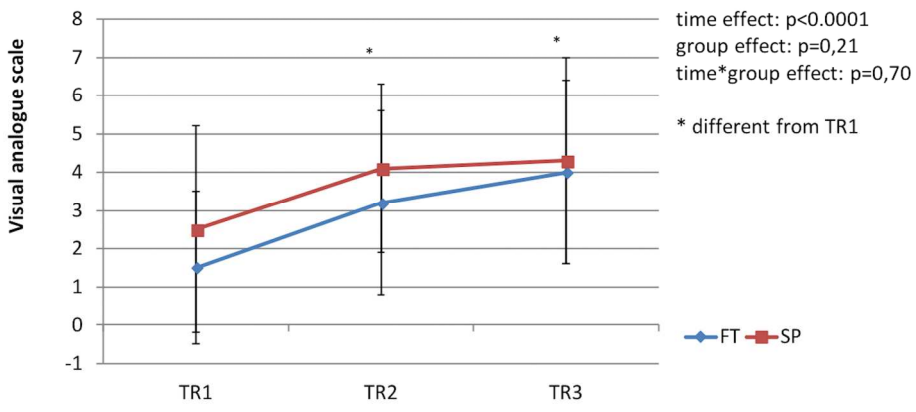


Prevalence of pregnancy-related lumbopelvic pain (LPP) in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

263x132mm (300 x 300 DPI)

review only

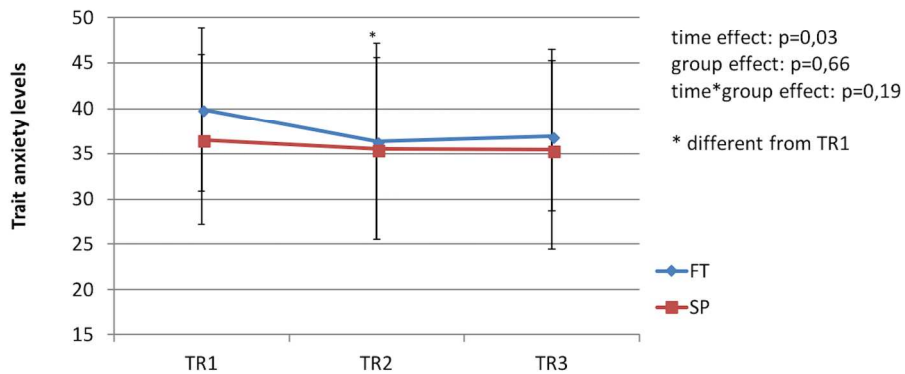
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Evolution of pregnancy-related lumbopelvic pain (LPP) severity in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

223x119mm (300 x 300 DPI)

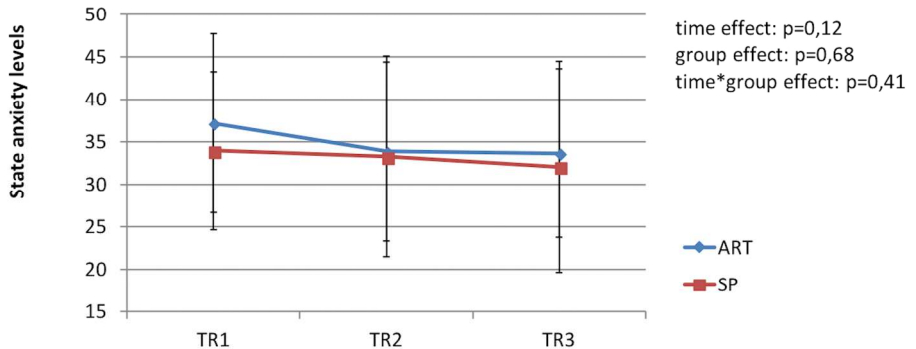
review only



Evolution of trait anxiety in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

227x101mm (300 x 300 DPI)

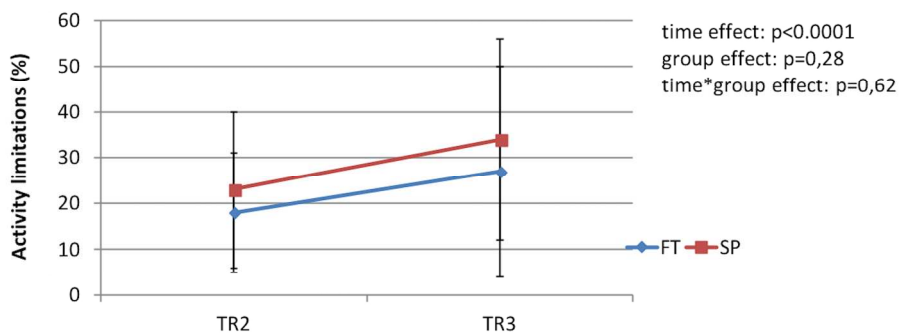
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Evolution of state anxiety in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

227x101mm (300 x 300 DPI)

er review only

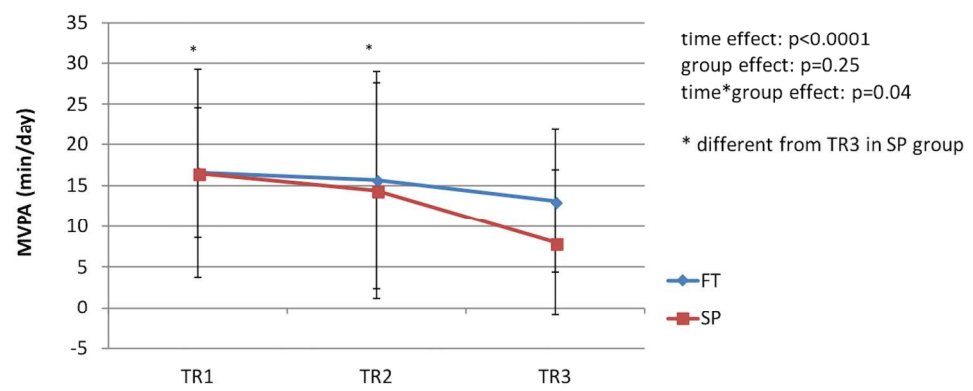


Evolution of activity limitations in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

223x128mm (300 x 300 DPI)

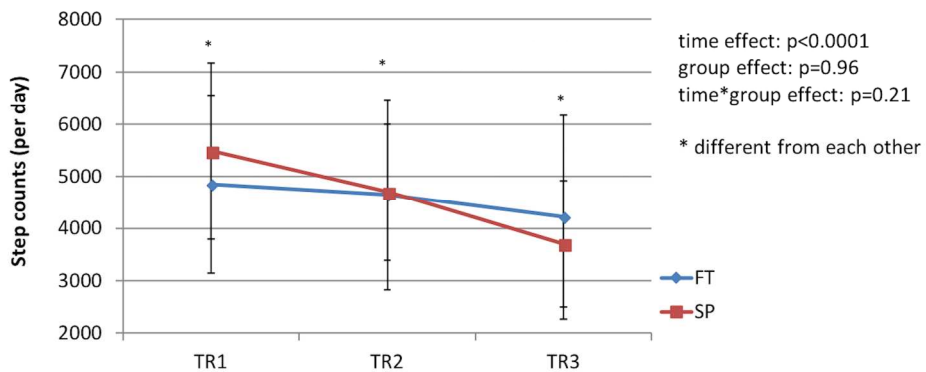
review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Evolution of daily moderate-to-vigorous physical activity (MVPA) in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

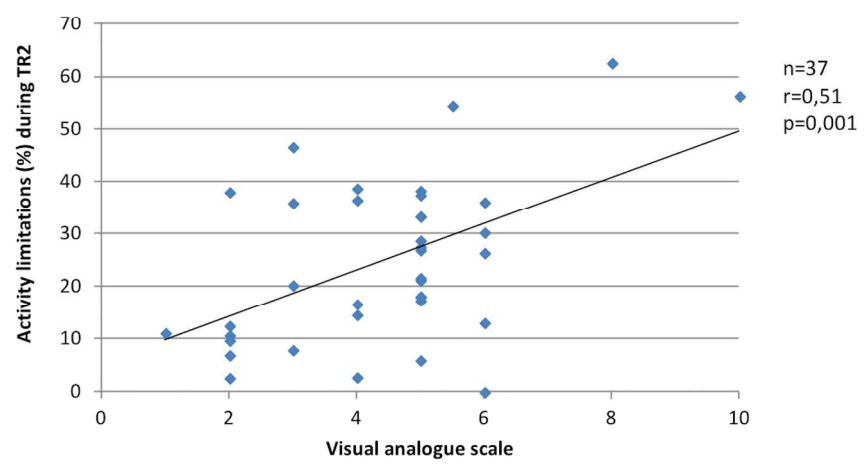
227x104mm (300 x 300 DPI)



Evolution of daily step counts in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

225x106mm (300 x 300 DPI)

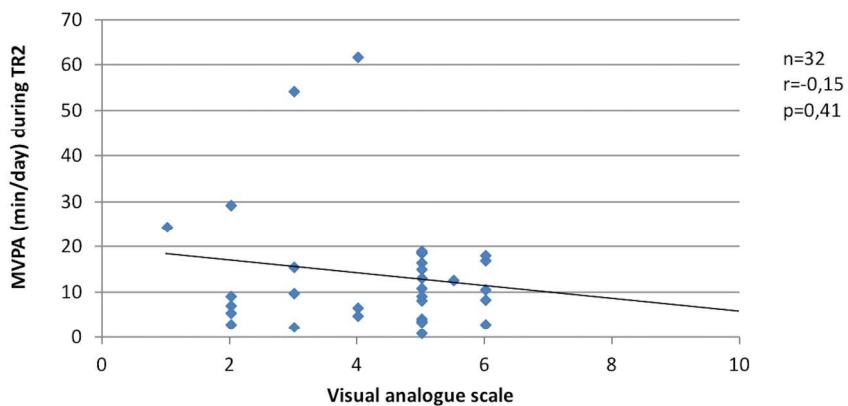
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and activity limitations in the 2nd trimester of pregnancy (TR2).

