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# ASSESSMENT OF FUNCTIONAL CAPACITY IN PREGNANT AND 6-WEEKS POSTPARTUM WOMEN

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**ABREVIATIONS LIST**

| | |
|---|---|
| ATS | American Thoracic Society |
| BMI | Body Mass Index |
| FC | Functional Capacity |
| FEC | Functional Exercise Capacity |
| H | Height |
| HR | Heart Rate |
| HRX' | Heart Rate at X minutes |
| MCID | Minimal Clinically Important Difference |
| PP-group | Postpartum-group |
| PP | Postpartum |
| PR-group | Pregnant-group |
| PR | Pregnant |
| SpO2 | Peripheral Saturation in Oxygen |
| SpO2X’ | Peripheral Saturation in Oxygen at X minutes |
| W | Weight |
| WG | Weight Gain |
| W-i | Weight-i (= before pregnancy) |
| 2MWD | 2-Minute Walk Distance |
| 4MWD | 4-Minute Walk Distance |
| 6MWD | 6-Minute Walk Distance |
| 6MWT | 6-Minute Walk Test |

## ABSTRACT

INTRODUCTION

Pregnancy has an important impact on the physiology of women and hence influences functional exercise capacity (FEC). In current scientific literature, there is no consensus regarding the measurement of FEC in postpartum women. Pregnant and postpartum women have never been studied in the same paper while using adequate guidelines. As pregnant women have sedentary behaviours, we hypothesized that both pregnant and postpartum women would have a decreased FEC compared to a non-pregnant group.

METHODS

Pregnant and post-partum women were asked to participate in the current study. They performed a 6 minute walking test (6MWT). Peripheral saturation in oxygen, heart rate and dyspnea were measured. Means were compared with an unpaired Students T-test. Pearson's correlation was used to examine correlations between variables of interest (e.g. 6 minute walking distance, heart rate, dyspnea, weight).

RESULTS

In total, 72 women volunteered for the study: 32 pregnant women, 9 postpartum women and 31 non-pregnant women (control-group). Distance walked during the 6MWT was significantly higher in the control-group (632m) compared to the pregnant and postpartum groups ($p<0{,}001$, $p<0{,}001$ respectively). Heart rate and dyspnea at starting line were significantly higher in the pregnant group in comparison with postpartum and control groups ($p<0.001$, $p<0.001$ - $p=0.015$, $p=0.030$, respectively).

CONCLUSION

The results of the current study confirm that functional exercise capacity is decreased in pregnant and postpartum women.

## INTRODUCTION

It is well known that exercising is more difficult during pregnancy, especially during the late stage [1, 2]. Different changes take place during this period and will impact several body systems which are mentioned below.

At rest, late stage pregnant women are in similar conditions as during exercise because of cardio-vascular adaptations. At rest, vascular volume, cardiac output and heart rate will respectively increase by 40%, 40-50% and 10-20% at the end of pregnancy [1, 3]. Oxygen consumption rises by 20-33% by term [4]. These increases are equal to those generally induced during exercise [5]. That partly explains why pregnant women have difficulties to realize a physical exercise [6].
Lung volume undergoes changes because of progressive uterine distension. Diaphragm raises from 4.0 to 5.0 cm and transversal diameter of the ribcage grows up to 2.1cm [7]. During the second half of pregnancy, expiratory reserve volume and residual volume decrease respectively by 8 to 40% and 7-22% at term [7]. Functional residual capacity decreases and inspiratory capacity increases in the same ratio. This implies that total lung capacity stays stable [7]. In the third trimester, tracheobronchial tree smooth muscles will relax, decreasing total airways resistance and making breathing easier [4]. These pulmonary changes permit women to breath normally while pregnant.
Concerning orthopaedics, body mass centre is anteriorized [8] and hormonal changes also occur in the pelvic area [9]. The relaxin hormone is indeed produced throughout pregnancy to relax muscles, joints and ligaments to make room for the foetus [10]. These hormonal changes can lead to lumbar lordosis, low back pain and pelvic girdle pain [11]. We know these can affect functional exercise capacity [12]. The static posture is also modified and therefore is the woman's gait changed [13]. All these elements influence functional exercise capacity [9, 14].

Postpartum period is arbitrarily defined as the period of 6 weeks following delivery [15]. After 6 weeks, most women regain normal function of their physiological systems [15].

