Physical activity during pregnancy: a review of evidence-based recommendations

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Abstract

Background: Physical activity, as a key part of healthy lifestyle, is essential to maternal and infant health. Healthcare workers should inform pregnant women about benefits of physical activity to prevent possible health issues. Those recommendations should elaborate on relevant contemporary evidence. The aim of this paper was to review evidence-based recommendations for physical activity during pregnancy.

Methods: A systematic search, analysis and synthesis of conducted randomised controlled trials (RCTs) was conducted from October 2021 to February 2022 in following databases: CINAHL, ScienceDirect and Web of Science. Literature was searched using inclusion and exclusion criteria and following PRISMA recommendations.

Results: Benefits for pregnant-women health and well-being were reported while performing aerobic exercise, lumbar stabilization and stretching exercise, water exercise, nerve and tendon-slip exercise, resistance training and strength training. For all exercise modalities it is recommended to perform moderate intensity activities during the whole time of pregnancy.

Conclusions: This systematic literature review supplements current knowledge on physical activity of pregnant women. It is believed that physical activity has many positive outcomes on maternal and infant health. Thus, interventions in terms of exercise prescriptions are listed and suggested in an integrative model to contextualize and promote physical activity among pregnant women.

1. Background

Physical activity (PA) is defined as “bodily movement produced by skeletal muscles that results in energy expenditure” (1). The terms PA, exercise, and physical fitness are distinct concepts. However, these concepts are often used interchangeably. A seminal paper defines exercise as “a subset of PA that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness”. Finally, physical fitness is deemed “a set of attributes that are either health- or skill-related” (2).

PA is believed to be essential to healthy pregnancy. Historically, Biblical writers noticed that Hebrew slave women gave birth more easily than sedentary Egyptian mistresses (3). Moreover, it is known that PA during pregnancy limits gestational weight-gain (4; 5; 6), decreases risk of maternal mental disorders after childbirth (7; 8) and improves body image satisfaction (9). PA in pregnancy is pivotal to facilitating positive health outcomes in infants (10).

However, pregnant women tend to demonstrate a lack of knowledge regarding PA during pregnancy (11; 12; 10). The reasons for insufficient knowledge include but are not limited to the mothers’ race (13), socio-economic and cultural context (14), and maternal education (15). Hereby, healthcare professionals play a pivotal role in promoting PA among the pregnant women. However, relatively low degree of pregnant women report that they had received exercise prescriptions from health providers during pregnancy (16).

On the other hand, women who were given guidelines for PA during pregnancy reported exercising (17). An important barrier to enhancing pregnant women' knowledge about PA is a result of absence of PA-related domains in the development of professional health workers (18). Consequently, most women are accessing information about healthy lifestyle during pregnancy via the internet with questionable credibility (19). While the Internet allows for accessibility and real-time scientific updates, it can also initiate and contribute to "misinfodemics" (20).

In addition to potential issues with credible sources of information, pregnant women might require tailored and goal-oriented interventions. Interventions should hence aim at prescribing various exercises. Evidence-based recommendation are thus listed and contextualized to be provided to pregnant women, professional healthcare workers involved in nursing, and wider society to provide best care for pregnant women.

2. Methods

In this chapter, study design, search methods, search outcomes, quality appraisal, data abstraction and data synthesis are described.

2.1 Design

A systematic review is a summary of the medical literature that uses explicit and reproducible methods to systematically search, critically appraise, and synthesize a specific health issue (21). Following steps were taken into account when performing a systematic review: 1) defining research question; 2) preliminary literature search; 3) development of search string, inclusion and exclusion criteria; 4) literature search and analysis; 5) literature synthesis; 6) assessment of literature quality and bias; and 7) interpretation of findings and proposition of future directions.

2.2 Search methods

For the development of research question, a Population, Intervention and Outcome - PIO (22) format was used. The research question was: *"How does physical activity impact pregnant women and infants?"*

Exclusion and inclusion criteria were developed based on the preliminary literature search and PIO research question (Table 1).