232x133mm (300 x 300 DPI)

Review only

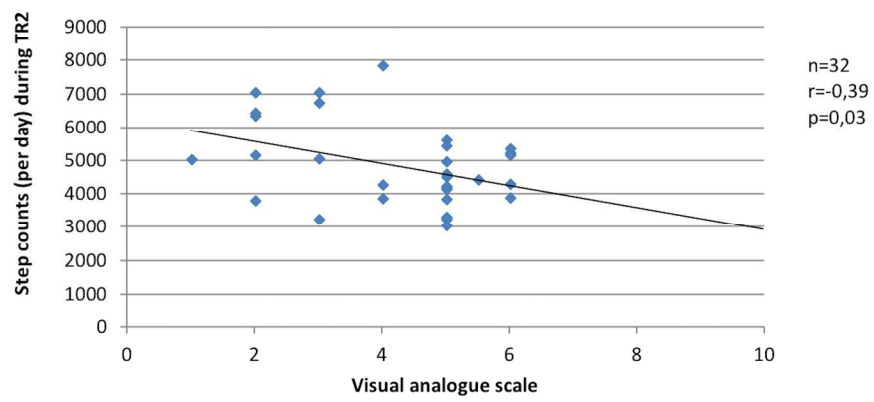


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily moderate-to-vigorous physical activity (MVPA) in the 2nd trimester of pregnancy (TR2).

233x115mm (300 x 300 DPI)

review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

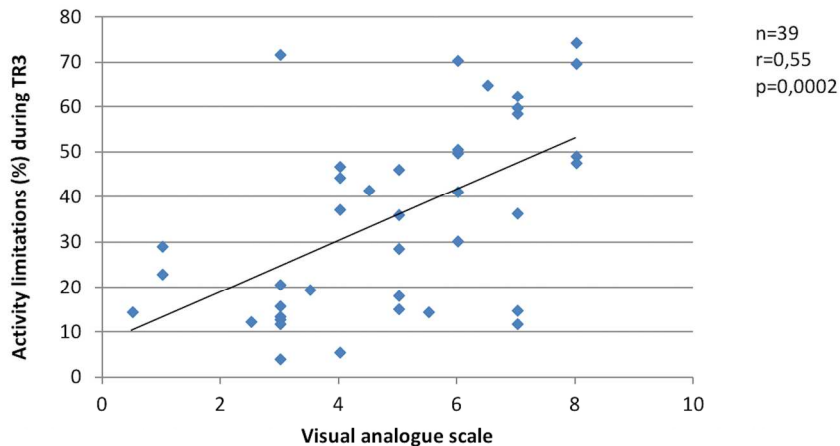


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily step counts in the 2nd trimester of pregnancy (TR2).

234x109mm (300 x 300 DPI)

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

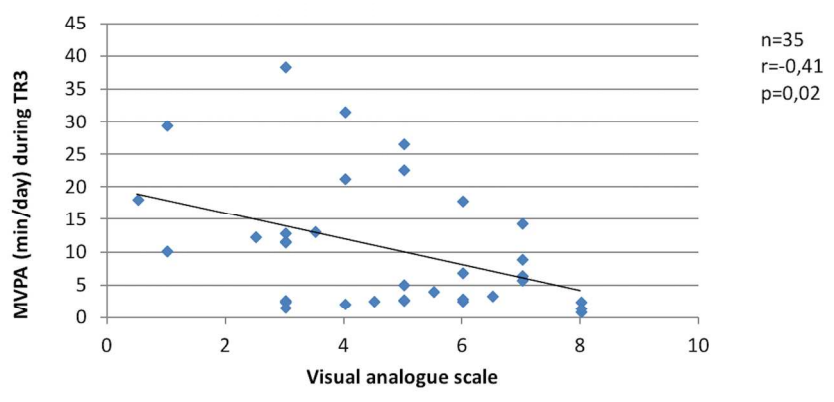


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and activity limitations in the 3rd trimester of pregnancy (TR3).

227x129mm (300 x 300 DPI)

Review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

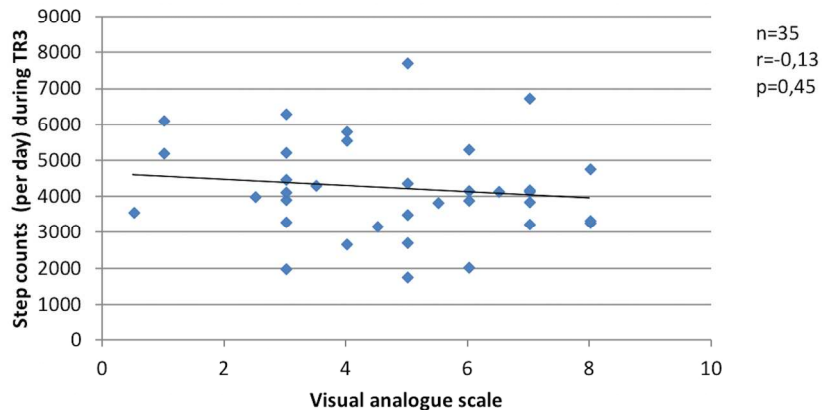


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily moderate-to-vigorous physical activity (MVPA) in the 3rd trimester of pregnancy (TR3).

227x106mm (300 x 300 DPI)

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily step counts in the 3rd trimester of pregnancy (TR3).

226x116mm (300 x 300 DPI)

review only

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	na
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	-
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	na
		(d) If applicable, explain how loss to follow-up was addressed	na
		(e) Describe any sensitivity analyses	na
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19 (table 1)
		(b) Indicate number of participants with missing data for each variable of interest	na
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-9, 20-28 (figures)
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	na
		(b) Report category boundaries when continuous variables were categorized	na
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	na
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Lumbopelvic pain, anxiety, physical activity and mode of conception: A prospective cohort study of pregnant women

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022508.R2
Article Type:	Research
Date Submitted by the Author:	28-Sep-2018
Complete List of Authors:	Lardon, Emeline; Universite du Quebec a Trois-Rivieres; Institut Franco-Européen de Chiropraxie St-Laurent, Audrey; Universite du Quebec a Trois-Rivieres Babineau, Véronique; Department of Obstetrics and Gynaecology, Centre intégré universitaire de santé et de services sociaux de la Mauricie-et-du-Centre-du-Québec, affiliated to the University of Montreal Descarreaux, M; Universite du Quebec, Human kinetics Ruchat, Stephanie-May; Universite du Quebec a Trois-Rivieres,
Primary Subject Heading:	Obstetrics and gynaecology
Secondary Subject Heading:	Sports and exercise medicine
Keywords:	pregnancy, fertility treatments, anxiety, physical activity, lumbopelvic pain

SCHOLARONE™
Manuscripts

Only

1
2
3 1 **Manuscript title:** Lumbopelvic pain, anxiety, physical activity and mode of conception: A
4 2 prospective cohort study of pregnant women
5

6 3
7 4 Emeline Lardon^{1,2, *}, Audrey St-Laurent¹, Véronique Babineau³, Martin Descarreaux¹,
8 5 Stephanie-May Ruchat^{1, *}
9
10

11 6
12 7 **Authors Institutional Information**

13
14 8 ¹ Département de Human Kinetics, Université du Québec à Trois-Rivières, Trois-Rivières,
15 9 Canada

16
17 10 ² Institut Franco-Européen de Chiropraxie, Paris, France

18
19 11 ³ Département de Obstetrics and Gynaecology, Centre intégré universitaire de santé et de
20 12 services sociaux de la Mauricie-et-du-Centre-du-Québec, affiliated to the University of
21 13 Montreal, Trois-Rivières, Canada

22
23 14 * these authors contributed equally to the work
24
25

26
27 16 **Corresponding author:**

28 17 Stephanie-May Ruchat, PhD,
29 18 Professor, Department of Human Kinetics
30 19 Université du Québec à Trois-Rivières
31 20 3351, Boul Des Forges, Trois-Rivières, QC G9A 5H7
32 21 E-mail : stephanie-may.ruchat@uqtr.ca
33
34
35

36
37 22
38 23
39 24 **Key words:** pregnancy; lumbopelvic pain; anxiety; physical activity; fertility treatments.
40 25

41 26 **Word count:** 3636
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 1 **ABSTRACT**

4
5 2 **Objectives:** Pregnancy-related lumbopelvic pain (LPP) is a frequent condition known to
6
7 3 significantly affect women's daily life. The etiology of pregnancy-related LPP pain is still not
8
9 4 clearly established but the mode of conception has been suggested to contribute LPP. Anxiety
10
11 5 related to fertility treatments may be one of the contributing factors. The primary objectives
12
13 6 were to determine the evolution of LPP prevalence and severity, and anxiety, throughout
14
15 7 pregnancy in women who conceived spontaneously (SP) or after fertility treatments (FT). A
16
17 8 further aim was to examine the relationship between pregnancy-related LPP severity and
18
19 9 anxiety. The secondary objective was to determine the evolution of physical activity and their
20
21 10 correlation with the severity of pregnancy-related LPP.

