PROGRAMA DE DOCTORADO EN BIOMEDICINA

PHYSICAL FITNESS ASSESSMENT DURING PREGNANCY:

Validity and reliability of fitness tests and association with maternal-fetal health. The GESTAFIT project

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Physical fitness assessment during pregnancy: validity and reliability of fitness tests and association with maternal-fetal health.

The GESTAFIT project

Lidia Romero Gallardo

International Doctoral Thesis / Tesis Doctoral Internacional

Physical fitness assessment during pregnancy: validity and reliability of fitness tests and association with maternal-fetal health.

Evaluación de la condición física durante el embarazo: validez y fiabilidad de pruebas de fitness y su relación con la salud materno-fetal. El proyecto GESTAFIT

PROGRAMA DE DOCTORADO EN BIOMEDICINA

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A Raúl, por ser mi
mejor compañero de vida.

A mi familia, por todos los valores
que me habéis inculcado.

To Raúl for being my best life partner

To my family for all the values that
they have instilled in me.

CONTENTS

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Abbreviations

PF: Physical Fitness

CRF: Cardiorespiratory Fitness

HRQoL: Health related quality of life

IFIS: International Fitness Scale

MEsH: Medical Subjec Heading

BMI: Body Mass Index

ICC: Intraclass Correlation Coefficient

HR_{Max}: Maximal Heart Rate

Ad hoc test: Test designed specifically for that study

NR: Not reported

PFS: Physical Fitness Score

kpm: kilopoundimeter

min: minutes

sec: seconds

VO_2 max: maximum oxygen consumption

RPE: rate of perceived exertion

AT: anaerobic threshold

ICC: intraclass correlation coefficient

MVCF: maximal voluntary contraction force

HGS: hand-grip strength

m: meters

mm: millimeters

FP: force platform

PP: pressure platform

RPM: revolutions per minute

GW: gestational week

Hz: herzios

cm: centimeters

Kg: kilograms

reps: repetitions

mph: miles per hour

bpm: beats per minute

km/h: kilometers/hour

vt: ventilatory threshold

METs: Metabolic Equivalents

ABSTRACT

Physical fitness (PF) is an important marker of health and a significant predictor of morbidity and mortality across the lifespan. During pregnancy, higher PF seems to be associated with better maternal and neonatal health-related outcomes. Consequently, assessing PF in pregnant women is of clinical relevance. However, a battery of fitness tests specific for pregnant women is not available. In fact, PF during pregnancy has been assessed with a wide variety of tests that have not been compilled to date. It must also be noted that PF can be assessed objectively through either laboratory or field-based fitness tests, and also subjectively through with self-reports, such as the International FItness Scale (IFIS). However, the validity and reliability both of objective measures of PF and the IFIS for subjective evaluation in pregnant women is unknown. The main aims of this International Doctoral Thesis were to provide a compilation of the fitness tests that have been used to assess PF in pregnant women and to assess the potential usefulness of the IFIS in this population. The association of objectively measured and self-reported PF with maternal and/or fetal health was also assessed. To address these aims, 2 studies were conducted.

Study I is a systematic review performed through PubMed and Web of Science that included all studies (n=189) evaluating one or more components of PF in pregnant women, to answer two research questions: 1) What fitness tests have been previously employed in pregnant women? and 2) What is the validity and reliability of these tests and their relationship with health-related outcomes? Two independent reviewers systematically examined the articles in each database. The information from the included articles was summarized by a single researcher.

Study II is a cross-sectional study assessing the construct validity of the IFIS to discriminate between different objectively measured PF and health-related quality of life (HRQoL) levels in pregnant women. A sample of 159 pregnant women completed the IFIS, performed the Bruce test to assess cardiorespiratory fitness (CRF), the handgrip to assess muscular strength, back scratch test to assess flexibility, and the 36-item short form health survey (SF-36) to assess HQRoL.

The main findings of this Doctoral Thesis were: I) PF has been assessed through a wide variety of protocols, mostly lacking validity and reliability data, and that no consensus exists on the most suitable fitness tests for pregant women; II) Information regarding the association of PF with maternal-fetal outcomes is scarce although it suggest that higher PF might be associated with favourable health outcomes; III) The IFIS is a useful, simple and quick tool to identify three

physical fitness levels (low, medium and high) in pregnant women; IV) IFIS is able to discriminate between pregnant women with different levels of HRQoL even better than objectively measured PF.

The results of this Doctoral Thesis enhance our understanding about physical fitness assessment during pregnancy as well as about the validity and reliability of the most frequently used protocols in this population.

RESUMEN

La condición física (CF) es un importante marcador de salud y un predictor de morbilidad y mortalidad a lo largo de toda la vida. Durante el embarazo, los niveles más altos de CF parecen estar asociados con una mejor salud materno-fetal. Por lo tanto, evaluar la CF en mujeres embarazadas tiene una gran relevancia clínica. Sin embargo, no existe una batería validada específica de evaluación de la CF en mujeres embarazadas. De hecho, la CF durante el embarazo ha sido evaluada a través de una gran variedad de tests muy diferentes que no han sido compilados y resumidos hasta la fecha. Existen diferentes formas de evaluar la CF, bien a través de pruebas objetivas a través de tests de laboratorio o de campo o de forma subjetiva a través de cuestionarios como el IFIS, de las siglas en ingés International FItness Scale. Sin embargo, la validez y fiabilidad tanto de las herramientas objetivas como subjetivas para evaluar la CF en las mujeres embarazadas aún es desconocida. Los principales objetivos de esta Tesis Doctoral Internacional pretenden proporcionar una recopilación de las pruebas más usadas y evaluar la utilidad y validez de IFIS en esta población. La asociación de la CF objetiva y subjetiva con parámetros de salud materno-fetal también se evaluó. Para ello, se realizaron 2 estudios:

El estudio 1 es una revisión sistemática realizada en dos importantes bases de datos PubMed y Web of Science, que incluye estudios que evalúan uno o más componentes de la CF en mujeres embarazadas, y que responde dos preguntas de investigación: 1) ¿Qué pruebas de CF han sdio previamente realizadas en mujeres embarazadas) y 2) ¿Qué validez, fiabilidad y asociación con la salud materno-fetal tienen esas pruebas? La búsqueda se realizó por 2 revisores independientes - en cada base de datos. La información de los artículos incluidos fue resumida y analizada por un único investigador.

El estudio 2 es un estudio longitudinal que evalúa la validez de constructo de IFIS y la relación de la calidad de vida en mujeres embarazadas. Una muestra de 159 mujeres embarazadas rellenó el cuestionario IFIS, realizaron el test de Bruce para la evaluación de la capacidad cardiorrespiratoria, un test de fuerza máxima de agarre manual con dinamómetro, “Back-Scratch test” para evaluar la flexibilidad y el cuestionario SF-36 para evaluar la calidad de vida.

Los principales hallazgos y conclusiones fueron: I) La CF ha sido evaluada a través de una gran variedad de protocolos, la mayoría sin datos de validez y fiabilidad. Además, no consiste ningún consenso entre los tests más adecuados a utilizar para mujeres embarazadas; II) La información respecto a la asociación de la CF con la salud materno-fetal es escasa, aunque

lo publicado sugiere que niveles altos de CF podrían ser asociados con mejores resultados de salud; III) IFIS es una herramienta útil, simple y rápida para identificar tres niveles de condición físisca (baja, media y alta) en mujeres embarazadas: IV) IFIS es capz de discriminar entre diferentes mujeres embarazadas con diferentes niveles de calidad de vida incluso mejor que la CF medida objetivamente.

Los resultados de esta tesis doctoral incrementan y mejoran la comprensión acerca de la evaluación de la condición física durante el embarazo, así como la validez y fiabilidad de los protocolos más usados en esta población.

INTRODUCTION

INTRODUCTION

1. The concept of physical fitness

Physical Fitness (PF) has been defined as the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and meet unforeseen emergencies[1,2]. Physical fitness can be divided into *health-related components* and *skill-related components. (Figure 1)* The *health-related components* include cardiorespiratory fitness (CRF; the ability to perform large muscle, dynamic, moderate-to-vigorous intensity exercise for prolonged periods of time), muscular fitness (strength, defined as the muscle's ability to exert a maximal force on one occasion; and endurance, defined as the ability of the muscle to continue to perform without fatigue) and flexibility (the ability to move a joint through its complete range of motion)[1,2]. The *skill-related components* includes agility (the ability to change the position of the body in space with speed and accuracy), coordination (the ability to use the senses, such as sight and hearing, together with body parts in performing tasks smoothly and accurately), balance (the maintenance of equilibrium while stationary or moving), power (the rate at which one can perform work), reaction time (the time elapsed between stimulation and the beginning of the reaction to it) and speed (the ability to perform a movement within a short period of time).[1,2]

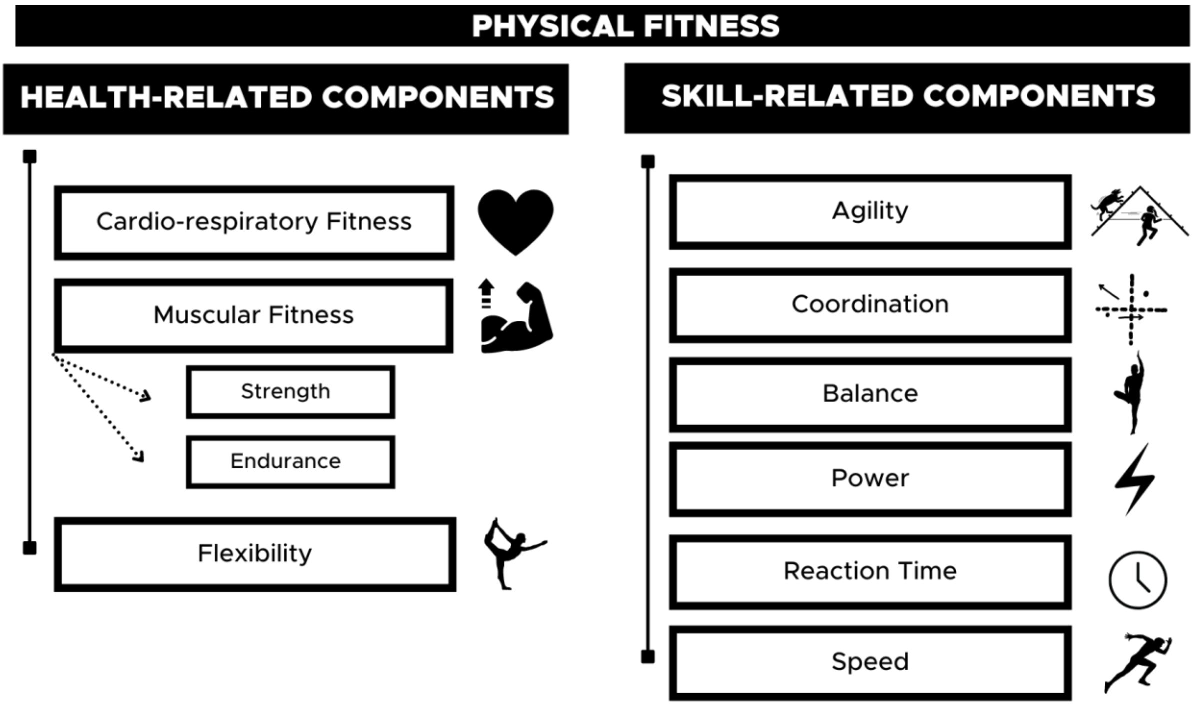

Figure 1. The components of physical fitness. Elaboration by the autor

2. The relation of physical fitness with health-related outcomes in different populations.

Physical fitness is considered a powerful marker of health that is associated with a lower risk of cardiovascular events, cancer and all-cause mortality in all ages[3–7]. In particular, CRF, also known as aerobic capacity or aerobic fitness, is the most widely studied health-related component of PF. Compeling evidence demonstrate that moderate to high levels of CRF are associated with a lower risk of all-cause and disease-specific mortality independently of sex and other cardiovascular diseases risk factors such as age, blood cholesterol, blood pressure, obesity, smoking status, family history of diseases, blood glucose and type 2 diabetes[4,8–10]. In healthy individuals, low levels of CRF (e.g. <5 metabolic equivalent, (METs; a multiple of the resting metabolic rate approximating 3.5 mL·kg−1·min−1)) are associated with high risk of mortality[8], hypertension, metabolic syndrome, and hypercholesterolemia[11]. High levels of CRF (e.g, >8 to 10 METs) was associated with increased survival[12] and improved cognitive functioning[13] between the adult population. Among children and youth, higher CRF levels are positively associated with more favourable cardiovascular and metabolic profiles[14]. Moreover, small increases in CRF (eg, 1-2 METs) are associated with lower adverse cardiovascular events including stroke, heart failure and cardiac surgery[8]. Higher CRF is also associated with a lower risk of mortality individuals with hypertension, dyslipidemia[15] and diabetes[16], and with better results during the pharmacological treatment of cardiovascular diseases[12].

Muscular fitness (MF) is the second most frequently studied health-related component of PF. Recent metanalyses have shown that higher muscular strength was associated with lower cardiovascular disease all-cause mortality risks in healthy adults[17,18]. Individuals with low levels of MF present more difficulties to perform activities of daily living and greater loss of muscle mass (sarcopenia)[17]. Higher levels of upper- and lower-body muscular fitness are associated with a lower risk of mortality in adults, in particular, adults with higher knee extension strength presenting a 14% lower risk of death[17]. In outpatient populations with chronic diseases, low levels of muscular strength was associated with a increased risk of mortality in patients with cancer, critical illness, renal disease, metabolic and vascular diseases and chronic obstructive pulmonary disease[19].

The relathinchip of flexibility with health-related outcomes has not been studied in detail. However, a recent systematic review has concluded that skeletal muscle stretching causes a significant microcirculatory response, which alters conduit arterial blood flow, shear rate, and the relationship between O_2 availability and O_2 utilization, thus flexibility might serve as a novel, alternative, low intensity intervention to combat the age- and sedentary-associated decline in cardiovascular function[20].

For all of the above, assessing PF of wide relevance because it allows: (a) to inform individuals about their PF levels in comparison with people of the same characteristics, (b) enable tailoring of exercise programs, (c) provide baseline and follow-up data to evaluate the effects of exercise interventions, (d) motivate individuals towards more specific physical activities/exercise, and (e) help with people's disease risk stratification[2].

3. Physical fitness and the pregnant women.

3.1. PF during pregnancy and health related outcomes

Pregnancy is characterized by different anatomical, biomechanical, physiological and psychological changes[2,21,22] which might compromise PF levels[23–25]. Several studies have underlined the association of PF with maternal and neonatal health[26–33]. For instance, low CRF levels are associated with higher newborn pH[34] and arterial umbilical PO_2[34,35], higher maternal heart rate[36], higher risk of caesarea[35], higher pre-pregnancy weight[37], poor postpartum recovery[29] and increased risk of gestational diabetes mellitus[27,28]. Pomerance et al.[37] and Wong et al.[36] revealed that high CRF levels were associated with shorter labor duration, and optimal duration of gestation (e.g, neither preterm nor posterm birth)[38]. Similarly, muscular fitness has been positively associated with an optimal weight birth[26,35,39]. Lastly, balance deserves special attention since the center of gravity is ahead during pregnancy. Some studies have indicated that pregnant women have poorer balance with back pain and a higher risk of falling[40].

Quality of life is another important health-related outcome that is to be considered during pregnancy, and is defined as "how well a person functions in their life and his or her perceived wellbeing in physical, mental, and social domains of health"[41]. Functioning refers to an individual's ability to carry out some pre-defined activities, while well-being refers to an individual's subjective feelings[41,42]. Health-related quality of life (HRQoL) might be compromised during pregnancy[43–45] and although exercise interventions seem to improve HRQoL[46,47], the association of physical fitness with HRQoL in pregnant women has received only limited attention[28] .

Given the link between fitness and health during pregnancy, and the fact that PF is a modifiable factor that can be enhanced through physical activity and/or exercise interventions in pregnant women[48], assessing PF in this period of the women's life is of major clinical importance. The assessment of PF is dependent on the aforementioned changes, setting, equipment available, temporary and personnel availability. The PF components, previously cited, can be assessed quickly and subjectively through questionnaires, objectively and accurately through laboratory tests, and efficiently, economically and easily through field-based tests.

3.1. Objectively measured physical fitness

Despite the clinical and public health relevance of assessing PF during pregnancy, a specific fitness battery for this purpose does not exist. In fact, a wide variety of fitness tests have been used to assess PF During pregnancy, and a compilation of these tests has not been published to date. Collecting all fitness tests performed in pregnant women would help practitioners to select the most useful test according to their purpose. It is also important to note that, although laboratory tests are generally the gold standard for assessing PF, these tests are not generally accessible to everyone because they need sophisticated and expensive equipment, and it is not possible to evaluate a relatively large sample in a short period of time. As an alternative, a number of field test exist that provide an opportunity to assess PF in a more accessible way[2]. However, there is no consensus on which fitness tests should be used to assess PF in pregnant women, and the validity and reliability of many of the tests used to assess PF during pregnancy is unknown[49].

Since the assessment of PF in pregnant women requires special considerations to preserve fetal and maternal health[25,50,51], understanding which fitness tests are valid, reliable, and associated with health-related outcomes, would provide a framework for improving PF assessment during pregnancy and also for improving exercise prescription in this population (Study I).

3.2. Self-reported physical fitness

Objective assessment of physical fitness (e.g. either through laboratory or field tests) is not always feasible due to time constraints in routine clinical practice, and the need of complex evaluated tools or qualified personnel. Therefore, other forms of PF assessment, such as self-reports might also be of interest. The International FItness Scale (IFIS) is a self-reported questionnaire that assesses the person's perceived physical fitness levels and has been suggested as a useful, quick, and inexpensive alternative to objectively measured physical fitness assessment[52]. In fact, several researchers have recommended the use of both subjective and objective measures of physical fitness because it can provide information about overestimation or unreal physical fitness levels[53–55]. The IFIS has shown acceptable construct and discriminant validity and reliability in different populations including children[56], adolescents[57], young[52] and older adults[58], and women with fibromyalgia[59]. However, its validity to discriminate different objectively measured physical fitness levels during pregnancy is unknown (Study II) Moreover, as the IFIS is a rather simple and quick-to-use tool that could be implemented in clinical practice, it is of clinical interest to investigate whether IFIS can discriminate between both objectively measured physical fitness and HRQoL levels in pregnant women (Study II)

AIMS/OBJETIVOS

AIMS

The main aims of this International Doctoral Thesis were to provide a compilation of the fitness tests that have been used to assess PF in pregnant women and to assess the potential usefulness of the IFIS in this population. The association of objectively measured and self-reported PF with maternal and/or fetal health was also assessed.

The outcomes of this Doctoral Thesis are organized in two studies, based on the following specific aims:

1. To compile the fitness tests that have been used to evaluate PF (ie, cardio-respiratory fitness, muscular fitness, flexibility, balance and speed) in pregnant women (study I).
2. To evaluate the validity and reliability of the fitness tests used to assess PF in pregnant women and their relationship with health-related outcomes (study I).
3. To examine the construct validity of the IFIS to discriminate between different objectively measured physical fitness levels in pregnant women (study II).
4. To assess the extent to which IFIS is able to discriminate between pregnant women with different levels of HRQoL during the early second trimester of pregnancy (study II).

OBJETIVOS

Los principales objeitvos de esta Tesis Doctoral Internacional se centraron en realizar una compilación de los tests de CF más usados en mujeres embarazadas, así como su validez y fiabilidad y evaluar la validez del cuestionario IFIS, en esta población. La asociación de la condición física objetiva y auto-reportada, también fue evaluada.

Los resultados de esta Tesis Doctoral, se organizaron en dos estudios que comprenden los siguientes objetivos:

1. Describir qué tests han sido usados para evaluar la condición cardio-respiratoria, la condición muscular, la flexibilidad, el equilibrio y la velocidad en mujeres embarazadas (estudio I).
2. Evaluar la validez y fiabilidad de las pruebas para evaluar la condición física en mujeres embarazadas y su posible relación con los efectos relacionados con la salud materno-fetal.
3. Determinar la validez de constructo de un cuestionario de fitness auto-reportado, IFIS, para discriminar entre diferentes niveles de condición física medida de de forma objetiva en mujeres embarazadas (estudio II).
4. Evaluar si el cuestionario IFIS es capaz de discriminar entre mujeres embarazadas con diferentes niveles de calidad de vida durante el comienzo del primer trimestre.


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METHODS

METHODS

This doctoral thesis includes two studies with two different methodologies described bellow:

The first study (Study I) was a systematic review following the PRISMA protocol and using validity, reliability and health-related outcomes quality scores.

The second study (Study II) was a cross-sectional and construct validity analysis.

Study I: Assessing physical fitness during pregnancy: validity and reliability of fitness tests, and relationship with health-related outcomes. A systematic review.

This systematic review was prospectively registered at PROSPERO (CRD42018117554; available at http://www.t.ly/fS6a). In addition, the review followed the PRISMA explanation and elaboration[60] and the PRISMA Checklist [61] is included in **anexes (anexe I).**

Search Strategy

Articles were searched from two major databases, MEDLINE (PubMed) and the Web of Science (WOS) from inception until January 2021. Two independent reviewers examined the articles in each database following the same search strategy. The reviewers screened studies conducted in healthy pregnant women (no restriction regarding gestational week) that included at least one field-based or laboratory fitness test.

The complete search strategy is shown in detail in **table 1 for PubMed and table 2 for WoS.** For PubMed, we used Medical Subject Heading (MeSH) terms. This is a powerful method to enhance the quality of the search. In addition, all MeSH terms were included without the command MeSH attached, to consolidate our results and avoid losing those papers not included in MeSH database. This is because some MeSH terms were introduced in a specific date (e.g., 'physical fitness' was included in 1996). Hence papers published in a previous date would be lost. The same process was developed with terms not available in the MeSH database such as agility, aerobic capacity, etc. (see **table 2**) for search criteria and related terms.

All terms were combined using the connector OR for similar criteria. The connector 'AND' was used to combine population group (i.e., pregnant women), to delimit date of publication ("0001/01/01"[PDat]:"2021/01/15"[PDat], to include full text papers, and to include studies performed in humans. A similar search strategy and terms combination was undertaken in WoS although MeSH terms and its appropriate terms connection were not used as they are exclusive for PubMed.

Table 1. Search strategy used and number of articles found in Pubmed.

		Search Strategy
("Pregnant Women"[Mesh] OR “Pregnant Women” OR "Pregnancy"[Mesh] OR “Pregnancy”) AND ("Physical Fi “Physical Conditioning” OR "Exercise Test"[Mesh] OR "Exercise Test" OR "Fitness Trackers"[Mesh] OR “Fitness or “Muscle Strength” OR “Muscular fitness” OR “Range of motion, articular”[Mesh] OR “Range of motion, articu “Postural Balance” OR “Walk Test”[Mesh] OR “Walk Test” OR “Cardiorespiratory Fitness” [Mesh] OR “Cardioresp speed” OR “aerobic fitness” OR “aerobic capacity” OR “maximal oxygen consumption” OR “V02max” OR “Phy "0001/01/01"[PDat] : "2021/01/15"[PDat]) AND Humans[Mesh]		

Search criteria 1	**MeSH Entry Terms for Criteria 1**	**Search criteria 2**
Pregnant Women (MeSH)	Women, Pregnant Pregnant Woman Woman, Pregnant	Physical fitness (MeSH)
		Exercise Test (MeSH)
Pregnancy (MeSH)		

Fitness Trackers (MeSH)

Muscle Strength (MeSH)
Muscle strength dynamometer (MeSH)
Range of motion, articular (MeSH)
Postural Balance (MeSH)
Walk Test (MeSH)

		Cardiorespiratory fitness (MeSH)
Total items found	**Without filters:** 1657	
	With Humans filter: 1135	
	With Full Text filter: 1388	
	With Humans & Full Text Filter: 930	

The search recruited articles published until 15.01.21: no starting date limit was set for the search. MeSH (Medical Subject He
controlled vocabulary thesaurus used for indexing articles for PubMed

Table 2. Search strategy used and number of articles found in Web of Science

Search Strategy	
TS=("Pregnant women" OR "pregnancy" OR "pregnan*") AND (("Physical Conditioning" OR "Physical fitness" OR "Exercise Test*" OR "Arm Ergometry Test*" OR "Bicycle Ergometry Test*" OR "Step Test*" OR "Treadmill Test*" OR "Physical Fitness Test*" OR "Cardiopulmonary Exercise Test*" OR "Fitness Tracker*" OR "Physical Fitness Tracker*" OR "Activity Tracker*" OR "Personal Fitness Tracker*") OR ("Muscle Strength" OR "Muscular Fitness" OR "Muscle strength dynamometer*") OR ("Joint Range of motion" OR "Joint flexibility" OR "Flexibility" OR "Range of motion" OR "Passive Range of Motion") OR ("Postural Balance" OR "Musculoskeletal Equilibrium" OR "Equilibrium" OR "Postural Equilibrium") OR ("Walk Test*" OR "6-Minute Walk Test*" OR "Incremental Shuttle Walk Test*" OR "Endurance Shuttle Walk Test") OR ("Cardiorrespiratory Fitness" OR "Cardiovascular Fitness OR "Aerobic Fitness" OR "Aerobic Capacity" OR "Maximal Oxygen Consumption" OR "V02max") OR ("Agility" OR "running speed" OR "aerobic fitness"))	
Total items found	1687

The search recruited articles published until 15.01.21 no starting date limit was set for the search.

The first step of the search was to look for systematic reviews and meta-analysis within the field of this systematic review. Since there was no such article published regarding our topic, the research team agreed on starting the search with no limit on the publication date. Then, an initial search was undertaken in both databases following the strategy explained. The results from both, were merged.

Inclusion Criteria for selected articles

The inclusion criteria were: 1) Healthy pregnant women, 2) At least one component of PF assessed either through field-based or laboratory tests, 3) Access to full text, 4) Only one original article from the same study/project using the same test were included, and 5) Text in English or Spanish.

Quality assessment of the articles

To assess the quality of the articles included for aim 2 of this doctoral thesis, we used three quality scores.

The first quality score[62], was used to evaluate the quality of the articles that assessed validity. This list included three items based on sample size, description of the article population and statistical analysis to assess validity of each article. The validity quality score ranged from 0 to 6 (**table 3**). A score of 0-2 defined a very low-quality article; a score of 3-4 defined a low-quality article; and a score of 5-6 defined a high-quality article.

Table 3. Quality assessment criteria to evaluate validity and reliability studies.

Grading system parameter	Grade	Criterion
Number of study subjects	0	n < 10
	1	n= 11-50
	2	n>51
Description of the study population regarding to age, sex, health status, fitness levels, etc	0	Less items than required for grade 1
	1	At least age and week of gestation.
	2	Age, week of gestation, health status and fitness levels and more.
Statistical analysis included in the study	0	Those not included in grade 1
	1	Error indexes or regression analysis
	2	≥3 items of Bland-Altamn plot and or ANOVA for repeated measurements

The second quality score [63] was employed to rate the studies that measured reliability (**table 4**). This ranking was formed by four items based on description of the participants, the time interval, the results and appropriateness of statistical analyses. Each item in both, was rated from 0 (the lowest quality) to 2 (the highest quality). The reliability quality score ranged from 0 to 8. A score of 0-1 defined a very low-quality article; a score of 2-5 defined a low-quality article; and a score of 6-8 defined a high-quality article.

Table 4. Quality assessment criteria to evaluate reliability studies.