Functional exercise capacity (FEC), or functional capacity (FC), is the capacity to endure daily exercises such as walking or climbing the stairs [16]. It is influenced by cardiovascular, respiratory and musculoskeletal parameters and is paramount to everyone [5].

The 6 minute walking test is commonly used to evaluate functional exercise capacity and has already been used with pregnant and postpartum women.

FEC is decreased during pregnancy. This is described [17] and has been assessed by the 6-minute walk test (6MWT) in several papers [18-20]. We know that pregnant women spent more than 50% of their time in sedentary behaviours [21, 22] which can lead to a decreased functional capacity. Therefore, we hypothesized that postpartum women have a decreased functional exercise capacity.

Two papers studied postpartum women using 6MWT [23, 24]: unfortunately, they did not evaluate their subjects with identical guidelines and do not reach same conclusions. Moreover, they did not assess the recommended cardiorespiratory parameters [16]. Altogether, this database is missing in the literature.

Therefore, the aim of this study was to evaluate functional capacity in pregnant and postpartum women using the 6 minute walking test. We compared exercise intensity and cardio-respiratory parameters during 6MWT in the two test groups. We put forward which parameters were correlated to 6MWT.

## METHODS

### Subjects

This study is consistent with the fundamental principles established with the Declaration of Helsinki and received the favourable report from the Ethical Committee of the Cliniques Universitaires Saint-Luc – Belgium.

Measurements were realized from July to August 2014 and February 2015 in the gynaecological department of the Cliniques Universitaires Saint-Luc. This article adheres to the STROBE guidelines [25].

Inclusion criteria were:

- Being a woman;
- Aged between 18-45 years old;
- Belonging to one of this 3 groups:

  - Pregnant women (PR-group): pregnancy of at least 29 weeks without any complications or multiple pregnancy;

- Non-pregnant women (control-group): unpregnant women or women who last delivered at least 2 years ago;

- Postpartum women (PP-group): women whit a postpartum period between 6 and 8 weeks.

Exclusion criteria were:

- Suffering from any disease or orthopaedic pain;
- Having a contraindication to exercise;
- Being under any medication that could influence heart rate;
- As the obesity threshold corresponds to a BMI of 30kg/m² [26], the control group couldn't have a BMI > 29kg/m²;
- Accordingly, the pregnant-group and postpartum-group couldn't have a BMI > 29kg/m² before pregnancy;
- Being a top-level athlete.

Pregnant subjects were recruited when coming for routine visits in the gynaecological department of the Cliniques Universitaires Saint-Luc. Postpartum subjects were recruited when coming for their first post-partum visit – 6 weeks after the delivery. Gynaecologists knew the inclusion and exclusion criteria. If the patient corresponded to the criteria's above-mentioned, the assessor was informed and could solicitate the subject. Due to this way of processing, all subjects were solicitate and not only the enthusiastic one's. That finally gave us a subject sample which is more representative of the population we intended to assess. Control subjects were recruited amongst hospital employees. Each subject had been informed about the protocol of the study without knowing the exact aim of it. They all received an information letter explaining the 6-minute walk test and some oral explanations. A consent letter has systematically been read and signed by all subjects. The same assessor (CVA) has done all the measurements.

**Outcome measures**

**Subject's characteristics**

Age, initial weight before pregnancy (W-i), current weight (W) and height (H) were recorded. We calculated the body mass index (BMI) ($BMI = W(kg)/(H(m))^2$) in the

3 groups using W-i for PR-group and W for PP- and control-groups. Weight gain (WG) by pregnant subjects was calculated as: WG=(W)-(W-i). Gynaecologists recorded gestation- and postpartum-period.

**6MWT**

The 6 minute walking test is a validated, reproductible, easy-to-make and non-costly functional test used as gold-standard to evaluate functional exercise capacity in cardio-pulmonary and chronic diseases [27, 28]. It has been used to diagnose and assess preeclampsia and low back pain in pregnant women [20, 29].

6MWT was performed as described in the American and Thoracic Society (ATS) guidelines of 2002 [16]. Subjects were asked to walk the longest distance possible in 6 minutes. If they had any problem, they could stop the test at any moment. The test took place in a flat hall of 30 meters long, distances were measured with an accuracy of 2 meters. Subjects were informed of the passage of time with standard phrases of encouragement. They could not speak during the test [16]. Each test was performed by the same assessor who was a physiotherapist (VAC). The walking distance was measured each two minutes: 2 minute walk distance (2MWD), 4 minute walk distance (4MWD) and 6 minute walked distance (6MWD). Heart rate (HR), dyspnea and peripheral oxygen saturation (SpO2) were measured.