22
23
24 11 **Design:** Prospective cohort study.

25
26 12 **Setting:** Pregnant women were recruited through physicians' referrals, posters and newspaper
27
28 13 advertisements in the local and surrounding communities (hospital, maternity care clinic,
29
30 14 prenatal centers, sports centers, local university) in the city of Trois-Rivières, Canada.

31
32 15 **Participants:** Fifty-nine pregnant women (33 SP and 26 FT) were assessed during the 1st, 2nd
33
34 16 and 3rd trimester of pregnancy.

35
36 17 **Primary and secondary outcome measures:** Pregnancy-related LPP prevalence and severity
37
38 18 (primary), trait and state anxiety, and physical activity levels (secondary).

39
40 19 **Results:** There was no relationship between the mode of conception and the outcome
41
42 20 measures. The prevalence and severity of LPP increased over the course of pregnancy (time
43
44 21 effect, $p < 0.0001$) whereas trait anxiety decreased from early to mid-pregnancy (time effect,
45
46 22 $p = 0.03$). Activity limitations increased throughout pregnancy (time effect, $p < 0.0001$) and
47
48 23 physical activity levels decreased (time effect, $p < 0.0001$). The severity of LPP was positively
49
50 24 correlated with activity limitations ($r = 0.51$ to 0.55) but negatively with physical activity
51
52 25 levels ($r = -0.39$ to -0.41).

1
2
3 1 **Conclusions:** Maternal health-related factors, such as LPP, anxiety and physical activity, are
4
5 2 not different in women who conceived spontaneously or after fertility treatments. The more
6
7 3 LPP was severe, the more the women were physically limited and inactive.
8
9 4

10
11 5 **Strengths and limitations of this study**
12

- 13
14 6 • This is a prospective cohort study of pregnant women who were assessed at each
15
16 7 trimester of pregnancy, allowing to determine the evolution of several maternal health-
17
18 8 related factors that are known to change over the course of pregnancy;
19
20 9 • Primary and secondary outcomes were collected using validated tools;
21
22 10 • The low number of women who achieved a pregnancy following *in vitro* fertilization
23
24 11 prevented us to fully test our hypotheses; thus larger studies are needed to better
25
26 12 understand whether IVF contribute to pregnancy-related LPP.
27
28 13 • More than half of the participants had a university degree, which is not representative of
29
30 14 our local population. The results may therefore not be broadly generalizable.
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 INTRODUCTION

2 More than 50% of women experience pain in the lumbopelvic area during pregnancy ¹. Low
3 back pain (LBP) is defined as pain localized below the ribs, but above the gluteal folds, with
4 or without radiation down the legs ², whereas pelvic girdle pain (PGP) is defined as pain
5 “experienced between the posterior iliac crest and the gluteal fold, particularly in the vicinity
6 of the sacroiliac joints. The pain may radiate in the posterior thigh and can also occur in
7 conjunction with/or separately in the symphysis” ¹. The term lumbopelvic pain (LPP) is used
8 when no distinction is made between PGP and LBP ³. Thus the wide range in the reported
9 prevalence of LPP in the literature (45–73%) ^{4,5} has been attributed to the different criteria
10 used to classify types and severity of pain, and the different periods during pregnancy LPP
11 was assessed. The onset of LPP varies considerably, between the end of the first trimester to
12 the first month post-delivery, with a peak of symptoms generally occurring between the 24th
13 and 36th weeks of pregnancy ⁶. Pregnancy-related LPP is a debilitating condition that is
14 known to affect women’s quality of life ⁷, with repercussions such as disruption of sleep,
15 increased psychological stress, social and sexual life and work capacity ^{4,7-10}. Pregnant women
16 experiencing LPP are also known to be less physically active during pregnancy ¹¹. Prenatal
17 physical activity is an important component of a healthy pregnancy ¹² and all women without
18 contraindication to exercise are encouraged to be regularly active throughout pregnancy to
19 benefit from it ^{13,14}. On the other hand, pregnancy-related LPP can contribute to maternal
20 physical inactivity and its associated maternal, fetal and neonatal complications ¹².

21 Several factors are believed to be involved in pregnancy-related LPP development, such as
22 degenerative metabolic, genetic, hormonal, and biomechanical factors/non-optimal joint
23 stability ¹⁶. Another factor of interest is the mode of conception, in other words, naturally or
24 after fertility treatments. A study reported that pregnant women who underwent *in vitro*
25 fertilization (IVF) treatments had a two times higher prevalence rate of sacral pain in early

1 and late pregnancy, as well as a higher frequency of positive results on pelvic pain
2 provocation tests in late pregnancy¹⁵. The authors concluded that relaxin causes pelvic pain
3 because relaxin is higher in IVF pregnancies¹⁶. Psychosocial factors may also be involved in
4 the development of LPP. Higher anxiety levels experienced in women who conceived after
5 IVF might contribute to the higher pregnancy-related LPP prevalence observed in these
6 women. As reported by a systematic review, women who conceived following fertility
7 treatments had greater pregnancy-specific anxiety than those who conceived naturally¹⁷.
8 Based on a multi-center study including 1,158 women, higher levels of anxiety was reported
9 to be among the most notable factors associated with a higher likelihood of reporting LBP¹⁸.
10 However, to the best of our knowledge, no study has examined pregnancy-related LPP among
11 women who achieve pregnancy naturally or after fertility treatment, and whether anxiety is a
12 contributing factor to the development of LPP.

13 The primary objectives of this prospective cohort study were to determine the evolution of
14 LPP prevalence and severity, as well as anxiety, over the course of pregnancy in women who
15 conceived naturally or after fertility treatments, and to examine the possible relationship
16 between pregnancy-related LPP severity and anxiety levels. As pregnancy-related LPP has a
17 significant impact on the women's daily life, the secondary objective of our study was to
18 determine the evolution of physical activity behaviors throughout pregnancy and whether the
19 severity of LPP was correlated to these factors. Our primary hypotheses are that LPP
20 prevalence and severity, as well as anxiety levels will increase over the course of pregnancy
21 but more strongly in women who conceived after fertility treatments, and that pregnancy-
22 related LPP severity will be positively correlated with anxiety levels. As a result, our
23 secondary hypotheses are that activity limitations will increase whereas physical activity
24 behaviors will decrease over the course of pregnancy but more significantly in women who

1 conceived after fertility treatments, and that the severity of pregnancy-related LPP will be
2 positively correlated with activity limitations but negatively with physical activity behaviors.

3 **MATERIALS AND METHODS**

4 **Study design and participants' selection**

5 This is a prospective cohort study of pregnant women who were recruited between October
6 2015 and September 2016. Women who achieved a spontaneous pregnancy (SP group) and
7 women who achieved pregnancy following fertility treatments (FT group) were recruited
8 through physicians' and a clinic coordinator's referrals, posters and newspaper advertisements
9 in the local and surrounding communities (hospital, maternity care clinic, prenatal centers,
10 sports centers, local university) in the city of Trois-Rivières, Canada. Women under 14 weeks
11 of gestation, with a singleton pregnancy and able to understand, speak and write French were
12 considered eligible to participate in the study. The study was approved by the local Research
13 Ethics Committees (CER-2015-003 and CER-15-214-07.10) and all participants provided
14 their written informed consent.

16 **Outcome measures and measurement tools**

17 Women were followed from the 1st trimester of pregnancy until delivery through three
18 evaluations (1st trimester [TR1]: 10–16 weeks, 2nd trimester [TR2]: 24–28 weeks and 3rd
19 trimester [TR3]: 32–36 weeks of gestation). In each trimester, a member of the research team
20 asked the women if they have had pregnancy-related LPP over the last 7 days or if they were
21 having LPP presently using the illustration provided in the French version of the Pelvic Girdle
22 Questionnaire (PGQ) ¹⁹. If a woman had or was having pregnancy-related LPP, she was asked
23 to rate pain intensity using a visual analog pain scale (VAS). This scale is a self-reported
24 measurement tool used by health professionals allowing the patient to rate pain from 0 (no
25 pain) to 10 (extreme pain) ²⁰.

1 The levels of anxiety was assessed during TR1, TR2 and TR3 using the French-Canadian
2 version ²¹ of the State-Trait Anxiety Inventory (STAI) ²². The STAI is a self-reported
3 questionnaire assessing the presence and severity of current symptoms of anxiety (state
4 anxiety scale) and a generalized propensity to be anxious (trait anxiety scale). Each scale
5 comprises 20 items rated with a 4-level Likert scale. The range of score for each scale is 20-
6 80, the higher score indicating greater anxiety levels. The STAI has been widely used in
7 research with pregnant women and it does reflect the anxiety-related experiences of pregnant
8 women. Its use with pregnant women is therefore appropriate ²³.