Grading system parameter	Grade	Criterion
Description of the participants	0	Less items than required for grade 1.
	1	At least age and week of gestation.
	2	Age, week of gestation, health status and fitness levels and more.
Description of the time interval	0	Interval unknown.
	1	Vague and imprecise information about interval.
	2	Precise and complete description about interval.
Description of the results	0	Less results presented than required for grade.
	1	Description of test-retest results or description of the differences.
	2	Description of test-retest results and description of the differences.

Appropriateness of statistic	0	Only coefficient of variation
	1	Everything between grades 0 and 2 (normally – but not always – correlation plus an additional statistic).
	2	At least paired statistics, ANOVA for repeated measures (or non-parametrical corresponding tests) or Bland- Altman method.

The third quality score (**table 5**) was created to evaluate those studies that assessed association of PF with health-related outcomes. We adapted a score previously used in the Effective Public Health Practice Project (EPHPP) [64] which has been used in similar reviews [65]. The health-related outcomes quality score ranged from 0 to 5. A score of 0-2 defined a very low-quality article, a score of 3-4 defined a low-quality article, and a score of 5 defined a high-quality score. Three quality scores were calculated by counting the number of positive items.

Table 5. Quality assessment criteria to evaluate health-related outcomes studies.

Grading system parameter	**Grade**	**Criterion**
Description of the study sample regarding to number of participants, age, sex, health status, fitness levels, etc	0	n ≤ 25 and including less item than required for grade 1.
	1	N ≥26 and at least age and gestational week.
Adequate assessment and report of physical fitness test.	0	Items for grade 1 are not included within the article.
	1	Validity and/or reliability reported of test and detailed description of testing protocol.
Adequate assessment of health-related outcomes	0	Items for grade 1 are not included within the article.
	1	Validity or reliability of the outcome measure reported and/or measurement procedure adequately described.
Adequate adjustment of confounders	0	No adjustment was done.
	1	Adjustment of confounders such as age and sex were done.
Description of both number and reasons to withdrawal and dropout.	0	No description included.
	1	Description included.

Process and data extraction

After checking manually for inclusion/exclusion criteria in title and abstract of each selected article, only the studies meeting all inclusion criteria were placed in a reference manager software (*Mendeley 2.2.1 2021, Mendeley Ltd*). One folder was created for each PF component, articles analyzing one single PF component were saved in each respective folder. For articles analyzing more than one PF component a folder named "mixed" was created.

This process was done independently by both reviewers. Once this process was completed, the reviewers discussed articles inclusion for final analysis. In the event of disagreement between reviewers concerning the selection of any article, further discussion to meet consensus was undertaken until resolved (there was no need of a third person). Afterwards, a snowball search was performed. Finally, the extracted information reference, age, sample size and fitness test description (in case of the three last parameters were shown) have been summarized and collected in a **table 6**.

Table 6. Overview of studies included in the systematic review and description of physical fitness tests.

REFERENCE (AUTHORS, YEAR)	SAMPLE SIZE (N)	GESTATION WEEKS (SD) OR RANGE IN WEEKS	MEAN AGE (SD), OR RANGE, IN YEARS	FITNES
			CARDIORESPIRATORY FITNESS	
CYCLE-ERGOMETER PROTOCOL				
Pomerance et al., (1974)[37]	54	17.5-27	35-37	Ad hoc, steady- kpm.
Erkkola, (1976)[66]	120	(2 weeks before term)	20-26	1) Ad hoc, incre 450 kpm/min. 2)
Morton et al, (1985)[67]	23	40.15 (1.5)	28.5 (2.1)	Ad hoc, steady-s . min^{-1} for 6 min.
Veille et al., (1985)[68]	17	35 (2)	31 (1)	Ad hoc, increme 50W for 10-15 m
Jovanovic et al., (1985)[69]	6	37.1 (0.9)	28.5 (1.7)	Ad hoc, increme 50% VO_2 max o
Wong & mckenzie, (1987)[36]	20	3 time-points, (10-14; 22-24; 34-36)	29.13	Ad hoc, increme 75 and 100 W fo

Kulpa et al., (1987)[70]	141	First trimester	18-34	Bruce protocol t
Carpenter et al., (1988)[71]	45	29 (3.7)	25.2 (3)	Ad hoc, increme 30 and 60W for fatigue.
Moore et al.,, (1988)[72]	11	21.3	26.6	Ad hoc, increme min to 60 to 75%
Sady & carpenter, (1988)[73]	40	29.2 (3.9)	25.9 (3.3)	2 incremental te 60 W at 30%, 50 increasing 10 W
Artal et al., (1989)[74]	37	29.8 (0.5)	28.3 (1.8)	Ad hoc, increm increments of 25
Hume et al., (1990)[75]	30	NR	28	Ad hoc, steady-s 20min.
Sady et al., (1990)[76]	9	25.6 (3.0);	29 (4.9)	Ad hoc, increme 30 and 60 W fo incremental con
Field et al., (1991)[77]	13	33 ± 2	30 (4)	Modified Balke p
Rafla & beazely, (1991)[78]	21	28-37	NR	Ad hoc, increme HR max (220-ag
Bung et al., (1991)[79]	1	3 time-points, (24, 28, 37)	25	Ad hoc, increme bpm.

Young & treadway, (1992)[80]	5	33 (1)	29 (1)	Ad hoc, steady-s 30 min.
Clapp et al., (1993)[81]	120	16-39	NR	Ad hoc, steady- max for 30 min.
Lotgering et al., (1995)[82]	33	3 time-points, 16.1 (1); 25 (0.7); 35 (0.6)	30.9 (0.7)	Ad hoc, increme to increase 10 W
Artal et al., (1995)[83]	7	33.86□1.46	24.9 (2.18)	Ad hoc, increm stage at 25, 50 a volitional fatigue
O'neill, (1996)[84]	11	35.8 (1.1)	30.3 (3.3)	1) Ad hoc, stea hoc, steady-stat steady-state tes
Soultanakis et al., (1996)[85]	20	27.1 (1.3)	31.4 (1.5)	1) Incremental increasing 25 W hoc, steady-stat 60% VO_2max at
Manders et al., (1997)[86]	12	29-32	20-36	Ad hoc, increme at 50W, to incre
Kemp et al., (1997)[87]	23	33 (1)	NR	Ad hoc, increme increasing 20 W
Mcgrath et al., (1999)[88]	41	3 time-points: 17.45 (0.45); 26.5 (0.2) and 37.15 (0.15)	29.4 (0.85)	Ad hoc, steady exercise brief (< bpm, 2) 45 W to

Brenner et al., (1999)[89]	20	27.0 (1.0) and 37.0 (1.0)	29 (3.35)	Ad hoc increme resistance, then of 18.
Macphail et al., (2000)[90]	23	32 (4)	20-40	Idem Kemp et a
Heenan et al., (2001)[91]	28	34.7 (0.4)	30.8 (1.5	Idem Kemp et a
Kennelly et al., (2002)[92]	22	32.1 (1.4)	25.9 (4.9)	Ad hoc increme increasing 10 W
Heenan & wolfe, (2003)[93]	22	37.0 (0.2)	29 (1.1)	1) Ad hoc, increr Then, to increa incremental ram 30-sec periods t
Wolfe et al., (2003)[94]	18	3 time-points: 19.2 (0.8) 27.8 (0.3) 37.0 (0.3)	28.3 (0.25)	Ad hoc increm resistance. Ther RPE of 18.
Lindqvist et al., (2003)[95]	14	5 time-points: 8, 15, 22, 29 and 36.	29 (5)	Ad hoc increm resistances. The max or pulse ox
Lynch et al., (2003)[96]	23	16, 20, 24, 28, 32, 36	28.7(4)	Ad hoc increm resistance. Ther stages to 130 ± beats/min.

Heenan et al., (2003)[97]	39	37.0 (0.2)	28.5 (1.4)	1) Ad hoc incren Then, to increas incremental ram 30-sec period. (1
Pirhonen et al., (2003)[98]	14	5 time-points: (8, 15, 22, 29, 36)	29.2 (4.6)	Ad hoc increme 2 min. Then, to i to 85% HR max
Kardel, (2005)[99]	41	17, 30, 36	27.7 (1.95)	Ad hoc, increme W, 100 W and 1 work maximally min stages.
Mcauley et al., (2005)[100]	14	17.05 (2.05)	29.9 (0.85)	Ad hoc increme min at 20 W at 6 170 bpm or volit
Weissgerber et al., (2006)[101]	11	7 - 22	25-40	Ad hoc increme Then, increasin bpm.
Jensen et al., (2007)[102]	22	3 time-points: 19.7 (1.2), 28.2 (0.3), 36.3 (0.3)	30.9 (0.9)	Idem test 1 of H
Jensen et al., (2008)[103]	15	34-38	30.6 (1.0)	Ad hoc increm period. After 25 the point of volit
Kardel et al., (2009)[104]	40	35-37	20-40	Ad hoc incremer to increase (8-1 maximal load.

Ong et al., (2009)[105]	12	2 time-points: 18 and 28.	30 (4)	Ad hoc, increme to 75 % HR Max
Thorell et al., (2010)[106]	520	4 time-points: 10.9, 24.0, 29.7, 36.5.	29.0 (4.4)	Ad hoc incremen on previous leve
Rojas-vega et al., (2011)[107]	20	34±1.6	35.2 (3.6)	Ad hoc increme speed for 2 min. to 150 bpm.
Thorell et al., (2015)[38]	520	10.9	29.6	Idem Thorell et a
Kim et al., (2015)[108]	32	13-35	24.8 (2.5)	Ad hoc, steady standing 2) peda
Nakagaki et al., (2016)[109]	20	25.1(6.3)	33.7(4.2)	Ad hoc, increm bpm or impossib
Jedrzejko,et al., (2016)[110]	22	37-41	24.4 (3.92)	Ad hoc, increm divided into thre 25 W to 75 W.
Sussman et al., (2019)[111]	23	2 time-points: 14-15 and 33-34 gw	30 (3)	YMCA protocol. 60-80% HR_{Max} o
Purdy et al., (2019)[112]	63	4 groups: 10-12, 20-27, 30-37	30.5 (4.5)	Ad hoc, increme 25 W at 50 rpm same speed to v
Bilodeau et al., (2019)[113]	58	3 time-points: 16.5 (1.0), 35.6 (0.9); 39.8 (1.1) gw	30 (3.7)	Modified Bruce r

Matenchuk et al., (2019)[114]	47	4 groups: nonpregnant; 1st trimester, 2nd trimester, 3rd trimester	NR	Ad hoc, increme min. Then, to inc
Correa et al., (2020)[115]	48	2 time-points: 18; 36 gw.	NR	Ad hoc, increme min. Then, to inc or HR_{Max} (220-ag
Bijl et al., (2020)[116]	40	11 (1)	NR	Ad hoc, increm ergometer for 3- rpm at 25 W foll 70% HR_{max} (Tan
TREADMILL PROTOCOL				
Sibley et al., (1981)[117]	13	2 time-points: 21.9 (2.3); 33.9 (2.3)	24.3 (1.4)	Balke protocol to
Veille, (1985)[68]	17	35 (2)	31 (1)	Ad hoc, increme HR_{Max} (no equat
Lewis et al., (1988)[118]	28	2 time-points: 22 wg and 30 wg	27.8 (3.3)	Modified Balke p
Artal et al., (1989) [74]	37	30.3 (1.9)	25.9 (2.5)	Modified Balke p
Clapp, little & capeless, (1993)[81]	120	16-39	NR	1) Ad hoc, stead min. 2) Idem at (

Winn et al., (1994)[119]	12	26-36	32 (4)	Modified Bruce
Marquez-sterling et al., (2000)[120]	15	19.1 (2.15)	29.5 (3.1)	Ad hoc increme min. Then, incre 150 bpm.
Santos et al., (2005)[121]	72	17.9 (3.6)	27.3 (4.65)	Ad hoc, increm grade to AT.
Yeo et al., (2005)[122]	9	19 (5)	30 (3)	2 Cornell Protoc systems (VO200
Mottola et al., (2006)[123]	156	16-22	30.8 (3.7)	Modified Balke (predicted) = (0. speed (mph)) + test at 3 mph fo every 2 min. Ma increasing spee fatigue.
Davenport, et al., (2008)[124]	106	16-20	20-39	Modified Balke p
Oliveria et al., (2012)[125]	187	3 time-points: 13, 20, 28.	24.7 (5.5)	Modified Balke p
Ruchat et al., (2012)[126]	44	2 time-points: 16-20 and 34-36	30.8 (4.2)	Modified Balke p
Szymanski, (2012)[127]	45	30.4 (1)	33.36	Modified Balke p

Salvesen et al., (2012)[128]	6	25.5	32	Ad hoc, increme speed in periods
Mottola et al., (2013)[129]	40	35.7 (0.4)	33.5 (0.7)	Ad hoc, steady-s warm-up increas
Bisson et al., (2013)[26]	65	16	29.9 (4.5)	Modified Balke p
Lemoyne et al., (2014)[25]	67	1st trimester, 2nd trimester, 3rd trimester	29.6 (5.5) 30.1 (3.1) 32.3 (3.7)	Ebbeling single-
Bisson et al., (2014)[130]	61	16 (0.6)	30.0 (4.5)	Modified Balke p
Marshall et al., (2015)[131]	51	3 time-points: 20, 32	29.2(5.3)	Ad hoc, increme 3.21 km/h for 5- and grades self and vigorous (jo
Santos et al., (2016)[132]	28	30.51 (3.3)	26 (6.9)	Modified Balke p
Hesse et al., (2018)[133]	25	22.1 (1.4)	30 (3.6)	Bruce protocol u
Baena-garcía et al., (2020)[35]	127	16	32.9 (4.6)	Modified Bruce p
Dobson et al., (2020)[134]	22	3 time-points: Early- (13–18 gw), mid- (24–28 gw) and late-	31.4 (3.7)	Submaximal inc during 21-min o 2% grade, to inc

		pregnancy (34–37 gw).		
ON TRACK				
Bung et al., (1991)[79]	1	3 time-points (24, 28, 37)	25	Ad hoc, maxima m on track
Da silva et al., (2010)[135]	74	37	21.5	6-minute walk te
Ramírez-vélez et al., (2011)[136]	64	2 time-points: 18.6 (3.4) and 16 weeks later.	19.5 (2.3)	6-minute walk te
Hjorth et al., (2012)[137]	304	25.0 (7.3)	23.0	Ad hoc, steady- level at their nor
Price et al., (2012)[30]	62	5 time-points: 12–14, 18–20, 24–26 and 30–32	29.05	Ad hoc test walk comfort zone a distance) / time.
Radzikowska et al., (2017)[138]	45	3-7	24-36	6-minute walk te
Oviedo-caro et al., (2018)[139]	134	20	32.5 (4.2)	6-minute walk te
Dennis et al., (2019)[140]	300	37 (1.3)	31 (4.2)	6-minute walk te
Amola et al., (2019)[141]	34	3rd trimestre	25.1 (7.5)	6-minute walk te

Birnbaumer et al., (2020)[142]	39	26 (7)	26 (3.4)	Ad hoc, increme was paced by a Then, to increa were unable to w
STEP PROTOCOL				
Dibblee & graham (1983)[143]	16	3 time-points: (the last month of each trimester)	23-31	Canadian Ho
Williams, reilly et al. (1988)[144]	16 (10 pregnant and 6 non-pregnant)	First, second and third trimester.	25.6 (3.6)	Ad hoc, increme min.
Melzer et al., (2010)[145]	44	38.27	31 (5.6)	Ad hoc, increme (rate of change was calculated frequency (num expressed in J/m
MUSCULAR FITNESS				
Baker & johnson (1994)[146]	200	NR	28-32	Hand Grip Sp inflated cuff of fo

Rogers & tomilson (1998)[147]	20	NR	5 times: 12, 18, 24, 30, 36	Hand Grip Sphy 2-min.
Feiner et al. (2000)[148]	34	22-36	22-35	Isometric Hand- one-third of MV
Gutke et al., (2008)[149]	301	12-18	29	1) Maximal volu fixed sensor hol for 5 sec during back flexors end for a maximum
Thorell et al., (2010)[106]	520	1 time-points: 10.9	29.0 (4.4)	Sit-up test. Supi and the feet fla without a rest or of 15 repetitions
O'connor et al., (2011)[150]	32	21-25	18-38	Ad hoc 5 tests: extension; (4) La
Hjorth et al., (2012)[137]	304	25.0 (7.3)	23.0	Hand-Grip maxi non-dominant si
Price et al. (2012)[30]	62	5 time-points: 12–14, 18–20, 24–26 and 30–32	29.1	Ad hoc test. Lift waist height as
Bisson et al. (2013)[26]	65	16	29.9 (4.5)	Hand-Grip maxi non-dominant si dynamometer.

Atay et al., (2015)[151]	37	2 time-points: 20 and 32	29.6 (5.9)	Hand-Grip maxi
Petrov et al., (2015)[152]	92	2 time-points: 13 and 35	30.7 (3.5)	Hand-Grip isom
Wickboldt (2015)[153]	43	32 (4)	37-42	Hand-Grip max contraction.
Kalliokoski et al. (2016)[154]	51	NR	28.3(6.4)	1) Hand-Grip m each hand.
				2) Ad hoc up movements: a) one leg for 30 evaluated able c
Ngaka et al. (2016)[155]	50	>37	28.8 (5.7)	Hand-Grip maxi
Rodriguez-díaz et al., (2017)[156]	105	24-30	32.2 (4.7)	Hand-Grip maxi
Zelazniewicz, (2018)[39]	95	3 time-points (once in each trimester)	29.6 (3.4)	Hand-Grip maxi non-dominant si
Takeda et al., (2019)[157]	21	22 and 23.25 gw.	32 (3.3)	1) Toe grip dyn fixed to the legs assess quadrice

Baena-garcía et al., (2020)[35]	156	16	32.9 (4.6)	1) Hand-grip m non-dominant si them. 2) 30-sec Chair
Yenisehir et al., (2020)[158]	167	Second and third trimester.	28.4 (4.6)	5 Times Sit to maneuver as fa chest.
		FLEXIBILITY		
Gilleard et al. (2002)[159]	21	4 time-points: 18 or less, 24, 32, 38	21-40	3 tests measure System: 1) Seat and standing sid
Marnach et al. (2003)[160]	46	3 time-points: 8-12, 16-22, 34-36.	28.8 (0.8)	Wrist flexion-ext goniometer
Garshasbi et al. (2005)[161]	212	17-22	26.4 (4.7)	Side bending te
Rice et al., (2012)[30]	62	5 time-points: 12–14, 18–20, 24–26 and 30–32.	29.1	Sit-and-reach te
Lindgren et al. (2014)[162]	200	3 time-points: 11, 24 and 36.	28.4 (5.9)	Ad hoc machine finger.
Atay et al., (2015)[151]	37	2 time-points: 20 and 32,	29.6 (5.9)	Back scratch tes

Rodriguez-díaz et al., (2017)[156]	105	24-30	32.2 (4.7)	Isquiosural flexil
Cherni et al., (2019)[163]	17	3 occassions: first, second and third trimester	36 (2)	4 tests measu Extensometer c index. 2) Figert reach the floor w adapted on deliv
Baena-garcía et al., (2020)[35]	156	16	32.9 (4.6)	Back Scratch
		STATIC BALANCE		
STABILOMETRY – ON FORCE PLATFORM OR PRESSURES PLATFORM				
Butler et al., (2006)[164]	12	3 time-points: 11-14, 19-22, 36-39	32.9 (5.5)	Standing with ey 3 trials. 1 piece.
Ribas et al., (2007)[165]	60	3 time-points: 1) Up to 12 week 2) 13-24 3) Upwards of 25 week.	23.3 (4.8)	Standing with bip pieces at 40 Hz.
Nagai et al., (2009)[166]	43	30.3 (0.8)	33 (0.65)	Standing with fe fixed at a 1.5 m c for 1 min each. 1

Oliveira et al., (2009)[167]	20	3 time-points: 15.1 (1.8); 24.0 (2.4); 34.5 (2.5)	28.7 (6.2)	Standing with 4 p between them: 1 2) Eyes closed w with feet togethe piece.
Karadag-saygi et al., (2010)[168]	35	33 (3)	29.8 (4.5)	Standing for 60 s
Yu et al., (2013)[169]	21	NR	30.2 (3.05)	Standing with he with visual tasks
Ersal et al., (2014)[170]	69	2 time-points: 20.9 (1.2) and 35.8 (1.5)	28.3 (5.0)	Standing with fe ahead on Equites
7opala-berdzik et al., (2014)[171]	31	36.2 (1.2)	28.2 (3.6)	Standing with ar stance on a stabl closed for 2 trials
Opala-berdzik et al., (2015)[172]	45	2 time-points: 13.1 (2.5) and 36.2 (1.2)	28.2 (3.6)	Idem Opala-Berd
Ozturk, (2016)[173]	68	31.5 (4.73)	30.3 (3.6)	Standing and arm sec: 1) facingforw closed head rota left; 4) Eyes clos Idem 30º forwar facing forward ey
Shibayama et al., (2016)[174]	161	28-33	33.3 (4.7)	Standing and fee piece.

Takeda et al., (2018)[175]	100	2nd and 3rd trimester	20-30	Standing with the Then, moving for each. 2 pieces.
Moreira et al., (2017)[176]	30	1st and 3rd trimester	26.8 (5.1)	Standing with ea plate (feet apart l eyes open focus eyes closed for 3 pieces.
Opala-berdzik et al., (2018)[177]	70	10.8 (1.6)	28.6 (4.4)	Standing with ar stance on a stab straight ahead at 1-min rest betwe
Catena et al., (2019)[178]	17	9 time-points: 16-20 gw, 36-40 gw and 1 time per month up to 7 months postpartum	28.9 (4.0)	2 trials: 1) quiet s force plate; 2) Ide plates.
Fontana et al., (2020)[179]	24	23 (3)	30 (6)	Standing barefo sides with eyes o at eye level durin The mean was re
Valerio et al., (2020)[180]	40	30.8 (3.9)	28 (2.5)	Standing barefo platform and arm the opposite wal trials with eyes c

Takeda et al., (2019)[157]	21	22 and 23.25 gw.	32 (3.3)	Standing barefo standing positio position; 3) 10-se
OTHERS				
Atay et al., (2015)[151]	37	2 time-points: 20 gw and 32 gw	29.6 (5.9)	One-legged stan
			DYNAMIC BALANCE	
ON PLATFORMS				
Davies et al., (2002)[181]	150	Day of labour	30.2 (5.8)	Balance Master Test, 3) Step and
Karadag-saygi et al., (2010)[168]	35	33 (3)	29.75 (4.5)	Walking barefoot
Mccrory et al, (2010)[182]	81	2 time-points: 20.9 (1.2) and 35.8 (1.5)	28 (5.7)	The Motor Co perturbations. Ec
Branco et al., (2013)[183]	22	27 (1.3)	32.5 (2.6)	Walking barefoot line at a natural a
Cakmak et al., (2014)[184]	41	6-12	26.5 (4.7)	Standing with kn and glare fixed platform provides of motion for 3 tr

Inanir et al., (2014)[185]	110	3 groups: 1st trimester, 2nd trimester and 3rd trimester.	24.7 (5.2)	Idem to Cakmak
3-D CAMERA MOTION CAPTURE SYSTEM				
Wu et al., (2004)[186]	25	27	33.1	Walking or (incrementi 3 min at ea
Forczeck et al., (2012)[187]	13	NR	29.2 (3.5)	Walking ba room durin
Takeda et al., (2012)[188]	16	24.85 (1.95)	35 (1.4)	Stand-to-si down; the l vertical floo of the lowe
Gottschall et al., (2013)[189]	13	2 time-points: 20 and 32	31.3 (4.5)	Walking al apparatus c continuous
Mccrory et al., (2014)[190]	69	28.35 (1.35)	28.0 (5.7)	Walking alo
Krkeljas, (2018)[191]	35	3 time-points: 9-12 gw; 20-22 gw and 28-32 gw.	27 (6.1)	Walking or along the 1
Catena et al., (2019)[192]	15	5 time-points: 16-20; 20-24, 24-28; 28-32; 32-36 gw.	29.3 (3.7)	60-second motion. 54 land.

Catena et al., (2019)[193]	15	7 time-points: 12-16; 16-20; 20-24, 24-28; 28-32; 32-36; 36-40 gw.	28.1 (4.3)	Walking or selected co
Forczek et al., (2019)[194]	30	3 time-points: 12, 25, 36 gw.	30.3 (3.4)	Walking ba 12m interva
Forczek et al., (2019)[195]	14	2 time-points: pre-pregnancy; 1st trimester.	20-40	Walking ba during 50 m
Catena et al., (2020)[196]	23	5 time-points: 18, 22, 26, 30, 34 gw.		Walking or selected co
Gimunova et al., (2020)[197]	41	4 time-points: 14, 28, 37 gw.	30.5 (4.1)	Walking ba selected.
Mccrory et al., (2020)[198]	95	2 time-points: 2nd and 3rd trimester.	28.4 (5.5)	Walking a walking spe
Rothwell et al., (2020)[199]	17	2 time-points: 16-20; 36-40 gw.	22-37	Walking or selected co
Forczek et al., (2019)[200]	36	3 time-points: 12; 25; 36 gw.	30.3 (3.4)	Walking ac interval. 10
OTHERS				
Sawa et al., (2015)[201]	27	2 groups: early pregnancy (<27 gw) or late pregnancy (>27 gw)	30.9 (4.2)	Walking at horizontal c motion-rec resistive tri

Błaszczyk et al., (2016)[171]	28	1st trimestrer and 3rd trimester	28.2 (3.4)	Walking alc times) at custom ma attached to
			SPEED	
Evensen et al., (2015)[202]	17	28.7 (7.4)	31.1(2.3)	Ten-metres
Evensen et al., (2016)[203]	18	28.9 (7.3)	31.4 (2.7)	10mTWT
			MULTICOMPONENT	
Evensen et al., (2015)[202]	17	28.7 (7.4)	31.1(2.3)	Timed Up a
Evensen et al., (2016)[203]	18	28.9 (7.3)	31.4 (2.7)	TUG
Christensen et al., (2019)[204]	74	23	31.2 (3.7)	TUG

Ad hoc: test designed specifically for that study; NR: Not reported; PFS: Physical Fitness Score; kpm: kilopoundimeter Heart Rate; VO_2 max: oxygen consumption maximum; RPE: rate of perceived exertion; AT: anaerobic threshold; MHR: coefficient; MVCF: maximal voluntary contraction force; HGS: hand-grip strength; m: meters; mm: millimeters; FP: revolutions per minute: GW: gestational week; Hz: herzios; CM: centimeters; KG: kilograms; REPS: repetitions; MPH : r kilometers/hour; VT: ventilatory threshold

Study II: International FItness Scale -IFIS: Validity and association with health-related quality of life in pregnant women.

Study design and sample

Pregnant women included in this study are part of the baseline evaluation of the GESTAtion and FITness (GESTAFIT) Project carried out in Granada (Spain). Briefly, the GESTAFIT Project is a quasi-experimental study with a supervised concurrent physical exercise intervention in groups with moderate-to-vigorous intensity, 3 days/week, 60 min/session, from the 17th gestational week until the delivery day. The full methodology has already been published elsewhere[205]. A total of 222 women were invited to participate at their 12th gestational week through the Gynaecology and Obstetrics Unit of the "San Cecilio" and "Virgen de las Nieves" University Hospitals (Granada, Spain). Of them, 159 women met the inclusion criteria and were assessed at the 16th (±2) gestational week. For this specific cross-sectional study, only pregnant women with complete data in all the variables analysed here were included. This study was performed between 2015 and 2018, and the analyses were performed in 2018.