Dyspnea was assessed with Borg scale as proposed by the ATS: at the beginning (Dyspnea-I) and end of the test (Dyspnea-F). The Borg scale was explained to the subject as:

- 0: “You are not out of breath at all”
- 10: “Your breathlessness is very, very severe” [16].

When dyspnea is evaluated following the Borg scale, the accepted MCID (minimally clinical important difference) is 1 unit [30].

Regarding the test distance, a MCID of 14-30.5m is commonly used in subjects with pathologies such as stroke, Parkinson, COPD, … [27]. However in healthy subjects, the MCID is between 54-80m [31]. We decided to use an MCID of 80 m. Distances are always presented in absolute value. We also related the distances they walked in percentage of the reference values for healthy women between 20-50 years old (593±57m) [32] as %6MWDpred. Difference between 100% and %6MWDpred was calculated as:

$$\delta\%6MWDpred = (\%6MWDpred - 100\%)$$

This represents the percentage of loss (-) or gain (+) of distance when compared to reference values.

**Heart rate, peripheral oxygen saturation, dyspnea**

HR and SpO2 were measured with a pulse oximeter (NONIN®, Onyx Vantage). HR and SpO2 were measured at basis line (HR0' – SpO20'), 6 minutes (HR6' – SpO26') and 8 minutes (HR8' – SpO28') as recommended [16]. δHR6' was calculated as:

$$\delta HR6' = (\frac{HR6'}{HR0'})$$

Maximal heart rate (MHR) was calculated with the equation proposed by Gulati et al. for asymptomatic women [33]:

$$MHR = 206 - (0.88 * age)$$

The predicted MHR percentage was obtained with:

$$\%MHR = \left(\frac{HR6'}{MHR}\right) * 100$$

The ratio 6MWD/HR6' (m/puls) represents the distance achieved per heart pulsation.

**Sample size and statistical analysis**

We calculated the sample size needed according a study done in postpartum women with pelvic pain. That study was conducted using the 6MWT [29]. With a standard deviation of 85m, a power of 0.80, a significance level of 0.05 and a clinically acceptable difference of walking distance between the groups of 80m, the calculated sample size necessary for our study was 34 subjects for each group.

Data are presented as mean value ± standard. Comparison between means was done using unpaired Student's t-test and paired Student's t-test in a same group. Coefficient of Pearson correlation was used to bring out correlations between 6MWD and anthropometric data or cardiorespiratory parameters. The database was processed using SPSS 22.0.

## RESULTS

### Subjects

Figure 1 respectively presents participants of pregnant-, control- and postpartum-groups. In total, 72 pregnant subjects were eligible. We were only able to solicit 38 of them as the others were seeing different physicians. Four subjects refused to participate on account of discomfort reasons or lack of time. Finally, 34 pregnant women participated to the study and two of them were later excluded because of an initial BMI > 29kg/$m^2$. Besides, 49 control subjects were solicited through the medical care staff (nurses, doctors, secretaries): 33 of them participated while 16 others lacked free-time. Two of them were excluded because of a BMI > 29kg/$m^2$. Finally, 23 post-partum women were eligible: 11 accepted to participate while the others plead fatigue or lack of time. Two of the 11 were excluded because of a too long postpartum period. So 72 subjects finally participated to our project over 21 non-consecutive days.