9 Activity limitations and symptoms associated with pregnancy-related LPP were assessed in
10 TR2 and TR3 using the completed the French-Canadian version of the PGQ was used ¹⁹. The
11 PGQ is a condition-specific measure developed for pregnant and postpartum women. It
12 consists of 20 activity items and five symptom items on a four-point response scale and
13 assesses activity limitations and symptoms associated with pain in the lumbopelvic region.
14 The range of score is 0-100%, with a higher score indicating greater activity limitations and
15 symptoms. The PGQ is reliable and valid for both pregnant and postpartum women with
16 pregnancy-related LPP ²⁴.

17 Finally, physical activity levels were objectively measured at each trimester of pregnancy
18 using the ActiGraph GT3X (ActiGraph, Pensacola, FL), a triaxial accelerometer measuring
19 data in a 60-s epoch. The women were instructed to wear the monitor over the hip on an
20 elastic belt for seven consecutive days from wake-up time to bedtime. They were allowed to
21 remove the accelerometer when sleeping, showering or engaging in water activities.
22 Furthermore, the women received a daily diary to document wear and non-wear time periods
23 and water activities. According to the method used in the Canadian Health Measures Survey,
24 valid data were defined as four days or more of monitoring for 10 hours or more of wear time
25 per day ²⁵. Pregnant women were encouraged to maintain their usual activities. Data were

1 processed using the Actilife software version 6.13.2 (ActiGraph, LLC, FL, USA). The
2 accelerometer data obtained were averaged across valid wear days. To derive the activity
3 frequency, intensity and duration of the measured activity in counts per minute per day, the
4 Freedson equation was used: sedentary (<100 counts), light (100–1951 counts), moderate
5 (1952–5724), vigorous (5725–9498), and very vigorous (>9498) ²⁶, as previously used in
6 pregnant women ²⁷. Non-wear time was defined as a period of zero counts for ≥ 60
7 consecutive minutes, admitting a maximum of two consecutive minutes between 1 and 100
8 counts/min. When a third observation was between 1 and 100 counts or one observation was
9 more than 100 counts, the non-wear period was ended. Bouts of moderate-to-vigorous
10 physical activity (MVPA) was defined as a minimum of 10 consecutive minutes above 1952
11 counts and ended with more than two consecutive records below this threshold.

12 **Patient and Public Involvement**

13 Patients and public were not involved in the design and conduct of this study. The results will
14 not be disseminated to study participants.

15 **Statistical analysis**

16 Means and standard deviations, as well as percentages, were computerized for variables of
17 interest. Student t-test was used to compare socio-demographic and anthropometric
18 characteristics between SP and FT women. For categorical variables, the χ square test was
19 used. The MIXED procedure of SAS was used to test the effect of time (trimesters), group
20 (SP and FT women) and potential interaction effects on the outcome measures (i.e. the
21 severity of pregnancy-related LPP and anxiety levels [objective 1], and physical activity
22 behaviors [objective 2]). The assumption of sphericity was tested using Mauchly's Test of
23 Sphericity. Variables that did not meet the sphericity assumption were analyzed following a
24 Geisser Greenhouse correction. When a significant effect of time, group or interaction effect
25
26

1 was found, post-hoc analyses were conducted using the Tukey test. To test whether the
2 severity of pregnancy-related LPP was correlated to the levels of anxiety (objective 1), and
3 physical activity behaviors (objective 2) at each trimester of pregnancy, Pearson's correlation
4 analyses were used. Statistical analyses were performed by using the SAS software (Institute,
5 Cary, NC, version 9.4) and the level of significance was set to $p\text{-value} \leq 0.05$.

7 RESULTS

8 Between October 2015 and September 2016, the study was presented by physicians to 117
9 eligible pregnant women, among which 62 women accepted to participate. Reasons for not
10 agreeing to participate to the study were lack of interest or lack of time. Three women (1 in
11 SP group and 2 in FT group) were excluded due to loss to follow-up (n=1), miscarriage (n=1)
12 or missing data (n=1), leaving 59 women (33 SP and 26 FT) for the statistical analyses.

13 The characteristics of pregnant women are presented in **Table 1**. No significant difference in
14 socio-demographic and pre-pregnancy anthropometric characteristics was found between the
15 groups ($p > 0.05$). Women were on average in their early thirties and approximately half of
16 them were nulliparous. More than half were of normal weight pre-pregnancy (BMI 18.5-24.9
17 kg/m^2) and had a university degree. Women's LPP history, related or not to a previous
18 pregnancy, was also similar between the groups, with approximately 50% of the women
19 reporting a history of LPP (**Table 1**). Finally, the prevalence and severity of pregnancy-
20 related LPP, anxiety and physical activity levels were not different between SP and FT
21 pregnant women at study entry (**Table 1**). Data showed that on average, women considered
22 LPP as moderate (4/10) and were slightly anxious (35/80). Moreover, based on daily steps
23 and physical activity recommendations^{28 29}, our population was considered inactive.

24 In our study, a total of 8 (13.5%), 8 (13.5%) and 9 (15%) women removed the accelerometer
25 to do water activities (aqua gym, swimming or bathing) during TR1, TR2 and TR3,

1 respectively. The accelerometer was removed between 1 and 5 times during the evaluation
2 period, and for 10 to 225 minutes. Furthermore, physical activity data was missing for 10
3 (17%), 7 (12%) and 8 (14%) women at TR1, TR2 and TR3, respectively, because those
4 women did not wear the accelerometer for at least 10 hours per day for at least four days.

5 The prevalence of pregnancy-related LPP was similar in both groups during each trimester of
6 pregnancy (TR1: $\chi^2 = 2.19$, $p=0.33$; TR2: $\chi^2 = 2.13$, $p=0.33$; TR3: $\chi^2 = 0.01$, $p=0.92$); the
7 pooled prevalence increased from 42% during TR1 to 65% during TR2 to 68% during TR3
8 ($\chi^2 = 8.45$; $p=0.01$) (**Fig 1**). Among women presenting with pregnancy-related LPP at one
9 time point during pregnancy ($n=44$, 26 SP and 18 FT), pain severity significantly increased
10 over the course of pregnancy in both groups (time effect: $F=14.81$, $p<0.0001$. **Fig 2**), with
11 pain severity being significantly higher during TR2 and TR3 compared to TR1. Trait anxiety
12 decreased over the course of pregnancy in both groups (time effect: $F=3.93$, $p<0.03$. **Fig 3**),
13 with lower levels during TR2 compared to TR1, whereas state anxiety did not significantly
14 change (**Fig 4**). Finally, activity limitations associated with pregnancy-related LPP increased
15 (time effect: $F=18.82$, $p<0.0001$. **Fig 5**) whereas daily steps decreased over the course of
16 pregnancy in both groups (time effect: $F=16.03$, $p<0.0001$. **Fig 6**). The only time by group
17 interaction effect was found for daily MVPA (time effect: $F=13.11$, $p<0.0001$; time*group
18 interaction effect: $F=3.38$, $p=0.04$. **Fig 7**), with daily MVPA being lower in TR3 compared to
19 TR1 and TR2 only in SP women.

20 Since changes in the severity of pregnancy-related LPP, levels of anxiety, and physical
21 activity behaviors were similar between the groups, result from SP and FT women were
22 pooled in the correlation analyses. Among women who presented with pregnancy-related
23 LPP, no correlation was found during TR1 between the severity of pregnancy-related LPP
24 and anxiety or physical activity levels. During TR2, the severity of pregnancy-related LPP
25 was positively correlated with activity limitations ($r=0.51$, $p=0.001$, **Fig 8**) but negatively

1 with daily steps ($r=-0.39$, $p=0.03$, **Fig 9**). No correlation was found with daily MVPA (**Fig**
2 **10**). During TR3, we found a positive correlation between the severity of pregnancy-related
3 LPP and activity limitations ($r=0.55$, $p=0.0002$, **Fig 11**) and a negative correlation with daily
4 MVPA ($r=-0.41$, $p=0.02$, **Fig 12**). No correlation was found with daily steps (**Fig 13**).

6 **DISCUSSION**

7 To the best of our knowledge, this is the first cohort study assessing the course of pregnancy-
8 related LPP prevalence and severity in pregnant women who conceived naturally and after
9 fertility treatments, and possible association with anxiety levels and physical activity
10 behaviors. Overall, our primary results showed no differences in LPP prevalence and severity,
11 or anxiety levels between women who achieved a pregnancy naturally or after fertility
12 treatments. As expected, the prevalence and severity of LPP increased over the course of
13 pregnancy and were of similar magnitude than that reported in previous studies^{10,18}. Anxiety
14 levels decreased from early to mid-pregnancy and were not correlated to the severity of LPP.
15 Only one study examined the evolution of the prevalence and severity of pregnancy-related
16 PGP (PPGP) according to the mode of conception¹⁵. This study was conducted in 31 women
17 who conceived after IVF and 200 women who conceived spontaneously and assessed PGP at
18 12, 24 and 34 weeks of pregnancy. The authors found an increase in PPGP prevalence and
19 severity over the course of pregnancy in all women, as we and other authors did³⁰. However,
20 they reported a two times higher rate of PPGP in early and late pregnancy in women who
21 achieved a pregnancy after IVF compared to those who achieved a pregnancy naturally but
22 similar severity of PPGP¹⁵. Importantly, many IVF women carried multiple pregnancies in
23 that study. Given that relaxin levels are higher after IVF¹⁶ and that the number of fetuses is
24 higher after IVF, and given that the mechanical load is higher in twin pregnancies, it is
25 difficult to establish what causes higher rates of PPGP after IVF in this previous study.