Table 1
Search criteria and inclusion and exclusion criteria

Databases	**PubMed, CINAHL, ScienceDirect and Web of Science**	
	Inclusion criteria	**Exclusion criteria**
Limits	English language, Publication between January 2016 and February 2022, RCTs	Other languages Publication before 2016 Pilot studies, protocols, secondary analyses, commentaries, cohort studies
Population (P)	Pregnant women (1. – 37./42. week)	Postpartum women, children, infants
Intervention (I)	PA (e.g., cardiorespiratory, fitness, endurance, strength, etc.)	Interventions that did not involve exercises and span beyond PA (e.g., mindfulness, diet)
Outcome (O)	On pregnant women during pregnancy and post labour (hormones, weight, gestational diabetes, pain, mental well-being, quality of life) and, if applicable, on infant - denoting something in an early stage of its development (development, growth, feelings)	Not related to pregnant women's, children's health outcomes or exercise modality.

A search string was developed based on preliminary literature search and was taken into account in the process of literature search (Table 2).

Table 2
Search results

Search string	**Database**	**Number of hits**
(sport* OR exercise* OR physical activit* OR fitness OR aerobic OR training*) AND (pregnant* OR pregnancy OR gestation* OR gestate OR gestational OR maternity OR maternal OR prenatal)	PubMed	616
	CINAHL	131
	Web of Science	122
	ScienceDirect	300

2.3 Search outcomes

Using the developed search string 1259 records were identified in four databases. After duplicates exclusion, literature was checked by title and abstract; 24 articles were retrieved and checked by the full

text. Finally, 18 articles were included in the final analysis and synthesis. Steps of literature search are presented in Fig. 1 (23).

2.4 Quality appraisal

The data quality was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system (24; 25). GRADE identified its five categories—study limitations, imprecision, inconsistency, indirectness, and publication bias. GRADE quality level is interpreted as high (++++), moderate (+++), low (++), or very low (+).

2.5 Data abstraction

Data were extracted using standardized data form in Microsoft Excel® by two reviewers. The first reviewer exported data and second reviewer checked for data accuracy. The literature screening was carried out independently by two researchers. Disagreements were solved by consensus. We extracted study characteristics such as study sample, intervention, main study results and conclusions.

2.6 Data synthesis

A narrative synthesis was conducted for all included studies. Results were synthesized by PA modality and intensity or duration of PA. Also, results were synthesised due to intervention effectiveness.

3. Results

In total, 18 articles were included in the final analysis (Table 3). Studies which fit the inclusion criteria were analysed due to sample, intervention, results and conclusions. Excluded studies are listed in the Appendix 1.

Table 3
Study characteristics

No.	Reference	Sample	Intervention	Results	Conclusions
1.	(26)	456 pregnant women	Moderate aerobic exercise performed three days per week (50–55 minutes per session) for 8–10 weeks to 38–39 weeks gestation.	Higher percentage of pregnant women gained excessive weight in the control group (p = 0.018) The prevalence of gestational diabetes was significantly higher in the control group (p = 0.033)	Exercise throughout pregnancy **reduces the risk of** excessive **maternal weight gain** and **GDM.**
2.	(27)	20 pregnant women with low back pain between 19–29 weeks of gestation	1) lumbar stabilization exercise protocol; 2) stretching exercise protocol.	There was significant reduction (p = 0.03) in pain for both interventions, but no change in disability score. Both interventions showed significant improvement in postural stability the velocity sway parameter, and significantly increased activation (p > 0.05) of the external abdominal oblique muscle after intervention.	Lumbar stabilization and stretching are efficient for **pain reduction**, **improving balance and increasing one trunk activity muscle**.
3.	(28)	639 pregnant women between 16 and 20 weeks of gestation	16-week supervised exercise program including aerobic and resistance training delivered in 60-minute sessions 3 times per week.	There was no significant difference for postpartum depression between the intervention group and the control group. There was no significant difference in rates of postpartum depression between the intervention group and the control group.	**Moderate-intensity exercise** during pregnancy **did not lead to reductions in postpartum depression.**

