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RESEARCH ARTICLE

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Impact of Gestational Period and Weight on Individual, Task and Environmental Constraints on Balance in Pregnant Women

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ABSTRACT

Pregnancy coincides with sensory, perceptual and motor changes that may affect a person's ability to perform basic activities of daily living (ADLs). Previous research suggested that weight and gestational age (trimester) may affect the way women negotiate balance related tasks, but these issues require further analysis. This study utilized Newell's Model of Constraints as a framework to shape a questionnaire investigating an individual's ability to perform different task-related activities across various constraints. Additionally, this study examined whether variables such as pre-pregnancy weight (under vs. over 155 pounds) and trimester (before vs. after 26 weeks) had an impact on their ability to perform different tasks requiring balance.

Twenty pregnant or postpartum women (M = 29.7 years; SD = 3.6) were recruited and asked to complete a 15 item online survey exploring their abilities to complete a variety of daily tasks involving balance. In addition, open-ended questions were posed to gain qualitative insights into their experiences. A series of independent sample t-tests showed predominantly no statistical difference between the levels of the variables manipulated. At the descriptive level the women indicated that they were relatively comfortable performing the different tasks. However, the qualitative responses suggested that although they were capable, it was clear that they expended a substantial amount of energy to avoid falling, resulting in fatigue and soreness, and they experienced overall mental anguish and feelings of being overwhelmed. Overall, it was surprising that weight and gestational age, which intuitively should have impact, did not have a more pronounced effect on the women's confidence in performing ADLs, nevertheless, qualitative responses confirmed the challenging effects of pregnancy on balance control.

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Introduction

Pregnancy, childbirth, and the postpartum period have a significant physical and emotional impact on pregnant women [1]. Often, these women experience significant changes related to their musculoskeletal as well as sensory and perceptual systems in order to accommodate for the growing fetus. Morphologically, these changes include joint laxity, increased anterior pelvic tilt, and weight gain [2]. Often these issues may prevent women from maintaining physical activity while performing ordinary activities of daily living. This is an important issue as physical activity may play an important role in counteracting some of the challenges associated with being pregnant [3]. A comprehensive study analyzing physical activity levels, before and during pregnancy noted that the potential decline in the levels of physical activity and functional ability may be time-specific, as women in the third trimester and in the postpartum period, tend to do less as compared to activity levels of their first and second trimesters and compared to their pre-pregnancy counterparts [4]. In addition, from a psychological standpoint, women in later stage pregnancy have reported an increasing lack of perceived competence in their ability to carry out everyday tasks due to physical and mental fatigue. In addition, many experience anxiety regarding safety issues around participating in regular physical activity and even simple daily physical tasks [3,5].

Newell's model of constraints [6] used across different motor behaviour fields, was incorporated in the present context to systematically examine how different factors prevent or afford pregnant women the ability to balance during daily living tasks [7]. In this model, the environmental constraints, as related to issues examined here, include factors within the environment that may have an impact on the way a person behaves motorically such as icy sidewalks, slippery floors, or temperature. Task constraints relate to the characteristics of the goal of an action that shape one's performance. In the present context, these included carrying heavy groceries, walking up or down the stairs with or without additional loads, cleaning floors, doing laundry or exercising. The last, but probably the most important category, pertains to individual constraints, which can be further subdivided into those of a functional and

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structural nature. Functional constraints may include perception of competency, pain, fear or anxiety, as well as the status of motor (inter-limb coordination), perceptual (proprioceptive function), or physiological (endurance/strength) systems. Structural constraints pertain to morphological characteristics of a person such as weight, height, size of the base of support (feet), or overall body composition. The relationship between these factors or constraints may guide the person towards certain movement patterns, while preventing them from performing others. Although these altered movement patterns are possible, they are not desirable as they may be ineffective, and over time may become contributing factors responsible for significant comorbid conditions leading to musculoskeletal issues such as sore limbs, overall fatigue or evenfalls. As well, psychological issues such as depression and stress could arise [8].