1 Our hypothesis was that higher anxiety levels reported in women who conceived after fertility
2 treatments ¹⁷ would contribute to higher pregnancy-related LPP prevalence and severity in
3 this population of pregnant women. However, we did not find any difference in anxiety levels
4 between women who conceived after fertility treatments and those who conceived naturally.
5 Several reasons may explain our result. First, the majority of women included in our sample
6 conceived after ovarian stimulation (OS, n=7) or intrauterine insemination (IUI, n=12),
7 whereas the majority of studies included in Gourounti's review reporting higher anxiety in
8 women who conceived following fertility treatments were conducted in the context of IVF ¹⁷.
9 Because the medical surveillance is more frequent and the procedure more invasive in the
10 context of IVF, it is likely that IVF generates more anxiety than OS and IUI. This might
11 partially explain why we found no differences in anxiety levels in our sample.
12 When examining anxiety levels over the course of pregnancy, we found a U-shaped curve,
13 with a significant decrease in anxiety from TR1 to TR2 and a non-significant trend toward an
14 increase from TR2 to TR3. These findings are similar to those of previous studies ^{31 32}. In
15 contrast, whereas some studies reported higher anxiety in pregnant women with LBP or PGP
16 ^{18 33}, we found no correlation between anxiety levels and LPP severity. Our findings suggest
17 that in our sample, anxiety and LPP were two independent phenomena.
18 Likewise, our secondary results showed no relationship between the mode of conception and
19 physical limitations and physical activity behaviors, except for MVPA during TR3. The
20 decrease in MVPA observed only in women who conceived naturally needs further
21 investigation. Similarly to previous studies ³⁴⁻³⁷, we found that with advancing pregnancy,
22 physical limitations increased ³⁶⁻³⁸ and physical activity behaviors decreased ^{34 35 39}. Our data
23 further showed that the greater pregnancy-related LPP severity the greater physical limitation
24 and lower physical activity levels in mid- and late pregnancy. These results are also in

1
2
3 1 accordance with previous studies reporting decreased physical activity levels as physical
4
5 2 limitations and low back pain increase with advancing pregnancy^{36 40}.

6
7 3

8 4 **Limitations**

9 5 The strength of our study is its longitudinal design that allowed us to examine the evolution of
10
11 6 several maternal health-related factors that are known to change over the course of pregnancy,
12
13 7 in the context of spontaneous pregnancies and pregnancies achieved following FT. Moreover,
14
15 8 our study adds knowledge about the relationship between pregnancy-related LPP severity and
16
17 9 physical activity behaviors. However, the current study has limitations that should be
18
19 10 acknowledged. First, our sample was heterogeneous with regards to fertility treatments used
20
21 11 to achieve a pregnancy, with the majority of women having conceived after OS or IUI. This
22
23 12 may explain the lower prevalence of PPGP and anxiety levels in women who conceived after
24
25 13 fertility treatments. The low number of women who achieved a pregnancy following IVF
26
27 14 prevented us to fully test our hypotheses and further larger studies are needed to better
28
29 15 understand whether IVF contribute to pregnancy-related. Second, more than half of the
30
31 16 women we recruited had a university degree, which is more than in our local population
32
33 17 (22.5%)⁴¹. This suggests a possible recruitment bias and limits the generalizability of our
34
35 18 results. Third, although accelerometers provide a valid and objective measure of physical
36
37 19 activity levels, non-waterproof accelerometers underestimate several types of physical
38
39 20 activity, such as water activities. In our data set, several women removed the accelerometer to
40
41 21 do water activities (aqua gym, swimming or bathing) during TR1, TR2 and TR3, suggesting
42
43 22 that we possibly underestimated the level of physical activity of these women. We also had
44
45 23 missing physical activity data because some women did not wear the accelerometer for at
46
47 24 least 10 hours per day for at least four days. Finally, physical activity levels were assessed
48
49 25 only for a seven-day period during each trimester of pregnancy. Given that each trimester
50
51 26 lasts for more than a week, the data obtained and the results reported in relation to physical
52
53
54
55
56
57
58
59
60

1 activity levels do not truly reflect the evolution of physical activity levels over each trimester
2 and over the entire course of pregnancy. Nevertheless, the majority of the women stated in the
3 daily diary that their physical activity behavior over the seven-day period of evaluation
4 reflected their habitual behaviors.

6 **CONCLUSION**

7 In conclusion, our findings suggest that maternal health-related factors, such as LPP, anxiety
8 and physical activity behaviors, are not different in women who conceived after fertility
9 treatments and those who conceived spontaneously. The lack of correlation between the
10 severity of pregnancy-related LPP and anxiety levels suggests that they are two independent
11 phenomena. The increase in LPP severity and activity limitations, and decrease in physical
12 activity behaviors with advancing gestation, and the fact that the more severe LPP the greater
13 activity limitations and physical inactivity in mid- and late pregnancy underline the
14 importance of pregnancy-related LPP management to allow pregnant women performing their
15 daily activities.

1
2
3 1 **Acknowledgments:** The authors would like to acknowledge and thank Sophie Drouin, the
4
5 2 coordinator of the fertility clinic, as well as the medical team who assisted with the
6
7 3 recruitment, and all the women who participated to the project.
8
9 4

10
11 5 **Funding:** This study was funded by a start-up grant from the Univeristé du Québec à Trois-
12
13 6 Rivières (Institutional funds for research).
14
15 7

16
17
18 8 **Declaration of conflicting interests:** The authors declare that there is no conflict of interest.
19
20 9

21
22 10 **Author Contributions:** SMR, MD, VB contributed to the study concept and design; EL and
23
24 11 AStL acquired the data; SMR, MD, EL performed the statistical analysis and interpreted the
25
26 12 data; EL and SMR drafted the manuscript; MD, AStL and VB critically reviewed the
27
28 13 manuscript for important intellectual content. All authors read and approved the final
29
30 14 manuscript.
31
32 15

33
34
35 16 **Competing interests:** None declared.
36
37 17

38
39 18 **Ethics approval:** The study was approved by the local Research Ethics Committees (CER-
40
41 19 2015-003 and CER-15-214-07.10)
42
43 20

44
45
46 21 **Data sharing statement:** No additional data are available.
47
48 22
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 1 12. Mudd LM, Owe KM, Mottola MF, et al. Health benefits of physical activity during
4 2 pregnancy: an international perspective. *Med Sci Sports Exerc* 2013;45(2):268-77. doi:
5 3 10.1249/MSS.0b013e31826cebc [published Online First: 2012/08/17]
6
7 4 13. Davies GA, Wolfe LA, Mottola MF, et al. Exercise in pregnancy and the postpartum
8 5 period. *Journal of obstetrics and gynaecology Canada : JOGC = Journal d'obstetrique et*
9 6 *gynecologie du Canada : JOGC* 2003;25(6):516-29. [published Online First: 2003/06/14]
11
12 7 14. ACOG Committee Opinion No. 650: Physical Activity and Exercise During Pregnancy
13 8 and the Postpartum Period. *Obstet Gynecol* 2015;126(6):e135-42. doi:
14 9 10.1097/aog.0000000000001214 [published Online First: 2015/11/26]
15
16 10 15. Kristiansson P, Nilsson-Wikmar L, von Schoultz B, et al. Back pain in in-vitro fertilized
17 11 and spontaneous pregnancies. *Hum Reprod* 1998;13(11):3233-8. [published Online First:
18 12 1998/12/16]
19
20 13 16. Kristiansson P, Svardsudd K, von Schoultz B, et al. Supraphysiological serum relaxin
21 14 concentration during pregnancy achieved by in-vitro fertilization is strongly correlated to the
22 15 number of growing follicles in the treatment cycle. *Hum Reprod* 1996;11(9):2036-40.
23
24 16 17. Gourounti K. Psychological stress and adjustment in pregnancy following assisted
25 17 reproductive technology and spontaneous conception: A systematic review. *Women Health*
26 18 2015:1-21. doi: 10.1080/03630242.2015.1074642 [published Online First: 2015/07/28]
27
28 19 18. Kovacs FM, Garcia E, Royuela A, et al. Prevalence and factors associated with low back
29 20 pain and pelvic girdle pain during pregnancy: a multicenter study conducted in the Spanish
30 21 National Health Service. *Spine (Phila Pa 1976)* 2012;37(17):1516-33. doi:
31 22 10.1097/BRS.0b013e31824dcb74 [published Online First: 2012/02/16]
32
33 23 19. Girard MP, Marchand AA, Stuge B, et al. Cross-cultural Adaptation of the Pelvic Girdle
34 24 Questionnaire for the French-Canadian Population. *J Manipulative Physiol Ther*
35 25 2016;39(7):494-9. doi: 10.1016/j.jmpt.2016.06.002 [published Online First: 2016/08/19]
36
37 26 20. Ostelo RW, Deyo RA, Stratford P, et al. Interpreting change scores for pain and
38 27 functional status in low back pain: towards international consensus regarding minimal
39 28 important change. *Spine (Phila Pa 1976)* 2008;33(1):90-4. doi:
40 29 10.1097/BRS.0b013e31815e3a10 [published Online First: 2008/01/01]
41
42 30 21. Gauthier J, Bouchard S. Adaptation canadienne-française de la forme révisée du State-
43 31 Trait Anxiety Inventory de Spielberg. *Canadian Journal of Behavioral Sciences* 1990;25
44 32 (4):559-89. [published Online First: 1993/10]
45
46 33 22. Spielberger CD. Manual for the State-Trait Anxiety Inventory (Form Y): Palo Alto:
47 34 Consulting Psychologist Press 1983.