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

No.	Reference	Sample	Intervention	Results	Conclusions
4.	(4)	436 pregnant women at < 20 weeks of gestation	5 face-to-face and ≤ 4 telephone coaching sessions using the principles of motivational interviewing.	In the health education and PA group, women achieved substantially less gestational weight gain than did the controls by 35 to 37 weeks. No improvements were seen in fasting or post load glucose levels or insulin concentrations. The birthweights and large and small for gestational age rates were similar.	The combined intervention showed **limitation of gestational weight gain.**
5.	(29)	One hundred and twenty-nine pregnant women from 20 to 37 week of pregnancy	The SWEP (study of water exercise during pregnancy) method.	The health-related quality of life score decreased significantly between weeks 12 and 35 of gestation, except for the mental health component. Among the control group, the score for the mental health component at week 35 was ≤ 42, indicating a positive screening risk of depression.	**PA** programmes in water, such as SWEP, **enhance the health-related quality of life** of pregnant women.
6.	(13)	594 pregnant women	The exercise-based intervention conducted three times/week for 16 weeks from 16–20 to 32–36 weeks' gestation.	There were no significant differences in the incidence of preterm birth and pre-eclampsia between groups. There were no differences between the two groups in mean gestational weight gain, gestational diabetes, birth weight, infant length, and head circumference.	The exercise program **did not have impacts** on maternal or infant health.

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

No.	Reference	Sample	Intervention	Results	Conclusions
7.	(30)	645 pregnant women	An intervention consisting of six sessions. Three sessions were face-to-face, with two provided by the dietitian shortly after trial entry and again at 28 weeks' gestation, and one provided by a research assistant at 36 weeks' gestation. Women received three telephone calls from the research assistant at 20-, 24- and 32-weeks' gestation.	There was no statistically significant difference in the proportion of infants with birth weight above 4.0 kg between groups (p = 0.732).	There are **improvements in maternal diet quality**, but **no significant differences** between the treatment groups were observed for total **gestational weight gain**, or other **pregnancy and birth outcomes**.
8.	(31)	40 pregnant women between 20–24 weeks of gestation	An aerobic exercise program in the form of walking on treadmill, three times weekly until the end of 37 weeks of gestation in addition to diet control.	There was a highly statistically significance decrease in fasting blood glucose level, fasting insulin level in both groups.	**Moderate intensity of aerobic exercises was effective** in reducing fasting blood glucose level and fasting insulin level in pregnant women with risk for GDM.

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

No.	Reference	Sample	Intervention	Results	Conclusions
9.	(32)	120 pregnant women	A supervised physical conditioning program consisting of three 60-min sessions per week for the whole duration of pregnancy (weeks 9–38).	No differences were found between the groups in maternal weight at 20-, 28-, 36- and 38-weeks' gestation or in weight gain at 38 weeks. The proportion of women with weight loss ≥ 9 kg at 6 weeks postpartum was higher in the exercise compared with the control group ($p = 0.02$). The ductus arteriosus pulsatility index at 20 weeks ($p < 0.05$) and the ejection fraction at 36 weeks ($p < 0.05$) were higher in the exercise compared with the control group.	Exercise during pregnancy **is not associated with a reduction in maternal weight gain** but **increases weight loss at 6 weeks postpartum**. Physical exercise during pregnancy is associated with increased fetal ductus arteriosus pulsatility index at 20 weeks and ejection fraction at 36 weeks.
10.	(33)	172 pregnant women	14-week supervised home-based stationary cycling program.	The recurrence rate of GDM was similar between groups ($p = 0.95$) and the severity of GDM at diagnosis was unaffected by the exercise program with similar glucose and insulin responses to the OGTT ($p > 0.05$). Maternal fitness was improved by the exercise program ($p < 0.01$) and psychological distress was reduced ($p = 0.02$). There were no differences in obstetric and neonatal outcomes between groups ($p > 0.05$).	Supervised home-based **exercise did not prevent the recurrence of GDM.** It showed **benefits for maternal fitness and psychological well-being**.