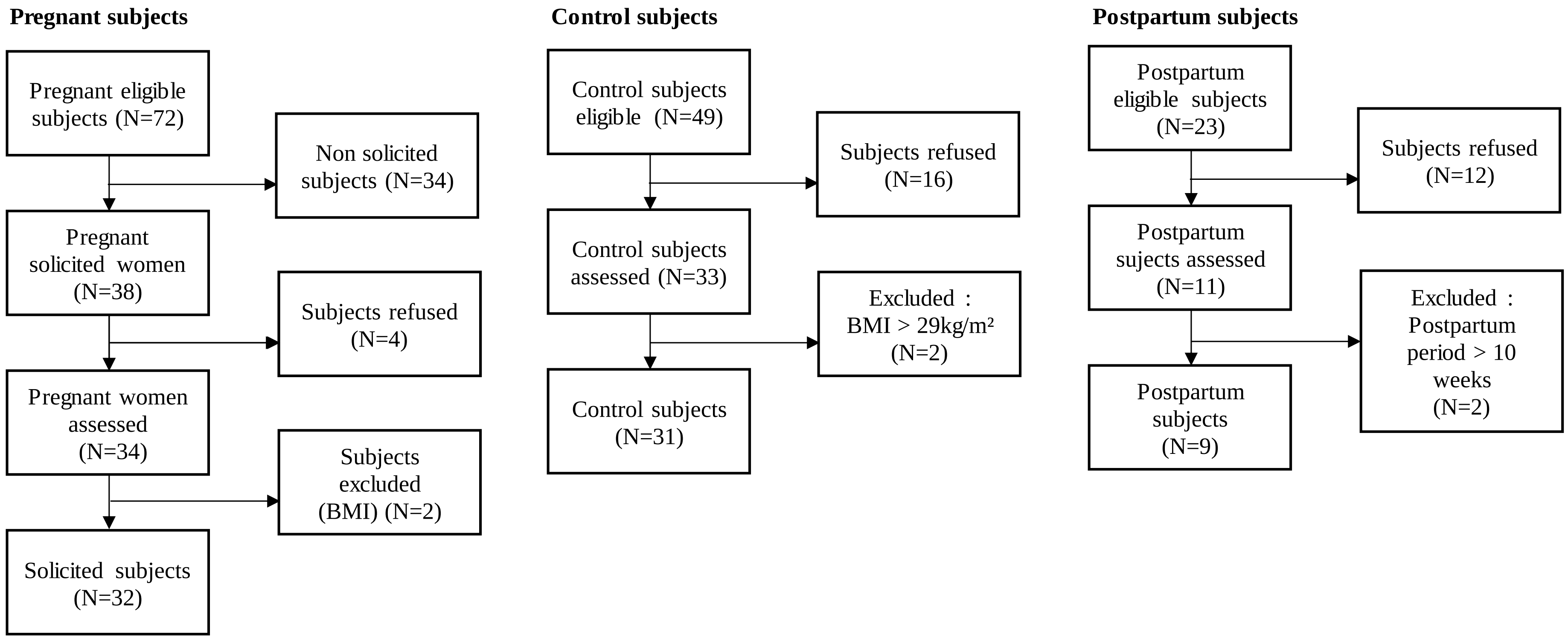


**Fig. 1** Subjects recruitment of the 3 Groups Flow Chart.

In the pregnant subjects, 38 of 72 subjects were solicited. 4 subjects refused and 2 were excluded after assessment. 34 pregnant women were assessed.

In the control subjects, 16 of 49 subjects refused. 2 subjects were exluded after assessment. 31 control subjects were assessed.

In the postpartum subjects, 12 of 23 subjects refused. 2 subjects were excluded after assessment. 19 subjects were assessed.

Table 1 summarizes the participants' characteristics. The age in the control-group was significantly lower than in the pregnant-group ($p=0.038$) and postpartum-group ($p=0.029$). There was no difference in height between the 3 groups ($p=0.038$, $p=0.469$, $p=0.308$). Weight gain was not comparable. The difference between the BMI of postpartum subjects and the two other groups is negligible whereas the BMI of the pregnant women was higher than the control subjects' ($p=0.007$). Mean gestation time in the PR-group was 33.79±3.55 weeks. Postpartum time was 6.1±0.9 weeks.

Means and standard deviations of cardiorespiratory parameters and 6MWT distances are shown in Table 2.

**Table 1.** Participants' Characteristics in the 3 Groups

| | PR | Control | P Value | PR | PP | P Value | PP | Control | P Value |
|---|---|---|---|---|---|---|---|---|---|
| n | 32 | 31 | | 32 | 9 | | 9 | 31 | |
| Age (y) | 30.0±5.7 | 26.9±5.5 | 0.038 | 30±5.78 | 31.5±4.8 | .469 | 31.5±4.8 | 26.9±5.5 | 0.029 |
| Height (m) | 1.64±0.07 | 1.68±0.05 | 0.060 | 1.64±0.07 | 1.65±0.05 | .745 | 1.65±0.05 | 1.68±0.05 | 0.308 |
| Weight (kg) | 64.5±10.5 | 60.7±6.9 | 0.093 | 64.5±10.5 | 65.0±12.3 | .854 | 65.0±12.3 | 60.7±6.9 | 0.298 |
| Weight-i (kg) | 76.8±11.6 | - | - | 76.8±11.6 | - | - | - | - | - |
| Weight gain (kg) | 12.2±4.9 | - | - | - | - | - | - | - | - |
| BMI (kg/m²) | 23.84±3.79 | 21.51±2.33 | 0.007 | 23.84±3.79 | 23.21±3.64 | .708 | 23.21±3.64 | 21.51±2.33 | 0.097 |
| Gestation time (w) | 33.9±3.6 | - | - | 33.9±3.6 | - | - | - | - | - |
| PP time (w) | - | - | - | - | 6.1±0.9 | - | 6.1±0.9 | - | - |