- 1
2
3 1 23. Gunning MD, Denison FC, Stockley CJ, et al. Assessing maternal anxiety in pregnancy
4 2 with the State - Trait Anxiety Inventory (STAI): issues of validity, location and participation.
5 3 *Journal of Reproductive and Infant Psychology* 2010;28(3):266-73.
6
7
8 4 24. Stuge B, Garratt A, Krogstad Jenssen H, et al. The pelvic girdle questionnaire: a
9 5 condition-specific instrument for assessing activity limitations and symptoms in people with
10 6 pelvic girdle pain. *Phys Ther* 2011;91(7):1096-108. doi: 10.2522/ptj.20100357 [published
11 7 Online First: 2011/05/21]
12
13 8 25. Colley RC, Garriguet D, Janssen I, et al. Activité physique des adultes au Canada:
14 9 résultats d'accélérométrie de l'Enquête Canadienne sur les mesures de la santé de 2007-2009.
15 10 *Statistique Canada Rapports sur la santé* 2011
16
17
18 11 26. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and
19 12 Applications, Inc. accelerometer. *Med Sci Sports Exerc* 1998;30(5):777-81. [published Online
20 13 First: 1998/05/20]
21
22
23 14 27. Harrison CL, Thompson RG, Teede HJ, et al. Measuring physical activity during
24 15 pregnancy. *Int J Behav Nutr Phys Act* 2011;8:19. doi: 10.1186/1479-5868-8-19
25
26 16 28. Tudor-Locke C, Bassett DR, Jr. How many steps/day are enough? Preliminary pedometer
27 17 indices for public health. *Sports Med* 2004;34(1):1-8.
28
29
30 18 29. Evenson KR, Mottola MF, Owe KM, et al. Summary of international guidelines for
31 19 physical activity after pregnancy. *Obstet Gynecol Surv* 2014;69(7):407-14. doi:
32 20 10.1097/OGX.0000000000000077
33
34 21 30. Kristiansson P, Svardsudd K, von Schoultz B. Back pain during pregnancy: a prospective
35 22 study. *Spine (Phila Pa 1976)* 1996;21(6):702-9. [published Online First: 1996/03/15]
36
37
38 23 31. Lee AM, Lam SK, Sze Mun Lau SM, et al. Prevalence, course, and risk factors for
39 24 antenatal anxiety and depression. *Obstet Gynecol* 2007;110(5):1102-12. doi:
40 25 10.1097/01.AOG.0000287065.59491.70
41
42
43 26 32. Teixeira C, Figueiredo B, Conde A, et al. Anxiety and depression during pregnancy in
44 27 women and men. *J Affect Disord* 2009;119(1-3):142-8. doi: 10.1016/j.jad.2009.03.005
45 28 [published Online First: 2009/04/07]
46
47
48 29 33. Elden H, Gutke A, Kjellby-Wendt G, et al. Predictors and consequences of long-term
49 30 pregnancy-related pelvic girdle pain: a longitudinal follow-up study. *BMC Musculoskelet*
50 31 *Disord* 2016;17:276. doi: 10.1186/s12891-016-1154-0
51
52 32 34. Evenson KR, Wen F. Prevalence and correlates of objectively measured physical activity
53 33 and sedentary behavior among US pregnant women. *Prev Med* 2011;53(1-2):39-43. doi:
54 34 10.1016/j.ypmed.2011.04.014
55
56
57
58
59
60

- 1
2
3 1 35. Rousham EK, Clarke PE, Gross H. Significant changes in physical activity among
4 2 pregnant women in the UK as assessed by accelerometry and self-reported activity. *Eur J Clin*
5 3 *Nutr* 2006;60(3):393-400.
6
7
8 4 36. Cramp AG, Bray SR. A prospective examination of exercise and barrier self-efficacy to
9 5 engage in leisure-time physical activity during pregnancy. *Ann Behav Med* 2009;37(3):325-
10 6 34. doi: 10.1007/s12160-009-9102-y
11
12 7 37. Robinson HS, Veierod MB, Mengshoel AM, et al. Pelvic girdle pain--associations
13 8 between risk factors in early pregnancy and disability or pain intensity in late pregnancy: a
14 9 prospective cohort study. *BMC Musculoskelet Disord* 2010;11:91. doi: 10.1186/1471-2474-
15 10 11-91
16
17
18 11 38. Chang HY, Lai YH, Jensen MP, et al. Factors associated with low back pain changes
19 12 during the third trimester of pregnancy. *J Adv Nurs* 2014;70(5):1054-64. doi:
20 13 10.1111/jan.12258
21
22
23 14 39. Downs DS, LeMasurier GC, DiNallo JM. Baby steps: pedometer-determined and self-
24 15 reported leisure-time exercise behaviors of pregnant women. *J Phys Act Health* 2009;6(1):63-
25 16 72.
26
27 17 40. Poston L, Briley AL, Barr S, et al. Developing a complex intervention for diet and activity
28 18 behaviour change in obese pregnant women (the UPBEAT trial); assessment of behavioural
29 19 change and process evaluation in a pilot randomised controlled trial. *BMC Pregnancy*
30 20 *Childbirth* 2013;13:148. doi: 10.1186/1471-2393-13-148
31
32
33 21 41. Statistics Canada. Labour Force Survey, special compilation, adapted by the Institut de la
34 22 statistique du Québec., July 14, 2017.
35 23
36
37 24
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 **Table 1:** Baseline characteristics of the 59 pregnant women included in study.

Variables	FT (n=26) Means \pm SD	SP (n=33) Means \pm SD	P values
Fertility treatments	OS=7 IUI=12 IVF=7	-	
Age (years)	32.2 \pm 3.6	30.9 \pm 4.2	0.23
Parity	0.4 \pm 0.6	0.6 \pm 0.6	0.36
0 (n)	57.7% (15)	45.5% (15)	0.35
\geq 1 (n)	42.3% (11)	54.6% (18)	
Pre-pregnancy BMI (kg/cm ²)	26.3 \pm 7.3	25.2 \pm 6.6	0.54
Underweight <18.4	0% (0)	3.1% (1)	0.81
Normal weight (18.5-24.9)	60.0 (15)	62.5% (20)	
Overweight (25.0-29.9)	20.0 (5)	18.8% (6)	
Obese \geq 30.0	20.0%(5)	15.6% (5)	
Education levels			
Non-university degree	42.3% (11)	33.3% (11)	0.48
University degree	57.7% (15)	66.7% (22)	
LPP history (yes) ¹	46.2% (12)	54.6% (18)	0.52
Prevalence of pregnancy-related LPP over the last week (yes)	34.6% (9)	48.5% (16)	0.33
Severity of pregnancy-related LPP over the last week	2.9 \pm 1.9	4.1 \pm 2.3	0.18
State anxiety	37.4 \pm 11.6	34.2 \pm 9.1	0.28
Trait anxiety	39.8 \pm 10.0	37.1 \pm 9.4	0.26
Daily steps	5328 \pm 1551	5569 \pm 1552	0.80
Daily MVPA (min)	16.3 \pm 10.0	17.4 \pm 13.2	0.97

FT: fertility treatment; SP: spontaneous conception; OS: ovarian stimulation; IUI: intrauterine insemination; IVF: *in vitro* fertilization; BMI : body mass index; LPP : lumbopelvic pain; MVPA: moderate-to-vigorous physical activity

¹ LPP history includes history of pregnancy-related LPP and LPP not related to pregnancy

Missing data: pre-pregnancy BMI: 1 FT, 1 SP; state and trait anxiety : 1 SP; accelerometer data: 4 SP; 6 FT

2

3

1
2
3 **1 Figure legend**
4

5 2

6
7 **3 Figure 1:** Prevalence of pregnancy-related lumbopelvic pain (LPP) in women who conceived
8
9 4 spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

10 **5 Figure 1 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
11
12 6 trimester of pregnancy.
13

14 7

15
16
17
18 **8 Figure 2:** Evolution of pregnancy-related lumbopelvic pain (LPP) severity in women who
19
20 9 conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

21
22 **10 Figure 2 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
23
24 11 trimester of pregnancy.
25

26 12

27
28
29 **13 Figure 3:** Evolution of trait anxiety in women who conceived spontaneously (SP) or after
30
31 14 fertility treatments (FT) over the course of pregnancy.

32
33 **15 Figure 3 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
34
35 16 trimester of pregnancy.
36

37 17

38
39
40 **18 Figure 4:** Evolution of state anxiety in women who conceived spontaneously (SP) or after
41
42 19 fertility treatments (FT) over the course of pregnancy.