Ethical issues

The Ethics Committee on Clinical Research of Granada, Regional Government of Andalusia (Spain) reviewed and approved this study (code: GESFIT-0448-N-15), which followed the ethical guidelines of the Declaration of Helsinki, lastly modified in 2013.

Variables assessed

a) Weight and height

Body weight was measured using a body weight scale (*model 803, Seca, Ltd*). Height was measured using a stadiometer (*Seca 22, Hamburg*). Body Mass Index (BMI) was calculated [BMI = Weight (kg) / Height (m2)].

b) Sociodemographic and lifestyle characteristics

All women completed an initial and general anamnesis with questions regarding age, marital status, living with partner or not, educational level, number of children and some life-style habits like tobacco or alcohol consumption.

c) Self-reported physical fitness

Self-reported physical fitness was measured through the Spanish version of the IFIS[52] questionnaire. The IFIS comprises five questions asking participants to rate their physical fitness in comparison with the average person of the same age in a Likert scale with the categories "very poor", "poor", "average", "good" or "very good". There is 1 question about overall physical fitness, and 4 questions about its specific components (i.e. CRF, muscular strength, speed/agility, and flexibility) and it can be completed in just one minute. This questionnaire has been validated in European adolescents[52], Spanish children[56], young adults[206], older adults[58], women with fibromialgia[59], and Colombian adolescents[57]. The questionnaire is available in different languages at the website of the PROFITH research group: https://profith.ugr.es/ifis **(anexe 2)**

d) Objectively measured physical fitness

All the tests that we employed to assess PF in pregnant women are secure and feasible and have been previously validated in adults. Muscular strength, flexibility and CRF were assessed in this respective order with the objective of preventing induced fatigue, which might potentially influence the results. Speed-agility was not assessed because of its potential risk for pregnant women.

Cardiorespiratory Fitness

The Bruce test is an incremental, multistage, continuous treadmill test for measuring, predicting, and evaluating maximal oxygen intake. In this upright test, there are progressive increments in the workload every 3 minutes to individually determine limits of maximal possible exertion. This test has been shown to be safe and easy to administer to pregnant women[207,208].

Upper-body muscular strength

The upper-body muscular strength was measured through handgrip strength with a digital dynamometer (*TKK 5101 Grip-D; Takey, Tokyo, Japan*), following the protocol described by Ruiz et al.[209]. The test was performed twice for each hand, with a rest of 30 seconds when alternating hands. The best value for each hand was selected, and the average value between right and left hand was calculated. Nowadays, this test is widely used and is a gold standard of muscle strength measure[209].

Flexibility

The upper-body flexibility was measured with the back-scratch test, in which the participants place one arm over their head towards their back and the other arm towards their back from their waist and attempt to touch their hands. Then, the distance between the two middle fingers is measured with a tape measure (cm) to determine the range of motion of the shoulder. The total score is obtained by calculating the average of the best attempt for each hand[210].

e) Health-related quality of life

The Spanish version of the Short-Form Health Survey-36 (SF-36)[211] was used to assess HRQoL. This scale has been developed by RAND Corporation (Santa Mónica, CA)[212], and it has been validated and translated into Spanish[211]. This questionnaire has been used in previous studies to evaluate the HRQoL during pregnancy[28,213–215]. The 36 items of the SF-36 measure eight health domains: 1) physical functioning (10 items); 2) physical role (4 items); 3) bodily pain (2 items); 4) social functioning (2 items); 5) mental health (5 items); 6) emotional role (3 items); 7) vitality (4 items), and 8) *General Health* perception[211,212]. These 8 domains are grouped in two overall scores: physical component summary (physical function, role-physical, bodily pain, and general health) and mental component summary (vitality, social function, role-emotional, and mental health). The scales range from 0 to 100, where higher scores mean better HRQoL[28,216].

Statistical Analysis

The validity of the IFIS to discriminate between objectively measured physical fitness levels in pregnant women (objective 3) was assessed by a one-way analysis of variance (ANOVA) with the corresponding objectively measured physical fitness component as outcome variable, and its IFIS self-reported counterpart as fixed factor. Post–hoc group comparisons with Tukey's correction were applied to assess the differences in objectively measured physical fitness across IFIS categories. To account for the "overall fitness" question of IFIS, a clustered score of measured physical fitness was computed as the average of the standardized scores ([value-mean]/SD) from the 3 objective fitness tests (Bruce test, hand grip, and back-scratch test).

To assess the extent to which IFIS and the different fitness tests are able to discriminate between pregnant women with different levels of HRQoL (objective 4), a lineal tendency ANOVA test and a linear regression was used with the SF-36 components as dependent variables and the different self-reported fitness variables as independent. The same statistical treatment was conducted/performed with the objectively measured physical fitness. The statistical analyses were performed with Stata v.13.1 (*Stata Corp LP., Texas, USA*), and the statistical significance was set at $p<0.05$.

RESULTS

RESULTS

The results of 2 studies comprising the present Doctoral Thesis are presented below.

Study I: Assessing physical fitness during pregnancy: validity and reliability of fitness tests, and relationship with health-related outcomes. A systematic review.

A comprehensive PRISMA flow diagram is presented in **figure 2.** This diagram shows articles excluded, articles by outcomes, and articles that analyzed validity, reliability, and association with health-related outcomes.

Overall results, quality assessment and gestational week.

Our review identified 2617 studies, of which 149 fulfilled inclusion criteria (Figure 2). These articles contained a sum of 191 fitness tests, using 149 different protocols that were included to answer objective 1. A comprehensive scheme of the fitness tests and the different protocols performed to date, divided by PF component, is presented in **figure 3**. A summary of the number and percentage of articles that assessed PF during pregnancy and protocols used for its assessment, divided by PF components, is presented in **table 7**.

With regards to aim 1, a total of 99 tests (that included 75 different protocols) were used to assess cardiorespiratory fitness, 28 tests (that included 16 different protocols) were used to assess muscular fitness, 14 tests (that included 13 different protocols) were used to assess flexibility, 45 tests (that included 40 different protocols) were used to assess balance, 2 tests using the same protocol to assess speed, and 3 tests using the same protocol were multidimensional. No results were found for other PF components such as agility or coordination.

We identified a limited number of articles related to aim 2. A total of 19 articles (13% of the total number of included articles) either assessed validity (n=4 tests) or reliability assessment (n=5 tests) of fitness tests, or the relationship of PF with health-related outcomes (n=16). Of these 16 articles, 11 were classified as very low quality [31,34,36,39,153,162,166,182,217,218] and 5 were classified as low quality [26,38,39,173,204]. Of the 3 articles [122,123,203] that assessed validity, 2 articles were classified as low quality [122,203] and 1 as high quality [123]. Of the 4 articles that assessed reliability criteria, 3 were considered high quality [122,158,202] and 1 low quality [149] (**table 8**).

The gestational week at PF assessment ranged from 8 to 41 across articles. Some articles assessed PF several times throughout pregnancy; therefore, we divided pregnancy into two stages. Early pregnancy (i.e., from week 0 to week 20 of gestation) and late pregnancy (i.e., from week 21 to week 40). Using this approach, 11 articles (7%) were performed in early pregnancy; 57 articles (38%) were performed in late pregnancy; 55 articles (37%) were performed several times (i.e., range 2 to 5 times) throughout pregnancy; 7 (5%) articles specified a range of weeks that included early to late pregnancy; 14 articles (9%) reported only the trimester without specifying gestational week; 4 articles (3%) provided no information, and 1 article (1%) was performed on the day of labor. (**table 6**).

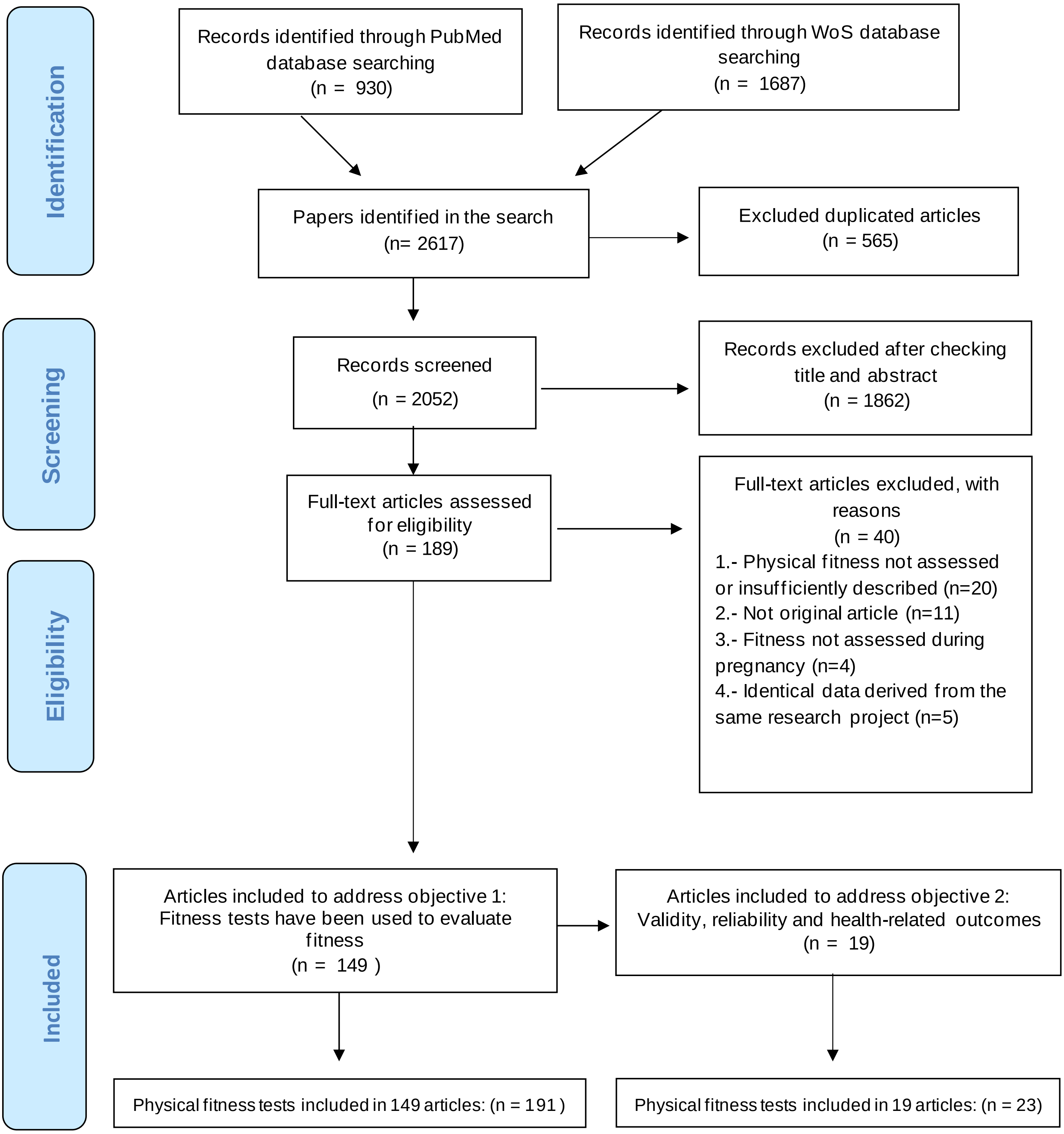

Figure 2. Flow chart of the literature search and paper selection process.

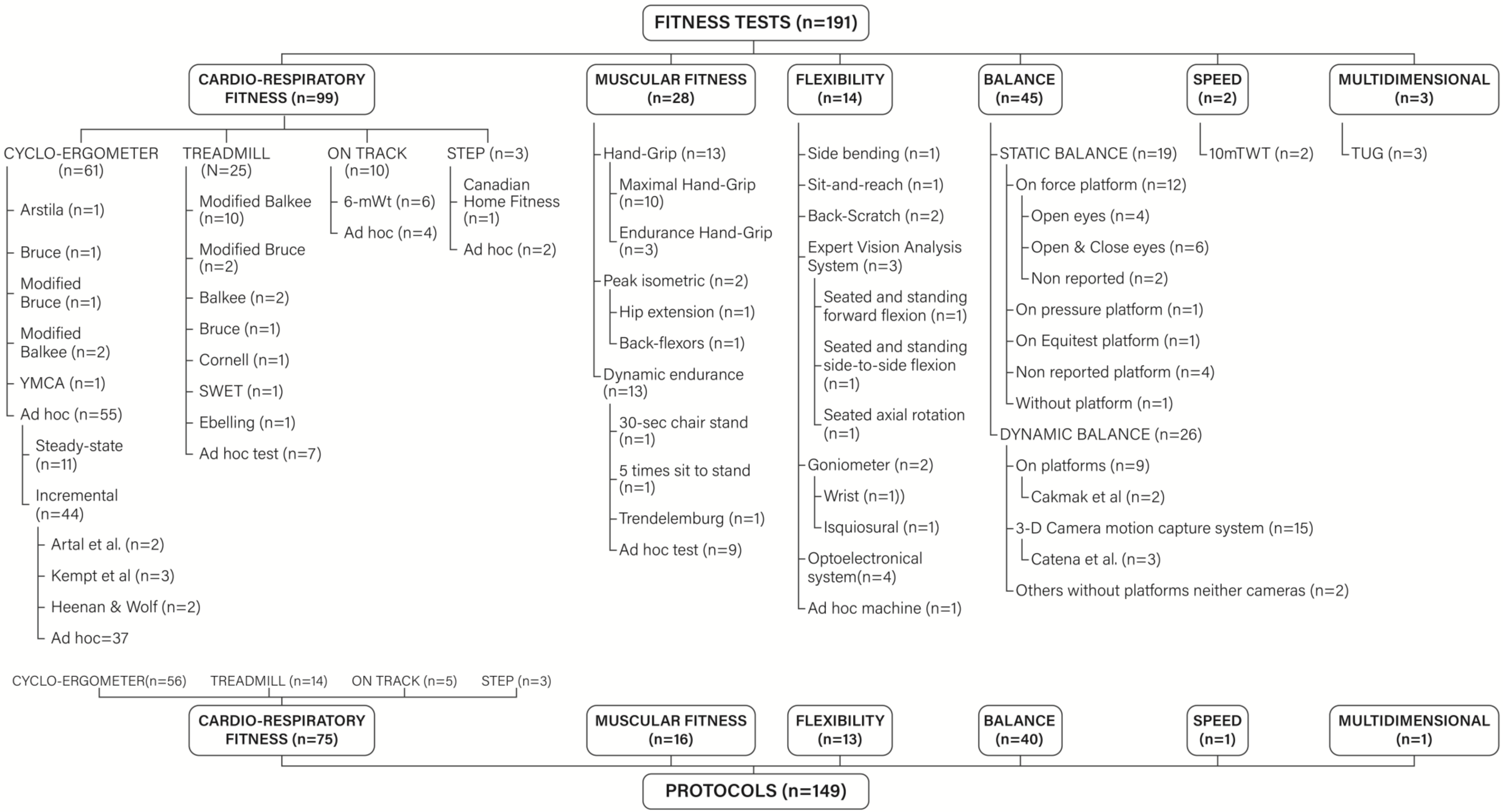

Figure 3. Scheme of the fitness tests and the different protocols divided by PF component.

Table 7. Number (%) of articles that assessed the different components of physical fitness during pregnancy and protocols used for its assessment.

	TOTAL	CRF	MF	Flexibility	Balance	Speed	Multidimensional
Fitness tests	191	99 (52)	28 (15)	14 (7)	45 (24)	2 (1)	3 (1)
Protocols	149	75 (50)	16 (11)	13 (9)	40 (29)	1 (0.5)	1 (0.5)

CRF: Cardio-respiratory fitness; MF: Muscular Fitness

The gestational week at PF assessment ranged from 8 to 41 across articles. Some articles assessed PF several times throughout pregnancy; therefore, we divided pregnancy into two stages. Early pregnancy (i.e., from week 0 to week 20 of gestation) and late pregnancy (i.e., from week 21 to week 40). Using this approach, 11 articles (7%) were performed in early pregnancy; 57 articles (38%) were performed in late pregnancy; 55 articles (37%) were performed several times (i.e., range 2 to 5 times) throughout pregnancy; 7 (5%) articles specified a range of weeks that included early to late pregnancy; 14 articles (9%) reported only the trimester without specifying gestational week; 4 articles (3%) provided no information, and 1 article (1%) was performed on the day of labor.

Cardiorespiratory fitness

a) Tests used

We identified 99 tests assessing CRF, of which 61 (62%) were performed on a cycle-ergometer, 25 (25%) on treadmill, 10 (10%) on track and there were 3 (3%) step protocols. Of the 99 tests, a total of 75 corresponded to different protocols. For instance, there were 56 different protocols using *cycle-ergometer*, distributed as follows: only one article used the Arstila test [34]; one used the Bruce Protocol at 75% HR_{max} [70]; one applied the Modified Bruce ramp protocol at anaerobic threshold [113]; two employed the Modified Balke protocol at 70% HR_{max} [77,85]; one used YMCA protocol [111]; and the remaining articles (n=55) used ad-hoc tests (i.e. specifically designed for the purpose of the investigation); 11 of which [67,75,80,81,85,108,217,219,220] used steady-state tests and 44 [34,36,38,68,69,71–74,78,79,82,83,85–87,89–101,103–106,109–116,221–224] used incremental tests. When analyzing the type of test based on intensity, we found that 13 articles used maximal tests [74,86,87,90–92,99,103,104,112–114,222], 37 submaximal tests [34,36–38,67–69,72,78–83,89,94–98,100,101,105,108–111,115,116,220,223,225,226] and 3 used mixed tests [71,85,221] containing submaximal and maximal stages within the same protocol.

There were 25 *treadmill* tests that used 14 different protocols, distributed as follows: the Modified Balke protocol was used in 10 articles [26,74,118,123–126,130,227,228]; the Modified Bruce protocol in 2 articles [31,119]; and the traditional Balke protocol -twice in the same article- [229]; the traditional Bruce protocol [133], the Cornell protocol [122], the SWET protocol and the Ebbelling single-stage protocol [25] were each used in 1 article. There were other 7 *ad hoc* tests of which 2 were steady-state [81,129], and 5 were incremental tests [68,120,128,131,207]. According to intensity, 3 were maximal tests [128,129,207] and 4 submaximal tests [68,81,120,131].

Of the 10 tests *on track*, 6 articles performed the 6-minute walk test protocol [135,136,138,140,141,230], and 4 were *ad hoc* tests (i.e. 1 maximal and 4 were submaximal). In regards to the 3 *step tests*, 1 Canadian Home Fitness test [143] was used and 2 *ad hoc* incremental submaximal tests were used [144,218].

b) Reliability and validity

We identified 2 articles examining validity [122,123]. Yeo et al. [122] aimed to validate a portable metabolic testing system (VO2000) on healthy sedentary pregnant women. The VO2000 consistently overestimated VO_2 measurements, compared to the same manufacturer's reference system, by 4.4±3.6 standard deviation (SD) ml/kg/min although the Pearson correlation was significant (r=0.48; p=0.01). When VO2000 was used twice, the mean difference was statistically significant (1.0±1.8 ml/kg/min; t(45)=3.9, p<0.001). Mottola et al. [123] provided a prediction equation for VO_{2peak} in pregnant women between 16 and 22 weeks of gestation, using a modified Balke protocol. The results of this equation revealed an adjusted R^2 of 0.71 (p value not reported). When the authors used this equation to predict VO_{2peak} in a cross-validation group (n=39), they found a predicted value of 23.38±4.03 $mL \times kg^{-1} \times min^{-1}$, while the actual value was 23.54 ± 5.9 $mL \times kg^{-1} \times min^{-1}$ (p value not reported).

c) Relationship with health-related outcomes

A total of 6 articles analyzed the association of CRF with health-related outcomes. Pomerance et al. [217] observed that VO_{2max} was inversely associated with the length of labor in multiparas (r=-0.65; p=0.001) and pre-pregnancy weight (r=-0.63; p=0.001). However, VO_{2max} was neither correlated with newborn weight, length, or head circumference, nor with the one-minute Apgar score (all p>0.05). In the same line, Wong & McKenzie [36], observed that fit mothers showed lower HR at submaximal exercise intensity (p<0.05) and the second stage of labor was shorter (no statistics reported) compared to unfit pregnant mothers. However, there was no difference between fit and unfit in the length of gestation or weight gained (no statistics reported). In the same article, the authors showed neither positive nor negative effect of maternal fitness on newborn weight or Apgar scores.

In addition, Erkkola et al. [34] found that newborn from fit pregnant women had higher pH than fetuses of less physically fit women (p<0.01). In this article, participants with low physical performance were more likely to have asphyxiated neonates than neonates of physically fit women (p<0.05). In the same line, Baena-García et al. [31] observed that maternal CRF at the

16th gestational week was related to higher arterial umbilical cord PO_2 ($r=0.267$, $p<0.05$), and women who had caesarean sections had significantly lower CRF compared with the women who had vaginal births ($p<0.001$).

On the other hand, Bisson et al. [26] studied the association of CRF in early pregnancy with physical activity before and during early pregnancy. The authors found that a higher $VO_{2\ peak}$ in early pregnancy was positively associated with physical activity spent at sports and exercise before and during early pregnancy ($p<0.001$).

Muscular fitness

a) Tests used

A total of 28 tests (i.e., 14% of all included articles) that included 16 different procols assessed muscular fitness, of which 10 performed maximal hand-grip strength tests [26,30,31,39,137,151–156], 3 performed endurance hand-grip test, 2 for 3-min [146,148] and 1 for 2-min period [147]. In 2 of the articles conducting an endurance hand-grip test [146,147], the equipment used was a hand grip sphygmomanometer instead of dynamometry. On the other hand, 1 used hand-held dynamometer fixed a chair to assess quadriceps strength [157] and 1 used toe-grip dynamometer [157]. Moreover, 2 *ad hoc* isometric tests were used to assess maximal voluntary hip extension and back flexors endurance in the same article [231]. Finally, 13 dynamic endurance tests were found, 9 were listed as *ad hoc* tests [30,150,154] and other 3 (30-sec Chair Stand Test, 5 Times Sit to Stand test, Trendelenburg's test) were classified as others dynamic tests [31,154,158].

b) Reliability and validity

Only 2 muscular fitness tests assessed reliability [149,158]. Yenisehir et al. [158] analyzed reliability and validity of Five Times Sit-to-Stand. Inter-rater reliability was excellent for subjects with and without pelvic girdle pain (ICC = 0.999, 95% CI = 0.999–1.000; ICC = 0.999, 95% CI = 0.999–0.999, respectively). Test-retest reliability was also very high for subjects with and without pelvic girdle pain (PGP) (ICC = 0.986, 95% CI = 0.959–0.995; ICC = 0.828, 95% CI = 0.632–0.920, respectively).

On the one hand, Gutke et al.[149] analyzed the reliability for an *ad hoc* test. This test consisted in a maximal voluntary isometric hip extension with a fixed sensor holding a sling around the thigh and pulling for 5 seconds during 3 reps with 5-10 seconds of rest ($r=0.82$ for the right leg and $r=0.88$ for the left leg; ICC=0.87 for the right leg and 0.85 for the left leg; with p value no reported).

c) Relationship with health-related outcomes.

The hand-grip strength has been associated with neonatal outcomes. Bisson et al.[26] observed that hand-grip strength was positively associated with infant birth weight (r=0.34, *p*=0.0068) even after adjustment for confounders (r=0.27, *p*=0.0480). Accordingly, Zelazniewicz et al. [39] observed that hand-grip strength was associated with offspring birth weight when controlled for the newborn sex and gestational age at delivery (F(2.182)=3.15; *p*=0.04). Baena-García et al. [31] found greater hand-grip strength weakly associated with greater neonatal birth weight (r = 0.191, p<0.05). On the other hand, Wickboldt [153] found that hand-grip strength was moderately correlated with pain scores. Mean hand-grip strength during contractions had the highest correlation coefficient (r=0.67; *p*<0.001) compared with peak handgrip strength (r=0.56; *p*<0.001) and the area under the curve of handgrip force (r=0.55; *p*<0.001).

Flexibility

a) Tests used

Our search identified 14 (7%) tests that assessed flexibility using 13 different protocols, including the side bending test [161], the sit-and-reach test [30], the back-scratch test (twice) [31,151], the Motion Analysis (i.e. including 3 different tests such as the seated and standing forward flexion, seated and standing side to side flexion and seated axial rotation [159]) and optoelectrical system (i.e. performing 4 different tests) [163]. Goniometry was used in two different articles to measure isquiosural flexibility, [232] wrist flexion-extension and medial lateral deviation [160]. Only one article used an *ad hoc* machine to test passive abduction of the left fourth finger [162].

b) Reliability and validity

Lindgren et al.[162] designed an *ad hoc* machine to test passive abduction of the left fourth finger and its relationship with low-back pain during pregnancy and early postpartum. Abduction angle was measured at three different times throughout the pregnancy and once in the postnatal period. Reliability of the abduction angle was analyzed by the intra-individual coefficient of variance. The coefficients of variance between the first and second measurement was 0.077, between the second and third 0.070 and between the third and fourth 0.071.

c) Relationship with health-related outcomes.

Only 2 flexibility tests evaluated associations with health-related outcomes. Lindgren et al. [162] found that women with greater passive abduction angle of the left fourth finger was associated with highest back pain incidence (OR=1.09; CI=1.01-1.17; *p*=0.022) and the highest number of previous pregnancies (OR=3.24; CI=1.57-6.68; *p*=0.002). Baena-Garcia et al. [31] found increased flexibility associated with a more alkaline arterial pH (r = 0.220, p<0.05), higher arterial PO_2 (r = 0.237, p<0.05) and lower arterial PCO_2 (r =-0.331, p<0.01) in the umbilical cord blood. No other articles assessed the association of flexibility with health-related outcomes in pregnant women.

Balance

a) Tests used

We identified 45 (24%) articles assessing balance of which 19 analyzed static balance and 26 dynamic balance trough 40 different protocols. With regard to *static balance*, 18 were laboratory tests of which 12 assessed balance through stabilometry tests on force platform [164–169,172,174,176–179], one on pressures platform [168] and another on Equitest® platform [170]. Four articles did not mention the type of platform used (40,150,176,177). Regarding protocols, all articles conducted the tests with participants standing with bipedal support. However, standing position varied between articles. Ten articles maintained a standing posture with feet separated [157,166,170–172,176–180], 1 with feet together [174], 2 used mixed protocols [167,173], 1 with medial malleoli separated [175] and 4 did not mention the standing posture [164,165,168,169]. Moreover, 3 articles used protocols with eyes open [165,177,179] exclusively, 8 articles used mixed protocols with eyes open and closed, 1 used visual target and visual tasks [169] and 6 did not specify whether participants kept their eyes closed or opened. Only 1 article used a field test, the one-legged standing protocol [151]. On the other hand, 1 test was field-test without platform.

In relation to the 26 articles measuring *dynamic balance*, 9 of them assessed balance using platforms. Each of these articles used different testing tool such as balance master platform [181], pressure platform [168], force platform [183], Equitest® platform [182] and movable platform, which was used in two articles [184,185]. Two of these articles were walking protocols [168,183], 1 with translational perturbations[172], one was standing with one knee flexed and arms across the chest [184,185]. Another 15 articles used 3-D camera motion capture systems using 13 different protocols. Twelve of the 15 articles were walking protocols [187,189–191,193–200,233] and 2 used a stand to sit motion protocol [188,192]. Moreover, 1 article used a triaxial accelerometer[201]; another article assessed balance through recording (without specification of camera type) [234], and another using instrumented insoles [235]. All three articles used walking protocols.

b) Reliability and validity

No validity or reliability assessments were performed regarding balance tests.

c) Relationship with health-related outcomes.