In the context of this research, balance control was operationalized as a person's ability to avoid staggering or falling during both static and dynamic tasks encountered during the activities of daily living. During pregnancy, the ability to maintain balance can become an issue due to the challenges of perceiving one's body in space, via proprioception [9,10]. Also, weight gain, decreased strength, altered posture, and anterior pelvic shift of the center of mass affects the ability to adapt to the potential perturbations that often lead to falls or staggering [1,2,11,12]. Most recent evidence showed that pregnant women who are in their second and third trimesters report a more pronounced perceived lack of balance control and a higher number of falls compared with women who are in earlier stages of pregnancy [10]. This may be related to the potential fatigue that often accompanies carrying additional weight [11]. These issues can be particularly challenging when trying to maintain balance when walking up and down stairs when the pressure on ankles, knees, and hips is even more pronounced compared to balancing on a flat surface, or performing more static activities [1].

Effective balance control, and confidence in the ability to prevent staggering and falling are critical to both the health of the developing fetus and the pregnant woman. As a result, it is important to systematically delineate which activities prove to be challenging and the strategies that are incorporated to alleviate the possibility of such occurrences. This type of descriptive analysis should also be carried out in the context of the different morphological changes such as weight, and the trimester. Thus, the purpose of this study was to delineate the degree to which various constraints placed upon pregnant women, affected their ability to maintain balance. It was hypothesized that increased weight and advanced gestational age (trimester) would negatively impact balance and confidence in the ability to ambulate while performing activities of daily living.

Methods

Participants

Twenty participants were recruited from local community centres via purposive and snowball sampling. In order to take part, the participants had to be at least 18 years of age, pregnant or postpartum after haven given birth within the last 6 months (Table 1). Additionally, participants were required to be free from all debilitating musculoskeletal disorders or deficits (determined by self-report) that might adversely affect their balance. The demographic information, including items such as weight, activity status and gestational age are presented in Table 1. This research was carried out in accordance with the ethical standards of the International Journal of Exercise Science [13].

Protocol

Utilizing Newel's model of constraints, the survey was constructed by categorizing and shaping questions surrounding task, individual (functional and structural) and environmental constraints. Task constraints captured the way in which different activities "shape" certain movement patterns in order to complete the tasks. For example, carrying groceries from a car to the house or standing up from a sitting position. Questions pertaining to individual constraints focused on the degree to which the participants had confidence, anxiety or perceived fatigue surrounding the performance of their daily tasks, as well as the way different morphological characteristics such as height, weight or gestational age affected their abilities. Lastly, items pertaining to the environmental constraints focused on the ability to navigate through different environments for example balancing while riding an escalator or when walking outdoors on slippery surfaces.

The questionnaire included five sections. Section one focused on demographic information (see Table 1). Section two included five questions under three different constraints, individual, task, and environmental, as related to performance of balance-related tasks. Section three investigated the perceived changes in only third trimester and postpartum women, and it also included five questions. This section asked questions surrounding altered functional abilities in late-stage pregnancy, for example the ability to walk or sit for long periods of time as well as whether they experienced increased fatigue. The participants were asked to rank their confidence in relation to the posed question on likert scale ranging from 1 (being not confidence) to 5 (being most confident). The final section included a single open-ended question, which prompted the participants to relay any changes, concerns, or noteworthy experiences they felt had not been covered in the survey, but were important in their pregnancy experiences. This section yielded qualitative insights into the balance and motor control related issues that the participants experienced throughout their pregnancies. The questionnaire took approximately 20 minutes to complete.

	Minimum	Maximum	Mean	Std Deviation
Participant Age (yrs.)	23	36	29.70	3.60
Pre-pregnancy weight (lbs.)	115	260	156.75	35.86
Activity level (min/week)	0	420	168.50	123.64
Gestational age (weeks)	8	39	25.27	9.16
Postpartum Duration (weeks)	7	29	14.25	10.04

Table 1: Descriptive statistics for weight, age, gestational age (pregnant/postpartum), and physical activity status.