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

No.	Reference	Sample	Intervention	Results	Conclusions
11.	(34)	33 pregnant women	Nerve and tendon-slip exercise.	There were no significant differences between the groups in terms of symptoms and clinical tests ($p > 0.05$). The symptom severity scale between the groups was significantly high in group 1 ($p < 0.05$). Patients receiving treatment showed a decrease in symptom severity and functional capacity, but only the former showed a significant decrease in group 2 ($p > 0.05$).	**Nerve and tendon slip exercises** for pregnant women with mild to moderate carpal tunnel syndrome symptoms are simple and reliable methods for **increasing functionality and to reduce the severity of the disease.**
12.	(35)	134 pregnant women in second trimester	12 weeks of wait list, education classes, or twice weekly low-to-moderate intensity resistance training.	The group by time interaction showed that scores were unchanged across time after resistance training but significantly decreased for the education ($p = 0.001$) and wait list ($p < 0.001$) groups, whereas post-test vitality scores for the pregnancy group were significantly higher than the wait list ($p = 0.05$) but not the education group ($p = 0.27$).	**Adverse changes** in symptoms of energy and fatigue during pregnancy were reported when performing low-to-moderate intensity resistance training.
13.	(36)	91 pregnant women	3 weekly supervised exercise sessions (35 min of moderate intensity walking/running and 25 min of resistance training), until delivery.	There was no between-group difference in depression ($p = 0.55$).	There is **no effect** of supervised exercise during pregnancy on psychological well-being among women with high BMI.

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

No.	Reference	Sample	Intervention	Results	Conclusions
14.	(37)	516 pregnant women	Unsupervised water exercise twice a week for a period of 12 weeks.	Low back pain intensity was significantly lower in the water exercise group ($p = 0.04$). No difference was found in the number of days spent on sick leave ($p = 0.83$), disability due to low back pain nor self-rated general health. More women in the water exercise group reported no low back pain at 32 weeks ($p = 0.07$).	Water exercise contributes to **significant lower intensity of low back pain** in healthy pregnant women.
15.	(5)	435 pregnant women	Healthy eating and PA promotion intervention, a healthy eating promotion intervention, or a PA promotion intervention.	Between-group total cost and effect differences were not significant, besides significantly less gestational weight gain. Cost-effectiveness acceptability curves indicated that the healthy eating and PA intervention was the preferred intervention strategy.	Healthy eating and **PA promotion were preferred strategy for limiting gestational weight gain**.
16.	(38)	1023 pregnant women	Diet-related intervention and PA (increasing walking and being more active in daily life).	The PA intervention significantly reduced the Processed ($p < 0.0001$) and Snacks ($p < 0.0001$) pattern scores. In the adjusted model, baseline scores for the African/Caribbean and Processed patterns were associated with increased risk of gestational diabetes.	An intensive dietary intervention **improved dietary pattern scores**. Absence of results specifically focused on PA.

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

No.	Reference	Sample	Intervention	Results	Conclusions
17.	(39)	105 sedentary, nulliparous pregnant women	Exercise included a 60-minute general fitness class, with 40 minutes of endurance training/aerobic and 20 minutes of strength training and stretching/relaxation, performed at least twice per week for a minimum of 12 weeks.	Women randomized to exercise rated their health significantly better compared to women in the control group ($p = 0.02$) and reported less fatigue related to everyday activities ($p = 0.04$). Women with complete exercise adherence had significantly better scores on measurements of feelings related to sadness, hopelessness and anxiety ($p < 0.01$). The control group reported higher life enjoyment ($p < 0.01$). There were no significant group differences in body-image or pregnancy depression.	Regular group exercise during pregnancy contributed to **improvements** in variables related to **maternal well-being and quality of life**. Women with high exercise adherence had better results.
18.	(40)	724 pregnant women	12-week standardized exercise program, including both aerobic and strength training (20–36 weeks' gestation).	No between-group difference in serum 25(OH)D and related parameters was identified. There is a between-group difference in levels of 25(OH)D ($p = 0.048$), free 25(OH)D ($p = 0.017$) and bioavailable 25(OH)D ($p = 0.036$).	Exercise affect vitamin D status positively. **No adverse events** related to regular exercise were reported.