Data are presented as mean ± standard deviation.

BMI: body mass index, kg: kilogram, m: meters, PP: postpartum, PR: pregnant, w: weeks, y: years.

## Unpaired Student's t-Test

### Pregnant-group versus Control-group

Pregnant subjects walked a significantly smaller distance compared to the Control subjects (see Table 2). The difference between the distance travelled by each group during the 6MWT (156m) is bigger than the difference with the MCID. Pregnant subjects walked slower than control subjects during the whole test as each speed gaits were significantly lower (see Table 2). %6MWDpred is lower and negative in the pregnant subjects.

Concerning heart rate and dyspnea, only heart rate at starting line and dyspnea at the beginning and the end of the test were higher in the pregnant group. %MHR was similar in both groups, showing they all realized the same intensity of effort.

### Pregnant-group versus Postpartum-group

Postpartum subjects walked more distance throughout the whole test than pregnant subjects but the MCID is not reached (see Table 2). All the gait speeds were higher in the postpartum group. No difference was found in %6MWDpred and δ%6MWDpred.

Concerning cardiorespiratory parameters, postpartum subjects had higher heart rates and dyspnea's parameters. Intensities of exercise (%MHR) were similar even though the increase of heart rate at the end of the test was higher in postpartum subjects. For the same intensity of exercise, efficiency of exercise was higher in postpartum subjects as their 6MWD/HR6' was higher.

### Postpartum-group versus Control-group

In our postpartum subjects, during the tests, 4 of our 9 subjects spontaneously declared fatigue before starting the test. Postpartum subjects walked smaller distances (see Table 2) and that was statistically and clinically significant. Gait speed was lower in postpartum subjects during the entire 6MWT.

Concerning cardiorespiratory parameters, heart rate after 6 minutes of walking and percentage of maximal heart rate were higher in the control group whereas there was no difference between dyspnea's parameters.