Once ethical approval was granted from a Lakehead University Regional Ethics Committee, recruitment posters were displayed at different locations including Maternity Care Midwives, the Lakehead Nurse Practitioner Clinic, Oakenfold's fitness (fitness company for pregnant and postpartum women), as well as via social media (Facebook/Instagram). Participants who showed interest in the study were sent a link to the survey administered via Survey Monkey, which also provided an information letter, and a consent letter. Participants were informed of their right to withdraw from the study or refuse any questions with which they were not comfortable. Once the appropriate sections were filled out giving informed consent and the information letter was read, the participants clicked next to fill out the questionnaire.

Statistical Analysis

The SPSS program (statistical package for the social sciences) was utilized to analyze the quantitative data. A series of independent samples t-tests were carried out at 0.05 alpha level. A between subjects design was incorporated with gestational age status (before and after 26 weeks) and the weight status (above or below 155lbs) as the independent variables. Cohen's d [14] was used as a measure of the effect sizes, with values of 0.2 considered as small; 0.5 being moderate; 0.8 representing a large effect size.

Results

Overall, the results of the analyses revealed predominately no statistically significant results, with low effect sizes (Table 2). The specific aspects of each analysis were reported below.

	Weight				
	1	2	3	4	5
Individual	.51;.09	.72;.06	.41; .05	.58; .06	.22; 08
Task	.39; .10	.55; 09	.27; .06	.56; .07	.29; .09
Environmental	.82; .03	.57.07	.58; .08	.51; .04	.07; .2
	Trimester				
Individual	.71; .07	.72; .03	.43; .07	.14; .10	.52; .1
Task	.88; .03	.97; .001	.50; .6	.22; .87	.84; .03
Environmental	.59; .07	.04; .32	.02; .57	.78; .03	.20; .17

Table 2: P values and corresponding d effect sizes (p; d) for all the comparisons for differences across the three types of constraints, because of Weight and Trimester.

Impact of Trimester on Balance Control

The analysis of how the duration of the pregnancy affected balance control, across different individual (Figure 1, question 1-5) and task (Figure 2, question 1-5) and environmental constraints (Figure 3, questions 1-5), revealed predominantly no statistically significant differences. Thus overall, the results did not support the initial hypothesis, as it was expected that women who were past 26 weeks of gestation would exhibit more pronounced issues with their ability to balance when compared to women who were pregnant for 26 weeks or less. However, the analysis of descriptive data, across the three sets of constraints, did provide some interesting trends.

Individual Constraints

In terms of the impact of individual constraints (Figure 1, questions 1 to 5) no reliable differences emerged, with the exception of question 5. Thus, both groups exhibited similar levels of confidence in their perception of their body in space and maintaining balance whilst not being able to see their feet over their pregnant belly (question 1). Question two referred to their ability to manage crowded spaces without bumping into people, whereas question 3 focused on the ability to maintain balance when their muscles become more fatigued during a task (question 3). Question 4 focussed on participants' perceived confidence to balance when they experience ankle and knee joint pain, while question 5 dealt with the issue of managing steep slopes and stairs, where women in later stage of pregnancy seemed to be more comfortable as opposed to the other group. It is also worth noting that with the exception of one set of responses, regardless of group belonging, the women overall viewed their abilities in a positive way, as indicated by scores above three.