PA = physical activity; p = p-values; statistical significance; SWEP = study of water exercise during pregnancy; n = number of participants; BMI = body mass index; GDM = gestational diabetes mellitus.

In the remainder of this paper the observed studies are assessed for quality using the GRADE system (table in Appendix 2). All studies included were RCTs because of the search criteria. RCTs are seen as a high-quality body-of-knowledge (25). When assessing quality of each evidence, study design, study limitations, inconsistency, indirectness, imprecision and risk of bias were considered. The results of the assessment are as follows. Among 18 units-of-analysis, three were assessed as moderate quality, eight as low quality, and seven as very low quality. In these seven, quality scored was lower due to numerous limitations (e.g., the absence of the control group, small study sample, lack of blinding, lack of robust analyses, etc.), higher deviations in CIs for interventions, or risk of bias.

Table 4
Data synthesis by intervention and outcome

No.	Intervention	Outcome
1.	Moderate aerobic exercise	Positive
2.	Lumbar stabilization and stretching exercise	Positive
3.	Moderate aerobic and resistance training	No changes
4.	Healthy lifestyle intervention (aerobic and resistance PA)	Positive
5.	Water exercise	Positive
6.	Various moderate-intensity exercises	No changes
7.	PA plan	No changes
8.	Moderate aerobic exercise	Positive
9.	Physical conditioning program	Positive
10.	Cycling program	No changes
11.	Nerve and tendon-slip exercise	Positive
12.	Moderate intensity resistance training	Positive
13.	Moderate intensity walking/running and resistance training	No changes
14.	Water exercise	Positive
15.	PA	Positive
16.	Individual or group sessions with a personal trainer	Not known
17.	Exercise intervention	Positive
18.	Aerobic and strength training	No changes
PA = physical activity		

Out of 18 identified RCTs, 11 (61.11%) reported positive maternal or infant health outcomes (Table 4). Others showed no changes or did not report the health outcome.

To help professional health workers in promoting PA we further categorize interventions by exercise modality (Table 5). Among a range of exercise modalities, four exercise modalities, namely strengthening, stretching, balance, and aerobic exercises, are commonly found in the existing body of literature that focuses on health outcomes (41; 42; 43; 44).

Table 5
An in-merge of evidence on positive outcomes by the exercise modality

Exercise modality	Intervention	Positive outcomes
Strengthening	Low-to-moderate intensity resistance exercise training twice per week for 12 weeks and, depending on availability (dual leg extension, dual leg press, dual arm lat pull, dual leg curl, lumbar extensions and a standing abdominal exercise) (35)	Adverse changes in symptoms of energy and fatigue
Balance	Two static upright balance postural tasks: two-legged stance either with eyes open and with eyes closed. Three balance sitting tasks on a Swiss ball: to remain seated on the ball in a static position, with both feet resting on the floor and hands resting on the sternum; sitting on the ball, raise the lower right leg off the floor and hold the lift for 10 seconds, with hands resting on the thighs; sitting on the ball, raise the lower left leg off the floor and hold the lift for 10 seconds, with hands resting on the (27)	Pain reduction; improved balance performance
Stretching	The tendon slip exercises (flexion, flat, hook, punch, table-top and flat-punch) and nerve-gliding exercises (moving the fingers and wrists in six different positions, focussing on the median nerve consisting of the disease grip, finger lengthening, wrist extension, thumb extension, forearm supination and gentle gait) (34)	Decrease in carpal tunnel syndrome severity and functional capacity
Aerobic exercise	Aerobic and resistance PA (4)	Lower gestational weight gain and sedentary behaviour; greater moderate-to-vigorous PA
	Moderate intensity aerobic exercises - exercise training program on the treadmill (31)	Decrease in fasting blood glucose level and fasting insulin level
Exercise modalities combined	Gradual warm-up; aerobic exercises; light muscle strengthening; coordination and balance exercises; stretching exercises; pelvic floor strengthening; relaxation and final talk (26)	Lower maternal weight gain; better OGTT results; lower chance to get GDM; lower ratio of macrosomia of neonate

PA = physical activity; OGTT = oral glucose tolerance test; GDM = gestational diabetes mellitus.