3 articles associated balance with health-related outcomes. Ozturk [173] observed that static balance decreased and fall risk increased in pregnant women with lower back pain (49.90±24.47 vs 28.47±19.60; $p<0.0001$). In relation to exercise, McCrory et al. [236] showed that exercise may play a role in fall prevention in pregnant women ($p=0.005$); they also found

that dynamic balance is altered in pregnant women who have fallen compared with non-fallers and non-pregnant women (*p*<0.001). Nagai et al. [166] studied the relationship between anxiety and balance. They concluded that when anxiety increases during pregnancy, the standing posture is destabilized (r=0.559, *p*=0.020), which may increase the chance of falling.

***Speed*.**

a) Test used.

The only protocol that was used to assess speed during pregnancy was the ten-meters timed walk test (10mTWT). However, the same test was identified in two different articles. [202,203]. In the 10mTWT, the participants commenced standing at a chair. When told to start, subjects walk as fast as possible along 14 meters marked with white blank tapes placed at 0 m, 2 m, 12 m and 14 m. The time (100th of a second) required to walk between the 2 m and 12 m markers was recorded and converted into speed in meters per second (m/sec).

b) Reliability and validity.

Validity and reliability for 10mTWT was studied by Evensen et al. in two different articles [202,203]. In 2015, Evensen al. [202] analyzed the test-retest reliability of 10mTWT showing an intraclass correlation coefficient (ICC) of (0.74). Intertester reliability was determined in the first 13 participants with strong correlation (ICC =0.94). In 2016 [203] the same authors analyzed the convergent validity of 10mTWT by comparing performances with scores achieved on the Active Straight Leg Raise (ASLR) test and observed moderate positive correlations between 10mTWT and ASLR (r=0.65, *p*=0.003).

c) Relationship with health-related outcomes.

This systematic review did not find any articles that analyzed the association of speedwith health-related outcomes.

Agility and coordination

No articles of agility and coordination were identified.

Multidimensional

a) Test used.

Our search identified a walking multidimensional test that was used in three studies [202–204]. In Timed Up and Go Test (TUG) the participant begins seated in a chair with their arms on armrests and their toes against a start line. The purpose is to cross the front white line at three meters away, turn around, and walk back to the chair and sit down as fast as possible. The performance is measured in time (100th of a second).

b) Reliability and validity.

Validity and reliability for TUG was analyzed by Evensen et al. in two different studies [202,203]. The TUG showed good test-retest reliability (ICC=0.88) and intertester reliability (ICC=0.95). Regarding reliability, strong correlations were found between the TUG and Active Straight Leg Raise (r= 0.73, *p*= 0.001).

c) *Relationship with health-related outcomes.*

The time on TUG among pregnant women with pelvic girdle pain was significantly higher (mean (95% CI) 6.9 (6.5, 7.3) seconds) than for asymptomatic pregnant (5.8 (5.5, 6.0), p < 0.001) and non-pregnant (5.5 (5.4, 5.6), *p* < 0.001) women.

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Table 8. Overview of studies that assessed the validity and/or reliability of fitness tests during pregnancy or the as
related outcomes in pregnant women.

REFERENCENCE (AUTHORS, YEAR)	VALIDITY	RELIABILITY	HRO	CAPACITY EVALUATED, SHORT TEST RELATED OUTCOMES OR STATISTICA
				CARDIO-RESPIRATORY FITNESS
Pomerance et al., (1974) [37]	No	No	Yes	*Ad hoc, continuous test on CE.* 1: PFS was inversely associated with p=0.001). 2: PFS was significantly associated with (r=-0.65; p=0.05). 3: PFS was not correlated with pre-pregn new-born length, new-born head circumfe (all p>0.05).
Erkkola et al., (1976) [34]	No	No	Yes	*Ad hoc, incremental submaximal test on C* 1: Fetal pH in fit pregnant women is higher pregnant women (p<0.01). 2: Pregnant women with low physical perf asphyxiated babies than the physically fit

Wong & McKenzie, (1987) [36]	No	No	Yes	*Ad hoc, incremental test on CE.* 1: HR at submaximal exercise was lower pregnant women (p<0.05). 2: Second stage of labor was shorter in f reported). 3: There were no differences between fit a of gestation, weight gained vs pre-pregnan positive nor negative effects of maternal test, birth weight); (no statistics reported).
Thorell et al., (2015) [38]	No	No	Yes	*Ad hoc, incremental maximal test on CE.* Absolute VO_{2peak}, was inversely correlated women with miscarriage (r=-0.52; *p*=0.02 gestation among women with spontaneous
Melzer et al., (2010) [218]	No	No	Yes	*Ad hoc, incremental step protocol test.* 1: Active women have better aerobic fi inactive women (34.9 vs 30.3 mL/kg/min;
Yeo et al., (2005) [122]	Yes	Yes	No	*Cornell Protocol on treadmill platform.* *Validity*: Bland-Altman plots. The mean dif Data indicated that VO2000 over- estim ml/kg/min compared to CPX/D. Pearson co average and difference of paired mea significant (r=0.48; *p*>0.01). *Reliability*: Pa Linear regression: y = 0.96X-1.6; 95% C 0.91, *p*<0.001

Mottola et al., (2006) [123]	Yes	No	No	*Modified Balke protocol on treadmill platfo* *Validity*: Pearson Correlation: R2=0.72, R2 statistics reported).
Baena-García et al., (2020) [31]	No	No	Yes	*Modified Bruce protocol until 85% HR_{max}* 1) Maternal CRF at the 16th gestational w umbilical cord PO2 (r=0.267, p<0.05). 2) The women who had caesarean sectio the 16th gestational week compared wi births.

MUSCULAR FITNESS

Gutke et al., (2008) [149]	No	Yes	No	*Maximal voluntary isometric hip extension* Reliability: Spearman's rho (r) and Intercor r=0.82; ICC=0.87. Left leg: r=0.88; ICC=0.
Bisson et al., (2013) [26]	No	No	Yes	*Hand Grip Strength* was positively associa p=0.048).
Wickboldt et al., (2015) [153]	No	No	Yes	*Hand Grip Strength* was moderately co Numerical Rate Scale. Mean handgrip highest correlation coefficient (r=0.67; p<0 force (r=0.56; p<0.001) and area under th p<0.001).

Zelazniewicz et al., (2018) [39]	*No*	*No*	*Yes*	*Hand Grip Strength* in pregnancy was posit weight when controlled for a child's sex and p=0.04). Women with greater hand grip st likely to give birth to a boy (p<0.05).
Baena-García et al., (2020) [31]	No	No	Yes	*Hand Grip Strength* was associated with 0.191, p<0.05)
Yenisehir et al., (2020) [158]	No	Yes	No	*Five Times Sit to Stand Test* Reliability: Inter-rater reliability of 5TSS w without PGP (ICC ¼ 0.999, 95% CI ¼ 0.9 0.999–0.999, respectively). Test-retest re for subjects with and without PGP (ICC ¼ ¼ 0.828, 95% CI ¼ 0.632–0.920, respecti

FLEXIBILITY

Lindgren et al., (2014) [162]	No	Yes	Yes	*Ad hoc passive abduction of the left fourth* The highest back pain incidence was sho passive abduction angle of the left fourt p=0.022) and the highest number of p CI=1.57-6.68; p=0.002). Reliability: Intra-i Between the first and second measureme and third = 0.070 and between the third ar

Baena-García et al., (2020) [31]	No	No	Yes	*Back-Scratch* Maternal flexibility was associated with a more p<0.05), higher arterial PO2 (r = 0.237, p<0.05 0.331, p<0.01) in umbilical cord blood.
				BALANCE
Nagai et al., (2009) [166]	No	No	Yes	*Static balance on force platform.* Increases in anxiety during pregnancy is standing posture (r= 0.559, *p*=0.020)
Ozturk et al., (2016) [173]	No	No	Yes	*Static balance on non-specific platform in diffe* Postural equilibrium decreases and fall risk inc lower back pain (49.90±24.47 vs 28.47±19.60
McCrory et al., (2010) [236]	No	No	Yes	*Dynamic balance on Equitest posture platform* Dynamic balance is altered in pregnant wome non-fallers and controls. (*p*<0.001). Exercise in pregnant women.

				SPEED
Evensen et al., (2015) [202]	No	Yes	No	*Ten-meters Timed walk Test* *Reliability*: ICC from a one-way random e 95% confidence interval (CI). Coefficien 10mTWT: (ICC= 0.74; 95% CI=0.42–0.90; m s^{-1}) Coefficients for intertester reliabil CI=0.82–0.98; SEM=0.09 m s^{-1}; MDC_{95}=0
Evensen et al., (2016) [203]	Yes	No	No	*Ten-meters Timed walk Test* *Validity*: Spearman correlation coefficien ASLR (r=-0.65, *p*=0.003). Between the 10 0.56).
				MULTIDIMENSIONAL
Evensen et al., (2015) [202]	No	Yes	No	*Timed Up and Go Test (TUG)* *Reliability*: ICC from a one-way random e 95% confidence interval (CI). Coefficient (ICC=0.88; 95% CI=0.70–0.95; SEM seconds.) Coefficients for intertester reli CI=0.84–0.98; SEM=0.36 m s^{-1}; MDC_{95}=
Evensen et al., (2016) [203]	Yes	No	No	*Timed Up and Go Test (TUG)* *Validity*: Spearman correlation coefficien (r_s=0.73, *p*=0.001). Between the TUG a Between the TUG and PGQ (r_s=0.41 to 0.

Christensen et al., (2019) [204]	No	No	Yes	*Timed Up and Go Test (TUG)* The time on TUG among pregnant wom higher (mean (95% CI) 6.9 (6.5, 7.3) se pregnant (5.8 (5.5, 6.0), $p < 0.001$) and n 0.001) women.

HrO: Health related outcome; CRF: Cardio-respiratory fitness; MS: Muscular Strength; PFS: Physical Fitness Score; C volum maximum oxygen; VO_{2peak}: volum peak oxygen; HR_{max}: maximal heart rate; PGP:Pelvic girdle pain; ICC: intrac 95% CI: 95% confidence interval; SE: Standard Error; SEM: standard error of measurement (absolute reliability); MDC9 odds ratio; TUG: Timed Up and Go test; 10mTWT: Ten-meter Timed Walk Test; ASLR: Active straight leg raise.

Study II: International FItness Scale -IFIS: Validity and association with health-related quality of life in pregnant women

Of the 222 women interested, 63 refused to participate due to the care of other children or the lack of time. A total of 159 women participated in this study, although only those with valid data regarding both self-reported and objectively measured physical fitness with IFIS (n=106; mean age 32.7, SD 4.4 years) were finally included in the analyses of the present study. The descriptive characteristics of the study participants are presented in **table 9**.

The distribution of IFIS responses revealed that only a small number of pregnant women rated their physical fitness as either "very poor" or "very good" (**figure 4**). Consequently, we re-categorized "very poor" and "poor" into a single category, and "good" and "very good" into another single category to avoid a lack of statistical power caused by the low number of participants in extreme categories.

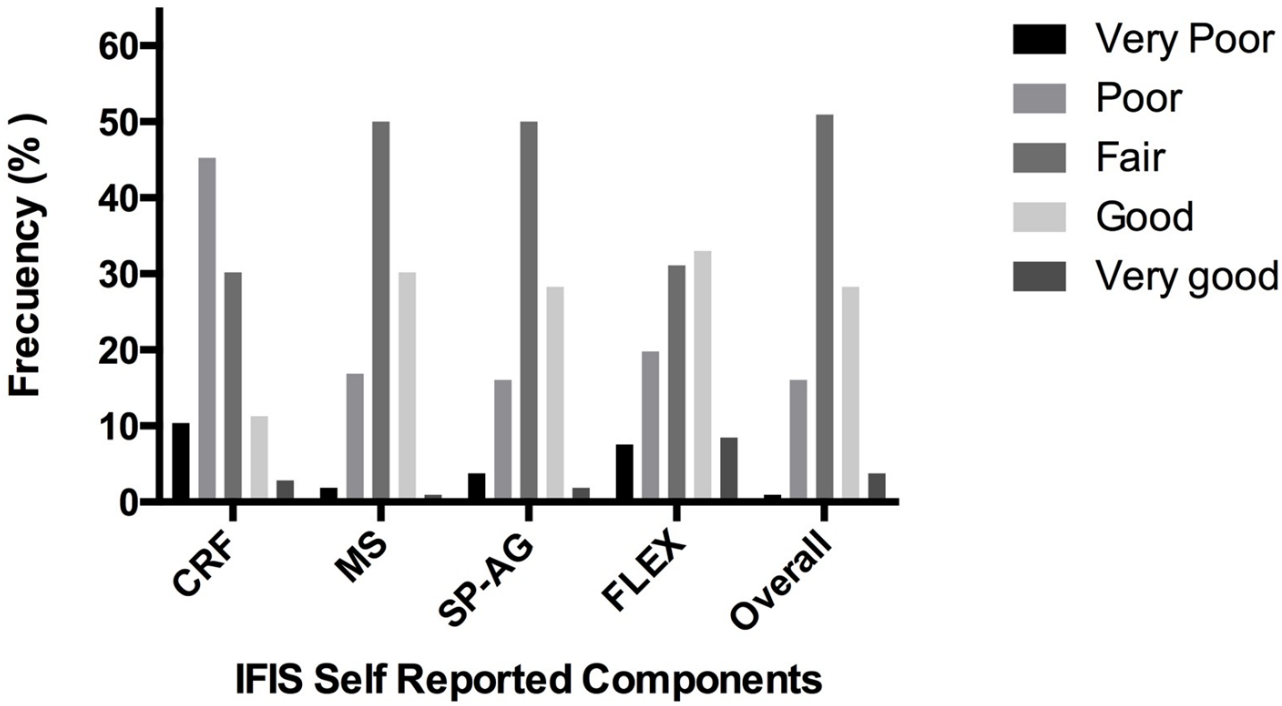


Figure 4. Distributions of the answers for the 5 questions of the International FItness Scale (IFIS) in pregnant women. CRF, cardiorespiratory fitness; MS, muscular strength; SP-AG, speed-agility; FLEX, flexibility; Overall, overall physical fitness.

Table 9. Characteristics of the pregnant women at early second trimester of pregnancy (gestational week 16).

Variable	Mean	SD	n
Age (y)	32.7	4.4	106
Body mass index (kg/m2)	24.7	4.1	106
Marital Status (n, %)			106
Married	63	(59.4)	
Single	43	(40.6)	
Living with a partner (n, %)			106
Yes	104	(98.1)	
No	2	(1.9)	
Educational Status (n, %)			106
Primary school	12	(11.3)	12
Professional training	19	(17.9)	19
Secondary school	14	(13.2)	14
University medium degree	23	(21.7)	23
University higher degree	38	(35.9)	38
Number of Children	0.6	0.08	106
Number of abortions	0.51	0.07	106
Smoking Status (n, %)			
Yes	97	(91.6)	106
No	9	(09.4)	106
Alcohol Consumption (n, %)			
Yes	0	(100.0)	106
No	106	(0.0)	106
Objectively measured physical fitness			
Bruce VO_{2max} (ml/kg/min)	23.1	5.5	87
Handgrip strength (kg)	27.6	4.0	106
Back-scratch (cm)	8.4	12.3	106

Values are shown as mean and standard deviation (SD), or n (%).

Construct validity of IFIS in pregnant women (aim 3)

The comparison between objective physical fitness levels across IFIS categories are displayed in **Table 10**. There were between-group differences in objectively measured physical fitness across IFIS categories ($p<0.05$), regardless of the physical fitness component evaluated. Regarding CRF, the post-hoc analyses revealed that women who self-rated their CRF (i.e. through IFIS) as “very poor/poor” had lower estimated VO2max than those in any other categories of IFIS (p<0.05). In relation to muscle strength, women who self-rated their strength as “good/very good” presented higher handgrip strength than those who rated it either as “average” or “poor-very poor” (p<0.05). Regarding flexibility, women who self-rated their flexibility as “poor-very poor” presented lower range of motion in the back-scratch test than those who rated it as “good-very good” (p<0.05).

Table 10. Objectively measured physical fitness across categories of the International FItness Scale (IFIS)

		Very Poor/Poor (1)	Average (2)	Good/Very Good (3)	ANOVA	Pair-Wise Compa				
	n	Mean (SE)	Mean (SE)	Mean (SE)	P	Comparison: 1 vs. 2			Comp	
CRF						Diff	95% CI	P	Diff	
Bruce test (ml/kg/min)	87	21.36 (0.75)	25.43 (0.98)	25.03 (1.57)	**<0.001**	4.07	(1.11-7.02)	**<0.001**	3.67	(-0
Muscular fitness										
Handgrip (kg)	106	26.53 (0.86)	26.92 (0.53)	29.40 (0.67)	**0.01**	0.39	(-2.0-2.78)	0.92	2.87	(0
Flexibility										
Back-scratch (cm)	106	4.64 (2.20)	6.35 (2.06)	12.51 (1.79)	**0.01**	1.71	(-5.47-8.90)	0.84	7.88	(1.

CRF=Cardiorespiratory fitness; SE=Standard Error; Diff=Difference between groups; CI: Confidence Interval.

Ability of the IFIS to discriminate Health-Related Quality of Life (HRQoL) in pregnant women (aim 4)

Figure 5 shows the linear association of self-reported physical fitness with the different dimensions of HRQoL in pregnant women. Higher self-reported overall physical fitness showed a positive linear trend with HRQoL in all domains of the SF-36 ($p<0.05$), except in the *Physical Role* and *Social Functioning* dimensions ($p>0.05$). With some exceptions, this tendency was consistent across the different physical fitness components as self-reported through IFIS.

Regarding the physical and mental component summary (PCS and MCS, respectively), there was a generally consistent linear trend so that higher self-reported physical fitness was associated with higher PCS and MCS scores, except for self-reported muscle strength (p>0.05) (**figure 6 and table 11**).

The post-hoc analyses revealed significant differences in HRQoL between the extreme groups ("very poor/poor" and "good/very good") in the overall physical fitness, CRF and flexibility categories.

Overall, objectively measured CRF and flexibility showed a positive linear relationship with several dimensions of HRQoL, although the overall physical fitness score did not show such relationship **(figure 7)**

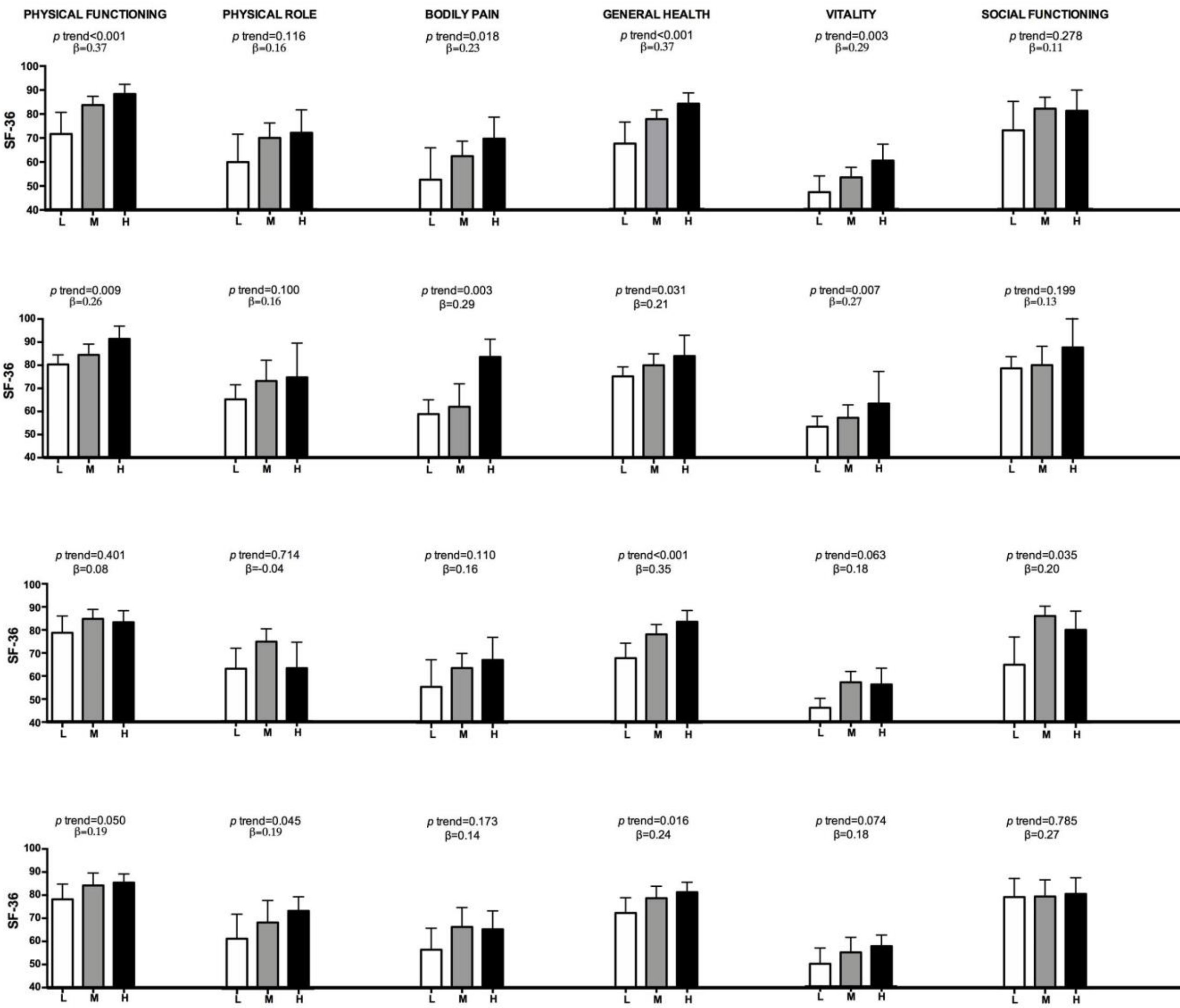


Figure 5.- Analysis of variance (ANOVA-p trend) assessing the linear association of self-reported fitness with the different dim
women. Data represented means, confidence intervals and standardized β; Overall, overall physical fitness; CRF, cardiorespirat
L= low fitness level (very low and low categories of IFIS); M=medium fitness level (average category of IFIS); H=high fitness le

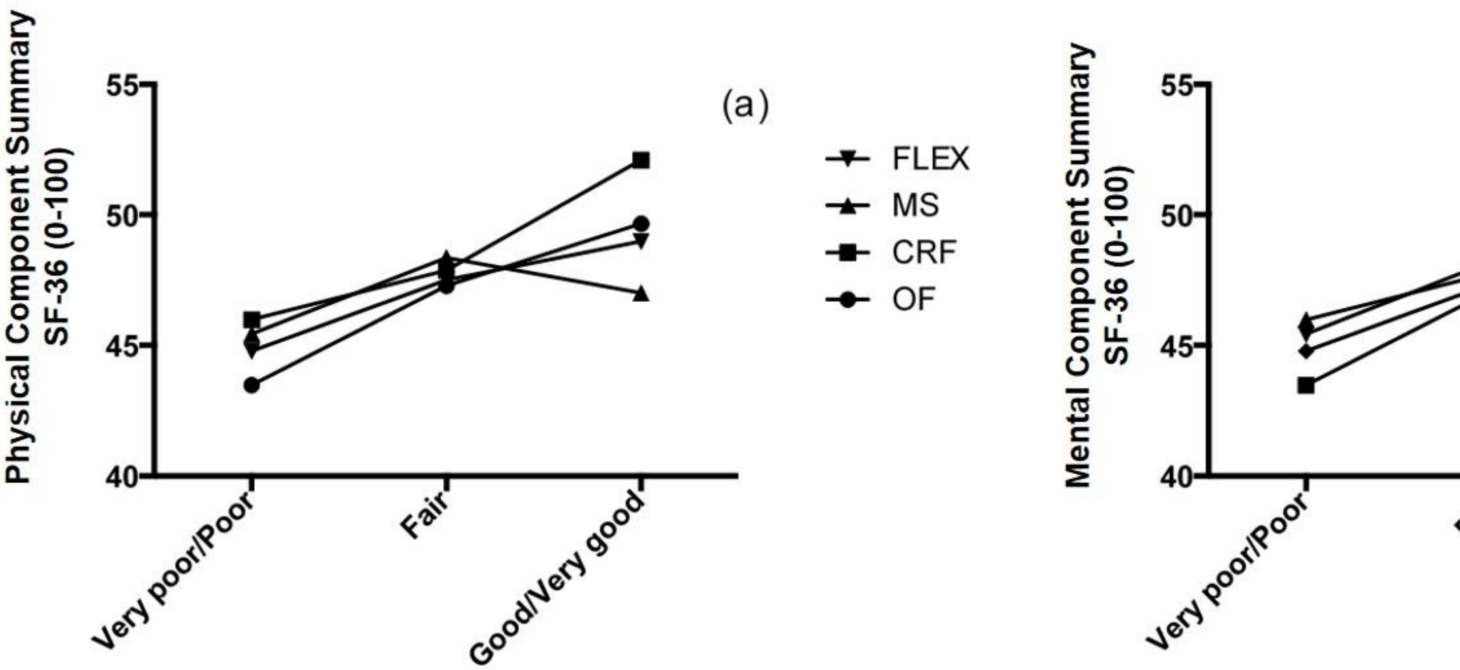


Figure 6.- Associations between Summary Physical Component (a) and Mental Component Summary (b) of health-related q
Survey-36 (SF-36) and self-reported physical fitness (IFIS) categories in pregnant women. Data represent means. All sign
significance levels were $p<0.05$, excepting CRF and FLEX (b). CRF, cardiorespiratory fitness; FLEX, flexibility; MS, muscul

Table 11. Physical component summary and mental component summary across International FItness Scal

		Very Poor/Poor (1)
		Mean
Physical component	IFIS Overall	43.48 (9.34)
	IFIS CRF	45.98 (6.83)
	IFIS MS	45.43 (8.52)
	IFIS Flex	44.78 (7.85)
Mental Component	IFIS Overall	46.36 (8.21)
	IFIS CRF	49.77 (7.33)
	IFIS MS	44.92 (8.41)
	IFIS Flex	49.44 (6.84)

Overall=overall physical fitness; CRF=cardiorespiratory fitness; MS=muscular strength. FLEX=flexibility.