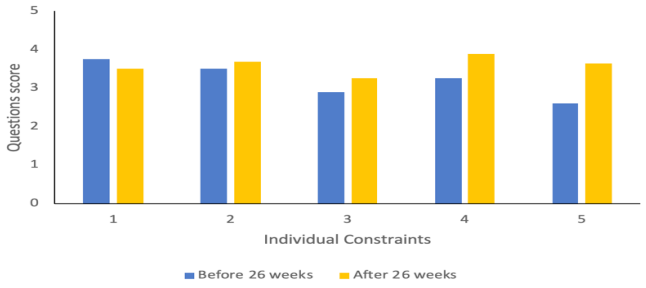

Figure 1: Responses averaged across all participants pertaining to the ability to maintain balance across different individual constraints.

Task Constraints

The analysis of the impact of different task constraints also provided somewhat unexpected results. As evident from Figure 2, even though no substantial differences between groups emerged, overall, both groups expressed mostly positive outcomes across scenarios presented. Regardless of the duration of their pregnancy they perceived that they were confident in their ability to carrying heavy loads without staggering or falling (question 1), navigating through crowded public spaces while maintaining balance (question 2), lifting items from waist height to above their head (question 3) and completing a full forward flexion as if to tie shoes without losing balance (question 5). The most pronounced descriptive difference emerged when the participants were asked about their confidence in taking part in exercises that they had participated during the pre-pregnancy stage (question 4). The participants who were in their earlier stages of pregnancy had more confidence in their abilities to maintain such exercise routines, as compared to those who were further along in their pregnancy.

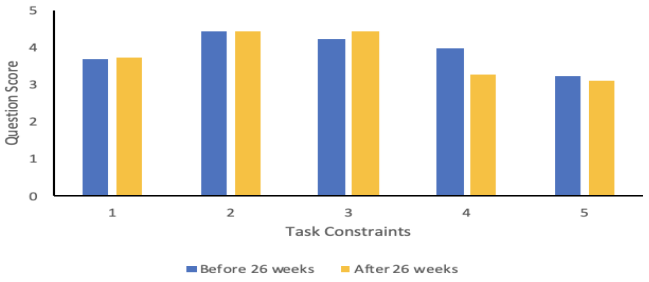

Figure 2: Responses averaged across all participants pertaining to the ability to maintain balance across different task constraints.

Environmental Constraints

The last set of questions focused on the impact of pregnancy duration on the ability to maintain balance across different environmental contexts. Among the three sets of constraints, these questions provided the most variability in responses. These data showed no substantial differences when the questions investigated the participants' confidence in their ability to balance while getting into and out of a car (question 1), navigating slippery or wet surfaces (question 3), as well as maintaining balance in the presence of perturbations (question 5). The significant differences between the groups were however observed when items were related to standing up and sitting down (question 2), as well as when stepping onto or off an escalator (question 3). In the former, women under 26 weeks perceived themselves as less capable at maintaining balance when getting in and out of the car, when compared to women who were in the more advanced stage of pregnancy, whereas the opposite scenario was evident in question 3. Lastly, as evident from the responses to question 4 pertaining to moving on slippery or wet surfaces, both groups were lacking confidence as they scored below 3, as compared to the other questions that were predominantly scored higher.

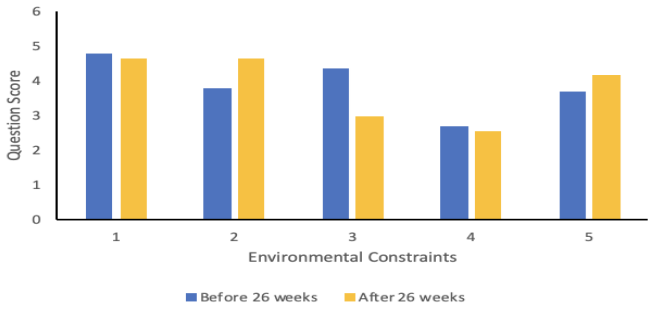

Figure 3: Responses averaged across all participants pertaining to the ability to maintain balance across different environmental constraints.