Exercise modality	Intervention	Positive outcomes
	Moderate PA in water: warm-up, main phase (with an aerobic element, followed by strength and endurance exercises) and final stretching and relaxation (29)	Better perineum status and physical functioning; lower pain; better general health, vitality, social functioning, role emotional and physical
	Physical conditioning program:10 minutes of warming up, 25 minutes of cardiovascular exercise, 10 minutes of strengthening exercises, 5 minutes of coordination and balance exercises, 5 minutes of pelvic floor exercises and 5 minutes of stretching and relaxation (32)	Faster postpartum weight loss; higher ductus arteriosus pulsatility index and the ejection fraction
	Five minutes warm up, 35 minutes of endurance training and aerobic dance, 15 minutes of strength training with focus on the deep abdominal stabilisation muscles, pelvic floor and back muscles and five minutes included stretching, relaxation and body awareness exercises, aerobic dance routine (39)	Better general health, less fatigue, better scores on measurements of feelings related to sadness, hopelessness and anxiety
	Water exercise: four swimming laps (100 m in total), six AquaMama exercises and four laps (37)	Lower back pain intensity
	Moderate PA, reducing sedentary time, upper and lower limb resistance exercise, increasing number of steps per day, increasing activity during weekends (5)	Lower gestational weight gain; more costly and effective intervention

PA = physical activity; OGTT = oral glucose tolerance test; GDM = gestational diabetes mellitus.

Table 5 demonstrates that positive outcomes of different exercise modalities on pregnant-women health and well-being were reported. The positive health outcomes of performing moderate aerobic exercise were extensively examined (26; 31; 40), followed by strengthening see e.g., (35), or a hybrid form using both (29; 37). In addition, a more comprehensive hybrid form of PA program included moderate aerobic exercise with gradual warm-up; aerobics; light muscle strengthening; balance; stretching; strengthening; and relaxation with final talk (26). Some of the remaining studies also focused on specific sub-types of,

for instance, stretching (27), and aerobic exercise (31). (40) proposed an exercise program of both aerobic and strength training among Norwegian pregnant women to examine vitamin-D mediated effect on maternal and fetal health outcomes. In addition, gestational diabetes mellitus was the main research subject by (5). Authors revealed that, complementary to healthy eating, exercise limits the gestational weight gain. (27) reported that involved pregnant women were included in either lumbal stabilization exercise group or lower limb and trunk stretching exercise group. Both interventions showed positive results in pain reduction caused by or perceived as a result of pregnancy. (29) reported that pregnant women performed a moderate PA consisting of a warm-up; aerobic exercise, strengthening, and stretching with relaxation to limit the negative effects on the body and to optimise well-being, mood and sleep patterns. Finally, positive results were also seen by combing individual diet and PA (30). Moreover, PA intervention entailed positive results in maternal diet quality. Similarly, (32) proposed a supervised PA program consisting of warm-up, aerobic exercise, strengthening, balance, and stretching with relaxation. Hereby, intensity of PA was mild-to-moderate. The PA showed positive results in weight loss at 6 weeks post-partum. Similar results are reported by (39) while performing PA with a 60-minute general-fitness class, comprised of 40 minutes of aerobic exercise and 20 minutes of strengthening and stretching with relaxation among pregnant women.

Among the combined exercise modalities, (26) introduced a 10-minutes warm-up (walking and stretching) with a main section that lasted 30–35 minutes and included moderate intensity aerobic and resistance exercises. Activity ended with a cool down (walking, stretching, relaxation and pelvic floor muscle training). (40) proposed a 12-week standardized PA program where women were encouraged to perform exercise modalities at home at least twice a week. (27) reported success of exercise interventions with a combination of stabilization of lower limbs and stretching. With an aim of reducing carpal-tunnel symptoms, pregnant women also conducted tailored nerve and tendon slip exercises on daily basis (34). With respect to duration, (37) suggested water exercise to be followed for 12 weeks. Similarly, (39) proposed a 60-minute training performed at least twice a week for a minimum of 12 weeks. Finally, a PA program aimed at conditioning was developed to encourage pregnant women to perform exercises throughout the entire pregnancy (32).