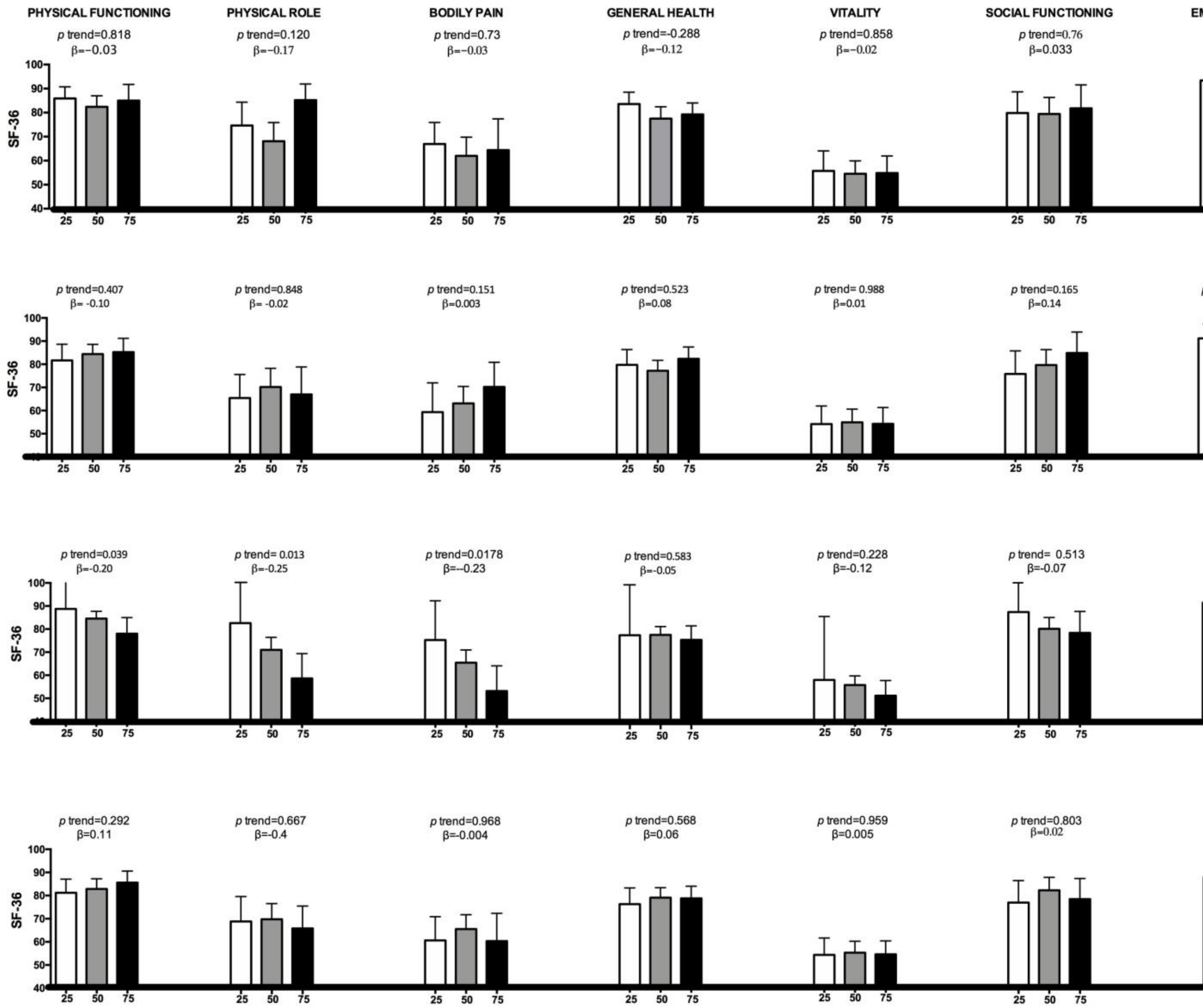


Figure 7. Analysis of variance assessing the linear association of objectively measured physical fitness with the dif life in pregnant women. Data represented means, confidence intervals and standardized β. Abbreviations: Overall, cardiorespiratory fitness; MS, muscular strength. FLEX, flexibility.

DISCUSSION

DISCUSSION

Study I: Assessing physical fitness during pregnancy: validity and reliability of fitness tests, and relationship with health-related outcomes. A systematic review.

1) Summary of tests used to assess physical fitness during pregnancy.

This systematic review revealed that PF has been assessed through a wide variety of tests during pregnancy. However, very little is known on the validity and reliability of the tests performed. These findings have important research and clinical implications. First, until a specific battery of fitness assessments for pregnant women is developed and validated, the confidence in PF data during pregnancy is limited and potentially unreliable and may prove harmful if unreliable values are used for exercise recommendation during pregnancy. Second, the large variety of tests used makes is challenging to compare results from different studies. Third, provided the lack of rigorous information on validity and reliability of PF tests, it is also difficult to evaluate the association of PF with health-related outcomes, which is of wide clinical and public health interest. However, some studies have attempted to present associations of PF with health-related outcomes, which undoubtedly needs to be replicated once a PF test battery is released. Before that, exhaustive research must be performed in validating such battery of tests.

a)Cardiorespiratory Fitness

This systematic review identified that cycle-ergometer has been the equipment most frequently used to assess PF followed by treadmill and field tests; although step tests have also been conducted. There is a large disparity of protocols and wide variety of *ad hoc* tests used, which makes comparing results between studies difficult. However, the Modified Balke treadmill Protocol validated by Mottola et al. [123] for pregnant women has been the most frequently used test. There have been more incremental tests used for CRF tests during pregnancy compared to steady-state tests and more submaximal compared to maximal tests. There is no consensus regarding test termination criteria for submaximal tests, which undoubtedly needs further research. Some articles used relative intensity using physiological variables such as $\%HR_{max}$ or $\%VO_{2max}$, and other used absolute intensity, such as specific HR (beats per minute). Among the studies that used $\%HR_{max}$ as a test termination criterion, there was a variety of percentages such as 70% [68,77,78,116], 75% [70,72,105,119] or 85% [31,98,122]. Among the studies that used $\%VO_{2max}$, there were different percentages such as 40% [81], 50% [69,80], 60% [75,81], or 70% [73]. Among the studies that used absolute HR as a test termination criterion, the HR for finalizing the tests were set either at 125 [106], 150 [36,79,220,223], 155 [144], 160 [109], or 170 [93,94,100,101] beats per minute. Some studies even used the rate perceived exertion as complementary criteria [89,94,111] or peak aerobic power [82]. These complementary criteria have been recommended and studied in pregnant women by authors like Hesse et al. [133] since the physical and emotional changes during pregnancy limit performance. It must be noted that the same equation was not used to estimate HR_{max}. Some articles used the traditional 220-age formula [72,78,98,105,119] while others used the Karvonen [122] or Tanaka [116] formulas. There were articles that did not mention how HR_{max} was estimated [68,70,77]. This heterogeneity could be due to the physiological complexity of the pregnant woman, in terms of cardiac changes and response to exercise and the lack of scientific information in this regard. Moreover, the gestational week could be a determinant for physiological response since Bijl et al. [116] observed a slower hemodynamic recovery and an increased ventilatory response to exercise in early pregnancy compared to non-pregnant women. With regards to maximal tests, different terms have been used with the same sense such as volitional fatigue [73,86,87,90,91,112,114,133,221], exhaustion [74], anaerobic threshold [113,128,207,222], and point of symptom limitation [103,104,115].

This lack of consensus has many drawbacks that need to be resolved in view of the need to accurately assess CRF during pregnancy. We advocate for an expert consensus to be developed in the following years to achieve the goal of appropriate and effective CRF assessment during pregnancy. In particular, it seems essential to develop a treadmill and a cycle ergometer submaximal test that reveals sufficient validity to confidently estimate VO_{2max} throughout gestation.

b) Muscular fitness

Muscular fitness tests included muscular strength, endurance and power [2]. The studies included in this systematic review show that muscular strength was the most frequently assessed component of muscular fitness, since only 6 studies [30,31,150,154,158,237] assessed endurance and none of them assessed power in pregnant women. In most studies, muscular strength was evaluated through handgrip maximal strength using a dynamometer. However, 2 studies used a handgrip sphygmomanometer test [146,147]. Some of the handgrip tests were performed in standing position [26,152], while others used sitting position [151] or supine position [155], and others did not reveal the position used for the assessment [39,137,154,232]. Some tests were completed 3 times [154], others twice [26,39,137], and others only once [151,155,232]. This clearly reveals a large methodological variability that might influence the results and make comparing results between studies difficult. Another limitation is the fact that the main strength outcome was handgrip strength. While handgrip strength is a good marker of health [17], it is unclear whether handgrip responds to changes following exercise interventions. Therefore, validating other muscular strength tests, including lower limb strength tests, is needed in order for researchers and practitioners to confidently assess muscular strength during pregnancy.

There were no validity studies and the reliability was assessed only in one maximal isometric hip extension test [149]. This test has limitations since the pregnant abdomen must be on a bed and, as acknowledged by the authors, it cannot be performed during the third trimester. It must be noted that higher handgrip strength was associated with higher birth weight [26,39]. Moreover, increased hand-grip strength was produced during uterine contraction [153]. The advantage of using handgrip is that it represents an inexpensive, rapid, and easy-to-use assessment with minimal training needed to appropriately administer. However, assessing the performance of pregnant athletes with this test seems clearly insufficient. More quality in tests employed is necessary since the association of muscular strength with health-related outcomes is of clinical importance. Moreover, other studies are needed to understand the extent to which preserving strength throughout pregnancy and postpartum relates to clinical outcomes.

c) Flexibility

Although there were 7 studies assessing flexibility, none of them used the same protocol. Once again, this reflects a lack of agreement when assessing the same component of PF. Moreover, Lindgren et al. [162] found that a higher flexibility showed a higher low back pain. Despite the limitation of a finger laxity test, we considered these findings an interesting association that warrants further article since passive stretching is one of the most common practical prescriptions for exercise professionals instead of mobility and breathing exercises. On the other hand, the results of Baena-García et al. [31] are very relevant to foetal health since the flexibility was associated with a better pH, PO_2 and PCO_2 in umbilical cord blood. Hence, more research about flexibility tests, their outcomes and their prescription are needed.

d) Balance

We identified that balance was the second PF component most frequently evaluated during pregnancy, following CRF. This makes sense since the center of gravity changes during pregnancy as a result of expansion of the uterus and the risk of falls increases. However, there is a great heterogeneity between the protocols employed in different studies. For *static balance*, the protocol most frequently used was stabilometry on force platform with bipedal support and eyes open and eyes closed within the same test [164–170,173–177]. For *dynamic balance*, there was a greater heterogeneity across protocols both in the platform used and in the movements over the platforms. Regarding the assessment tool, the 3-D camera was the device most frequently used [170,187–189,191,233]. Likewise, we observed differences between the number of platform pieces, trials and Hz utilized. Some protocols were performed on 2 piece-platforms [165,175,176], others on 1 piece-platforms [164,166,167,171,172,174,177] and others did not specify the type of platform [168–170]. Although the number of trials and the frequency of recording (i.e. Hz) are important parameters that should be carefully described about the protocols, only 5 (out of 13) articles described the number of trials [164,171,172,176,238] and 1 described frequency of recording [165]. The usefulness of these tests are restricted to the research area and all of them use expensive technological tools; therefore, it is difficult to extrapolate these tests to fitness centers or clinical settings. We could prevent falls during pregnancy if we could assess balance easily. For this reason, it is necessary to develop an inexpensive and easy-to-use balance field-test.

2) Validity, reliability and health-related outcomes

Unfortunately, studies that examine validity and reliability of PF tests are scarce. The physical fitness component most frequently studied was CRF, however we have only found two studies that analyzed the validity of the CRF tests and no studies examined the reliability of these tests. On treadmill platform, Mottola et al. [123], validated a special equation for modified Balke protocol that has been used by numerous other authors. In contrast, Yeo tried to validate a portable metabolic testing system (*mod. VO2000*) but it overestimated VO_2 measurements for pregnant women compared to non-pregnant women and males[122].

Regarding muscular fitness, hand grip test was most commonly used; this test was used as the gold standard for muscular fitness during pregnancy. Only Gutke et al. [149], studied the reliability of a test for hip extension. However, the *p* value was not reported, and the position adopted in the test could be uncomfortable for pregnant participants. Finally, the studies evaluating validity and reliability of speed tests and multidimensional components of PF have been researched by Evensen et al. [202,203]. They demonstrated that TUG and 10mTWT are reliable and valid tests for pregnant women.

The validity and reliability of balance (without tests), agility and/or coordination tests has not been investigated to date.

We suggest that specific tests to be performed in pregnant women are needed and their validity and reliability must be assessed to understand the extent to which one might rely on such measures when prescribing exercise, or making clinical recommendations.

Regarding health-related outcomes, we can conclude that more research is also necessary. Nevertheless, from this review we can highlight some interesting associations with different fitness components. A better CRF was associated with a shorter labor [36,37] and a lower risk of cesarean section [31]. However, no association was found regarding other fetal outcomes such as Apgar scores or the newborn anthropometrics [36,37]. By contrast, muscular strength was associated with optimum infant birth weight [26,31,39]. Other neonatal outcomes like fetal umbilical cord pH were positively associated with maternal CRF [34]. On the other hand, better balance scores are associated with decreased fall risk [40,166,239]. These results are very useful for exercise professionals, as it implies that protocols during pregnancy must be implemented with balance exercises. Finally, Evensen et al.[204] found that pelvic girdle pain could be a limiting factor to assess physical fitness in pregnant women since the time of TUG was significantly higher in women with pain than in asymptomatic pregnant and non-pregnant women.

To note that none of the studies reviewed in this article have described adverse events during PF assessment. Moreover, official institutions such as the American College of Obstetrician and Gynaecology or the Canadian Society of Exercise Physiology have highlighted the benefits of an adequate PF assessment, and assert the need of consensus in the PF assessment during pregnancy [240].

Study II: International FItness Scale -IFIS: Validity and association with health-related quality of life in pregnant women

The main findings of this study indicate that the IFIS might be a useful questionnaire to discriminate pregnant women with "low/very low" physical fitness and low HRQoL. This simple and easy-to-implement questionnaire might be a useful tool for clinical practitioners and exercise professionals to obtain complementary information about the health status of pregnant women.

1) Construct validity

The distribution of IFIS mainly showed three fitness categories. Among pregnant women, there were only a few participants who responded that their physical fitness was "very good" or "very poor". Therefore, as we explained previously, we re-classified in the three categories ("very poor and poor", "average", and "good and very good") where the vast majority of answers fell. All of this is consistent with the results and central tendency showed by Merellano-Navarro et al.[58] in older adults and Ortega et al.[241] in young adults avoiding low levels of ceiling effect (i.e. most of the scores showing "very good" levels) and floor effect (i.e. most of the scores showing "very poor" levels). However, these findings differ when the population is younger, like in children[56] or adolescents[52], remaining at least 4 differentiated categories, showing more cases in "very good". This may be because children tend to over-report upper categories as they do not identify health problems as theirs. Furthermore, the gender of the participants could be another reason for this difference, as women tend to report central values instead of overestimate their physical fitness, as shown in previous studies[59,242]. Our sample was composed of women, who usually over-report less than men, except for flexibility (our participants showed higher levels of self-reported flexibility along with CRF than other physical fitness components) in agreement with Sánchez-López et al[56].

We observed differences in objectively measured physical fitness across categories of self-reported physical fitness (IFIS), in concordance with previous studies in young adults[241] and women with fibromyalgia[59].

Regarding CRF, the post-hoc analyses showed that IFIS-CRF discriminated between "unfit" [3] women (i.e. those with the lowest levels of objectively measured CRF) and those with average or higher CRF. From a public-health perspective, this outcome is particularly relevant because low CRF fitness is a risk factor for cardiovascular diseases, psychiatric disorders, and all-cause mortality/morbidity [10,243,244]. In this line, IFIS-CRF could be a useful complementary tool to be used in clinical practice to detect pregnant women with very low CRF. This might have important clinical implications in the follow up of pregnancy; further research to understand the potential of IFIS to identify women at risk of pregnancy complications is warranted. We propose that IFIS could be a useful complementary tool to be implemented in clinical practice, although further research is needed to understand its potential to identify women at risk of pregnancy complications.

In regard to muscular strength, the post-hoc analyses revealed that those participants that self-reported "good/very good" muscular strength had higher objectively measured muscular (i.e. handgrip) strength than those who self-reported "average" or "poor/very poor" levels. These results for muscular strength differ from those of CRF, in concordance with previous studies in young adults[241,242]. Although this is a matter of further research, these results suggest that IFIS-muscular strength could be used to detect pregnant women with higher levels of muscular strength, which has been associated with healthier perinatal outcomes[26]. Finally, self-reported flexibility differed more between the extreme groups ("very poor/poor" and "good/very good"), in line with previous studies reported in adults[58,59]. The extent to which flexibility is associated to health-related outcomes during pregnancy is still to be investigated.

2) Ability of IFIS to discriminate between levels of HRQoL

On the other hand, with respect to the relation of physical fitness and HRQoL during pregnancy, Engberg et al.[28] showed that better CRF was positively associated with better HRQoL. Besides that, practicing physical activity improves the physical fitness.–Other researchers, such as Mourady el al.[245], found positive associations between total and light intensity PA with the psychological domain of quality of life and social-relationships assessed with the WHOQOL-brief questionnaire. Kolu et al.[246] observed that meeting PA recommendations before pregnancy (150 minutes per week) was associated with a better HRQoL and Montoya et al.[47] showed that the pregnant women which followed an aerobic exercise program (PA structured and scheduled along time) improved HRQoL.

To the best of our knowledge, there are not validated questionnaires to estimate physical fitness in pregnant women. Our study has shown that IFIS is able to discriminate levels of HRQoL better than objectively measured physical fitness. Indeed, the dimension SF36-*General Health* was associated with all IFIS components. Similarly, all IFIS components were positively associated with *SF36-General Health*. The CRF-IFIS and overall-IFIS were the components which were more related to HRQoL. Contrarily, the association between objectively measured physical fitness and HRQoL was weaker. This makes sense since the IFIS and SF-36 are both self-reported tools in contrast to the objective assessment of physical fitness. In this context, IFIS might be reliable to detect very low levels of HRQoL and could represent a more useful tool than objective physical fitness assessment, especially in those circumstances with time constrains and limited equipment.

LIMITATIONS AND STRENGTHS

Limitations

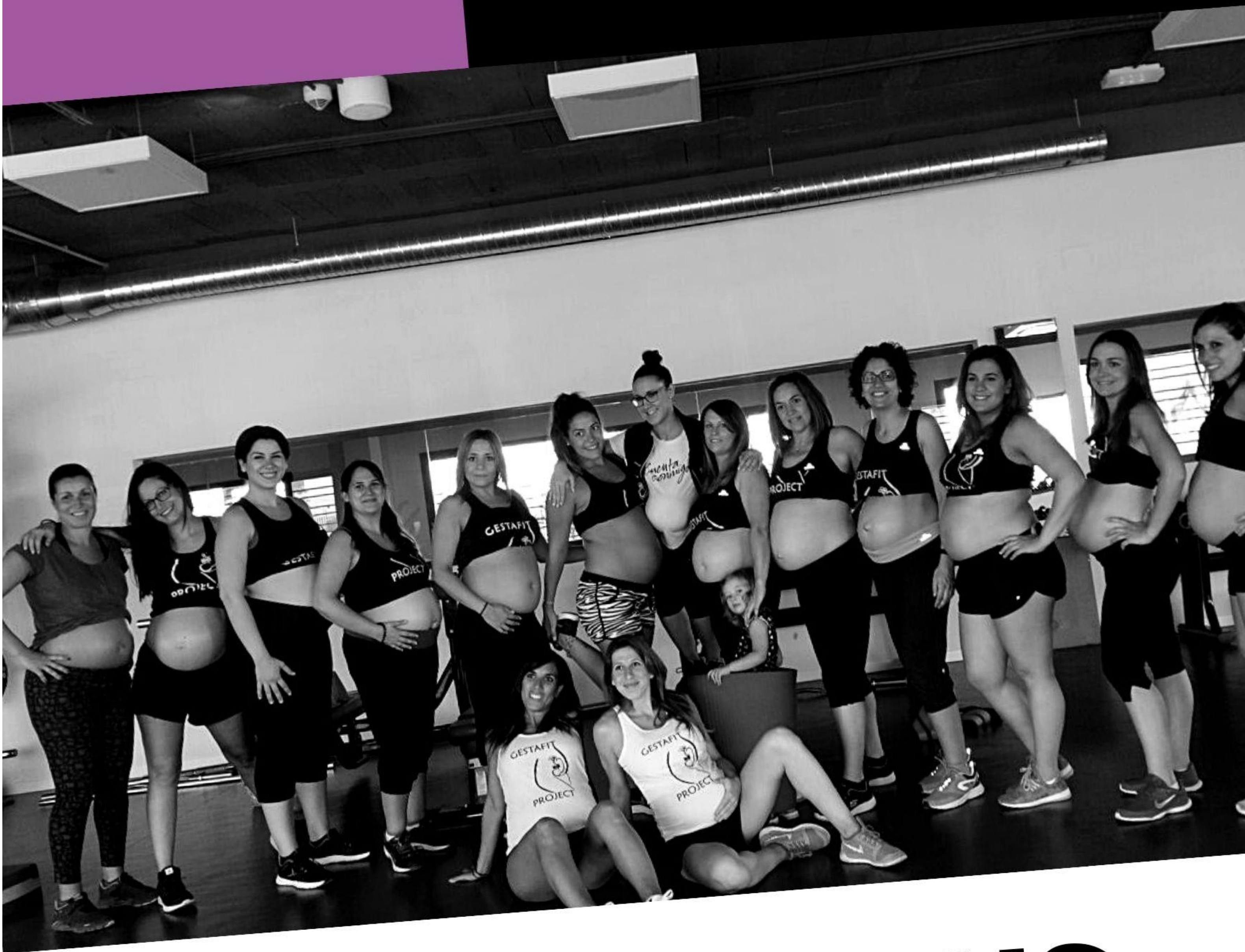
The studies comprising this Doctoral Thesis have several limitations that must be highlighted. In regard to study I, we need to assume that, although PubMed and WOS are among the most relevant databases in the medical literature, the possibility that a small number of studies have been overlooked cannot be discarded. Nevertheless, these two databases are the biggest databases in sports medicine and sports sciences and, therefore, include the vast majority of studies. On the other hand, regarding study II, the sample size was relatively small and composed only of Spanish pregnant women, while IFIS was designed to be used in large populations[52]. Future studies with larger sample sizes and with women from different regions/countries are needed to confirm or contrast these findings. This reason justifies the merge in 3 big categories ("very poor/poor", "average" and "good/very good"), which may explain some non-significant results in the post-hoc comparisons and some borderline results. The test-retest reliability of IFIS could not be assessed and is currently to be investigated. Finally, objectively measured speed-agility (one of the questions of the IFIS) was not assessed because these tests could involve an obstetric risk during pregnancy. Consequently, we considered leaving this component of physical fitness out of the scope of this thesis.

Strengths

One strength of study I is the fact that, to the best of our knowledge, this is the first review to comprehensively analyze PF assessments, the validity and reliability of fitness tests, and their relationship with health-related outcomes during pregnancy.

The results from this systematic review provide an overall picture of how PF is being assessed in this population, what type of tests are being performed, their specific characteristics, whether these tests have been tested for validity and/or reliability; and whether PF is associated with health-related outcomes. All this information is of wide and undoubted clinical interest.

As strength of study II that this was, to the best of out knowledge, the first to analyze the construct validity of the IFIS in pregnant women, a population that has been traditionally understudied. Finally, the IFIS can be useful to determine physical fitness levels beyond field-based physical fitness tests, which demand more time, trained personnel and greater space.



CONCLUSIONS

CONCLUSIONS

The results of the present International Doctoral Thesis suggest that:

1. During pregnancy, physical fitness has been assessed through a wide variety of protocols without risk for maternal or neonatal health. Cardiorespiratory fitness and balance have been the fitness components most frequently assessed. To date, there is no consensus on the most suitable tests to assess physical fitness in pregnant women. Extensive research is needed to design and validate a battery of fitness tests to be used for the safe and effective assessment of physical fitness during pregnancy.

2. The validity and reliability of most of the fitness protocols used to assess PF during pregnancy has not been determined. In addition, there is little information on the association of PF with maternal-fetal outcomes. Although it seems that higher PF levels is associated with more favorable outcomes, and considering its clinical and public health importance, further research using validated tests is needed to corroborate and expand current knowledge.

3. The IFIS is a useful, simple and quick tool to identify three (low, medium and high) physical fitness levels in pregnant women, which might have practical implications for both health and exercise professionals. In particular, the IFIS might be a useful questionnaire to discriminate pregnant women with “low/very low” levels of cardiorespiratory fitness, which is wide clinical interest.

4. The IFIS might also detect low (very poor/poor) levels of HRQoL, even to a greater extent than objectively measured PF. Consequently, the IFIS could be an interesting tool for clinical practitioners and exercise professionals to obtain complementary information about the health status of pregnant women.

CONCLUSIONES

Los resultados de la presente Tesis Doctoral Internacional sugieren que:

1. Durante el embarazo, la condición física ha sido evaluada a través de una gran variedad de protocolos que no han supuesto ningún riesgo maternal ni fetal. La capacidad aeróbica y el equilibrio han sido los componentes más evaluados. Hasta la fecha, no existe consenso acerca de los tests más adecuados para evaluar la condición física durante el embarazo. Se necesita de una mayor investigación para diseñar y validar una batería de pruebas físicas para que sea segura y efectiva la evaluación de condición física en esta etapa.

2. La mayoría de protocolos de condición física evaluados carecen de datos de validez y fiabilidad. La asociación de los resultados de esas pruebas con los efectos de salud materno-fetal es escasa y debería ser evaluada en el futuro, ya que es de relevancia pública y clínica. Por lo tanto, una vez detectada la nececesidad de evaluar la CF durante el embarazo y la importancia que tiene tanto en el estado físico como para la prescripción adecuada de ejercicio en esta población, debe desarrollarse un consenso de expertos con el fin de diseñar y validar una batería específica de fitness para mujeres embarazadas.

3. El cuestionario de fitness auto-percibido, IFIS, es una herramienta útil, simple y rápida para identificar 3 niveles diferentes de condición física (bajo, medio y alto) en mujeres embarazadas, lo cual tiene implicaciones prácticas tanto para los profesionales de la salud como para los profesionales del ejercicio físico. Profundizando, IFIS detecta mejor, niveles bajos de capacidad aeróbica que niveles altos y niveles altos de fuerza muscular que niveles bajos. Por ello, usar IFIS podría tener importantes implicaciones clínicas en el seguimiento del embarazo.

4. IFIS, siendo una herramienta de medición subjetiva de la condición física, es capaz de discriminar niveles de calidad de vida, mejor que los tests objetivos. Por ello, IFIS podría ser una interesante herramienta para identificar niveles bajos de calidad de vida, además de evaluar la CF en mujeres embarazadas.

REFERENCES

1. Caspersen CJ, Christenson GM. Physical Activity, Exercise, and Physical Fitness: Definitions and Distinctions for Health-Related Research. *Public Health Rep*. 1985;100(April):126-131. Accessed October 30, 2020. /pmc/articles/PMC1424733/?report=abstract

2. American College of Sports Medicine, In Riebe D, In Ehrman JK, In Liguori G, In Magal M. *ACSM's Guidelines for Exercise Testing and Prescription.10th Edition*.; 2018.

3. Blair S, Kohl H, Barlow C. Changes in physical fitness and allcause mortality. A prospective study of healthy and unhealthy men. *JAMA*. 1995;273:1093-1098.

4. Kodama S, Saito K, Tanaka S, et al. Cardiorespiratory Fitness as a Quantitative Predictor of All-Cause Mortality and Cardiovascular Events. *JAMA*. 2009;301(19):2024-2035.