Impact of Weight on Balance Control

In line with the previous analysis, this data set also showed no statistically significant difference between groups across the questions. Thus, the initial hypothesis, those pregnant women who were heavier would have more difficulty navigating through their activities of daily living than those who had a lower weight, was not supported. Nevertheless, the analysis of the descriptive data sets, including all three sets of constraints, revealed some robust trends.

Individual Constraints

As evident, no statistical differences between the groups emerged indicating that differences in weight did not affect the ability to maintain balance when the women were not able to see their feet over their pregnant bellies (question 1). In addition, this variable had no impact on the ability to perceive how close or far objects or people were away in space surrounding the individual (question 2), or when performing activities after their muscles were fatigued (question 3). The same was true for question 4 and 5, capturing their confidence in their abilities to maintain balance performing activities with sore knees and ankles (question 4), and maintaining balance while navigating steep slopes and stairs respectively. In terms of inter-item variability, there was a consistent pattern showing that overall, the women were rather confident across the different individual constraints, scoring 3 or above.

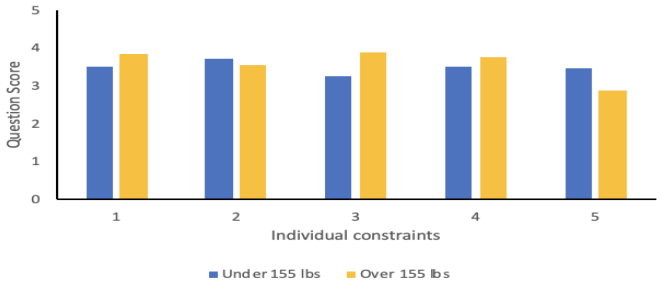

Figure 4: Responses pertaining to the ability to maintain balance across different individual constraints.

Task Constraints

In terms of the effect of weight on the ability to maintain balance control across different task demands, once again no statistically significant differences emerged. Thus, regardless of the weight, the participants did not exhibit different perceptions in their ability to maintain balance while carrying heavy loads (question 1), navigating through crowded spaces (question 2) and completing tasks that require pronounced knee and hip flexion (question 3). In a similar fashion, no difference emerged when making inferences about participating in activities that they had done pre-pregnancy (question 4), and during forward flexion while bending forward (question 5). As it was the case with the previous set of constraints, the women expressed rather positive perceptions in regards to their abilities, especially in questions 2 and 3.

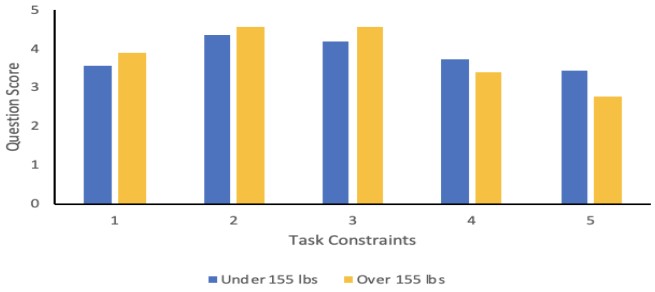

Figure 5: Responses averaged across all participants pertaining to the ability to maintain balance across different task constraints.

Environmental Constraints

The analysis of different environmental constraints showed that weight had no impact on the ability to maintain balance while getting into and out of a vehicle (question 1), and standing up and sitting down (question 2). In addition, the women felt that they were rather capable when navigating slippery or wet surfaces (question 4), and staying balanced if someone bumped into them unexpectedly. In terms of the differences between the different questions, it appears that stepping onto and off the escalator (question 3) was perceived as the most challenging environment constraint to negotiate, while getting in and out the car did not represent any considerable concern.