4. Discussion

Our findings reveal that past research on PA in pregnancy focused mostly on health outcomes for the pregnant women and infants. Similar to Evenson et al. (2014), our analysis revealed heterogeneity of findings in terms of exercise modality, duration, and intensity. To overcome some of these shortcomings, we call for a standardization in terms of measurable and comparative characteristics of PA in pregnancy. Following this train-of-thought, a commonly used FITT framework (see e.g., 47) has been applied to numerous sub-domains where exercise prescriptions from the health workers play a significant role, ranging from patients with cancer (45), exercise prescriptions for cardiometabolic health (46), and occasionally as a one-size-fits-all to general population (47).

Applying a framework similar to FITT to pregnant women would allow for quantifying the common characteristics of PA in pregnancy (e.g., intensity). The development of such framework that would guide the hands-on recommendations from the health-care workers would require acknowledging for any challenges pregnant women might have as a result of, for instance, deteriorating health, lack of physical fit, and maturity of pregnancy (48; 49). Finally, a growing number of pregnant women have a propensity to remain physically fit notwithstanding pregnancy. Physical fitness is defined as a »state characterized by: (a) an ability to perform daily activities with vigour; and (b) demonstration of traits and capacities that are associated with low risk of premature development of physical inactivity (50). In a broader sense, one's physical fitness represents their capability to carry out a range of exercise modalities and daily tasks. (51) emphasize the need to improve this capability concomitantly with the management any fatigue, stress, or change in health condition which is especially relevant assertion to the pregnant women.

The physical fitness is achieved, maintained and facilitated by prescribing exercise that accounts for the components of physical fitness. These components might differ with respect to the existing literature; however, most commonly the components are cardiorespiratory fitness, muscular strength, muscular endurance, body composition, and flexibility (44). As shown in the Table 6, elaborating on the physical-fitness components, some complementary outcomes (in addition to health outcomes) could also be achieved among pregnant women. We suggest the future research to focus on further examination of the complementary role of maintaining physical fitness, and to account for the associated health- and physical-fitness-related outcomes.

Table 6
Components of physical fitness and sample references

Component of physical fitness	Sample references
cardiorespiratory fitness	(52)
muscular strength	(53)
muscular endurance	(54)
body composition	(55)
flexibility	(56)

While maintaining components of physical fitness is achievable, the aforementioned context-based challenges for pregnant women should be acknowledged. The current study also has some methodological limitations in addition to the limited feasibility of data analysis. First, we deliberately examined the more-recent literature (published after 2016) which may result in fewer manuscripts and exclusion of older yet relevant evidence. We omitted analysing non-published papers or papers without a free access. Second, a heterogeneity of findings partially prevented from more thorough analyses. Finally, we did not use data processing software, which to some degree reduces the reliability of the qualitative analysis. To complement the existing body of the literature with PA recommendations for pregnant

women, future research should ensure the scientific nature of such reviews by e.g., addressing the listed limitations, and expanding the data obtained.

5. Conclusion

PA during pregnancy has numerous health benefits. Recommendations for pregnant women focus on preforming at least 150 minutes per week moderate-intensity aerobic PA. However, further explanations are not provided. A systematic literature review showed that, except the aerobic PA, there are various exercise modalities (strengthening, balance, stretching and exercise modalities combined) that have positive maternal and infant outcomes but are not rigorously explored. It is evident that research does not focus on different components of PA or components of physical fitness. Also, PA recommendations lack of context-dependency, namely by considering pregnant woman's characteristics such as age, previous PA status, comorbidities, other measures (e.g., BMI), mental well-being, pregnancy status (e.g., stage of pregnancy, health issues during pregnancy, micronutrient levels etc.) and other factors that may impact the development and realization of PA. Future research should focus on these emphasized discrepancies in past research that limit the development of tailored evidence-based PA recommendations. Ultimately, we suggest that, in addition to health outcomes, the future research devotes more attention to the role and plausibility of PA that would help pregnant women maintain physical-fitness components. Ultimately, such enriched guidelines could benefit both pregnant women and healthcare workers in care of pregnant women, especially those women that aim at remaining as physically-active as possible.