43
44 **20 Figure 4 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
45
46 21 trimester of pregnancy.
47

48 22

49
50 **23 Figure 5:** Evolution of activity limitations in women who conceived spontaneously (SP) or
51
52 24 after fertility treatments (FT) over the course of pregnancy.
53
54

55
56
57
58
59
60

1
2
3 1 **Figure 5 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
4 trimester of pregnancy.
5
6

7 3

8
9 4 **Figure 6:** Evolution of daily moderate-to-vigorous physical activity (MVPA) in women who
10 conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.
11
12

13 6 **Figure 6 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
14 trimester of pregnancy.
15
16

17 8

18
19 9 **Figure 7:** Evolution of daily step counts in women who conceived spontaneously (SP) or
20 after fertility treatments (FT) over the course of pregnancy.
21
22

23 11 **Figure 7 footnote:** TR1: 1st trimester of pregnancy; TR2: 2nd trimester of pregnancy; TR3: 3rd
24 trimester of pregnancy.
25
26

27 13

28
29 14 **Figure 8:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
30 activity limitations in the 2nd trimester of pregnancy (TR2).
31
32

33 16

34
35 17 **Figure 9:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
36 daily moderate-to-vigorous physical activity (MVPA) in the 2nd trimester of pregnancy (TR2).
37
38

39 19

40
41 20 **Figure 10:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
42 daily step counts in the 2nd trimester of pregnancy (TR2).
43
44

45 22

46
47 23 **Figure 11:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
48 activity limitations in the 3rd trimester of pregnancy (TR3).
49
50

51 25

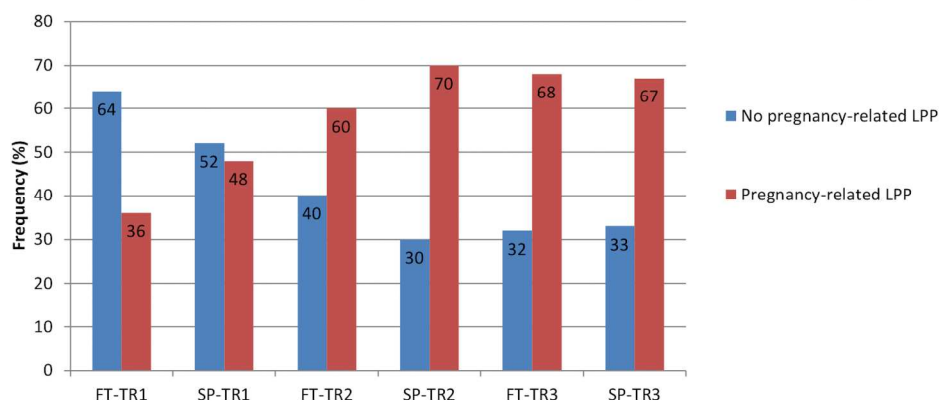
1
2
3 1 **Figure 12:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
4
5 2 daily moderate-to-vigorous physical activity (MVPA) in the 3rd trimester of pregnancy (TR3).
6

7 3

8
9 4 **Figure 13:** Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and
10
11 5 daily step counts in the 3rd trimester of pregnancy (TR3).
12

13 6
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

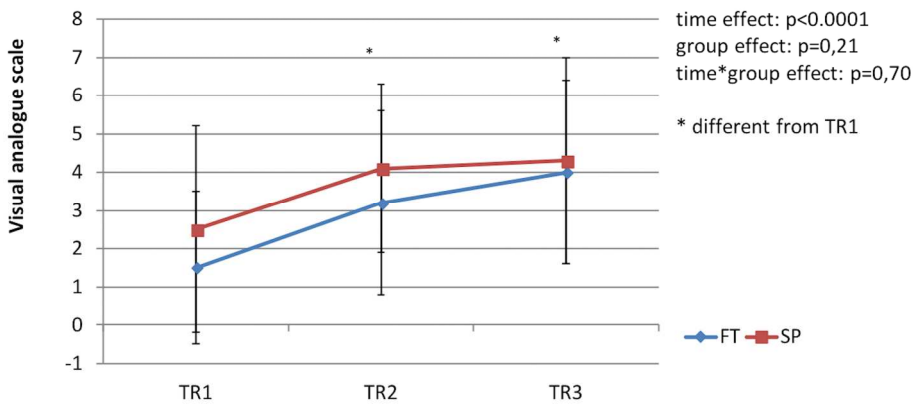


Prevalence of pregnancy-related lumbopelvic pain (LPP) in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

263x132mm (300 x 300 DPI)

review only

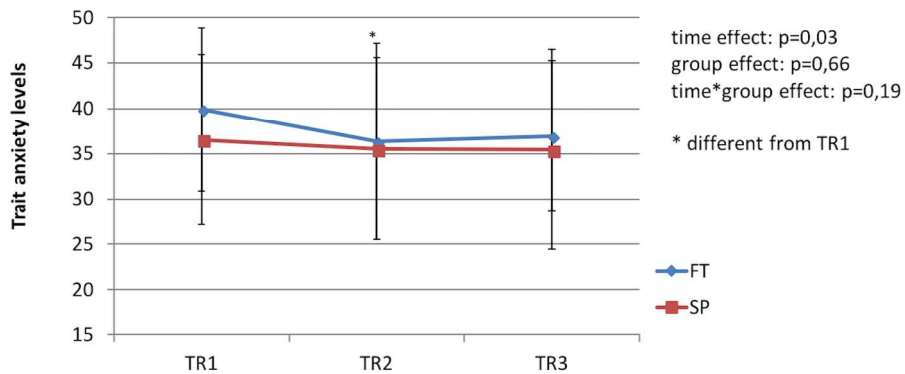
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Evolution of pregnancy-related lumbopelvic pain (LPP) severity in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

223x119mm (300 x 300 DPI)

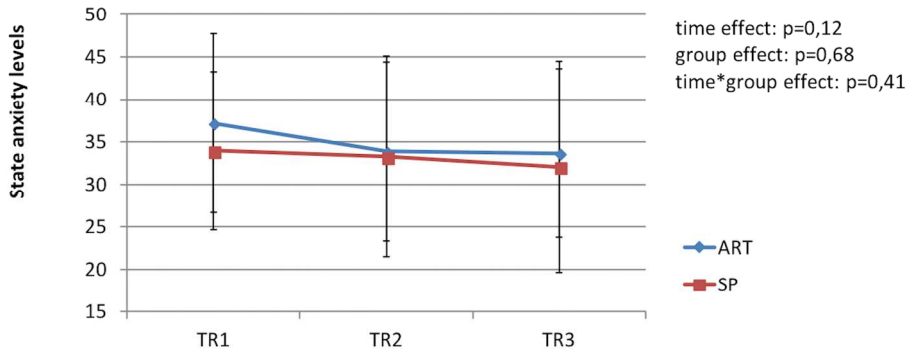
review only



Evolution of trait anxiety in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

227x101mm (300 x 300 DPI)

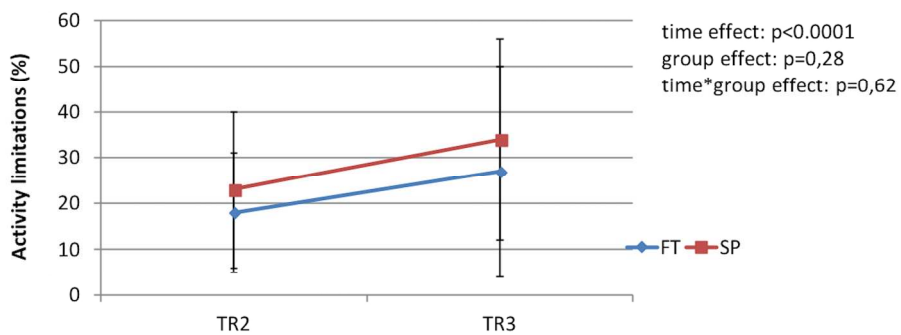
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Evolution of state anxiety in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

227x101mm (300 x 300 DPI)

er review only

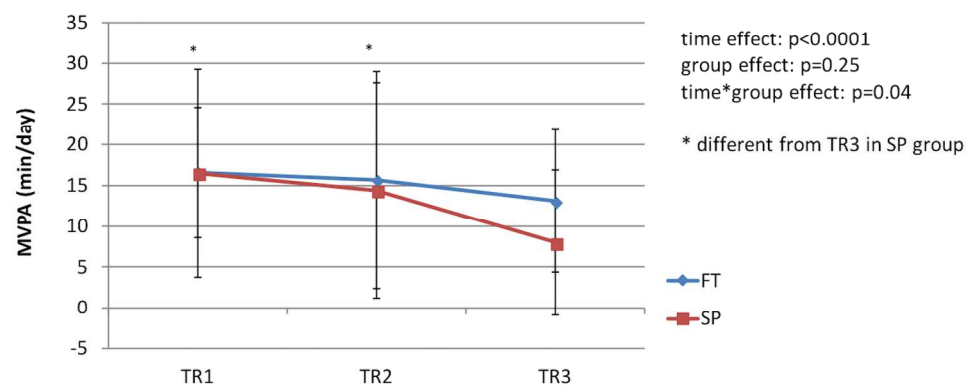


Evolution of activity limitations in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

223x128mm (300 x 300 DPI)