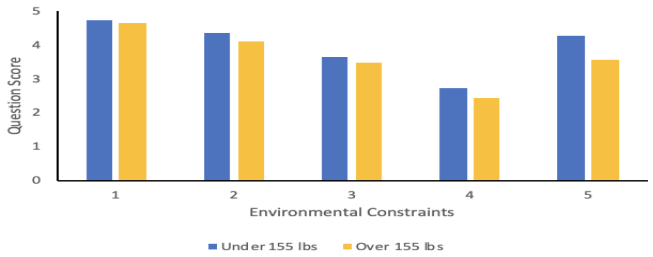

Figure 6: Responses averaged across all participants pertaining to the ability to maintain balance across environmental constraints.

Qualitative Insights

The participants were prompted to share any additional information that was not covered in the survey. The qualitative data, as displayed in Table 2, yielded two major themes. First, several women reported the pain resulting from comorbid disease or MSK injuries caused by pregnancy. These issues were often associated with their ability to perform even seemingly simple tasks during their daily routines. Second, the other key theme, which was contradictory to the quantitative data, was related to issues of falling while performing different tasks, across different environmental constraints. Moving slower, a necessity to use different devises for support, frequent rests, and higher energy expenditure emerged as some key factors in this domain.

Table 2: Examples of key themes expressed in the qualitative data.

Pain as a result of comorbidities	Fear of falling relating to fatigue
Participant 5 - "I have been using a squatty potty when going to the washroom to help alleviate added tension/pressure on the pelvic floor."	Participant 2 - "Taking things a lot slower than I have pre-pregnancy when going out for longer walks or on uneven/slippery terrain to have someone with me to be able to use for stability if needed."
Participant 6 - "My pelvic bone hurt daily to walk, climb stairs, change weight from one leg to another and in bed my pelvic bone throbbed while asleep"	Participant 9 - "Going down the stairs while carrying something large (think full laundry basket) is scary puts my balance off in a way where I no longer feel comfortable in the movement"
Participant 6 - "I feel as though I separated my pelvic bone during delivery and was not able to obtain a walker as I couldn't bear any weight on my pelvic bone post-delivery"	Participant 12 - "Using handrails on stairs while carrying my other baby. I also walk slowly (waddle) on ice. I also have to take frequent breaks while housecleaning."
Participant 8 - "Being placed on the modified bed from 25-36 weeks put a significant role in my end-stage pregnancy. I do believe that the modified bed rest is directly correlated to my decreased mobility, weight gain, and increased third-trimester pregnancy symptoms such as pregnancy-induced carpal tunnel syndrome and pitting edema."	Participant 20 - "Yes, anxiety and fear of falling 100% affect my confidence when walking and actually make me more at risk for injury as I don't walk/move naturally but am more stiff/robotic like."
	Participant 31 - " I plan my day according to energy levels"

Discussion

The purpose of this research was to examine the degree to which body morphology, such as weight, and the duration of the gestation period affected balance control of women who were pregnant, across different constraints. The statistical analysis did not support the original hypothesis as no reliable statistical differences emerged. Nevertheless, the analysis of descriptive data, and triangulated qualitative insights provided some robust and interesting inferences.

Previous research indicated that women who are further along in their pregnancy exhibited pronounced physiological and morphological changes that may impact their confidence in maintaining balance across different tasks [4]. This finding was not confirmed by the present results. Regardless of the gestational period, the participants reported that, overall, they were confident in their ability to balance during activities of daily living across different contexts. This was a robust finding as across the five items and different constraints, their scores were 3, or higher. Once again, this finding was not in line with previous reports as pregnant women often reported joint laxity, anterior pelvic tilt, fatigue, and hormonal changes [2], which may affect a person's ability to balance, and even more so later on during the pregnancy [9]. Among the three types of constraints examined, the responses pertaining to the environmental factors provided the most variability. Although relatively static tasks such as getting into and out of a car, as well as standing up and sitting down were not perceived as challenging, navigating through slippery or wet surfaces and maintaining balance when mounting or dismounting an escalator, were more concerning. From the motor behaviour perspective, this is not surprising, as these tasks likely require more reliance on different perceptual systems that are often altered by the morphological changes pregnant women experience. In line with the analysis of the impact of gestational period on balance control, also the examination of weight did not reveal any reliable statistical differences. Previous work suggested that weight gain represents an important constraint on motor behaviour of women who are pregnant as it may affect the biomechanical aspect of control, as well as physiological status, such as endurance and energy expenditure [3]. However, the results derived from this research showed that the differences in weight did not affect the participants' perceptions regarding their ability to maintain balance control. In fact, regardless of the weight, and the different constraints examined, women tended to perceive their abilities to maintained balance as relatively high. This trend was consistent with the initial analysis.