**Table 2.** 6-Minute Walking Test Distances and Cardiorespiratory Parameters in the 3 Groups

| n | PR 32 | Control 31 | P Value | PR 32 | PP 9 | P Value | PP 9 | Control 31 | P Value |
|---|---|---|---|---|---|---|---|---|---|
| 2MWD (m) | 160.94±3.74 | 214.35±3.05 | 0.001 | 160.94±3.74 | 173.30±6.81 | 0.323 | 173.30±6.81 | 214.35±3.05 | 0.001 |
| 4MWD (m) | 312.35±8.13 | 421.76±5.92 | 0.001 | 312.35±8.13 | 346.8±13.80 | 0.029 | 346.8±13.80 | 421.76±5.92 | 0.001 |
| 6MWD (m) | 476.68±10.34 | 632.00±9.73 | 0.002 | 476.68±10.34 | 520.4±20.51 | 0.039 | 520.4±20.51 | 632.00±9.73 | 0.001 |
| Speed (0-2') (m/s) | 1.34±0.17 | 1.79±0.15 | <0.001 | 1.34±0.17 | 1.47±0.20 | <0.001 | 1.47±0.20 | 1.79±0.15 | <0.001 |
| Speed (2-4') (m/s) | 1.25±0.26 | 1.73±0.16 | 0.074 | 1.25±0.26 | 1.39±0.25 | 0.186 | 1.39±0.25 | 1.76±0.14 | 0.424 |
| Speed (4-6') (m/s) | 1.38±0.33 | 1.750.21 | <0.001 | 1.38±0.33 | 1.48±0.27 | <0.001 | 1.48±0.27 | 1.75±0.16 | 0.002 |
| %6MWDpred | 80.52±10.60 | 103.54±20.92 | 0.001 | 80.52±10.60 | 87.25±13.43 | 0.173 | 87.25±13.43 | 103.54±20.92 | 0.001 |
| δ%6MWDpred | -19.01±10.47 | +3.54±20.92 | <0.001 | -19.01±10.47 | -12.74±13.43 | 0.112 | -12.74±13.43 | +3.54±20.92 | <0.001 |
| HR0’ (puls/min) | 89.1±2.5 | 74.0±1.4 | <0.001 | 89.1±2.5 | 69.6±2.8 | <0.001 | 69.6±2.8 | 74.0±1.4 | 0.134 |
| HR6’ | 108.2±13.7 | 116.6±4.8 | 0.121 | 108.2±13.7 | 99.1±5.9 | 0.517 | 99.1±5.9 | 116.6±4.8 | 0.038 |
| HR8’ | 92.2±12.2 | 88.3±3.0 | 0.285 | 92.2±12.2 | 74.8±3.7 | 0.001 | 74.8±3.7 | 88.3±3.0 | 0.011 |
| δHR6’ (puls/min) | 1.22±0.16 | 1.59±0.39 | <0.001 | 1.22±0.16 | 1.42±0.19 | 0.003 | 1.42±0.19 | 1.59±0.39 | 0.235 |
| %MHR (%) | 59.52±7.37 | 63.51±14.80 | 0.182 | 59.52±7.37 | 54.62±10.26 | 0.187 | 54.62±10.26 | 63.51±14.80 | 0.044 |
| 6MWD/HR6' (m/puls) | 4.51±0.72 | 5.71±1.21 | <0.001 | 4.51±0.72 | 5.43±1.04 | 0.003 | 5.43±1.04 | 5.71±1.21 | 0.518 |
| Dyspnea-I | 1.9±4.5 | 0.2±0.9 | 0.030 | 1.9±4.5 | 0.0±0.0 | 0.015 | 0.0±0.0 | 0.2±0.9 | 0.382 |
| Dyspnea-F | 3.6±2.4 | 2.5±1.9 | 0.040 | 3.6±2.4 | 1.9±2.1 | 0.023 | 1.9±2.1 | 2.5±1.9 | 0.351 |
| δDyspnea | 1.86±1.84 | 2.23±1.75 | 0.417 | 1.86±1.84 | 1.61±1.68 | 0.687 | 1.61±1.68 | 2.23±1.75 | 0.327 |

Data are presented as mean ± standard deviation.

F: final, HR0’: heart rate at 0 minute, HR6’: heart rate at 6 minutes, HR8’: heart rate at 8 minutes, I: initial, kg: kilogram, PR: pregnant, PP: postpartum, m: meters, min: minute, puls/min: pulsations per minute, w: weeks, 2,4,6-MWD: 2,4,6-minutes walking distance, δ%6MWDpred: difference between 6MWD realized and the reference value in percentage.

**Pearson's correlation:**

All correlations between 6MWD and other parameters in PR- and PP-group are shown in table 3. In both groups, no correlations were found between anthropometric data and 6MWD.

In the PR-group, amongst all cardiorespiratory parameters, only δHR6' was correlated to 6MWD (r=0.423 - p=0.019). In the PR-group, HR6', HR8' and Dyspnea-F were correlated to 6MWD (r=0.587 - p=< 0.028, r=0.549 - p=0.034 and r=0.561 - p=0.030, respectively). No correlations were found between gestation time or postpartum time and 6MWD.

**Table 3** Correlation between 6MWD and other parameters in pregnant and postpartum subjects

| Coefficient correlation between 6MWD and | Pregnant-group | Postpartum-group |
|---|---|---|
| Age (y) | r = - 0.031 - p = 0.867 | r = - 0.063 - p = 0.871 |
| Height (m) | r = 0.139 - p = 0.461 | r = 0.662 - p = 0.051 |
| Weight (kg) | r = - 0.190 - p = 0.313 | r = 0.492 - p = 0.177 |
| Weight-i (kg) | r = - 0.133 - p = 0.480 | - |
| Weight gain (kg) | r = - 0.163 - p = 0.387 | - |
| HR0' (puls/min) | r = - 0.228 - p = 0.224 | r = 0.283 - p = 0.459 |
| HR6' (puls/min) | r = 0.153 - p = 0.416 | r = 0.587 - p = 0.028 |
| HR8' (puls/min) | r = 0.035 - p = 0.850 | r = 0.549 - p = 0.034 |
| δHR6' | r = 0.423 - p = 0.019 | r = 0.263 - p = 0.492 |
| %MHR | r = 0.031 - p = 0.867 | r = 0.447 - p = 0.227 |
| Dyspnea-I | r = - 0.105 - p = 0.580 | r = 0.352 - p = 0.351 |
| Dyspnea-F | r = - 0.119 - p = 0.528 | r = 0.561 - p = 0.030 |
| Gestation time (w) | r = - 0.097 - p = 0.609 | - |
| Postpartum time (w) | - | r = 0.239 - p = 0.534 |