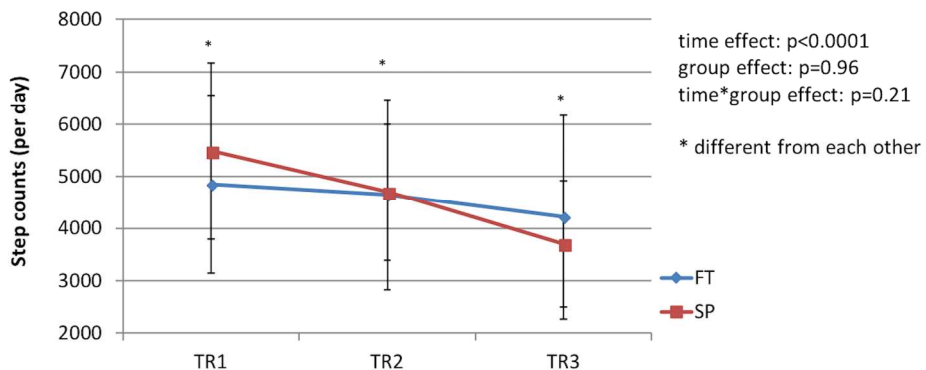
review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Evolution of daily moderate-to-vigorous physical activity (MVPA) in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

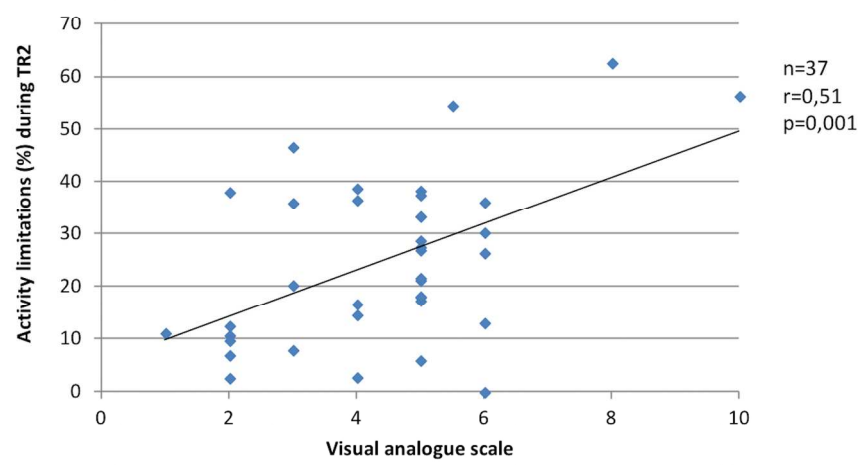
227x104mm (300 x 300 DPI)



Evolution of daily step counts in women who conceived spontaneously (SP) or after fertility treatments (FT) over the course of pregnancy.

225x106mm (300 x 300 DPI)

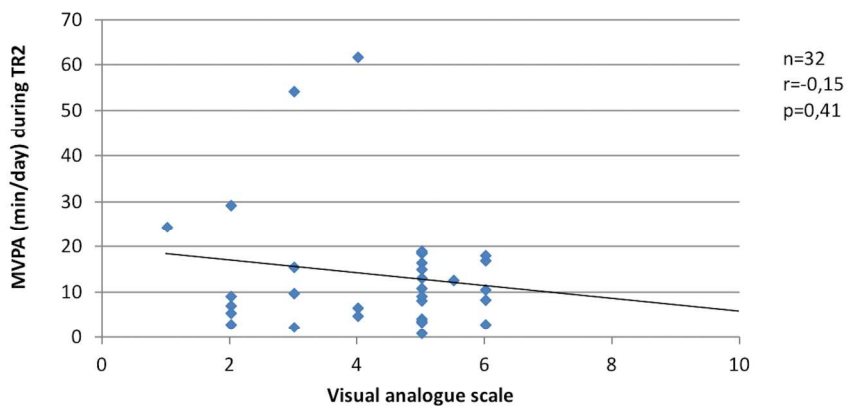
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and activity limitations in the 2nd trimester of pregnancy (TR2).

232x133mm (300 x 300 DPI)

Review only

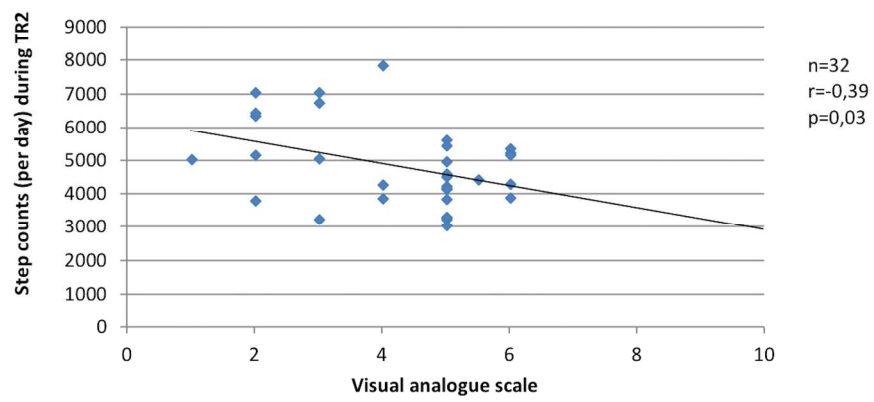


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily moderate-to-vigorous physical activity (MVPA) in the 2nd trimester of pregnancy (TR2).

233x115mm (300 x 300 DPI)

review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

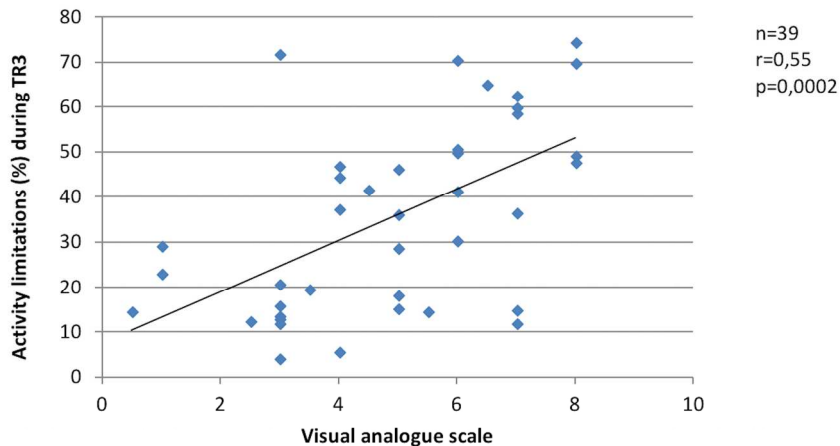


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily step counts in the 2nd trimester of pregnancy (TR2).

234x109mm (300 x 300 DPI)

For review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

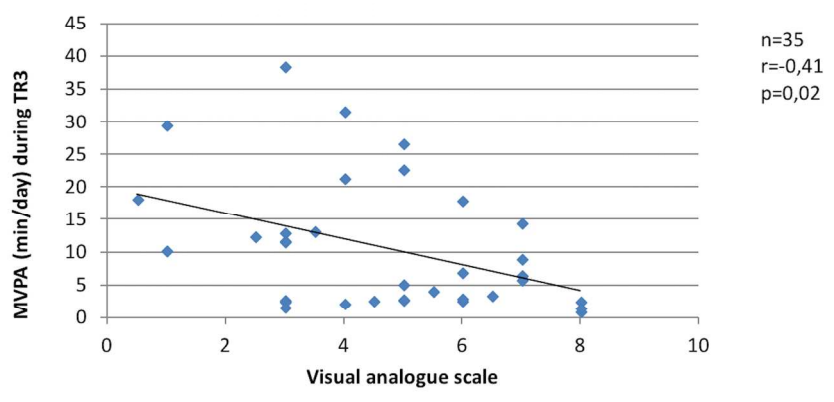


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and activity limitations in the 3rd trimester of pregnancy (TR3).

227x129mm (300 x 300 DPI)

Review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

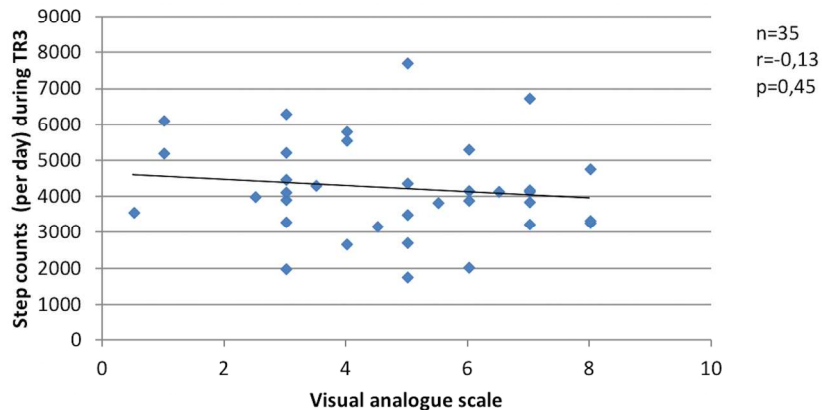


Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily moderate-to-vigorous physical activity (MVPA) in the 3rd trimester of pregnancy (TR3).

227x106mm (300 x 300 DPI)

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60



Correlation between the severity of pregnancy-related lumbopelvic pain (LPP) and daily step counts in the 3rd trimester of pregnancy (TR3).

226x116mm (300 x 300 DPI)

review only

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cohort studies

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		(b) For matched studies, give matching criteria and number of exposed and unexposed	na
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	-
Study size	10	Explain how the study size was arrived at	-
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	na
		(d) If applicable, explain how loss to follow-up was addressed	na
		(e) Describe any sensitivity analyses	na
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19 (table 1)
		(b) Indicate number of participants with missing data for each variable of interest	na
		(c) Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-9, 20-28 (figures)
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	na
		(b) Report category boundaries when continuous variables were categorized	na
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	na
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	na
Discussion			
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.