Abbreviations

BMI - body mass index

GDM – gestational diabetes mellitus

GRADE - the Grading of Recommendations, Assessment, Development, and Evaluation system

n – number of participants

OGTT - oral glucose tolerance test

p - p-value of statistical significance

PA – physical activity

PIO - Population, Intervention and Outcome

RCT – randomised controlled trial

SWEP - study of water exercise during pregnancy

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

LCB and MB were involved in the study conceptualization and design of the systematic review. LCB and MB were responsible for generating the systematic review terms, performing the systematic searches, extracting the data, analysing the data, performing the data synthesis, and for creating the manuscript, tables and figures. Both authors have read and approved the final manuscript.

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Figures

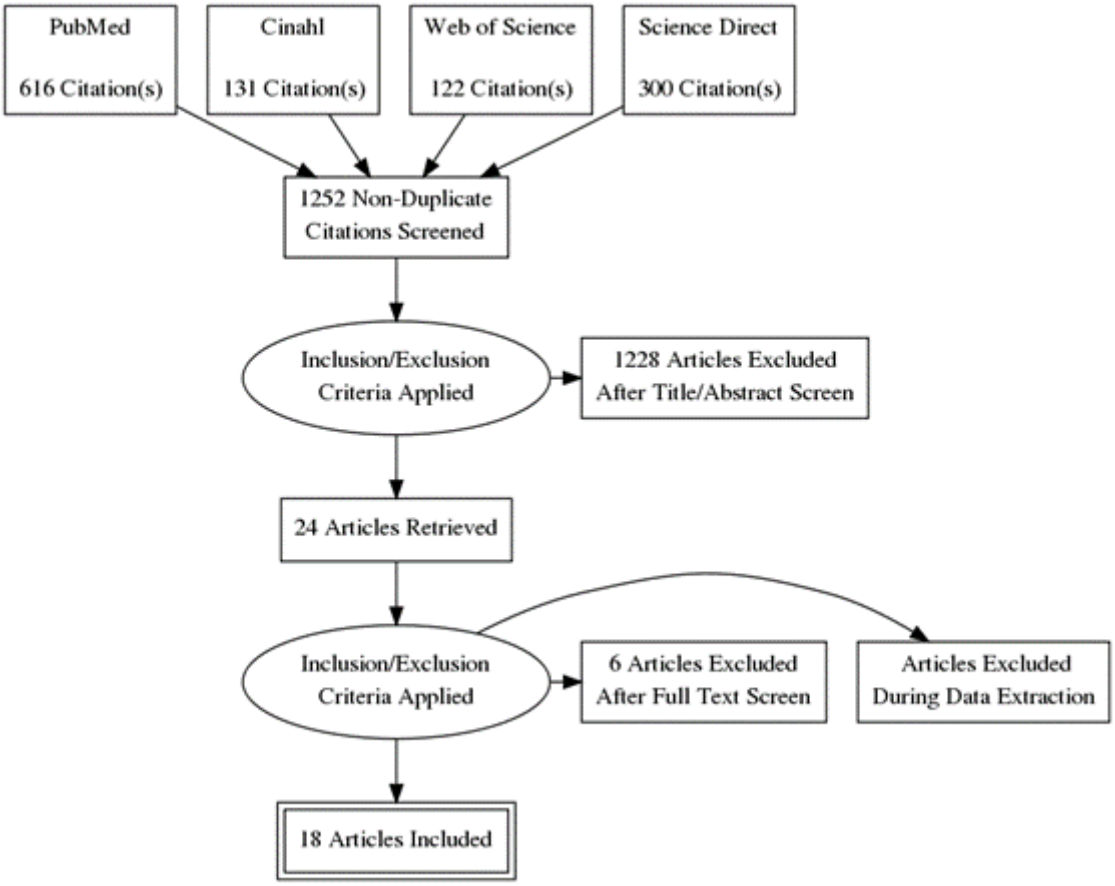

Figure 1

PRISMA flow diagram

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