F: final, HRx': heart rate at x minute(s), I: initial, kg: kilograms, m: meters, MHR: maximal heart rate, puls: pulsations, w: weeks, y: years, 6MWD: 6 minute walking distance.

## DISCUSSION

Above all, using the predicted values proposed by Chetta et al. for women between 20 and 50 years old, we showed that the 6MWD realized by our control-group is similar to standard values [32]. We were concerned that the age could be a factor during the test as the age of postpartum subjects (32 y) was higher than control's (27 y). However, we do not think it has an impact on our results as this difference of age is not usually relevant in papers using 6MWT in adult population [32, 34].

In pregnant women, 6MWD is similar to results of Dennis et al. (495±99m) and Da Silva et al. (497±38m). That is probably explained by the fact that we used the same guidelines [16] and their subjects had similar gestation time than ours (37 and 37±1.3 respectively for da Silva et al. and Dennis et al.). On the other side, Kan et al. found a walking distance of 526.79m in 35 pregnant women of 36.7±2.2w gestation time [18]. This result differs from the ones we obtained. That difference could be due to different guidelines during the test as we did not get any information about these. For instance, we know that encouragement can change 6MWD [35]. That implies that these results could not be relevantly compared with ours.

Ekman and al. showed that subjects improve their average 6MWD of 51 m after losing weight. The study included subjects who started with BMI of 40.5kg/m² which decreased to 34.8kg/m² [36]. We made the assumption that the opposite could be true. We thought weight gain would have a major effect on 6MWD and thus functional exercise capacity. In this case, pregnant weight or weight gain would have been correlated to 6MWD. However, that hypothesis did not work out. In fact, functional exercise capacity in our pregnant subjects is not directly impacted by their weight. While body systems become more impacted throughout pregnancy, we thought gestation time could influence 6MWD. This proved to be wrong as we found no correlation between 6MWD and gestation time.

Mean heart rate of the pregnant-group (89±2.5p/min) was already higher than the control-group at the starting line. Our data are similar to Dennis et al. (85±10.8p/min) and Da Silva et al. (84±15p/min) [19, 20]. This increased heart rate is explained by needs of the foetus. To grow up, it needs nutriments and oxygen carried by vascular flow to the placenta [37]. In order to answer the need, vascular flow will increase up to 20% at third trimester by increasing cardiac output and heart rate up to 40-50% and 10-20%. Same mechanisms occur when body is at exercise [5].

Heart rate is a very good indicator of exercise intensity [5] and maximal heart rate is a well-established method used by professionals to gauge exercise intensity [38]. Comparing %MHR between pregnant and control subjects, we showed that exercise intensity was similar in both groups. This is also supported by the fact that they have the same increase of HR.

6MWD/HR6' was calculated to put forward the distance walked during 1 heart pulsation. This could be interpreted as the efficiency of one heart pulsation to produce exercise. Pregnant women are less efficient as they have a smaller ratio 6MWD/HR6'. In comparison with control subjects, efficiency of the effort made by pregnant women is decreased even if they achieve similar intensity of exercise.

Da Silva et al. showed a similar increase of 2 units on the dyspnea Borg scale in 37 pregnant women [20]. However, δDyspnea does not differ between our pregnant and control subjects. Pregnant women are consequently more breathlessness at rest and will increase their dyspnea similarly to control subjects. It is not surprising as we know 70% of pregnant women declare dyspnea or breathlessness during their daily living activities as soon as the first trimester of pregnancy [4, 39].

There was no variability in gait speed in pregnant women as it has been showed by cystic fibrosis patients [40].

Concerning postpartum subjects, no cardiorespiratory data were ever recorded during 6MWT in the literature [23, 24].