5. Gibbons LW, Blair SN, Cooper KH, Smith M. Association between coronary heart disease risk factors and physical fitness in healthy adult women. *Circulation*. 1983;67(5):977-983. doi:10.1161/01.CIR.67.5.977

6. Ortega F, Cadenas-Sanchez C, Lee D, Ruiz J, Blair S, Sui X. Fitness and Fatness as Health Markers through the Lifespan: An Overview of Current Knowledge. *Prog prev med*. 2018;3(2):e0013. doi:10.1097/pp9.0000000000000013

7. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M. Physical fitness in childhood and adolescence: A powerful marker of health. *Int J Obes*. 2008;32(1):1-11. doi:10.1038/sj.ijo.0803774

8. Ross R, Blair SN, Arena R, et al. *Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign: A Scientific Statement from the American Heart Association*. Vol 134.; 2016. doi:10.1161/CIR.0000000000000461

9. Harber MP, Kaminsky LA, Arena R, et al. Impact of Cardiorespiratory Fitness on All-Cause and Disease-Specific Mortality: Advances Since 2009. *Prog Cardiovasc Dis*. 2017;60(1):11-20. doi:10.1016/j.pcad.2017.03.001

10. Blair S., Kohl HW, Paffenbarger RS, Clark DG, Cooper KH, Gibbons LW. Physical Fitness and All-Cause Mortality A Prospective Study of Healthy Men and Women. *JAMA*. 1989;262(17):2395-2401.

11. Lee DC, Sui X, Church TS, Lavie CJ, Jackson AS, Blair SN. Changes in fitness and fatness on the development of cardiovascular disease risk factors: Hypertension, metabolic

syndrome, and hypercholesterolemia. *J Am Coll Cardiol*. 2012;59(7):665-672. doi:10.1016/j.jacc.2011.11.013

12. Myers J, Kokkinos P, Arena R, LaMonte MJ. The impact of moving more, physical activity, and cardiorespiratory fitness: Why we should strive to measure and improve fitness. *Prog Cardiovasc Dis*. 2021;64:77-82. doi:10.1016/j.pcad.2020.11.003

13. Davenport MH, Hogan DB, Eskes GA, Longman RS, Poulin MJ. Cerebrovascular reserve: The link between fitness and cognitive function? *Exerc Sport Sci Rev*. 2012;40(3):153-158. doi:10.1097/JES.0b013e3182553430

14. Lang JJ, Tomkinson GR, Janssen I, et al. Making a Case for Cardiorespiratory Fitness Surveillance among Children and Youth. *Exerc Sport Sci Rev*. 2018;46(2):66-75. doi:10.1249/JES.0000000000000138

15. Kokkinos PF, Faselis C, Myers J, Panagiotakos D, Doumas M. Interactive effects of fitness and statin treatment on mortality risk in veterans with dyslipidaemia: A cohort study. *Lancet*. 2013;381(9864):394-399. doi:10.1016/S0140-6736(12)61426-3

16. Kokkinos P, Myers J, Faselis C, Doumas M, Kheirbek R, Nylen E. BMI-mortality paradox and fitness in African American and Caucasian men with type 2 diabetes. *Diabetes Care*. 2012;35(5):1021-1027. doi:10.2337/dc11-2407

17. García-Hermoso A, Cavero-Redondo I, Ramírez-Vélez R, et al. Muscular Strength as a Predictor of All-Cause Mortality in an Apparently Healthy Population: A Systematic Review and Meta-Analysis of Data From Approximately 2 Million Men and Women. *Arch Phys Med Rehabil*. 2018;99(10):2100-2113.e5. doi:10.1016/j.apmr.2018.01.008

18. Wu Y, Wang W, Liu T, Zhang D. Association of Grip Strength With Risk of All-Cause Mortality, Cardiovascular Diseases, and Cancer in Community-Dwelling Populations: A Meta-analysis of Prospective Cohort Studies. *J Am Med Dir Assoc*. 2017;18(6):551.e17-551.e35. doi:10.1016/j.jamda.2017.03.011

19. Jochem C, Leitzmann M, Volaklis K, Aune D, Strasser B. Association Between Muscular Strength and Mortality in Clinical Populations: A Systematic Review and Meta-Analysis. *J Am Med Dir Assoc*. 2019;20(10):1213-1223. doi:10.1016/j.jamda.2019.05.015

20. Kruse NT, Scheuermann BW. Cardiovascular Responses to Skeletal Muscle Stretching: "Stretching" the Truth or a New Exercise Paradigm for Cardiovascular Medicine? *Sport Med*. 2017;47(12):2507-2520. doi:10.1007/s40279-017-0768-1

21. Bonnie L, Bermas M. Musculoskeletal changes and pain during pregnancy and postpartum. *UpToDate*. Published online 2016:1-17.

22. Tan EK, Tan EL. Alterations in physiology and anatomy during pregnancy. *Best Pract Res Clin Obstet Gynaecol*. 2013;27(6):791-802. doi:10.1016/j.bpobgyn.2013.08.001

23. Miller MJ, Kutcher J, Adams KL. Effect of Pregnancy on Performance of a Standardized Physical Fitness Test. *Mil Med*. 2017;182(11):e1859-e1863. doi:10.7205/MILMED-D-17-00093

24. Treuth MS, Butte NF, Puyau M. Pregnancy-Related Changes in Physical Activity, Fitness, and Strength. *Med Sci Sport Exerc*. 2005;37(5):832-837. doi:10.1249/01.MSS.0000161749.38453.02

25. LeMoyne EL, Curnier D, Ellemberg D. Pregnancy and cognition: Deficits in inhibition are unrelated to changes in fitness. *J Clin Exp Neuropsychol*. 2014;36(2):178-185. doi:10.1080/13803395.2013.875520

26. Bisson M, Alméras N, Plaisance J, et al. Maternal fitness at the onset of the second trimester of pregnancy: Correlates and relationship with infant birth weight. *Pediatr Obes*. 2013;8(6):464-474. doi:10.1111/j.2047-6310.2012.00129.x

27. Gar C, Rottenkolber M, Grallert H, et al. Physical fitness and plasma leptin in women with recent gestational diabetes. Hu C, ed. *PLoS One*. 2017;12(6):e0179128. doi:10.1371/journal.pone.0179128

28. Engberg E, Tikkanen HO, Koponen A, et al. Cardiorespiratory fitness and health-related quality of life in women at risk for gestational diabetes. *Scand J Med Sci Sports*. 2017;(April):1-9. doi:10.1111/sms.12896

29. Weissgerber TL, Wolfe LA, Davies GAL, Mottola MF. Exercise in the prevention and treatment of maternal – fetal disease : a review of the literature. 2006;674:661-674. doi:10.1139/H06-060

30. Price BB, Amini SB, Kappeler K. Exercise in Pregnancy: Effect on Fitness and Obstetric Outcomes-A Randomized Trial. *Med Sci Sport Exerc*. 2012;44(12):2263-2269. doi:10.1249/MSS.0b013e318267ad67

31. Baena-García L, Coll-Risco I, Ocón-Hernández O, et al. Association of objectively measured physical fitness during pregnancy with maternal and neonatal outcomes. The GESTAFIT Project. Luo Z-C, ed. *PLoS One*. 2020;15(2):e0229079. doi:10.1371/journal.pone.0229079

32. Marín-Jiménez N, Acosta-Manzano P, Borges-Cosic M, et al. Association of self-reported physical fitness with pain during pregnancy: The GESTAFIT Project. *Scand J Med Sci Sport*. 2019;29(7):1022-1030. doi:10.1111/sms.13426

33. Romero-Gallardo L, Soriano-Maldonado A, Ocón-Hernández O, et al. International Fitness Scale—IFIS: Validity and association with health-related quality of life in pregnant women. *Scand J Med Sci Sport*. 2019;(October):1-10. doi:10.1111/sms.13584

34. Erkkola R, Rauramo L. Correlation of Maternal Physical Fitness During Pregnancy with Maternal and Fetal Ph and Lactic Acid at Delivery. *Acta Obstet Gynecol Scand*. 1976;55(5):441-446. doi:10.3109/00016347609158527

35. Baena-García L, Coll-Risco I, Ocón-Hernández O, et al. Association of objectively measured physical fitness during pregnancy with maternal and neonatal outcomes. The GESTAFIT Project. *PLoS One*. 2020;15(2):e0229079. doi:10.1371/journal.pone.0229079

36. Wong SC, McKenzie DC. Cardiorespiratory fitness during pregnancy and its effect on outcome. *Int J Sports Med*. 1987;8(2):79-83. doi:10.1055/s-2008-1025645

37. Pomerance JJ, Gluck L, Lynch VA. Physical fitness in pregnancy: its effect on pregnancy outcome. *Am J Obstet Gynecol*. 1974;119(7):867-876. Accessed November 14, 2018. https://www.sciencedirect.com/science/article/pii/0002937874900015?via%3Dihub

38. Thorell E, Goldsmith L, Weiss G, Kristiansson P. Physical fitness, serum relaxin and duration of gestation. *BMC Pregnancy Childbirth*. 2015;15(1):1-7. doi:10.1186/s12884-015-0607-z

39. Żelaźniewicz A, Pawłowski B. Maternal hand grip strength in pregnancy, newborn sex and birth weight. *Early Hum Dev*. 2018;119:51-55. doi:10.1016/j.earlhumdev.2018.03.004

40. Ozturk G, Kulcu DG, Aydog E, Kaspar C, Ugurel B. Effects of lower back pain on postural equilibrium and fall risk during the third trimester of pregnancy. *J Matern NEONATAL Med*. 2016;29(8):1358-1362. doi:10.3109/14767058.2015.1049148

41. Karimi M, Brazier J. Health, Health-Related Quality of Life, and Quality of Life: What is the Difference? *Pharmacoeconomics*. 2016;34(7):645-649. doi:10.1007/s40273-016-0389-9

42. Wilson IB, Cleary PD. Linking Clinical Variables With Health-Related Quality of Life: A Conceptual Model of Patient Outcomes. *JAMA J Am Med Assoc*. 1995;273(1):59-65. doi:10.1001/jama.1995.03520250075037

43. Alidost F, Dolatian M, Shams J, Nasiri M, Sarkhoshpour E. The Correlation of Sexual Dysfunction with Prenatal Stress and Quality of Life: A Path Analysis. *Iran Red Crescent Med J*. 2017;19(7). doi:10.5812/ircmj.55686

44. Rogers RG, Ninivaggio C, Gallagher K, Borders AN, Qualls C, Leeman LM. Pelvic floor symptoms and quality of life changes during first pregnancy: a prospective cohort study.

Int Urogynecol J. 2017;28(11):1701-1707. doi:10.1007/s00192-017-3330-7

45. Kazemi F, Nahidi F, Kariman N. Disorders affecting quality of life during pregnancy: A qualitative study. *J Clin Diagnostic Res*. 2017;11(4):QC06-QC10. doi:10.7860/JCDR/2017/23703.9560

46. Campolong K, Jenkins S, Clark MM, et al. The association of exercise during pregnancy with trimester-specific and postpartum quality of life and depressive symptoms in a cohort of healthy pregnant women. *Arch Womens Ment Health*. Published online 2017:1-10. doi:10.1007/s00737-017-0783-0

47. Montoya Arizabaleta AV, Orozco Buitrago L, Aguilar de Plata AC, et al. Aerobic exercise during pregnancy improves health-related quality of life: a randomised trial. *J Physiother*. 2010;56(4):253-258. doi:10.1016/S1836-9553(10)70008-4

48. American College of Obstetricians and Gynecologists. Physical Activity and Exercise During Pregnancy and the Postpartum Period. *Comm Opin*. 2015;(650):268-273. doi:10.1097/aog.0000000000001214

49. Meah VL, Backx K, Davenport MH, International Working Group on Maternal Hemodynamics. Functional hemodynamic testing in pregnancy: recommendations of the International Working Group on Maternal Hemodynamics. *Ultrasound Obstet Gynecol Off J Int Soc Ultrasound Obstet Gynecol*. 2018;51(3):331-340. doi:10.1002/uog.18890

50. May LE, Allen JJB, Gustafson KM. Fetal and maternal cardiac responses to physical activity and exercise during pregnancy. *Early Hum Dev*. 2016;94:49-52. doi:10.1016/j.earlhumdev.2016.01.005

51. Wolfe LA, Weissgerber TTL. Clinical physiology of exercise in pregnancy: a literature review. *J Obstet Gynaecol Can*. 2003;25(6):473-483. doi:10.1016/s1701-2163(16)30309-7

52. Ortega FB, Ruiz JR, España-Romero V, et al. The International Fitness Scale (IFIS): Usefulness of self-reported fitness in youth. *Int J Epidemiol*. 2011;40(3):701-711. doi:10.1093/ije/dyr039

53. Hoeymans N, Feskens EJM, Bos GAM Van Den. Measuring Functional Status : Cross H Sectional And Longitudinal Associations Between Performance And Self- Report (Zutphen Elderly Study 1990-1993). 1993;49(10):1993.

54. Kivinen P, Sulkava R, Halonen P, Nissisen A. Self-reported and performance-based functional status and associated factors among elderly men: the Finnish cohorts of the Seven Countries Study. *J Clin Epidemiol*. 1998;51:1243-1252.

55. Amris K, Wæhrens E, Stockmarr A, H B, DAnneskiold-Samsøe B. Factors influencing

observed and self-reported functional ability in women with chronic widespread pain: a cross-sectional study. *J Rehabil Med*. 2014;46:1014-1021.

56. Sánchez-López M, Martínez-Vizcaíno V, García-Hermoso A, Jiménez-Pavón D, Ortega FB. Construct validity and test-retest reliability of the International Fitness Scale (IFIS) in Spanish children aged 9-12 years. *Scand J Med Sci Sport*. 2015;25(4):543-551. doi:10.1111/sms.12267

57. Ramírez-Vélez R, Cruz-Salazar SM, Martínez M, et al. Construct validity and test–retest reliability of the International Fitness Scale (IFIS) in Colombian children and adolescents aged 9–17.9 years: the FUPRECOL study. *PeerJ*. 2017;5:e3351. doi:10.7717/peerj.3351

58. Merellano-Navarro E, Collado-Mateo D, García-Rubio J, Gusi N, Olivares PR. Validity of the International Fitness Scale "IFIS" in older adults. *Exp Gerontol*. 2017;95:77-81. doi:10.1016/j.exger.2017.05.001

59. Álvarez-Gallardo IC, Soriano-Maldonado A, Segura-Jiménez V, et al. International fitness scale (IFIS): Construct validity and reliability in women with fibromyalgia: The al-ándalus project. *Arch Phys Med Rehabil*. 2016;97(3):395-404. doi:10.1016/j.apmr.2015.08.416

60. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *PLoS Med*. 2009;6(7):e1000100. doi:10.1371/journal.pmed.1000100

61. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med*. 2009;6(7):e1000097. doi:10.1371/journal.pmed.1000097

62. Castro-Piñero J, Artero EG, España-Romero V, et al. Criterion-related validity of field-based fitness tests in youth: A systematic review. *Br J Sports Med*. 2010;44(13):934-943. doi:10.1136/bjsm.2009.058321

63. Artero EG, Espaa-Romero V, Castro-Piero J, et al. Reliability of field-based fitness tests in youth. *Int J Sports Med*. 2011;32(3):159-169. doi:10.1055/s-0030-1268488

64. Armijo-Olivo S, Stiles CR, Hagen NA, Biondo PD, Cummings GG. Assessment of study quality for systematic reviews: A comparison of the Cochrane Collaboration Risk of Bias Tool and the Effective Public Health Practice Project Quality Assessment Tool: Methodological research. *J Eval Clin Pract*. 2012;18(1):12-18. doi:10.1111/j.1365-2753.2010.01516.x

65. Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, et al. Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and

Adolescents: A Systematic Review and Meta-Analysis. *Sport Med*. 2019;49(9):1383-1410. doi:10.1007/s40279-019-01099-5

66. Erkkola R. The influence of physical training during pregnancy on physical work capacity and circulatory parameters. *Scand J Clin Lab Invest*. 1976;36(8):747-754. doi:10.3109/00365517609081933

67. Morton MJ, Paul MS, Campos GR, Hart M V., Metcalfe J. Exercise dynamics in late gestation: Effects of physical training. *Am J Obstet Gynecol*. 1985;152(1):91-97. doi:10.1016/S0002-9378(85)80187-3

68. Veille J-CC, Hohimer ARR, Burry K, Speroff L. The effect of exercise on uterine activity in the last eight weeks of pregnancy. *Am J Obstet Gynecol*. 1985;151(6):727-730. doi:10.1016/0002-9378(85)90505-8

69. Jovanovic L, Kessler A, Peterson CM. Human maternal and fetal response to graded exercise. *J Appl Physiol*. 1985;58(5):1719-1722. doi:10.1152/jappl.1985.58.5.1719

70. Kulpa PJ, White BM, Visscher R. Aerobic exercise in pregnancy. *Am J Obstet Gynecol*. 1987;156(6):1395-1403. doi:10.1016/0002-9378(87)90006-8

71. Carpenter MW, Sady SP, Hoegsberg B, et al. Fetal heart rate response to maternal exertion. *JAMA J Am Med Assoc*. 1988;259(20):3006-3009. doi:10.1001/jama.259.20.3006

72. Moore DH, Jarrett JC 2nd, Bendick PJ. Exercise-induced changes in uterine artery blood flow, as measured by Doppler ultrasound, in pregnant subjects. *Am J Perinatol*. 1988;5(2):94-97. doi:10.1055/s-2007-999663

73. Sady SP, Carpenter MW, Sady MA, et al. Prediction of VO2max during cycle exercise in pregnant women. *J Appl Physiol*. 1988;65(2):657-661. doi:10.1152/jappl.1988.65.2.657

74. Artal R, Masaki DI, Khodiguian N, Romem Y, Rutherford SE, Wiswell RA. Exercise prescription in pregnancy: weight-bearing versus non-weight-bearing exercise. *Am J Obstet Gynecol*. 1989;161(6 Pt 1):1464-1469. doi:10.1016/0002-9378(89)90905-8

75. Hume RFFJ, Bowie JDD, McCoy C, et al. Fetal umbilical artery Doppler response to graded maternal aerobic exercise and subsequent maternal mean arterial blood pressure: predictive value for pregnancy-induced hypertension. *Am J Obstet Gynecol*. 1990;163(3):826-829. doi:10.1016/0002-9378(90)91077-p

76. Sady MA, Haydon BB, Sady SP, Carpenter MW, Thompson PD, Coustan DR. Cardiovascular response to maximal cycle exercise during pregnancy and at two and seven months post partum. *Am J Obstet Gynecol*. 1990;162(5):1181-1185. doi:10.1016/0002-9378(90)90012-v

77. Field SK, Bell SG, Cenaiko DF, Whitelaw WA. Relationship between inspiratory effort and breathlessness in pregnancy. *J Appl Physiol*. 1991;71(5):1897-1902. doi:10.1152/jappl.1991.71.5.1897

78. Rafla NM, Beazely JM. The effect of maternal exercise on fetal umbilical artery waveforms. *Eur J Obstet Gynecol Reprod Biol*. 1991;40(2):119-122. doi:10.1016/0028-2243(91)90102-Q

79. Bung P, Huch R, Huch A. *Maternal and Fetal Heart Rate Patterns: A Pregnant Athlete during Training and Laboratory Exercise Tests; a Case Report*. Vol 39.; 1991. Accessed November 27, 2018. https://www.ejog.org/article/0028-2243(91)90143-9/pdf

80. Young JC, Treadway JL. The effect of prior exercise on oral glucose tolerance in late gestational women. *Eur J Appl Physiol Occup Physiol*. 1992;64(5):130-133. doi:10.1136/bmj.39546.498796.34

81. Clapp JF, Little KD, Capeless EL. Fetal heart rate response to sustained recreational exercise. *Am J Obstet Gynecol*. 1993;168(1):198-206. doi:10.1016/S0002-9378(12)90914-X

82. Lotgering FK, Struijk PC, Doorn MBVAN, Spinnewijn WEM, Wallenburg HCS. Anaerobic threshold and respiratory compensation in pregnant women. *J Appl Physiol*. 1995;85(6):1772-1777. http://www.ncbi.nlm.nih.gov/pubmed/7649911

83. Artal R, Fortunato V, Welton A, et al. A comparison of cardiopulmonary adaptations to exercise in pregnancy at sea level and altitude. *Am J Obstet Gynecol*. 1995;172(4):1170-1180. doi:10.1016/0002-9378(95)91475-7

84. O’Neill ME. Maternal rectal temperature and fetal heart rate responses to upright cycling in late pregnancy. *Br J Sports Med*. 1996;30(1):32-35. doi:10.1136/bjsm.30.1.32

85. Soultanakis HN, Artal R, Wiswell RA. Prolonged exercise in pregnancy: glucose homeostasis, ventilatory and cardiovascular responses. *Semin Perinatol*. 1996;20(4):315-327. doi:10.1016/s0146-0005(96)80024-3

86. Manders MA., Sonder GJ., Mulder EJ., Visser GH. The effects of maternal exercise on fetal heart rate and movement patterns. *Early Hum Dev*. 1997;48(3):237-247. doi:10.1016/S0378-3782(96)01858-0

87. Kemp JG, Greer FA, Wolfe LA. Acid-base regulation after maximal exercise testing in late gestation. *J Appl Physiol*. 1997;83(2):644-651.

88. Mcgrath MJ, Wolfe LA, Preston RJ, Burggraf GW, Mcgrath MJ. Effects of pregnancy and chronic exercise on maternal cardiac structure and function. *Artic Can J Physiol Pharmacol*. Published online 1999. doi:10.1139/cjpp-77-11-909

89. Brenner IKM, Wolfe LA, Monga M, McGrath MJ. Physical conditioning effects on fetal heart rate responses to graded maternal exercise. *Med Sci Sports Exerc*. 1999;31(6):792-799. doi:10.1097/00005768-199906000-00006

90. MacPhail A, Davies GA., Victory R, Wolfe LA. Maximal exercise testing in late gestation: fetal responses. *Obstet Gynecol*. 2000;96(4):565-570. doi:10.1016/S0029-7844(00)00940-6

91. Heenan AP, Wolfe LA, Davies GA. Maximal exercise testing in late gestation: maternal responses. *Obstet Gynecol*. 2001;97(1):127-134. doi:10.1016/S0029-7844(00)01089-9

92. Kennelly MM, Geary M, McCaffrey N, McLoughlin P, Staines A, McKenna P. Exercise-related changes in umbilical and uterine artery waveforms as assessed by Doppler ultrasound scans. *Am J Obstet Gynecol*. 2002;187(3):661-666. doi:10.1067/MOB.2002.125741

93. Heenan AP, Wolfe LA. Plasma osmolality and the strong ion difference predict respiratory adaptations in pregnant and nonpregnant women. *Can J Physiol Pharmacol*. 2003;81(9):839-847. doi:10.1139/y03-072

94. Wolfe LA, Heenan AP, Bonen A. Aerobic conditioning effects on substrate responses during graded cycling in pregnancy. *Can J Physiol Pharmacol*. 2003;81(7):696-703. doi:10.1139/y03-059

95. Lindqvist PG, Marsal K, Merlo J, Pirhonen JP. Thermal response to submaximal exercise before, during and after pregnancy: a longitudinal study. *J Matern neonatal Med Off J Eur Assoc Perinat Med Fed Asia Ocean Perinat Soc Int Soc Perinat Obstet*. 2003;13(3):152-156. doi:10.1080/jmf.13.3.152.156

96. Lynch A-MM, McDonald S, Magann EF, et al. Effectiveness and safety of a structured swimming program in previously sedentary women during pregnancy. *J Matern Neonatal Med*. 2003;14(3):163-169. doi:10.1080/jmf.14.3.163.169

97. Heenan AP, Wolfe LA, Davies GAL, McGrath MJ. Effects of human pregnancy on fluid regulation responses to short-term exercise. *J Appl Physiol*. 2003;95(6):2321-2327. doi:10.1152/japplphysiol.00984.2002

98. Pirhonen JP, Lindqvist PG, Marsal K. A longitudinat study of maternal oxygen saturation during short-term submaximal exercise. *Clin Physiol Funct Imaging*. 2003;23(1):37-41. doi:10.1046/j.1475-097X.2003.00467.x

99. Kardel KR. Effects of intense training during and after pregnancy in top-level athletes. *Scand J Med Sci Sport*. 2005;15(2):79-86. doi:10.1111/j.1600-0838.2004.00426.x

100. McAuley SE, Jensen D, McGrath MJ, Wolfe LA. Effects of human pregnancy and aerobic conditioning on alveolar gas exchange during exercise. *Can J Physiol Pharmacol*. 2005;83(7):625-633. doi:10.1139/y05-054

101. Weissgerber TL, Wolfe LA, Hopkins WG, Davies GALL. Serial respiratory adaptations and an alternate hypothesis of respiratory control in human pregnancy. *Respir Physiol Neurobiol*. 2006;153(1):39-53. doi:10.1016/j.resp.2005.09.004

102. Jensen D, Webb KA, Wolfe LA, O'Donnell DE. Effects of human pregnancy and advancing gestation on respiratory discomfort during exercise. *Respir Physiol Neurobiol*. 2007;156(1):85-93. doi:10.1016/J.RESP.2006.08.004

103. Jensen D, Webb KA, Davies GAL, O'Donnell DE. Mechanical ventilatory constraints during incremental cycle exercise in human pregnancy: implications for respiratory sensation. *J Physiol*. 2008;586(19):4735-4750. doi:10.1113/jphysiol.2008.158154

104. Kardel KR, Johansen BBBB, Voldner N, Iversen PO, Henriksen T. Association between aerobic fitness in late pregnancy and duration of labor in nulliparous women. *ACTA Obstet Gynecol Scand*. 2009;88(8):948-952. doi:10.1080/00016340903093583

105. Ong MJ, Guelfi KJ, Hunter T, Wallman KE, Fournier PA, Newnham JP. Supervised home-based exercise may attenuate the decline of glucose tolerance in obese pregnant women. *Diabetes Metab*. 2009;35(5):418-421. doi:10.1016/J.DIABET.2009.04.008

106. Thorell E, Svärdsudd K, Andersson K, Kristiansson P. Moderate impact of full-term pregnancy on estimated peak oxygen uptake, physical activity and perceived health. *Acta Obstet Gynecol Scand*. 2010;89(9):1140-1148. doi:10.3109/00016349.2010.487894

107. Vega SR, Kleinert J, Sulprizio M, Hollmann W, Bloch W, Strueder HK. Responses of serum neurotrophic factors to exercise in pregnant and postpartum women. *Psychoneuroendocrinology*. 2011;36(2):220-227. doi:10.1016/j.psyneuen.2010.07.012

108. Kim J-H, Roberge RJ, Powell JB. Effect of external airflow resistive load on postural and exercise-associated cardiovascular and pulmonary responses in pregnancy: a case control study. *BMC Pregnancy Childbirth*. 2015;15(1):45. doi:10.1186/s12884-015-0474-7

109. Nakagaki A, Inami T, Minoura T, Baba R, Iwase S, Sato M. Differences in autonomic neural activity during exercise between the second and third trimesters of pregnancy. *J Obstet Gynaecol Res*. 2016;42(8):951-959. doi:10.1111/jog.12990

110. Jędrzejko M, Nowosielski K, Poręba R, Ulman-Włodarz I, Bobiński R. Physical efficiency and activity energy expenditure in term pregnancy females measured during

cardiopulmonary exercise tests with a supine cycle ergometer. *J Matern Neonatal Med*. 2016;29(23):3800-3805. doi:10.3109/14767058.2016.1147550

111. Sussman D, Saini BS, Schneiderman JE, et al. Uterine artery and umbilical vein blood flow are unaffected by moderate habitual physical activity during pregnancy. *Prenat Diagn*. 2019;39(11):976-985. doi:10.1002/pd.5517