While the quantitative results regarding balance, as affected by trimester and weight, remained equivocal, the participants provided interesting insights into their experiences in managing balance during pregnancy in general. Despite the fact that the quantitative data showed a relatively high degree of confidence in maintaining balance across the different every day activities, the qualitative data revealed a different scenario. Among the several themes that emerged, the participants acknowledged that because of various comorbidities related to pregnancy, they experienced moderate to severe pain while performing everyday tasks. Pain was clearly identified as a factor that affected balance throughout pregnancy and during postpartum period, specifically in the pelvic region including lower back pain and pelvic floor pressure and pain. Often the prolonged feeling of pain and discomfort may have affected the sensory and perceptual status, as their less-than-optimal ability to perceive the surroundings makes them feel uncomfortable. In addition, a general fatigue was a theme that persisted in the anecdotal reports of those who had comorbid musculoskeletal or physiological deficits. These participants indicated that physical as well as metal fatigue did in fact affect their balance, and caused an enhanced fear of falling or staggering. As an example, one participant (#20) indicated that she plans her day in accordance with her energy levels. In addition, another participant indicated that due to the physical burden that comes with pregnancy, in her final trimester she was placed on modified bed rest to cope with a comorbid musculoskeletal issue resulting in very limited amount of physical activity. In addition to perceptual and motor factors that may contribute

to less-than-optimal balance control, participants reported that other constraints were affecting the quality of their pregnancies. They commented on a lack of information and resources available to them in the local Northern communities. Also, obtaining items such as walkers or being able to see a physiotherapist were noted as a common issue amongst participants. As evident, these qualitative inferences did not corroborate the quantitative analysis, which confirms that the issues exhibited by pregnant women in regards to balance control are complex, and from the methodological perspective may require different types of measures.

Limitations

It is interesting to note that the qualitative analysis captured the many challenges that were expected to surface, which quantitative analysis failed to reveal. The reason for the presence of such unequivocal findings is difficult to delineate. However, one possibility is that the participants self-reported a high level of confidence due to social pressures they may have felt to represent their pregnancy experience in a positive way Or, to represent themselves in a way that highlighted their capabilities and adaptability to adjust successfully to the changes or struggles they experienced. Also, from the psychometric perspective, it is plausible that the relevance and representativeness of the items in the survey requires further validation in order to assure the accuracy of the construct being investigated. Finally, the inter-individual differences in the amount of physical activity exhibited may have contributed to the results. The participants ranged from those who were very active, as they exercised above 180 minutes per week advised by guidelines [15], and those who were completely sedentary. Thus, those who had a higher fitness status may have exhibited substantially higher perceptions of their abilities to control balance, as opposed to those who did very little.

Conclusion

Previous research supported the notion that enhanced gestational age (trimester) as well as weight gain are factors which may negatively affect balance control of pregnant women [1,11,12]. The current analyses failed to support these inferences as only very subtle, and variable differences emerged across the different types of constraints examined. Nevertheless, some robust trends did emerge. Most notably, the participants expressed a relatively high level of confidence and positive perceptions in regards to their ability to maintain stance and avoid falling or staggering. This was a consistent finding across the varying constraints examined. In the future, studies, the fitness or levels of physical activity status, before as well as during the pregnancy, could be considered as the independent variable to further examine the impact of this individual constraint on motor behaviour of pregnant women.

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