The 6MWT done with our postpartum subjects is similar to Liu et al. who showed that 196 6-weeks postpartum women made a mean 6MWD of 367.6m [23]. Conversely, Deering & al. measured a distance walked of 640±65m by 8-10 weeks postpartum women [24]. That is lower than their control-group which realized 689±57m. Although they do not explain if they used guidelines to realize 6MWT, they insist on the fact that they asked their subjects to "Walk as quick as possible", which is the instructions recommended in the ATS guidelines. That could probably explain the dissimilarity between our results. However, they gave the same instructions to all subjects and found a difference of 49m between their pregnant and postpartum subjects, which is rather close to our result of 44m.

6MWD is significantly and clinically lower in PP-group in comparison with control-group whereas it is only significantly higher than PR-group. The reduction of distance (δ%6MWDpred) were similar in postpartum and control groups.

Heart rate values of postpartum subjects are similar to normal values [5] and thus lower in comparison to PR-group [32]. As postpartum and control subjects reach similar %MHR but have bigger 6MWD/HR6', their efficiency is higher than the pregnant-group although the intensity of exercise is similar.

Consequently, we cannot say functional capacity is totally recovered in postpartum women. However, we showed that they recover normal cardiorespiratory parameters and that they have a better efficiency for similar intensity of exercise than pregnant subjects.

If we compare to control subjects, %MHR was lower in postpartum subjects. Therefore, postpartum subjects walked a smaller distance but mainly because they did not reach an equal intensity of exercise. 6MWD/HR6' confirms that postpartum subjects have similar efficiency as control-subjects. The positive correlations between HR6' and dyspnea-F in the postpartum group confirm the link known between 6MWT, HR and dyspnea.

Gait speeds realized in the first, second and third 2 minutes are constant. This parameter was also steady with the pregnant woman, as we discussed earlier.

It seems important to us to recall that 4 of 9 postpartum subjects spontaneously complained about fatigue before starting the test. 5 of them also explained they could not easily do their usual daily activities yet. This is often mentioned in the literature: postpartum women have difficulties with new habits of life, short nights, breastfeeding and suffer from fatigue [41-43]. We suppose it had an impact on our results.

The main limitation of our study is the fact that pregnant and postpartum subjects were not the same individuals. Moreover, we needed 34 postpartum subjects and it was not possible to assess that much subjects in this short period of time. Finally, we had a large amount of refusals. So the postpartum-group is small compared to the a priori sample size calculation.

The strengths of this study were multiple. The fact that all subjects were tested by the same assessor enabled to avoid inter-raters variability. Before starting the study, the assessor practiced explaining the approach and walking the subject through the "6 minute walking test", increasing his reproducibility.

This paper promotes to enhance assessment of functional exercise capacity by pregnant and postpartum women.

## CONCLUSION

Functional exercise capacity is decreased during pregnancy and the current results suggests it is also decreased in postpartum women. Pregnant women realize an exercise which is from the same intensity as the control group but with a lesser efficiency.

## DECLARATION OF INTEREST

No conflict of interest declaration.

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ABSTRACT

INTRODUCTION

Pregnancy has an important impact on the physiology of women and hence influences functional exercise capacity (FEC). In current scientific literature, there is no consensus regarding the measurement of FEC in postpartum women. Pregnant and postpartum women have never been studied in the same paper while using adequate guidelines. As pregnant women have sedentary behaviours, we hypothesized that both pregnant and postpartum women would have a decreased FEC compared to a non-pregnant group.

METHODS

Pregnant and post-partum women were asked to participate in the current study. They performed a 6 minute walking test (6MWT). Peripheral saturation in oxygen, heart rate and dyspnea were measured. Means were compared with an unpaired Students T-test. Pearson's correlation was used to examine correlations between variables of interest (e.g. 6 minute walking distance, heart rate, dyspnea, weight).

RESULTS

In total, 72 women volunteered for the study: 32 pregnant women, 9 postpartum women and 31 non-pregnant women (control-group). Distance walked during the 6MWT was significantly higher in the control-group (632m) compared to the pregnant and postpartum groups ($p<0,001$, $p<0,001$ respectively). Heart rate and dyspnea at starting line were significantly higher in the pregnant group in comparison with postpartum and control groups ($p<0.001$, $p<0.001$ - $p=0.015$, $p=0.030$, respectively).

CONCLUSION

The results of the current study confirm that functional exercise capacity is decreased in pregnant and postpartum women.

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