112. Purdy GM, James MA, Wakefield PK, et al. Maternal cardioautonomic responses during and following exercise throughout pregnancy. *Appl Physiol Nutr Metab*. 2019;44(3):263-270. doi:10.1139/apnm-2018-0397

113. Bilodeau J-F, Bisson M, Larose J, et al. Physical fitness is associated with prostaglandin F-2 alpha isomers during pregnancy. *PROSTAGLANDINS Leukot Essent Fat ACIDS*. 2019;145:7-14. doi:10.1016/j.plefa.2019.05.001

114. Matenchuk BA, James M, Skow RJ, et al. Longitudinal study of cerebral blood flow regulation during exercise in pregnancy. *J Cereb BLOOD FLOW Metab*. 2020;40(11):2278-2288. doi:10.1177/0271678X19889089

115. Correa M da S, Catai AM, Milan-Mattos JC, Porta A, Driusso P. Is pelvic floor muscle training able to alter the response of cardiovascular autonomic modulation and provide a possible cardiovascular benefit to pregnant women? *Neurourol Urodyn*. 2020;39(8):2272-2283. doi:10.1002/nau.24481

116. Bijl RC, Cornette JMJ, van Der Ham K, et al. The physiological effect of early pregnancy on a woman’s response to a submaximal cardiopulmonary exercise test. *Physiol Rep*. 2020;8(21). doi:10.14814/phy2.14624

117. Sibley L, Ruhling R, Ph D, Christensen C, Bolen T. Swimming and Physicalfitness Duringpregnancy. 1981;26(6):3-12.

118. Lewis RD, Yates CY, Driskell JA. Riboflavin and thiamin status and birth outcome as a function of maternal aerobic exercise. *Am J Clin Nutr*. 1988;48(1):110-116. doi:10.1093/ajcn/48.1.110

119. Winn HN, HESS O, Goldstein I, Wackers F, HOBBINS JC. FETAL RESPONSES TO MATERNAL EXERCISE - EFFECT ON FETAL BREATHING AND BODY MOVEMENT. *Am J Perinatol*. 1994;11(4):263-266. doi:10.1055/s-2007-994588

120. Marquez-Sterling S, Perry AC, Kaplan TA, Halberstein RA, Signorile JF. Physical and psychological changes with vigorous exercise in sedentary primigravidae. *Med Sci Sports Exerc*. 2000;32(1):58-62. doi:10.1097/00005768-200001000-00010

121. Santos IA, Stein R, Fuchs SC, et al. Aerobic exercise and submaximal functional

capacity in overweight pregnant women - A randomized trial. *Obstet Gynecol*. 2005;106(2):243-249. doi:10.1097/01.AOG.0000171113.36624.86

122. Yeo S, Ronis DLDL, Antonakos CLCL, Roberts K, Hayashi R. Need for population specific validation of a portable metabolic testing system: A case of sedentary pregnant women. *J Nurs Meas*. 2005;13(3):207-218. doi:10.1891/jnum.13.3.207

123. Mottola MF, Davenport MH, Brun CR, Inglis SD, Charlesworth S, Sopper MM. V̇O2peak prediction and exercise prescription for pregnant women. *Med Sci Sports Exerc*. 2006;38(8):1389-1395. doi:10.1249/01.mss.0000228940.09411.9c

124. Davenport MH, Charlesworth S, Vanderspank D, Sopper MM, Mottola MF. Development and validation of exercise target heart rate zones for overweight and obese pregnant women. *Appl Physiol Nutr Metab*. 2008;33(5):984-989. doi:10.1139/H08-086

125. de Oliveria Melo AS, Silva JLPJLP, Tavares JS, Barros VO, Leite DFBB, Amorim MMRR. Effect of a Physical Exercise Program During Pregnancy on Uteroplacental and Fetal Blood Flow and Fetal Growth A Randomized Controlled Trial. *Obstet Gynecol*. 2012;120(2, 1):302-310. doi:10.1097/AOG.0b013e31825de592

126. Ruchat S-M, Davenport M, Giroux I, et al. Walking Program of Low or Vigorous Intensity During Pregnancy Confers an Aerobic Benefit. *Int J Sports Med*. 2012;33(08):661-666. doi:10.1055/s-0032-1304635

127. Szymanski LM, Satin AJ. Strenuous exercise during pregnancy: is there a limit? *Am J Obstet Gynecol*. 2012;207(3):179.e1-179.e6. doi:10.1016/j.ajog.2012.07.021

128. Salvesen K a. Å, Hem E, Sundgot-Borgen J. Fetal wellbeing may be compromised during strenuous exercise among pregnant elite athletes. *Br J Sports Med*. 2012;46(4):279-283. doi:10.1136/bjsm.2010.080259

129. Mottola MF, Inglis S, Brun CR, Hammond J-A. Physiological and metabolic responses of late pregnant women to 40 min of steady-state exercise followed by an oral glucose tolerance perturbation. *J Appl Physiol*. 2013;115(5):597-604. doi:10.1152/japplphysiol.00487.2013

130. Bisson M, Rhéaume C, Bujold E, Tremblay A, Marc I. Modulation of blood pressure response to exercise by physical activity and relationshipwith resting blood pressure during pregnancy. *J Hypertens*. 2014;32(7):1450-1457. doi:10.1097/HJH.0000000000000185

131. Marshall MR, Pivarnik JM. Perceived Exertion of Physical Activity During Pregnancy. *J Phys Act Heal*. 2015;12(7):1039-1043. doi:10.1123/jpah.2013-0458

132. Perales M, Santos-Lozano A, Ruiz JR, Lucia A, Barakat R. Benefits of aerobic or

resistance training during pregnancy on maternal health and perinatal outcomes: A systematic review. *EARLY Hum Dev*. 2016;94:43-48. doi:10.1016/j.earlhumdev.2016.01.004

133. Hesse CM, Tinius RA, Pitts BC, et al. Assessment of endpoint criteria and perceived barriers during maximal cardiorespiratory fitness testing among pregnant women. *J Sports Med Phys Fitness*. 2018;58(12):1844-1851. doi:10.23736/S0022-4707.17.07750-7

134. Dobson KL, da Silva DF, Dervis S, Mohammad S, Nagpal TS, Adamo KB. Physical activity and gestational weight gain predict physiological and perceptual responses to exercise during pregnancy. *Birth Defects Res*. Published online September 23, 2020:bdr2.1808. doi:10.1002/bdr2.1808

135. Da Silva EG, De Godoy I, De Oliveira Antunes LC, Da Silva EG, Peraçoli JC. Respiratory parameters and exercise functional capacity in preeclampsia. *Hypertens Pregnancy*. 2010;29(3):301-309. doi:10.3109/10641950902779271

136. Ramírez-Vélez R, Aguilar de Plata AC, Escudero MM, et al. Influence of regular aerobic exercise on endothelium-dependent vasodilation and cardiorespiratory fitness in pregnant women. *J Obstet Gynaecol Res*. 2011;37(11):1601-1608. doi:10.1111/j.1447-0756.2011.01582.x

137. Hjorth MF, Kloster S, Girma T, et al. Level and intensity of objectively assessed physical activity among pregnant women from urban Ethiopia. *BMC Pregnancy Childbirth*. 2012;12(1):154. doi:10.1186/1471-2393-12-154

138. Radzikowska E, Wiatr E, Franczuk M, Bestry I, Roszkowski-Sliz K. Lung Function in Pregnancy in Langerhans Cell Histiocytosis. In: Pokorski, M, ed. *PULMONARY DISORDERS AND THERAPY*. Vol 1023. Advances in Experimental Medicine and Biology. ; 2018:73-83. doi:10.1007/5584_2017_72

139. Oviedo-Caro MA, Bueno-Antequera J, Munguía-Izquierdo D. Explanatory factors and levels of health-related quality of life among healthy pregnant women at midpregnancy: A cross-sectional study of The PregnActive Project. *J Adv Nurs*. 2018;74(12):2766-2776. doi:10.1111/jan.13787

140. Dennis AT, Salman M, Paxton E, et al. Resting Hemodynamics and Response to Exercise Using the 6-Minute Walk Test in Late Pregnancy: An International Prospective Multicentre Study. *Anesth Analg*. 2019;129(2):450-457. doi:10.1213/ANE.0000000000003818

141. Amola M, Pawara S, Kalra S. Effect of Inspiratory Muscle Training and Diaphragmatic Breathing Exercises on Dyspnea, Pulmonary Functions, Fatigue and Functional Capacity in Pregnancy during Third Trimester. *J Clin DIAGNOSTIC Res*. 2019;13(8):YC1-YC4. doi:10.7860/JCDR/2019/41732.13037

142. Birnbaumer P, Dietz P, Watson ED, et al. Absolute Accelerometer-Based Intensity Prescription Compared to Physiological Variables in Pregnant and Nonpregnant Women. *Int J Environ Res Public Health*. 2020;17(16). doi:10.3390/ijerph17165651

143. Dibblee L, Graham TEE. A longitudinal study of changes in aerobic fitness, body composition, and energy intake in primigravid patients. *Am J Obstet Gynecol*. 1983;147(8):908-914. doi:10.1016/0002-9378(83)90244-2

144. WILLIAMS A, Reilly T, CAMPBELL I, Sutherst J. Investigation of changes in responses to exercise and in mood during pregnancy. *Ergonomics*. 1988;31(11):1539-1549. doi:10.1080/00140138808966803

145. Melzer K, Schutz Y, Soehnchen N, et al. Effects of recommended levels of physical activity on pregnancy outcomes. *Am J Obstet Gynecol*. 2010;202(3):266.e1-6. doi:10.1016/j.ajog.2009.10.876

146. Baker PN, Johnson IR. The use of the hand-grip test for predicting pregnancy-induced hypertension. *Eur J Obstet Gynecol Reprod Biol*. 1994;56(3):169-172. doi:10.1016/0028-2243(94)90165-1

147. Rogers MS, Tomlinson B. Change in cardiovascular indices with position and isometric exercise throughout pregnancy: Assessment by impedance cardiography and oscillometric sphygmomanometry. *Hypertens Pregnancy*. 1998;17(2):191-202. doi:10.3109/10641959809006075

148. Feiner B, Weksler R, Ohel G, Degani S. The influence of maternal exercise on placental blood flow measured by Simultaneous Multigate Spectral Doppler Imaging (SM-SDI). *Ultrasound Obstet Gynecol*. 2000;15(6):498-501. doi:10.1046/j.1469-0705.2000.00146.x

149. Gutke A, Östgaard HC, Öberg B. Association between muscle function and low back pain in relation to pregnancy. *J Rehabil Med*. 2008;40(4):304-311. doi:10.2340/16501977-0170

150. O'Connor PJ, Poudevigne MS, Cress ME, Motl RW, Clapp JF. Safety and efficacy of supervised strength training adopted in pregnancy. *J Phys Act Health*. 2011;8(3):309-320. Accessed November 12, 2018. http://www.ncbi.nlm.nih.gov/pubmed/21487130

151. Atay E, Başalan İz F. Investigation of the effect of changes in muscle strength in gestational age upon fear of falling and quality of life. *Turkish J Med Sci*. 2015;45(4):977-983. doi:10.3906/sag-1404-9

152. Petrov Fieril K, Glantz A, Fagevik Olsen M. The efficacy of moderate-to-vigorous resistance exercise during pregnancy: A randomized controlled trial. *Acta Obstet Gynecol*

Scand. 2015;94(1):35-42. doi:10.1111/aogs.12525

153. Wickboldt N, Savoldelli G, Rehberg-Klug B. Continuous assessment of labour pain using handgrip force. *Pain Res Manag*. 2015;20(3):159-163. doi:10.1155/2015/281976

154. Kalliokoski P, Rodhe N, Bergqvist Y, Lofvander M, Löfvander M. Long-term adherence and effects on grip strength and upper leg performance of prescribed supplemental vitamin D in pregnant and recently pregnant women of Somali and Swedish birth with 25-hydroxyvitamin D deficiency: a before-and-after treatment study. *BMC Pregnancy Childbirth*. 2016;16(1):353. doi:10.1186/s12884-016-1117-3

155. Ngaka TCC, Coetzee JFF, Dyer RAA. The Influence of Body Mass Index on Sensorimotor Block and Vasopressor Requirement During Spinal Anesthesia for Elective Cesarean Delivery. *Anesth Analg*. 2016;123(6):1527-1534. doi:10.1213/ANE.0000000000001568

156. Rodriguez-Diaz L, Ruiz-Frutos C, Maria Vazquez-Lara J, Ramirez-Rodrigo J, Villaverde-Gutierrez C, Torres-Luque G. Effectiveness of a physical activity programme based on the Pilates method in pregnancy and labour. *Enferm Clin*. 2017;27(5):271-277. doi:10.1016/j.enfcle.2017.05.007

157. Takeda K, Yoshikata H, Imura M. Do Squat Exercises With Weight Shift During Pregnancy Improve Postural Control? *Int J WOMENS Heal Reprod Sci*. 2019;7(1):10-16. doi:10.15296/ijwhr.2019.02

158. Yenişehir S, Çıtak Karakaya İ, Sivaslıoğlu AA, Özen Oruk D, Karakaya MG. Reliability and validity of Five Times Sit to Stand Test in pregnancy-related pelvic girdle pain. *Musculoskelet Sci Pract*. 2020;48:102157. doi:10.1016/j.msksp.2020.102157

159. Gilleard W, Crosbie J, Smith R. Effect of pregnancy on trunk range of motion when sitting and standing. *Acta Obstet Gynecol Scand*. 2002;81(11):1011-1020. doi:10.1034/j.1600-0412.2002.811104.x

160. Marnach ML, Ramin KD, Ramsey PS, Song S-W, Stensland JJ, An K-N. Characterization of the relationship between joint laxity and maternal hormones in pregnancy. *Obstet Gynecol*. 2003;101(2):331-335. doi:10.1016/s0029-7844(02)02447-x

161. Garshasbi A, Faghih Zadeh S. The effect of exercise on the intensity of low back pain in pregnant women. *Int J Gynecol Obstet*. 2005;88(3):271-275. doi:10.1016/j.ijgo.2004.12.001

162. Lindgren A, Kristiansson P. Finger joint laxity, number of previous pregnancies and pregnancy induced back pain in a cohort study. *BMC Pregnancy Childbirth*. 2014;14(1):61. doi:10.1186/1471-2393-14-61

163. Cherni Y, Desseauve D, Decatoire A, et al. Evaluation of ligament laxity during pregnancy. *J Gynecol Obstet Hum Reprod*. 2019;48(5):351-357. doi:10.1016/j.jogoh.2019.02.009

164. Butler EE, Colon I, Druzin ML, Rose J. Postural equilibrium during pregnancy: Decreased stability with an increased reliance on visual cues. *Am J Obstet Gynecol*. 2006;195(4):1104-1108. doi:10.1016/j.ajog.2006.06.015

165. Ribas I S, Guirro ECO. Analysis of plantar pressure and postural balance during different phases of pregnancy. *BRAZILIAN J Phys Ther*. 2007;11(5):391-396.

166. Nagai M, Isida M, Saitoh J, Hirata Y, Natori H, Wada M. Characteristics of the control of standing posture during pregnancy. *Neurosci Lett*. 2009;462(2):130-134. doi:10.1016/j.neulet.2009.06.091

167. Oliveira LF, Vieira TMM, Macedo AR, Simpson DM, Nadal J. Postural sway changes during pregnancy: A descriptive study using stabilometry. *Eur J Obstet Gynecol Reprod Biol*. 2009;147(1):25-28. doi:10.1016/J.EJOGRB.2009.06.027

168. Karadag-Saygi E, Unlu-Ozkan F, Basgul A. Plantar Pressure and Foot Pain in the Last Trimester of Pregnancy. *Foot Ankle Int*. 2010;31(2):153-157. doi:10.3113/FAI.2010.0153

169. Yu Y, Chung HC, Hemingway L, Stoffregen TA. Standing body sway in women with and without morning sickness in pregnancy. *Gait Posture*. 2013;37(1):103-107. doi:10.1016/j.gaitpost.2012.06.021

170. Ersal, T., McCrory, J. L., & Sienko KH, Ersal T, McCrory JL, Sienko KH. Theoretical and experimental indicators of falls during pregnancy as assessed by postural perturbations. *Gait Posture*. 2014;39(1):218-223. doi:10.1016/j.gaitpost.2013.07.011

171. Opala-Berdzik A, Bacik B, Markiewicz A, et al. Comparison of Static Postural Stability in Exercising and Non-Exercising Women During the Perinatal Period. *Med Sci Monit*. 2014;20:1865-1870. doi:10.12659/MSM.890846

172. Opala-Berdzik A, Błaszczyk JW, Bacik B, et al. Static Postural Stability in Women during and after Pregnancy: A Prospective Longitudinal Study. McCrory JL, ed. *PLoS One*. 2015;10(6):e0124207. doi:10.1371/journal.pone.0124207

173. Öztürk G, Geler Külcü D, Aydoğ E, Kaspar Ç, Uğurel B. Effects of lower back pain on postural equilibrium and fall risk during the third trimester of pregnancy. *J Matern Neonatal Med*. 2016;29(8):1358-1362. doi:10.3109/14767058.2015.1049148

174. Shibayama Y, Kuwata T, Yamaguchi J, et al. Changes in standing body sway of pregnant women after long-term bed rest. *J Obstet Gynaecol (Lahore)*. 2016;36(4):479-482.

doi:10.3109/01443615.2015.1086983

175. Takeda K, Yoshikata H, Imura M. Changes in Posture Control of Women That Fall During Pregnancy. Published online 2018. doi:10.15296/ijwhr.2018.43

176. Moreira LS, Elias LA, Gomide AB, Vieira MF, Do Amaral WN. A longitudinal assessment of myoelectric activity, postural sway, and low-back pain during pregnancy. *Acta Bioeng Biomech*. 2017;Vol. 19(nr 3). doi:10.5277/ABB-00753-2016-02

177. Opala-Berdzik A, Błaszczyk JW, Świder D, Cieślińska-Świder J. Trunk forward flexion mobility in reference to postural sway in women after delivery: A prospective longitudinal comparison between early pregnancy and 2- and 6-month postpartum follow-ups. *Clin Biomech*. 2018;56:70-74. doi:10.1016/j.clinbiomech.2018.05.009

178. Catena RD, Campbell N, Wolcott WC, Rothwell SA. Anthropometry, standing posture, and body center of mass changes up to 28 weeks postpartum in Caucasians in the United States. *Gait Posture*. 2019;70:196-202. doi:10.1016/j.gaitpost.2019.03.009

179. Fontana Carvalho AP, Dufresne SS, de Oliveira M, et al. Effects of lumbar stabilization and muscular stretching on pain, disabilities, postural control and muscle activation in pregnant woman with low back pain. *Eur J Phys Rehabil Med*. 2020;56(3):297-306. doi:10.23736/S1973-9087.20.06086-4

180. Valerio PM, Goncalves VE, Zordao CC, Rezende MS, Dantas Moises EC, de Olveira Guirro EC. Influence of type 1 diabetes on the postural control of women in the third gestational trimester. *Clin Biomech*. 2020;77. doi:10.1016/j.clinbiomech.2020.105062

181. Davies J, Fernando R, McLeod A, Verma S, Found P. Postural stability following ambulatory regional analgesia for labor. *Anesthesiology*. 2002;97(6):1576-1581. doi:10.1097/00000542-200212000-00033

182. McCrory JLL, Chambers AJJ, Daftary A, Redfern MSS. Dynamic postural stability during advancing pregnancy. *J Biomech*. 2010;43(12):2434-2439. doi:10.1016/j.jbiomech.2009.09.058

183. Branco M, Santos-Rocha R, Aguiar L, Vieira F, Veloso A. Kinematic analysis of gait in the second and third trimesters of pregnancy. *J Pregnancy*. 2013;2013:718095. doi:10.1155/2013/718095

184. Cakmak B, Inanir A, Nacar MC, Filiz B. The Effect of Maternity Support Belts on Postural Balance in Pregnancy. *PM&R*. 2014;6(7):624-628. doi:10.1016/j.pmrj.2013.12.012

185. Inanir A, Cakmak B, Hisim Y, Demirturk F. Evaluation of postural equilibrium and fall risk during pregnancy. *Gait Posture*. 2014;39(4):1122-1125.

doi:10.1016/j.gaitpost.2014.01.013

186. Wu X, Yeoh HT. Intrinsic factors associated with pregnancy falls. *Workplace Health Saf*. 2014;62(10):403-408. doi:10.3928/21650799-20140902-04

187. Forczek W, Staszkiewicz R. Changes of kinematic gait parameters due to pregnancy. *Acta Bioeng Biomech*. 2012;14(4):113-119. doi:10.5277/abb120413

188. Takeda K. A Kinesiological Analysis of the Stand-to-Sit during the Third Trimester. *J Phys Ther Sci*. 2012;24(7):621-624. doi:10.1589/jpts.24.621

189. Gottschall JS, Sheehan RC, Downs DS. Pregnant women exaggerate cautious gait patterns during the transition between level and hill surfaces. *J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol*. 2013;23(5):1237-1242. doi:10.1016/j.jelekin.2013.04.011

190. McCrory JL, Chambers AJ, Daftary A, Redfern MS. The pregnant "waddle": An evaluation of torso kinematics in pregnancy. *J Biomech*. 2014;47(12):2964-2968. doi:10.1016/j.jbiomech.2014.07.009

191. Krkeljas Z. Changes in gait and posture as factors of dynamic stability during walking in pregnancy. *Hum Mov Sci*. 2018;58:315-320. doi:10.1016/j.humov.2017.12.011

192. Catena RD, Bailey JP, Campbell N, Music HE. Stand-to-sit kinematic changes during pregnancy correspond with reduced sagittal plane hip motion. *Clin Biomech*. 2019;67:107-114. doi:10.1016/j.clinbiomech.2019.05.014

193. Catena RD, Campbell N, Werner AL, Iverson KM. Anthropometric Changes During Pregnancy Provide Little Explanation of Dynamic Balance Changes. *J Appl Biomech*. 2019;35(3):232-239. doi:10.1123/jab.2018-0345

194. Forczek W, Ivanenko Y, Curyło M, et al. Progressive changes in walking kinematics throughout pregnancy-A follow up study. *Gait Posture*. 2019;68:518-524. doi:10.1016/j.gaitpost.2019.01.004

195. Forczek W, Masłoń A, Frączek B, Curyło M, Salamaga M, Suder A. Does the first trimester of pregnancy induce alterations in the walking pattern? *PLoS One*. 2019;14(1):e0209766. doi:10.1371/journal.pone.0209766

196. Catena RD, Bailey JP, Campbell N, Stewart BC, Marion SJ. Correlations between joint kinematics and dynamic balance control during gait in pregnancy. *Gait Posture*. 2020;80:106-112. doi:10.1016/j.gaitpost.2020.05.025

197. Gimunova M, Zvonar M, Sebera M, Turcinek P, Kolarova K. Special footwear designed for pregnant women and its effect on kinematic gait parameters during pregnancy

and postpartum period. *PLoS One*. 2020;15(5). doi:10.1371/journal.pone.0232901

198. McCrory JL, Chambers AJ, Daftary A, Redfern MS. Torso kinematics during gait and trunk anthropometry in pregnant fallers and non-fallers. *Gait Posture*. 2020;76:204-209. doi:10.1016/j.gaitpost.2019.11.012

199. Rothwell SA, Eckland CB, Campbell N, Connolly CP, Catena RD. An analysis of postpartum walking balance and the correlations to anthropometry. *Gait Posture*. 2020;76:270-276. doi:10.1016/j.gaitpost.2019.12.017

200. Forczek W, Ivanenko Y, Salamaga M, et al. Pelvic movements during walking throughout gestation - the relationship between morphology and kinematic parameters. *Clin Biomech*. 2020;71:146-151. doi:10.1016/j.clinbiomech.2019.11.001

201. Sawa R, Doi T, Asai T, Watanabe K, Taniguchi T, Ono R. Differences in trunk control between early and late pregnancy during gait. *Gait Posture*. 2015;42(4):455-459. doi:10.1016/j.gaitpost.2015.07.058

202. Evensen NM, Kvale A, Braekken IH, Kvåle A, Braekken IH. Reliability of the Timed Up and Go test and Ten-Metre Timed Walk Test in Pregnant Women with Pelvic Girdle Pain. *Physiother Res Int*. 2015;20(3):158-165. doi:10.1002/pri.1609

203. Evensen NM, Kvåle A, Brækken IH. Convergent validity of the Timed Up and Go Test and Ten-metre Timed Walk Test in pregnant women with pelvic girdle pain. *Man Ther*. 2016;21:94-99. Accessed November 10, 2018. https://www.sciencedirect.com/science/article/pii/S1356689X15001319

204. Christensen L, Vollestad NK, Veierod MB, Stuge B, Cabri J, Robinson HS. The Timed Up & Go test in pregnant women with pelvic girdle pain compared to asymptomatic pregnant and non-pregnant women. *Musculoskelet Sci Pract*. 2019;43:110-116. doi:10.1016/j.msksp.2019.03.006

205. Aparicio VA, Ocón O, Padilla-Vinuesa C, et al. Effects of supervised aerobic and strength training in overweight and grade I obese pregnant women on maternal and foetal health markers: the GESTAFIT randomized controlled trial. *BMC Pregnancy Childbirth*. 2016;16(1):290. doi:10.1186/s12884-016-1081-y

206. Sloan RA, Sawada SS, Martin CK, Church T, Blair SN. Associations between cardiorespiratory fitness and health-related quality of life. *Health Qual Life Outcomes*. 2009;7:3-7. doi:10.1186/1477-7525-7-47

207. Santos IA, Stein R, Fuchs SC, et al. Aerobic Exercise and Submaximal Functional Capacity in Overweight Pregnant Women. *Obstet Gynecol*. 2005;106(2):243-249.

doi:10.1097/01.AOG.0000171113.36624.86

208. Barker D, Mason G, Schlosshan D, McLoughlin H, Tan L-BB. Maximal exercise testing can be safely used to assess pregnant cardiac patients. *Am J Obstet Gynecol*. 2005;193(6, S):S80. doi:10.1016/J.AJOG.2005.10.790

209. Ruiz-Ruiz J, Mesa JLM, Gutiérrez A, Castillo MJ. Hand size influences optimal grip span in women but not in men. *J Hand Surg Am*. 2002;27(5):897-901. doi:10.1053/JHSU.2002.34315

210. Rikli, R, Jones J. Development and validation of a functional fitness test for community-residing older adults. *J Aging Phys Act*. 1999;7(2):129-162.

211. Alonso J, Prieto L, Antó JM. La versión española del SF-36 Health Survey (Cuestionario de Salud SF-36): un instrumento para la medida de los resultados clínicos. *Med Clin*. 1995;104:771-776.

212. Ware JE, Sherbourne CD. The MOS 36-item short-form health survey (SSF-36): I. Conceptual framework and item selection. *Med Care*. 1992;30(6):473-483.

213. Do NC, Secher AL, Cramon P, et al. Quality of life, anxiety and depression symptoms in early and late pregnancy in women with pregestational diabetes. *Acta Obstet Gynecol Scand*. 2017;96(2):190-197. doi:10.1111/aogs.13048

214. Abbasi M, Van Den Akker O, Bewley C. Persian couples' experiences of depressive symptoms and health-related quality of life in the pre- and perinatal period. *J Psychosom Obstet Gynecol*. 2014;35(1):16-21. doi:10.3109/0167482X.2013.865722

215. Akmeşe ZB, Oran NT. Effects of Progressive Muscle Relaxation Exercises Accompanied by Music on Low Back Pain and Quality of Life During Pregnancy. *J Midwifery Women's Heal*. 2014;59(5):503-509. doi:10.1111/jmwh.12176

216. Gutiérrez V, Luque GT, Gómez-salgado J. Calidad de vida relacionada con la salud en una población de gestantes sanas tras un programa de actividad física en el medio acuático (pafmae). 2017;91:1-10.

217. Pomerance JJ, Gluck L, Lynch VA. Maternal exercise as a screening test for uteroplacental insufficiency. *Obstet Gynecol*. 1974;44(3):383-387. Accessed November 14, 2018. http://www.ncbi.nlm.nih.gov/pubmed/4853105

218. Melzer K, Schutz Y, Soehnchen N, et al. Effects of recommended levels of physical activity on pregnancy outcomes. *Am J Obstet Gynecol*. 2010;202(3):266.e1-266.e6. doi:10.1016/J.AJOG.2009.10.876

219. O'Neill ME, Cooper KA, Hunyor SN, Boyce S. Cardiorespiratory response to walking in trained and sedentary pregnant women. *J Sports Med Phys Fitness*. 1993;33(1):40-43. Accessed November 27, 2018. http://www.ncbi.nlm.nih.gov/pubmed/8350606

220. Mcgrath MJ, Wolfe LA, Preston RJ, Burggraf GW, Mcgrath MJ. Effects of pregnancy and chronic exercise on maternal cardiac structure and function. *Artic Can J Physiol Pharmacol*. 1999;77(11):909-917. doi:10.1139/cjpp-77-11-909

221. Sady MA, Haydon BB, Sady SP, Carpenter MW, Thompson PD, Coustan DR. Cardiovascular response to maximal cycle exercise duringpregnancy and at two and seven months postpartum. *Am J Obstet Gynecol*. 1990;162(5):1181-1185. doi:10.1016/0002-9378(90)90012-V

222. Kennelly MM, McCaffrey N, McLoughlin P, Lyons S, McKenna P. Fetal heart rate response to strenuous maternal exercise: not a predictor of fetal distress. *Am J Obstet Gynecol*. 2002;187(3):811-816. doi:10.1067/MOB.2002.125892

223. Rojas Vega S, Kleinert J, Sulprizio M, Hollmann W, Bloch W, Strüder HK. Responses of serum neurotrophic factors to exercise in pregnant and postpartum women. *Psychoneuroendocrinology*. 2011;36(2):220-227. doi:10.1016/J.PSYNEUEN.2010.07.012

224. Jensen D, Webb KA, O'Donnell DE. Chemical and mechanical adaptations of the respiratory system at rest and during exercise in human pregnancy. *Appl Physiol Nutr Metab*. 2007;32(6):1239-1250. doi:10.1139/H07-120

225. Sady SP, Carpenter MW, Sady MA, et al. Prediction of VO2max during cycle exercise in pregnant women Prediction of VO 2 max during cycle exercise in pregnant women. *J Appl Physiol*. 1988;65(2):657-661.

226. ONeill ME, O'Neill ME. Maternal rectal temperature and fetal heart rate responses to upright cycling in late pregnancy. *Br J Sports Med*. 1996;30(1):32-35. doi:10.1136/BJSM.30.1.32

227. Szymanski LM, Satin AJ. Strenuous exercise during pregnancy: Is there a limit? *Am J Obstet Gynecol*. 2012;207(3):179.e1-179.e6. doi:10.1016/j.ajog.2012.07.021

228. Santos CM dos, Santos WM dos, Gallarreta FMP, et al. Effect of maternal exercises on biophysical fetal and maternal parameters: a transversal study. *Einstein (São Paulo)*. 2016;14(4):455-460. doi:10.1590/s1679-45082016ao3758

229. SIBLEY L, RUHLING RO, Cameron-Foster J, et al. Swimming and physical fitness during pregnancy. *J Nurse Midwifery*. 1981;26(6):3-12. doi:10.1016/0091-2182(81)90169-5

230. Angel Oviedo-Caro M, Bueno-Antequera J, Munguia-Izquierdo D. Associations of 24-

hours activity composition with adiposity and cardiorespiratory fitness: The PregnActive project. *Scand J Med Sci Sports*. 2020;30(2):295-302. doi:10.1111/sms.13566

231. Gutke A, Östgaard HC, Öberg B. Predicting Persistent Pregnancy-Related Low Back Pain. *Spine (Phila Pa 1976)*. 2008;33(12):E386-E393. doi:10.1097/BRS.0b013e31817331a4

232. Rodríguez-Díaz L, Ruiz-Frutos C, Vázquez-Lara JM, Ramírez-Rodrigo J, Villaverde-Gutiérrez C, Torres-Luque G. Efectividad de un programa de actividad física mediante el método Pilates en el embarazo y en el proceso del parto. *Enfermería Clínica*. 2017;27(5):271-277. doi:10.1016/J.ENFCLI.2017.05.008

233. Wu W, Meijer OG, Lamoth CJCC, et al. Gait coordination in pregnancy: Transverse pelvic and thoracic rotations and their relative phase. *Clin Biomech*. 2004;19(5):480-488. doi:10.1016/j.clinbiomech.2004.02.003

234. Błaszczyk JW, Opala-Berdzik A, Plewa M. Adaptive changes in spatiotemporal gait characteristics in women during pregnancy. *Gait Posture*. 2016;43:160-164. doi:10.1016/j.gaitpost.2015.09.016

235. Martinez-Marti F, Martinez-Garcia MS, Carvajal MA, Palma AJ, Anguiano M, Lallena AM. Fractal behavior of the trajectories of the foot centers of pressure during pregnancy. *Biomed Phys Eng EXPRESS*. 2019;5(2). doi:10.1088/2057-1976/aaf0f3

236. McCrory J, Chambers A, Daftary A, Redfern M. Dynamic postural stability in pregnant fallers and non-fallers. *BJOG An Int J Obstet Gynaecol*. 2010;117(8):954-962. doi:10.1111/j.1471-0528.2010.02589.x

237. Gutke A, Kjellby-Wendt G, Oberg B. The inter-rater reliability of a standardised classification system for pregnancy-related lumbopelvic pain. *Man Ther*. 2010;15(1):13-18. doi:10.1016/j.math.2009.05.005

238. Cakmak B, Ribeiro AP, Inanir A. Postural balance and the risk of falling during pregnancy. *J Matern Neonatal Med*. 2016;29(10):1623-1625. doi:10.3109/14767058.2015.1057490

239. McCrory JL, Chambers AJ, Daftary A, Redfern MS. Ground reaction forces during gait in pregnant fallers and non-fallers. *Gait Posture*. 2011;34(4):524-528. doi:10.1016/J.GAITPOST.2011.07.007

240. Birsner ML, Gyamfi-Bannerman C. Physical Activity and Exercise During Pregnancy and the Postpartum Period ACOG Committee Opinion Summary, Number 804. *Obstet Gynecol*. 2020;135(4):E178-E188. doi:10.1097/AOG.0000000000003772

241. Ortega FB, Sánchez-López M, Solera-Martínez M, Fernández-Sánchez A, Sjöström

M, Martínez-Vizcaino V. Self-reported and measured cardiorespiratory fitness similarly predict cardiovascular disease risk in young adults. *Scand J Med Sci Sport*. 2013;23(6):749-757. doi:10.1111/j.1600-0838.2012.01454.x

242. Mikkelsson L, Kaprio J, Kautiainen H, Kujala UM, Nupponen H. Associations between self-estimated and measured physical fitness among 40-year-old men and women. *Scand J Med Sci Sport*. 2005;15(5):329-335. doi:10.1111/j.1600-0838.2004.00429.x

243. Henriksson P, Henriksson H, Tynelius P, Berglind D, Löf M, Lee I et al. Fitness and Body Mass Index During Adolescence and Disability Later in Life: A Cohort Study. *Ann Intern Med*. 2019;170:230-239.

244. Ross R, Blair SN, Arena R, et al. Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign: A Scientific Statement From the American Heart Association.

245. Mourady D, Richa S, Karam R, et al. Associations between quality of life, physical activity, worry, depression and insomnia: A cross-sectional designed study in healthy pregnant women. *PLoS One*. 2017;12(5):1-15. doi:10.1371/journal.pone.0178181

246. Kolu P, Raitanen J, Luoto R. Physical activity and health-related quality of life during pregnancy: a secondary analysis of a cluster-randomised trial. *Matern Child Health J*. 2014;18(9):2098-2105. doi:10.1007/s10995-014-1457-4

ANEXES

Anexe I. PRISMA Checklist of the literature review

Section/topic	#	Checklist item
TITLE		
Title	1	Identify the report as a systematic review, meta-analysis, or both.
ABSTRACT		
Structured summary	2	Provide a structured summary including, as applicable: backgrou sources; study eligibility criteria, participants, and interventions; st synthesis methods; results; limitations; conclusions and implicatio systematic review registration number.
INTRODUCTION		
Rationale	3	Describe the rationale for the review in the context of what is alrea
Objectives	4	Provide an explicit statement of questions being addressed with r participants, interventions, comparisons, outcomes, and study de
METHODS		
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accesse and, if available, provide registration information including registra
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) an (e.g., years considered, language, publication status) used as crit giving rationale.
Information sources	7	Describe all information sources (e.g., databases with dates of co study authors to identify additional studies) in the search and date
Search	8	Present full electronic search strategy for at least one database, i used, such that it could be repeated.
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, i review, and, if applicable, included in the meta-analysis).

Data collection process	10	Describe method of data extraction from reports (e.g., piloted form duplicate) and any processes for obtaining and confirming data fr
Data items	11	List and define all variables for which data were sought (e.g., PIC and any assumptions and simplifications made.
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual stu specification of whether this was done at the study or outcome lev information is to be used in any data synthesis.
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference
Synthesis of results	14	Describe the methods of handling data and combining results of s including measures of consistency (e.g., I^2) for each meta-analysi
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cu publication bias, selective reporting within studies).
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or sub regression), if done, indicating which were pre-specified.
RESULTS		
Study selection	17	Give numbers of studies screened, assessed for eligibility, and inc reasons for exclusions at each stage, ideally with a flow diagram.
Study characteristics	18	For each study, present characteristics for which data were ext PICOS, follow-up period) and provide the citations.
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any ou (see item 12).
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for summary data for each intervention group (b) effect estimates a ideally with a forest plot.
Synthesis of results	21	Present results of each meta-analysis done, including confidence of consistency.
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or su regression [see Item 16]).

DISCUSSION		
Summary of evidence	24	Summarize the main findings including the strength of evidence f consider their relevance to key groups (e.g., healthcare provic makers).
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), a incomplete retrieval of identified research, reporting bias).
Conclusions	26	Provide a general interpretation of the results in the context o implications for future research.
FUNDING		
Funding	27	Describe sources of funding for the systematic review and other data); role of funders for the systematic review.

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items fo The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Anexe II. IFIS questionnaire

IFiS

Cuestionario de autoevaluación de la condición física

International FItness Scale

Es muy importante que contestes a estas preguntas tú solo, sin tener en cuenta las respuestas de otras personas. Tus respuestas sólo son útiles para el progreso de la ciencia. Por favor, contesta todas las preguntas y no las dejes en blanco. Y aún más importante, se sincero. Gracias por tú cooperación con la ciencia.

Por favor, piensa sobre tu nivel de condición física (comparado con personas de tu edad) y elige la opción más adecuada.

1. Mi condición física general es:

- ☐ Muy mala (1)
- ☐ Mala (2)
- ☐ Aceptable (3)
- ☐ Buena (4)
- ☐ Muy buena (5)

2. Mi condición física cardio-respiratoria (capacidad para hacer ejercicio, por ejemplo, correr durante mucho tiempo) **es:**

- ☐ Muy mala (1)
- ☐ Mala (2)
- ☐ Aceptable (3)
- ☐ Buena (4)
- ☐ Muy buena (5)

3. Mi fuerza muscular es:

- ☐ Muy mala (1)
- ☐ Mala (2)
- ☐ Aceptable (3)
- ☐ Buena (4)
- ☐ Muy buena (5)

4. Mi velocidad / agilidad es:

- ☐ Muy mala (1)
- ☐ Mala (2)
- ☐ Aceptable (3)
- ☐ Buena (4)
- ☐ Muy buena (5)

5. Mi flexibilidad es:

- ☐ Muy mala (1)
- ☐ Mala (2)
- ☐ Aceptable (3)
- ☐ Buena (4)
- ☐ Muy buena (5)

IS has been developed by the PROFITH research group, Granada, Spain. Versions of IFIS in different languages and for different age groups are available at: tp://profith.ugr.es/IFIS IFIS was originally design and validated under the umbrella of the HELENA study, original reference: Ortega et al. The International Fitness ale (IFIS): usefulness of self-reported fitness in youth. Int J Epidemiol 2011;40:701-1. IFIS has also been validated in adults: Ortega et al. Scand J Med Sci Sports, 13;23:749-57; in children: Sanchez-Lopez et al. Scand J Med Sci Sports. 2015;25:543-51;and in women with fibromyalgia: Alvarez-Gallardo et al. Arch Phys Med habil. 2016;97:395-404.

Short CV

1. PERSONAL INFORMATION

Name: Lidia Romero Gallardo
Address: C/ Kárate, 3 Bajo A.
Phone: +34 627977868
Date of birth: 01/02/1988
Nationality: Spanish

2. CURRENT PROFESSIONAL STATUS

Founder and Director of OWA (Only about Women Academy) www.owacademy.com

3. ACADEMIC TRAINING

- GRADUATE DEGREE IN SPORT SCIENCES. Faculty of Sport Sciences, University of Granada. Date 2006-2011
- MASTER DEGREE IN PERSONAL TRAINING. Faculty of Sport Sciences, University of Granada. Date: 2011-2012.
- RESEARCH STAY (3 months). School of Sport and Exercise Science, Swansea University. Date: 01/09/2018 to 01/12/2018.

4. RESEARCH AND EXTRACURRICULAR COURSES:

2018/11: Certificate of Professional Development. Swansea University. Academy for Professional Development. Hand on Anatomy training incorporating 2 days practical experience and human cadaveric dissection

2017/10: "El tratamiento de los datos en Ciencias del Deporte" Biofanex. 8 hours. University of Sevilla.

2017/05: Early Programming: factores que condicionan la salud posnatal. Introducción metodológica e implicaciones clínicas" 15 hours. University of Granada. Spain.

2017/09: Scientific research, publishing and ethics" by Igor Vlahović of the University of Zagreb, Croatia, 9 hours. Granada.

5. INVITED LECTURES:

2016/04: ¿Las mujeres embarazadas deben de entrenar a lo largo de su embarazo hasta el momento del parto? Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada. Spain. 1 hour.

2017/03: ¿Estás aconsejando bien a tus pacientes acerca del suelo pélvico? Una visión interdisciplinar desde la fisioterapia y el ejercicio físico. III Congreso de Estudiantes de Investigación Biosanitaria (III CEIBS). Faculty of Medicine, University of Granada. Spain. 1 hour

2017/07: El entrenamiento de fuerza durante el embarazo ¿incompatibles?. Simposio de Fuerza y Poblaciones Especiales. Vigo. Spain. 1 hour.

2017/11: Entrenamiento de fuerza en el embarazo “Better By Science” Congress. Granada. Spain. 50 min.

2017/12: Entrenamiento de fuerza durante el embarazo. II Congreso Profesional de Entrenamiento Personal. Valencia. Spain. 2 hours.

2018/01: GESTAFIT Project: Proyecto de investigación sobre el efecto del ejercicio físico en la salud materno-fetal. XIII Encuentro de Investigación del Departamento de Educación. University of Almería. Spain. 90 min.

2018/05: Entrenamiento y Suelo Pélvico: Charlas FID. FIDIAS. Sevilla. Spain. 1 hour.

2018/10: The Gestation and Fitness Project: improving maternal and foetal biomarkers. School of Sport and Exercise Science, Swansea University. Wales. 90 min

2018/10: Planning physical exercise in pregnant women. International workshop: Exercise and pregnancy. Bay Campus, Swansea University. Wales. 1 hour.

2019/10: Women in sports Barça Innovation Hub, FC Barcelona’s. XI ASPC International forum on elite sport. Spain. 1 hour.

2019/10: Planificación del entrenamiento en atletas embarazadas. Sociedad Andaluza de Medicina del Deporte (SAMEDE). University of Almeria. Spain. 1 hour

2019/10: “Mujer y entrenamiento: ¿Tenemos que entrenar diferente? ¿Por qué y para qué? II Congreso Andaluz de Profesionales de las Ciencias del Deporte. Colegio Oficial de Licenciados en Educación Física y en Ciencias de la Actividad Física y del Deporte de Andalucía, University of Granada.Spain. 1 hour.

2020/12: Planificación del entrenamiento en la mujer embarazada. IX International Symposium in Strength Training held in Faculty of Physical Activity and Sports Sciences (INEF), Technical University of Madrid. Spain. 1 hour.

6. CONFERENCES ATTENDED

Invited upon abstract submission

2016/10: L. Romero-Gallardo, Olga Ocón, P. Acosta-Manzano, I. Coll-Risco, M. Rodriguez-Ayllón, M. Borges-Cosic, P. Ruiz-Cabello, A. Soriano- Maldonado, V. A. Aparicio. Influencia del sobrepeso/obesidad sobre la calidad de vida relacionada con la salud de la embarazada. El proyecto GESTAFIT. Symposium Exernet: Exercise is Medicine (poster presentation).

2016/12: Romero - Gallardo, L., Ocón, O., Montero-Hernandez J., Campos-Marcos F., Gutiérrez Sáinz, A: Respuesta materna y fetal durante un protocolo de fuerza para la búsqueda de una Repetición Máxima en una embarazada de 24 semanas. Presentación de un caso. Simposium de Fuerza. Universidad Politécnica de Madrid, 2016. Abstract selected among top ten. (oral presentation).

2018/10: Romero-Gallardo, L., O. Ocón-Hernández, I. Coll-Risco, M. Borges-Cosic, P. Acosta-Manzano, C. Navarro-Mateos, A. De la O, C. Reguera-Fernández, M.T. Jiménez-Oviedo, M.M. Jiménez Quirantes, V.A. Aparicio: Association of sedentary time and moderate-to-vigorous physical activity with health-related of quality of life during early pregnancy. Findings from the gestafit project. Neurocientific Seminars. Granada, 2018 (oral presentation).

2017/06: Romero-Gallardo L., Coll-Risco I., Acosta-Manzano P., Borges-Cosic M., Espinosa-Rosso M., Corcuera-Ortiz L., Ocón-Hernández O., Soriano-Maldonado A., Aparicio VA. A novel concurrent exercise training program designed for a healthy pregnancy. The Gestafit Project. Comunicación Oral. I Jornadas Científicas del Centro de Investigación Biomédica (CIBM). Granada. (oral presentation).

2017/07: Romero-Gallardo, L., Coll-Risco, I , Ocón, O. , Borges-Cosic, M., Acosta-Manzano, P., Espinosa-Rosso, M., López-Criado, S., Gallo JL., Padilla-Vinuesa C, Aparicio, VA: The effects of a concurrent exercise training program on the quality of life of pregnant women. The GESTAFIT Project. International Symposium Active Brains for All: Exercise, Cognition and Mental Health. Granada (poster presentation).

2018/12: Romero-Gallardo, L., Baena-García, L., Soriano-Maldonado, A., Serrano, M., Coll-Risco, I., Acosta-Manzano, P., Moreno-Hoyos, MC, Aparicio, V.A.: “Association of muscular strength in early second trimester of pregnancy with birth outcomes and neonate weight. The GESTAFIT Project”. XI International Symposium in Strength Training held in Faculty of Physical Activity and Sports Sciences (INEF) Technical University of Madrid, Madrid (Spain). (oral presentation).

7. TEACHING EXPERIENCES:

- 90 hours of teaching in Master Degree in Personal Training at University of Granada. Module Exercise during pregnancy and postpartum.
- More than 100 hours in several Masters Degree relationated with Physical Activity, Physical Exercise, Pregnancy and Postpartum. Various universities: Cádiz, Navarra, CEU San Pablo (Sevilla), European of Madrid, etc.
- More than 1000 hours in an extra academic course: Certificación en Entrenamiento durante el embarazo y tras el parto. Authorship of the own agenda and intellectual property registration with number 04/2018/2938.
- Supervision of 4 different students with practicum and 5 master degree theses.

8. AWARDS:

- First Oral Communication Award to "Association of muscular strength in early second trimester of pregnancy with birth outcomes and neonate weight. The GESTAFIT Project" by Romero-Gallardo, L, Baena-García, L; Soriano-Maldonado, A.; Serrano, M.2; Coll-Risco, I.; Acosta-Manzano, P.; Moreno-Hoyos, M.C.; Aparicio, V.A. Madrid 15 december 2018
- First Award Andalusia Entrepreneurship by Almería. December 2020.
- Finalist Awards of Entrepreneurship Association of Young entrepreneurs. Almería 2019.

9. SCIENTIFIC PUBLICATIONS DIRECTLY DERIVED FROM THE PRESENT DOCTORAL THESIS:

a) STUDY I: Romero-Gallardo L, Soriano-Maldonado A, Ocon-Hernandez O, et al. International Fitness Scale-IFIS: Validity and association with health-related quality of life in pregnant women. Scand J Med Sci Sports. 2020;30(3):505-514. doi:10.1111/sms.13584.(Q1 Sports Sciences)

b) STUDY II: Assessing physical fitness during pregnancy: validity and reliability of fitness tests, and relationship with health-related outcomes. A systematic review. (Submitted)

10. PUBLICATION LIST:

1. Rodriguez-Ayllon, M., Acosta-Manzano, P., Coll-Risco, I., **Romero-Gallardo, L.**, Borges-Cosic, M., Estévez-López, F. and Aparicio, V.A. (2021). Associations of physical activity, sedentary time, and physical fitness with mental health during pregnancy: The GESTAFIT project. *Journal of Sport and Health Science*, [online] 10(3), pp.379–386. Available at: https://pubmed.ncbi.nlm.nih.gov/34024352/

2. Baena-García, L., Coll-Risco, I., Ocón-Hernández, O., **Romero-Gallardo, L**., Acosta-Manzano, P., May, L. and Aparicio, V.A. (2020). Association of objectively measured physical fitness during pregnancy with maternal and neonatal outcomes. The GESTAFIT Project. PLOS ONE, [online] 15(2), p.e0229079. Available at: https://pubmed.ncbi.nlm.nih.gov/32069319/

3. Baena-García, L., Acosta-Manzano, P., Ocón-Hernández, O., Borges-Cosic, M., **Romero-Gallardo, L.,** Marín-Jiménez, N. and Aparicio, V.A. (2020). Objectively measured sedentary time and physical activity levels in Spanish pregnant women. Factors affecting the compliance with physical activity guidelines. Women & Health, [online] 61(1), pp.27–37. Available at: https://pubmed.ncbi.nlm.nih.gov/33143596/

4. Baena-García, L., Ocón-Hernández, O., Acosta-Manzano, P., Coll-Risco, I., Borges-Cosic, M., **Romero-Gallardo, L.,** de la Flor-Alemany, M. and Aparicio, V.A. (2018). Association of sedentary time and physical activity during pregnancy with maternal and neonatal birth outcomes. The GESTAFIT Project. Scandinavian Journal of Medicine & Science in Sports, [online] 29(3), pp.407–414. Available at: https://pubmed.ncbi.nlm.nih.gov/30450596/

5. Acosta-Manzano, Coll-Risco, Van Poppel, Segura-Jiménez, Femia, Romero-Gallardo, Borges-Cosic, Díaz-Castro, Moreno-Fernández, Ochoa-Herrera and Aparicio (2019). Influence of a Concurrent Exercise Training Intervention during Pregnancy on Maternal and Arterial and Venous Cord Serum Cytokines: The GESTAFIT Project. Journal of Clinical Medicine, [online] 8(11), p.1862. Available at: https://pubmed.ncbi.nlm.nih.gov/31684183/

6. Marín-Jiménez, N., Acosta-Manzano, P., Borges-Cosic, M., Baena-García, L., Coll-Risco, I., **Romero-Gallardo, L**. and Aparicio, V.A. (2019). Association of self‐reported physical fitness with pain during pregnancy: The GESTAFIT Project. Scandinavian Journal of Medicine & Science in Sports. [online] Available at: https://pubmed.ncbi.nlm.nih.gov/30933387/

7. Aparicio VA, Ocón O, Padilla-Vinuesa C, Soriano-Maldonado A, **Romero-Gallardo L**, Borges-Césic M, Coll-Risco I, Ruiz-Cabello P, Acosta-Manzano P, Estévez-López F, Álvarez-Gallardo IC, Delgado-Fernández M, Ruiz JR, Van Poppel MN, Ochoa-Herrera JJ: Effects of supervised aerobic and strength training in overweight and grade I obese pregnant women on maternal and foetal health markers: the GESTAFIT randomized controlled trial. BMC Pregnancy Childbirth. 2016 Sep 29;16(1):290.

8. Aparicio VA, Ocón O, **Romero L**, Soriano-Maldonado A. The role of physical activity on weight gain and hypertensive disorders during pregnancy. Letter to de Editor. Am J Hypertens. 2016 Oct;29(10):e3.

9. Soriano-Maldonado, A., **Romero, L**., Femia, P., Roero C., Ruiz J.R., Gutierrez, A. (2013) "A Learning Protocol Improves the Validity of the Borg 6–20 RPE Scale During Indoor Cycling". International Journal of Sports Medicine. Octubre 2013

11. DIVULGATIVE ARTICLES

1. 2020: Revista HOLA: Ejercicios que si puedes hacer en el último trimestre de embarazo: https://www.hola.com/ninos/galeria/20200918175548/ejercicios-embarazo-tercer-trimestre/1/
2. 2020: Portal Embarazo.net: Entrenar de forma segura en casa: https://blog.elembarazo.net/entrevista-estas-embarazada-y-quieres-entrenar-en-casa-de-forma-segura-lidia-romero-te-ofrece-todas-las-claves.html
3. 2020: Revista HOLA: Si estás embarazada, así puedes seguir entrenando en casa: https://www.hola.com/ninos/galeria/20200406165039/embarazo-ejercicios-casa-cuarentena/1/
4. 2017: Entrenamiento de la fuerza durante el embarazo. Sport Life Mujer.
5. 2016: Ejercicios durante el embarazo ¡A ENTRENAR! Especial de 13 páginas en Sport Life Mujer.
6. 2016: ¿Se puede practicar ejercicio durante el embarazo? http://www.iAnfosalus.com/mujer/noticia-puede-practicar-ejercicio-embarazo-20160429060036.html
7. 2017: Deportistas con barriga: http://www.diariosur.es/sociedad/201701/09/deportistas-barriga-20170109204840.html
8. 2016: Deporte y embarazo no son palabras antagónicas:: http://www.diariodesevilla.es/vivirensevilla/Deporte-embarazo-palabras-antagonicas_0_1027997320.html
9. 2014: Running tras el parto, preguntas y consejos.: http://www.cmdsport.com/running/running-tras-el-parto-preguntas-y-consejos/
10. 2014: ELLAS: Deporte y sus etapas vitales: http://issuu.com/sportvicious/docs/n__mero_16
11. 2014: "¿Por qué la mujer prefiere el running como deporte?". http://www.menecesitas.com/2014/03/10/en-que-aspectos-importantes-difiere-el-entrenamientofemenino-del-masculino/

Agradecimientos/ Acknowledgements/

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